



# Prevalence of swallow, communication, voice and cognitive compromise following hospitalisation for COVID-19: the PHOSP-COVID analysis

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## ABSTRACT

**Objective** Identify prevalence of self-reported swallow, communication, voice and cognitive compromise following hospitalisation for COVID-19.

**Design** Multicentre prospective observational cohort study using questionnaire data at visit 1 (2–7 months post discharge) and visit 2 (10–14 months post discharge) from hospitalised patients in the UK. Lasso logistic regression analysis was undertaken to identify associations.

**Setting** 64 UK acute hospital Trusts.

**Participants** Adults aged >18 years, discharged from an admissions unit or ward at a UK hospital with COVID-19.

**Main outcome measures** Self-reported swallow, communication, voice and cognitive compromise.

**Results** Compromised swallowing post intensive care unit (post-ICU) admission was reported in 20% (188/955); 60% with swallow problems received invasive mechanical ventilation and were more likely to have undergone proning ( $p=0.039$ ). Voice problems were reported in 34% (319/946) post-ICU admission who were more likely to have received invasive ( $p<0.001$ ) or non-invasive ventilation ( $p=0.001$ ) and to have been proned ( $p<0.001$ ). Communication compromise was reported in 23% (527/2275) univariable analysis identified associations with younger age ( $p<0.001$ ), female sex ( $p<0.001$ ), social deprivation ( $p<0.001$ ) and being a healthcare worker ( $p=0.010$ ). Cognitive issues were reported by 70% (1598/2275), consistent at both visits, at visit 1 respondents were more likely to have higher baseline comorbidities and at visit 2 were associated with greater social deprivation ( $p<0.001$ ).

**Conclusion** Swallow, communication, voice and cognitive problems were prevalent post hospitalisation for COVID-19,

## WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ COVID-19 is a multisystem disease with primary and potentially long-lasting impacts on respiratory function, musculoskeletal, gastrointestinal, circulatory, cardiac and nervous systems.
- ⇒ We do not yet know what the impact on swallow, communication, voice and cognition are post hospitalisation, so we explored what longer-term functional problems people experienced.

## WHAT THIS STUDY ADDS

- ⇒ We now know that swallow, communication, voice and cognitive problems are prevalent post hospitalisation for COVID-19 and were commonly associated with being younger, female and living in socially deprived areas.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ This study tells us a significant number of people are experiencing swallow communication voice and cognitive issues, and they are likely to require support and effective rehabilitation to improve their function.
- ⇒ Future research and phenotype determination need to capture swallow, communication, voice and cognition subtypes, using detailed assessments and measurements of these important symptoms so we can improve outcomes.



alongside whole system compromise including reduced mobility and overall health scores. Research and testing of rehabilitation interventions are required at pace to explore these issues.

## INTRODUCTION

SARS-CoV-2 has complex and multifaceted effects and results in the multisystem disease COVID-19. The primary impact of the virus and its variants are on respiratory function; however musculoskeletal, gastrointestinal, circulatory, cardiac and nervous systems can also be compromised.<sup>1–4</sup> Many experience symptoms persisting beyond 4 weeks from initial presentation, irrespective of severity of acute illness (long COVID).<sup>5</sup> Our analysis explores data from PHOSP-COVID,<sup>6</sup> which collected holistic clinical information from a large cohort of patients hospitalised with COVID-19 across the UK to determine chronic health sequelae. To date, there are no population-based studies on the prevalence of self-reported swallowing, communication, voice and cognitive problems post-COVID-19.

### Swallowing problems and COVID-19

Causes of swallow compromise following COVID-19 are multifactorial. For those intubated and ventilated in hospital, iatrogenic injury to the larynx and upper airway frequently impacts on anatomy fundamental to safe and effective swallowing.<sup>7</sup> Numerous patients who were not ventilated also experienced swallowing problems<sup>8</sup> associated with respiratory compromise, neurological issues, encephalopathies and pre-existing comorbidities.<sup>9–10</sup> Respiration and swallowing occur in synchrony via neural mechanisms. Consequently, when breathing is impacted by disease or respiratory support,<sup>11</sup> destabilisation of the breathe-swallow pattern can result in aspiration (food and/or drink passing below the level of the vocal cords and into the trachea).<sup>11</sup> This can cause a range of consequences from coughing and choking during eating and drinking to pneumonia and death.<sup>12</sup>

### Communication and cognitive difficulties in COVID-19

Communication compromise may arise from a range of aetiologies associated with numerous pathologies.<sup>13</sup> Word finding difficulties post COVID-19 have been described,<sup>14</sup> potentially due to encephalopathies and associated dysexecutive syndromes. However no studies have prospectively investigated this symptom, its severity or recovery trajectory. Alongside communication issues, 'brain fog'<sup>6,15</sup> and neurocognitive problems<sup>16</sup> have been reported.<sup>15</sup> People may experience language deficits (dysphasia), or a conglomerate of symptoms involving language production and processing, and concurrent cognitive challenges which simultaneously impact on memory, perception, attention and reasoning. These cognitive processes are core components of successful communicative interactions and language use.<sup>17</sup> These

problems can be insidious and physically difficult for the individual to describe due to the nature of compromised language function.<sup>18</sup>

### Voice and COVID-19

Voice changes (dysphonia) have been identified in both the acute presentation of the virus in hospitalised patients<sup>19</sup>; and in up to 43% of non-hospitalised patients.<sup>20</sup> Laryngeal injury including vocal fold palsy can be a consequence of intubation and postviral infection,<sup>21</sup> along with alteration to the physiology of the larynx and upper airway causing voice changes. Voice and vocal competence are fundamental to communication, and essential for individuals to work and function effectively in society.<sup>22</sup> Significant distress has been reported as an effect of an inability to communicate.<sup>23</sup> Impaired voice competence is an immediate and long-term risk to individual function, quality of life and ability to return to work, therefore a socioeconomic burden to the UK workforce.<sup>24</sup>

### Clinical questions

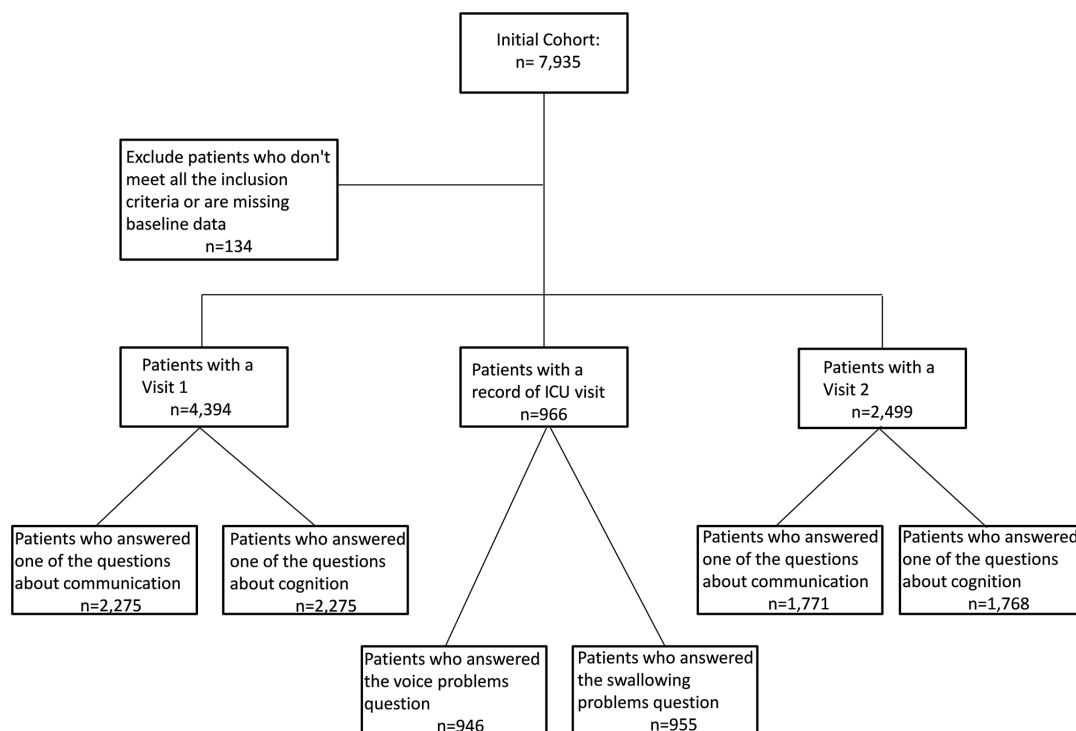
1. What is the prevalence of swallow, voice, communication and cognitive problems after discharge from hospital following COVID-19?
2. What were the associations with individual characteristics in those who experienced these issues?

### METHODS

Methods, analysis and results are reported in line with Strengthening the Reporting of Observational Studies in Epidemiology guidelines.<sup>25</sup> Prevalence of swallow, voice, communication and cognitive problems are reported, this is the proportion of the population included in the PHOSP data collection at and during particular time points, who self-reported these particular functional compromise.<sup>26</sup>

### Data source

Data from PHOSP-COVID<sup>6</sup> that recruited adult patients discharged from a ward or admissions unit at 64 UK hospital Trusts, with confirmed diagnosis of COVID-19 were analysed to explore swallow communication, voice and cognitive symptoms. Participants were asked to complete two research visits; between 2–7 (visit 1) and 10–14 months (visit 2) post discharge, visits outside this timeframe were excluded ( $\pm 14$  days). Outcomes of interest were all derived from questionnaire responses completed at research visits. A number of participants were unable to attend their first visit but attended the second and therefore respondents included in the cohort at visit 2 may not have been in the visit 1 cohort (figure 1).



**Figure 1** Flow chart. ICU, intensive care unit.

## Variables

Six outcomes of interest were self-reported communication issues and cognitive issues at visits 1 and 2, and self-reported voice and swallow problems during an intensive care unit (ICU) stay at some point in the index admission. Only people treated in ICU were asked whether they had voice or swallow problems. We defined someone as having a communication issue at either visit if they answered ‘yes’/‘yes—some difficulty’/‘yes—a lot of difficulty’ or ‘cannot do at all’ to “Using your usual (customary) language, do you have difficulty communicating, for example, understanding or being understood” or if they answered ‘yes’ to having ‘difficulty with communication’ within the last 7 days. Cognitive symptoms were identified if the respondent stated they had at least one of the following within the last 7 days; ‘confusion or fuzzy head’, ‘difficulty with concentration’, ‘short-term memory loss’, ‘physical slowing down’ or ‘slowing down in your thinking’. Swallowing and voice data were only collected from respondents who stated they had been admitted to ICU and answered ‘yes’ to either CRF question 3 “Are you having difficulties eating, drinking or swallowing such as coughing, choking or avoiding any food or drinks?” or the Patient Symptom Questionnaire (PSQ) “Have you or your family noticed any changes to your voice such as difficulty being heard, altered quality of the voice, your voice tiring by the end of the day or an inability to alter the pitch of your voice?” Any comorbidities listed as ‘other’ were reviewed individually and categorised, ensuring comprehensive data were included. Number of comorbidities were calculated as a count and treated as a continuous variable. Respondents’ body mass

indices (BMI) were not collected at baseline but were collected at each of the follow-up visits.

## Outcome measures

Relationships between six outcome variables and factors from the baseline visit were investigated, with further outcomes from questionnaires at both visits 1 and 2. We used the EQ-5D-5L<sup>27</sup> health-related quality-of-life questionnaire, the Medical Research Council (MRC) Dyspnoea Scale,<sup>28</sup> Dyspnoea 12,<sup>29</sup> the Post-traumatic Checklist for DSM-5 (PCL-5), a 20-item questionnaire which assesses the requirements for a Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) diagnosis of post-traumatic stress disorder (PTSD) (overall score was categorised into 0–32 unlikely to have PTSD, and 33–80 indicative of probable PTSD) as per guidance,<sup>30</sup> the Montreal Cognitive Assessment (MoCA) assessment of cognition, visuospatial abilities, short-term memory, attention, working memory, language and orientation<sup>31</sup> presenting a summary of the overall score, categorised as per published guidance<sup>31</sup> into normal (>25), mild (18–25) and moderate or severe cognitive impairment (<18), and finally the Rockwood Clinical Frailty (RCF) score,<sup>32</sup> a clinical measure of frailty from 1 (very fit) to 9 (terminally ill). We categorised the RCF into 1–4 (fit to vulnerable) and 5+ (mildly frail to terminally ill).

*Explanatory variables:* age and ethnicity were grouped and distributed. Respondents’ postcodes were linked to Indices of Multiple Deprivation (IMD)<sup>33</sup> to provide an estimate of deprivation. We detailed ranked quintiles of IMD, 1 being most, 5 being least deprived.<sup>33</sup>



All levels of respiratory support during index admission were captured, with a combined variable relating to the WHO clinical progression scale. WHO respiratory support classification was 'class 7–9' for extracorporeal membrane oxygenation (ECMO), renal replacement therapy (RRT) or invasive mechanical ventilation (IMV), 'class 6' for high flow nasal O<sub>2</sub> (HFN), bi-level non-invasive ventilation (NIV), continuous positive airway pressure (CPAP), 'class 5' for supplemental O<sub>2</sub> and 'class 4' if the patient received none of these interventions.

### Statistical methods

Respondents missing age, sex and gender were excluded from analysis. Categorical variables are reported as counts and percentages; continuous variables are presented as medians with IQRs. Univariable analysis of categorical variables was undertaken using either  $\chi^2$  test or Fisher's exact test for small numbers, for continuous variables the Kruskal-Wallis test was used. Only completed data have been included for the summaries of the in-hospital, pre-hospital and outcomes. Although included in our protocol, after reviewing data for maximal inspiratory pressure and maximal expiratory pressure, handgrip and quadriceps strength and chest X-ray findings, we decided not to investigate these further due to incomplete data. P values <0.05 were considered statistically significant.

Before multivariable analyses were undertaken, a subset of variables were chosen to be included based on clinical knowledge. From the demographics section, we chose to exclude healthcare worker status and shielding status, the only COVID-19 symptoms included were cough, fever, headache confusion or other symptoms relating to ear, nose or throat problems, all comorbidities, new diagnoses, pre-admission medications and respiratory support were included. We only included antibiotic therapy, systemic steroids, therapeutic dose anticoagulation and RRT as these were treatment options available for the whole time period. For respondents included in the study, we included unknown categories for missing data in the baseline demographics in the multivariable analysis. For any pre-hospital or in-hospital variables included in the multivariable analysis, we included an unknown category.

We undertook lasso logistic regression with the binary outcomes of swallow, communication, voice or cognitive problems as the dependent variable for variable selection. We investigated a number of techniques including cross validation with 10 folds, adaptive lasso and elasticnet and chose the solution with the best out of sample model goodness of fit. We required age at admission and sex be included in the final models given their contextual importance.<sup>34</sup> As a sensitivity analysis, we performed a complete-case analysis.

### RESULTS

Overall, 7935 participants were included in the study, n=134 were excluded as they did not meet the inclusion

criteria or had missing data. N=4394 had visit 1 data, n=966 had an intensive care unit visit and n=2499 had a visit 2 (see figure 1). Swallow, communication, voice and cognitive problems were prevalent and persisted over time from visit 1 to visit 2 (see tables 1 and 2). Swallow problems were reported in 20% (188/955) and voice problems in 34% (319/946) of those admitted to ICU. Of the whole cohort, communication issues were reported by 23.2% (527/2275) at visit 1 which remained at 22.5% (399/1771) at visit 2. Cognitive problems were more highly prevalent and reported by 70.2% (1598/2275) at visit 1, and remained at 69.6% (1231/1768) at visit 2.

### Swallow problems

Only participants who had been treated in ICU could report swallow problems. Important clinical features included the following: they were more likely to have undergone IMV (p<0.001), to have been prone (p=0.039) (table 3), to be younger (p=0.001) and female (p=0.041) (table 1). Significant physiological comorbidities associated with swallow problems were asthma (26% vs 16%, p=0.002) and gastro-oesophageal reflux disease (15% vs 8%, p=0.002) (table 4). There did not appear to be any difference in ethnicity, education, deprivation, healthcare worker or shielding status prior to admission.

Respondents with swallow problems spent longer in hospital (median length of stay: 24 vs 16 days) and were more likely to report worsening mobility (p<0.001), self-care (p<0.001), usual activities (p=0.005), pain or discomfort (p=0.006) and have lower health score (p<0.001) (table 5). They had a higher overall score on the Dyspnoea 12 (p<0.001), and on physical and affective subdomains (p<0.001), had a higher PCL-5 (PTSD) overall score (p<0.001) and were more likely to be clinically frail according to the RCF (p<0.001) (table 5). Swallow problems were only collected at one time point so it is not possible to determine how long these problems persisted. Variables included in the final model chosen by cross-validation are detailed in online supplemental data 1.1.

### Voice problems

Over a third of eligible respondents reported voice problems (319/946, 34%) during their admission. There were no demographic differences between participants with and without voice problems (table 1); however, they were more likely to have asthma (23% vs 15%, p=0.003) to have received CPAP (59% vs 47%, p=0.001), NIV (16% vs 10%, p=0.021) and almost twice as likely to have received IMV (65% vs 36%) (table 3). These are important associations which identify relationships between perceived voice problems and respiratory compromise. They were also more likely to receive antibiotics (93% vs 86%), to have been prone (54% vs 35%) and to have a new diagnosis of renal failure requiring dialysis (12% vs 7%). They were more likely to state one of their COVID-19 symptoms was

**Table 1** Demographics of patients who answered questions about voice and swallow problems during their index admission

		ICU swallow problems			ICU voice problems		
		No	Yes	P value	No	Yes	P value
	N (%)	767 (80.3%)	188 (19.7%)		627 (66.3%)	319 (33.7%)	
Age at admission (years)	Median* (IQR)	60 (51–67)	57 (51–64.5)	<b>0.001</b>	60 (51–68)	59 (52–64)	0.071
	Under 40	48 (6.3%)	14 (7.4%)	<b>0.026</b>	47 (7.5%)	14 (4.4%)	<b>0.012</b>
	40–49	105 (13.7%)	26 (13.8%)		79 (12.6%)	50 (15.7%)	
	50–59	216 (28.2%)	73 (38.8%)		177 (28.2%)	106 (33.2%)	
	60–69	260 (33.9%)	53 (28.2%)		203 (32.4%)	110 (34.5%)	
	70–79	138 (18.0%)	22 (11.7%)		121 (19.3%)	39 (12.2%)	
Sex	Female	219 (28.6%)	68 (36.2%)	<b>0.041</b>	187 (29.8%)	97 (30.4%)	0.853
	Male	548 (71.4%)	120 (63.8%)		440 (70.2%)	222 (69.6%)	
Ethnicity	White	548 (71.4%)	127 (67.6%)	0.102	446 (71.1%)	223 (69.9%)	0.915
	South Asian	79 (10.3%)	27 (14.4%)		67 (10.7%)	39 (12.2%)	
	Black	75 (9.8%)	12 (6.4%)		57 (9.1%)	28 (8.8%)	
	Other†	65 (8.5%)	22 (11.7%)		57 (9.1%)	29 (9.1%)	
BMI	Under/Normal weight	52 (6.8%)	10 (5.3%)	0.237	43 (6.9%)	19 (6.0%)	0.153
	Overweight	196 (25.6%)	52 (27.7%)		160 (25.5%)	84 (26.3%)	
	Obese	271 (35.3%)	70 (37.2%)		212 (33.8%)	127 (39.8%)	
	Severe obesity	67 (8.7%)	23 (12.2%)		58 (9.3%)	31 (9.7%)	
	Not recorded	181 (23.6%)	33 (17.6%)		154 (24.6%)	58 (18.2%)	
IMD quintile‡	1—most deprived	175 (22.8%)	40 (21.3%)	0.528	140 (22.3%)	75 (23.5%)	0.121
	2	170 (22.2%)	50 (26.6%)		150 (23.9%)	65 (20.4%)	
	3	155 (20.2%)	40 (21.3%)		115 (18.3%)	75 (23.5%)	
	4	135 (17.6%)	25 (13.3%)		115 (18.3%)	40 (12.5%)	
	5—least deprived	130 (16.9%)	35 (18.6%)		100 (15.9%)	60 (18.8%)	
	Unknown	§	§		§	§	
Educational level	None	42 (5.5%)	8 (4.3%)	0.135	39 (6.2%)	10 (3.1%)	0.331
	Primary school	219 (28.6%)	53 (28.2%)		180 (28.7%)	89 (27.9%)	
	Secondary school	94 (12.3%)	20 (10.6%)		72 (11.5%)	42 (13.2%)	
	Sixth form college	98 (12.8%)	35 (18.6%)		82 (13.1%)	50 (15.7%)	
	Vocational qualification	131 (17.1%)	24 (12.8%)		106 (16.9%)	48 (15.0%)	
	Undergraduate	103 (13.4%)	20 (10.6%)		76 (12.1%)	46 (14.4%)	
	Postgraduate	80 (10.4%)	28 (14.9%)		72 (11.5%)	34 (10.7%)	
	Unknown	91 (11.9%)	24 (12.8%)		66 (10.5%)	47 (14.7%)	
Healthcare worker	494 (64.4%)	111 (59.0%)	0.273	398 (63.5%)	201 (63.0%)	0.128	
Shielding status prior to admission	Not	130 (16.9%)	30 (16.0%)	0.145	108 (17.2%)	50 (15.7%)	0.653
	Voluntary shielding	32 (4.2%)	11 (5.9%)		25 (4.0%)	18 (5.6%)	
	Extremely vulnerable	57 (7.4%)	13 (6.9%)		48 (7.7%)	21 (6.6%)	
	Letter issued by HCP	54 (7.0%)	23 (12.2%)		48 (7.7%)	29 (9.1%)	
	Unknown	175 (22.8%)	40 (21.3%)		140 (22.3%)	75 (23.5%)	

Unless otherwise specified, numbers are shown as counts (percentages) and p values have been calculated using  $\chi^2$  test; 20% of respondents who answered the question had swallow problems, patients were significantly more likely to be younger and female; 34% of respondents voice problems; there do not appear to be any significant differences in the demographics of patients who had voice problems compared with those who did not.

\*P value calculated using Kruskal-Wallis,  $p < 0.05$  are bolded.

†Includes mixed and unknown.

‡Where numbers could be calculated, the other values have been rounded to the nearest 5 and % calculated on this new value.

§Numbers  $\leq 5$  have been suppressed.

BMI, body mass index; HCP, healthcare professional; ICU, intensive care unit; IMD, indices of multiple deprivation.

**Table 2** Demographics at the time of initial COVID-19 admission split by whether respondents have communication or cognitive issues at visit 1 or visit 2

	Visit 1 cognitive issues			Visit 2 cognitive issues			Visit 1 communication issues			Visit 2 communication issues		
	No	Yes	P value	No	Yes	P value	No	Yes	P value	No	Yes	P value
N (%)	677 (29.8%)	1598 (70.2%)		537 (30.4%)	1231 (69.6%)		1748 (76.8%)	527 (23.2%)		1372 (77.5%)	399 (22.5%)	
Age at admission (years)												
Median* (IQR)	60 (49–68)	58 (50–66)	0.976	60 (50–68)	60 (52–68)	0.361	60 (51–68)	56 (49–63)	<0.001	61 (52.5–69)	57 (51–64)	<0.001
Under 40	64 (9.5%)	118 (7.4%)	<b>0.002</b>	49 (9.1%)	68 (5.5%)	0.102	142 (8.1%)	40 (7.6%)	<0.001	86 (6.3%)	31 (7.8%)	<0.001
40–49	106 (15.7%)	252 (15.8%)		74 (13.8%)	159 (12.9%)		262 (15.0%)	96 (18.2%)		172 (12.5%)	61 (15.3%)	
50–59	158 (23.3%)	494 (30.9%)		143 (26.6%)	368 (29.9%)		451 (25.8%)	201 (38.1%)		362 (26.4%)	151 (37.8%)	
60–69	203 (30.0%)	461 (28.8%)		163 (30.4%)	378 (30.7%)		528 (30.2%)	136 (25.8%)		432 (31.5%)	110 (27.6%)	
70–79	119 (17.6%)	225 (14.1%)		91 (16.9%)	214 (17.4%)		299 (17.1%)	45 (8.5%)		265 (19.3%)	38 (9.5%)	
80 and over	27 (4.0%)	48 (3.0%)		17 (2.2%)	44 (3.6%)		66 (3.8%)	9 (1.7%)		55 (4.0%)	8 (2.0%)	
Sex												
Female	186 (27.5%)	699 (43.7%)	<0.001	140 (26.1%)	525 (42.6%)	<0.001	631 (36.1%)	254 (48.2%)	<0.001	490 (35.7%)	177 (44.4%)	<b>0.002</b>
Male	491 (72.5%)	899 (56.3%)		397 (73.9%)	706 (57.4%)		1117 (63.9%)	273 (51.8%)		882 (64.3%)	222 (55.6%)	
Ethnicity												
White	458 (67.7%)	1243 (77.8%)	<0.001	382 (71.1%)	980 (79.6%)	<0.001	1297 (74.2%)	405 (76.9%)	0.629	1060 (77.3%)	304 (76.2%)	0.404
South Asian	103 (15.2%)	153 (9.6%)		69 (12.8%)	92 (7.5%)		203 (11.6%)	53 (10.1%)		126 (9.2%)	35 (8.8%)	
Black	61 (9.0%)	99 (6.2%)		44 (8.2%)	78 (6.3%)		123 (7.0%)	36 (6.8%)		98 (7.1%)	25 (6.3%)	
Other†	55 (8.1%)	103 (6.4%)		42 (7.8%)	81 (6.6%)		125 (7.2%)	33 (6.3%)		88 (6.4%)	35 (8.8%)	

Continued

Table 2 Continued

	Visit 1 cognitive issues			Visit 2 cognitive issues			Visit 1 communication issues			Visit 2 communication issues		
	No	Yes	P value	No	Yes	P value	No	Yes	P value	No	Yes	P value
BMI												
Under/Normal weight	68 (10.0%)	137 (8.6%)	<0.001	61 (11.4%)	85 (6.9%)	<0.001	166 (9.5%)	39 (7.4%)		119 (8.7%)	27 (6.8%)	0.047
Overweight	197 (29.1%)	390 (24.4%)		163 (30.4%)	285 (23.2%)		456 (26.1%)	131 (24.9%)	0.259	365 (26.6%)	83 (20.8%)	
Obese	231 (34.1%)	611 (38.2%)		176 (32.8%)	460 (37.4%)		645 (36.9%)	196 (37.2%)		487 (35.5%)	150 (37.6%)	
Severe obesity	45 (6.6%)	191 (12.0%)		27 (5.0%)	122 (9.9%)		170 (9.7%)	66 (12.5%)		110 (8.0%)	40 (10.0%)	
Not recorded	136 (20.1%)	269 (16.8%)		110 (20.5%)	279 (22.7%)		311 (17.8%)	95 (18.0%)		291 (21.2%)	99 (24.8%)	
IMD quintile†												
1—most deprived	142 (21.0%)	388 (24.3%)	0.149	100 (18.6%)	300 (24.4%)	<0.001	390 (22.3%)	140 (26.6%)	0.010	308 (22.4%)	95 (23.8%)	0.020
2	162 (23.9%)	367 (23.0%)		110 (20.5%)	275 (22.3%)		390 (22.3%)	135 (25.6%)		276 (20.1%)	108 (27.1%)	
3	132 (19.5%)	265 (16.6%)		100 (18.6%)	220 (17.9%)		300 (17.2%)	95 (18.0%)		250 (18.2%)	65 (16.3%)	
4	110 (16.2%)	274 (17.1%)		100 (18.6%)	220 (17.9%)		320 (18.3%)	65 (12.3%)		262 (19.1%)	59 (14.8%)	
5—least deprived	123 (18.2%)	296 (18.5%)		125 (23.3%)	215 (17.5%)		330 (18.9%)	90 (17.1%)		269 (19.6%)	72 (18.0%)	
Unknown	8 (1.2%)	8 (0.5%)		\$	\$		\$	\$		7 (0.5%)	0	
Educational level												
None	14 (2.1%)	46 (2.9%)	<0.001	10 (1.9%)	34 (2.8%)	0.008	44 (2.5%)	16 (3.0%)	0.009	36 (2.6%)	9 (2.3%)	0.020
Primary school	14 (2.1%)	40 (2.5%)		10 (1.9%)	26 (2.1%)		43 (2.5%)	11 (2.1%)		30 (2.2%)	6 (1.5%)	
Secondary school	166 (24.5%)	511 (32.0%)		161 (30.0%)	393 (31.9%)		519 (29.7%)	159 (30.2%)		429 (31.3%)	126 (31.6%)	
Sixth form college	97 (14.3%)	198 (12.4%)		63 (11.7%)	161 (13.1%)		225 (12.9%)	70 (13.3%)		159 (11.6%)	65 (16.3%)	
Vocational qualification	65 (9.6%)	204 (12.8%)		50 (9.3%)	165 (13.4%)		185 (10.6%)	84 (15.9%)		157 (11.4%)	59 (14.8%)	
Undergraduate	142 (21.0%)	258 (16.1%)		106 (19.7%)	198 (16.1%)		329 (18.8%)	70 (13.3%)		255 (18.6%)	49 (12.3%)	
Postgraduate	109 (16.1%)	197 (12.3%)		95 (17.7%)	149 (12.1%)		242 (13.8%)	64 (12.1%)		193 (14.1%)	51 (12.8%)	
Unknown	70 (10.3%)	144 (9.0%)		42 (7.8%)	105 (8.5%)		161 (9.2%)	53 (10.1%)		113 (8.2%)	34 (8.5%)	

Continued

Table 2 Continued

	Visit 1 cognitive issues			Visit 2 cognitive issues			Visit 1 communication issues			Visit 2 communication issues		
	No	Yes	P value	No	Yes	P value	No	Yes	P value	No	Yes	P value
Healthcare worker	84 (12.4%)	238 (14.9%)	0.252	70 (13.0%)	180 (14.6%)	0.210	230 (13.2%)	91 (17.3%)	<b>0.010</b>	186 (13.6%)	64 (16.0%)	0.452
Shielding status prior to admission	464 (68.5%)	988 (61.8%)	<b>&lt;0.001</b>	377 (70.2%)	750 (60.9%)	<b>0.001</b>	1142 (65.3%)	309 (58.6%)	<b>0.001</b>	884 (64.4%)	244 (61.2%)	0.091
Voluntary shielding	112 (16.5%)	284 (17.8%)		91 (16.9%)	226 (18.4%)		309 (17.7%)	88 (16.7%)		253 (18.4%)	65 (16.3%)	
Extremely vulnerable	24 (3.5%)	99 (6.2%)		21 (3.9%)	79 (6.4%)		83 (4.7%)	40 (7.6%)		75 (5.5%)	26 (6.5%)	
Letter issued by HCP	24 (3.5%)	121 (7.6%)		22 (4.1%)	91 (7.4%)		96 (5.5%)	49 (9.3%)		77 (5.6%)	36 (9.0%)	
Unknown	53 (7.8%)	106 (6.6%)		26 (4.8%)	85 (6.9%)		118 (6.8%)	41 (7.8%)		83 (6.0%)	28 (7.0%)	

Unless otherwise specified, numbers are shown as counts (percentages) and p values have been calculated using  $\chi^2$  test; 70% of respondents at both visits 1 and 2 reported cognitive issues, and 23% of respondents reported communication issues. There did not appear to be significant difference in the proportion of patients who reported problems by whether or not they were healthcare workers. For communication issues, there did not appear to be any significant difference based on ethnicity or BMI.

\*P value calculated using Kruskal-Wallis,  $p < 0.05$  are bolded.

†Includes mixed and unknown.

‡Where numbers could be calculated, the other values have been rounded to the nearest 5 and % calculated on this new value.

§Numbers  $\leq 5$  have been suppressed.

BMI, body mass index; HCP, healthcare professional; IMD, indices of multiple deprivation.



**Table 3** COVID-19 symptoms and treatments before and during the index admission for respondents who answered questions about voice or swallow problems

		ICU swallow*			ICU voice*		
		No	Yes	P value	No	Yes	P value
Duration of COVID-19 symptoms	Median (IQR)†	8 (6–11)	8 (6–12)	0.791	8 (6–11)	8 (6–12)	0.228
COVID-19 symptoms*	Fever	582 (81.4%)	144 (85.2%)	0.245	475 (80.0%)	247 (87.6%)	<b>0.006</b>
	Cough	603 (84.2%)	135 (81.3%)	0.364	497 (83.7%)	234 (83.9%)	0.940
	Sore throat	70 (12.0%)	24 (17.1%)	0.101	53 (10.7%)	41 (18.1%)	<b>0.006</b>
	Runny nose	26 (4.4%)	12 (8.8%)	<b>0.041</b>	27 (5.4%)	11 (4.9%)	0.781
	Shortness of breath	626 (86.7%)	152 (88.9%)	0.443	511 (86.3%)	257 (88.3%)	0.375
	Loss of taste	111 (19.8%)	30 (21.7%)	0.602	102 (21.1%)	38 (17.9%)	0.334
	Loss of smell	91 (16.1%)	26 (19.3%)	0.373	86 (17.8%)	31 (14.5%)	0.275
	Headache	128 (21.4%)	37 (26.8%)	0.170	103 (20.4%)	59 (26.0%)	0.094
	Confusion	89 (14.2%)	25 (16.9%)	0.400	74 (14.0%)	41 (16.9%)	0.306
Pre-admission medications	Immunosuppressant	71 (10.5%)	23 (14.5%)	0.153	58 (10.3%)	35 (13.3%)	0.207
	Anti-infectives	84 (12.3%)	22 (14.1%)	0.549	77 (13.6%)	28 (10.6%)	0.233
	ACEI	107 (15.8%)	23 (14.2%)	0.616	75 (13.3%)	53 (19.9%)	<b>0.013</b>
	ARBS	49 (7.3%)	16 (10.0%)	0.245	38 (6.7%)	27 (10.2%)	0.083
	NSAID	48 (7.2%)	17 (11.0%)	0.115	38 (6.8%)	27 (10.6%)	0.065
Respiratory support	Supplemental O2	708 (94.4%)	172 (93.0%)	0.460	576 (93.2%)	295 (95.5%)	0.199
	CPAP	361 (50.3%)	97 (56.4%)	0.154	283 (47.5%)	168 (59.2%)	<b>0.001</b>
	Bi-level NIV	78 (11.4%)	24 (14.6%)	0.245	58 (10.2%)	43 (15.7%)	<b>0.021</b>
	High flow nasal O2	306 (44.0%)	61 (37.4%)	0.125	244 (42.1%)	119 (43.9%)	0.627
	Invasive mechanical ventilation	319 (42.3%)	103 (59.6%)	<b>&lt;0.001</b>	223 (35.6%)	201 (64.8%)	<b>&lt;0.001</b>
	ECMO	24 (3.3%)	9 (5.2%)	0.242	22 (3.7%)	11 (3.8%)	0.925
Highest respiratory level	WHO class 3–4	40 (5.2%)	11 (5.9%)	<b>&lt;0.001</b>	39 (6.2%)	12 (3.8%)	<b>&lt;0.001</b>
	WHO class 5	142 (18.5%)	28 (14.9%)		132 (21.1%)	36 (11.3%)	
	WHO class 6	260 (33.9%)	39 (20.7%)		227 (36.2%)	68 (21.3%)	
	WHO class 7–9	325 (42.4%)	110 (58.5%)		229 (36.5%)	203 (63.6%)	
Treatments given	Antibiotic therapy	644 (87.5%)	167 (92.3%)	0.079	521 (86.3%)	282 (92.8%)	<b>0.005</b>
	Systemic steroids	452 (64.5%)	89 (54.3%)	<b>0.014</b>	368 (63.3%)	167 (60.5%)	0.406
	Therapeutic dose anticoagulation	396 (56.1%)	93 (56.4%)	0.949	320 (55.0%)	164 (58.6%)	0.320
	Proning	267 (39.9%)	75 (49.0%)	<b>0.039</b>	194 (34.9%)	141 (54.4%)	<b>&lt;0.001</b>
	Renal replacement therapy	75 (10.6%)	21 (12.5%)	0.473	58 (9.8%)	37 (13.3%)	0.132
Other diagnoses made during admission	PE/Microthrombi	123 (17.0%)	22 (12.8%)	0.181	87 (14.5%)	55 (19.1%)	0.080
	Renal failure requiring dialysis	60 (8.3%)	20 (11.8%)	0.155	44 (7.4%)	35 (12.2%)	<b>0.013</b>
Duration of stay	Median (IQR)†	16 (9–33)	24 (12–42.5)	<b>&lt;0.001</b>	14 (8–28)	28 (14–47)	<b>&lt;0.001</b>

Unless otherwise specified, numbers are shown as counts (percentages) and p values have been calculated using  $\chi^2$  test. Patients who had invasive mechanical ventilation were significantly more likely to report swallow and voice problems, likewise patients who were treated with systemic steroids and proning were significantly more likely to report swallow problems. Patients with swallow and voice problems had a significantly longer length of stay.

\*The denominators vary for most variables, the number of excluded records due to missing data are recorded in online supplemental table S1.

†P value calculated using Kruskal-Wallis,  $p < 0.05$  are bolded.

ACEI, ACE inhibitors; ARBS, angiotensin II receptor blockers; CPAP, continuous positive airway pressure; ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit; NIV, non-invasive ventilation; NSAID, non-steroidal anti-inflammatory drugs; PE, pulmonary embolism.



**Table 4** Self-reported comorbidities recorded at baseline visit for those respondents who answered questions on voice or swallow problems

	ICU swallow			ICU voice		
	No	Yes	P value	No	Yes	P value
N (%)	767 (80.3%)	188 (19.7%)		627 (66.3%)	319 (33.7%)	
Myocardial infarction	34 (4.4%)	6 (3.2%)	0.446	25 (4.0%)	15 (4.7%)	0.605
Ischaemic heart disease	46 (6.0%)	14 (7.4%)	0.463	37 (5.9%)	22 (6.9%)	0.549
Atrial fibrillation	33 (4.3%)	10 (5.3%)	0.547	30 (4.8%)	13 (4.1%)	0.620
Hypertension	298 (38.9%)	65 (34.6%)	0.279	236 (37.6%)	124 (38.9%)	0.712
Congestive heart failure/ Congenital heart disease/ Valvular heard disease/ Pacemaker/Implantable device/Peripheral vascular disease	40 (5.2%)	11 (5.9%)	0.728	34 (5.4%)	18 (5.6%)	0.888
Hypercholesterolaemia/ Dyslipidaemia	166 (21.6%)	35 (18.6%)	0.362	138 (22.0%)	62 (19.4%)	0.359
Cerebrovascular accident/ Transient ischaemic attack	42 (5.5%)	8 (4.3%)	0.501	33 (5.3%)	17 (5.3%)	0.966
Depression or anxiety	103 (13.4%)	41 (21.8%)	<b>0.004</b>	86 (13.7%)	56 (17.6%)	0.118
Chronic fatigue syndrome, fibromyalgia, chronic pain	37 (4.8%)	19 (10.1%)	<b>0.006</b>	32 (5.1%)	24 (7.5%)	0.136
Any previous treatment with antidepressant medication	81 (10.6%)	40 (21.3%)	<b>&lt;0.001</b>	78 (12.4%)	40 (12.5%)	0.965
Any previous treatment by a mental health professional for a mental health problem	33 (4.3%)	21 (11.2%)	<b>&lt;0.001</b>	25 (4.0%)	27 (8.5%)	<b>0.004</b>
Chronic obstructive pulmonary disease	32 (4.2%)	8 (4.3%)	0.959	27 (4.3%)	12 (3.8%)	0.690
Asthma	126 (16.4%)	49 (26.1%)	<b>0.002</b>	96 (15.3%)	74 (23.2%)	<b>0.003</b>
Obstructive sleep apnoea	39 (5.1%)	14 (7.4%)	0.205	35 (5.6%)	18 (5.6%)	0.969
Interstitial lung disease/ Bronchiectasis/Obesity hypoventilation syndrome/ Pleural effusion	*	*	*	14 (2.2%)	11 (3.4%)	0.271
Rheumatoid arthritis	*	*	*	20 (3.2%)	9 (2.8%)	0.756
Osteoarthritis	75 (9.8%)	21 (11.2%)	0.570	57 (9.1%)	38 (11.9%)	0.172
Peptic ulcer disease/Liver disease	41 (5.3%)	6 (3.2%)	0.221	34 (5.4%)	13 (4.1%)	0.367
Gastro-oesophageal reflux disease	62 (8.1%)	29 (15.4%)	<b>0.002</b>	52 (8.3%)	39 (12.2%)	0.052
Irritable bowel syndrome	21 (2.7%)	9 (4.8%)	0.149	14 (2.2%)	16 (5.0%)	<b>0.021</b>
Diabetes	186 (24.3%)	45 (23.9%)	0.928	151 (24.1%)	77 (24.1%)	0.985
Hypothyroidism	38 (5.0%)	9 (4.8%)	0.924	30 (4.8%)	17 (5.3%)	0.716
Chronic kidney disease (any stage)	43 (5.6%)	7 (3.7%)	0.299	39 (6.2%)	11 (3.4%)	0.072
Cancer	58 (7.6%)	9 (4.8%)	0.182	44 (7.0%)	23 (7.2%)	0.913
Infectious disease	*	*	*	11 (1.8%)	8 (2.5%)	0.435
Number of comorbidities	2 (1–3)	2 (1–3)	0.528	2 (1–3)	2 (1–3)	0.171

Unless otherwise specified, numbers are shown as counts (percentages) and p values have been calculated using  $\chi^2$  test.

\*Numbers  $\leq 5$  have been suppressed,  $p < 0.05$  are bolded. Patients reporting asthma, gastro-oesophageal reflux disease, depression, chronic fatigue syndrome and previous treatments for a mental health problem were significantly more likely to report a swallow problem, likewise patients reporting irritable bowel syndrome, asthma and previous treatment by a mental health professional were more likely to report voice problems.

ICU, intensive care unit.

**Table 5** Outcomes for respondents who stated they had voice or swallow problems

	ICU swallow—visit 1*			ICU swallow—visit 2*			ICU voice—visit 1*			ICU voice—visit 2*		
	No	Yes	P value	No	Yes	P value	No	Yes	P value	No	Yes	P value
EQ-5D-5L												
Mobility												
Improved	30 (5.9%)	9 (6.5%)	<0.001	34 (7.5%)	7 (6.4%)		25 (6.1%)	14 (6.0%)		25 (7.1%)	16 (7.7%)	
Stayed the same	300 (58.8%)	54 (38.8%)		269 (59.5%)	42 (38.5%)	<0.001	247 (60.5%)	104 (44.4%)	<0.001	217 (61.8%)	93 (44.9%)	<0.001
Worsened	180 (35.3%)	76 (54.7%)		149 (33.0%)	60 (55.0%)		136 (33.3%)	116 (49.6%)		109 (31.1%)	98 (47.3%)	
Self-care												
Improved/Stayed the same	270 (52.9%)	51 (36.7%)	<0.001	262 (57.8%)	39 (35.8%)	<0.001	228 (55.7%)	90 (38.6%)	<0.001	213 (60.5%)	86 (41.5%)	<0.001
Worsened	240 (47.1%)	88 (63.3%)		191 (42.2%)	70 (64.2%)		181 (44.3%)	143 (61.4%)		139 (39.5%)	121 (58.5%)	
Usual activities												
Improved	20 (3.9%)	7 (5.0%)	0.005	24 (5.3%)	7 (6.4%)		20 (4.9%)	7 (3.0%)		19 (5.4%)	11 (5.3%)	
Stayed the same	274 (53.7%)	53 (38.1%)		259 (57.2%)	37 (33.9%)	<0.001	231 (56.5%)	91 (39.1%)	<0.001	208 (59.1%)	86 (41.5%)	<0.001
Worsened	216 (42.4%)	79 (56.8%)		170 (37.5%)	65 (59.6%)		158 (38.6%)	133 (57.1%)		125 (35.5%)	110 (53.1%)	
Pain/Discomfort												
Improved	99 (19.4%)	22 (15.8%)	0.006	98 (21.6%)	22 (20.2%)		82 (20.1%)	39 (16.7%)		78 (22.2%)	40 (19.3%)	
Stayed the same	246 (48.3%)	52 (37.4%)		226 (49.9%)	35 (32.1%)	<0.001	200 (49.0%)	94 (40.3%)	0.009	177 (50.3%)	83 (40.1%)	0.006
Worsened	164 (32.2%)	65 (46.8%)		129 (28.5%)	52 (47.7%)		126 (30.9%)	100 (42.9%)		97 (27.6%)	84 (40.6%)	
Anxiety / Depression												
Improved	68 (13.4%)	8 (5.8%)	0.001	60 (13.3%)	11 (10.1%)		52 (12.7%)	24 (10.3%)		50 (14.2%)	21 (10.2%)	
Stayed the same	242 (47.5%)	53 (38.1%)		229 (50.7%)	40 (36.7%)	0.004	203 (49.6%)	89 (38.4%)	0.004	177 (50.3%)	89 (43.2%)	0.030
Worsened	199 (39.1%)	78 (56.1%)		163 (36.1%)	58 (53.2%)		154 (37.7%)	119 (51.3%)		125 (35.5%)	96 (46.6%)	
Summary—How good or bad is your health overall?												
Current score*	75 (60–85)	64 (50–80)	<0.001	80 (60–90)	60 (50–80)	<0.001	79 (60–86)	65 (50–80)	<0.001	80 (60–90)	70 (50–80)	<0.001
Improved	67 (13.6%)	14 (10.7%)	0.152	80 (18.3%)	14 (13.9%)		54 (13.6%)	26 (11.8%)		62 (18.3%)	32 (16.3%)	
Stayed the same	109 (22.1%)	21 (16.0%)		74 (16.9%)	13 (12.9%)	0.264	100 (25.2%)	29 (13.2%)	0.001	64 (18.9%)	23 (11.7%)	0.057
Worsened	317 (64.3%)	96 (73.3%)		283 (64.8%)	74 (73.3%)		243 (61.2%)	165 (75.0%)		213 (62.8%)	141 (71.9%)	
MRC Dyspnoea Scale												
Improved/Stayed the same	110 (43.8%)	28 (33.7%)	0.106	53 (57.0%)	19 (51.4%)	0.560	86 (44.1%)	50 (37.0%)	0.207	45 (61.6%)	27 (47.4%)	0.104
Worsened	141 (56.2%)	55 (66.3%)		40 (43.0%)	18 (48.6%)		109 (55.9%)	85 (63.0%)		28 (38.4%)	30 (52.6%)	
Dyspnoea 12+												
Overall score	3 (0–9)	8 (2–19)	<0.001	2 (0–7)	8 (1–18)	<0.001	2 (0–8)	6 (1–15)	<0.001	1 (0–6)	5 (1–15)	<0.001
Physical domain	2 (0–7)	6 (2–12)	<0.001	2 (0–6)	6 (1–11)	<0.001	2 (0–6)	4 (1–10)	<0.001	1 (0–5)	4 (1–10)	<0.001
Affective domain	0 (0–2)	1.5 (0–7)	<0.001	0 (0–1)	2 (0–6)	<0.001	0 (0–1)	1 (0–5)	<0.001	0 (0–1)	0 (0–5)	<0.001

Continued

Table 5 Continued

	ICU swallow—visit 1*			ICU swallow—visit 2*			ICU voice—visit 1*			ICU voice—visit 2*		
	No	Yes	P value	No	Yes	P value	No	Yes	P value	No	Yes	P value
PCL-5	9 (3–24)	25 (8–41.5)	<0.001	7 (2–21)	19.5 (7–42)	<0.001	7 (2–21)	20 (7–39)	<0.001	6 (1–19)	15 (5–38)	<0.001
Overall score <sup>x</sup>	107 (16.0%)	65 (36.1%)	<0.001	79 (11.8%)	48 (26.4%)	<0.001	78 (14.6%)	91 (29.7%)	<0.001	54 (10.0%)	71 (23.1%)	<0.001
>32												
MoCA§	26.5 (24–28)	26 (23–28)	0.306	27 (25–29)	27 (25–29)	0.439	26 (24–28)	27 (24–28)	0.757	27 (25–29)	27 (25–29)	0.612
Overall score <sup>x</sup>	346 (61.1%)	78 (53.8%)	0.071	337 (69.8%)	81 (66.4%)	0.471	275 (59.5%)	143 (59.6%)	0.937	267 (69.2%)	149 (69.3%)	
Normal function	204 (36.0%)	58 (40.0%)		146 (30.2%)	41 (33.6%)		172 (37.2%)	88 (36.7%)		109 (28.2%)	59 (27.4%)	0.884
Mild impairment	16 (2.8%)	9 (6.2%)					15 (3.2%)	9 (3.8%)		10 (2.6%)	7 (3.3%)	
Moderate/Severe impairment												
Frail¶	41 (6.3%)	23 (14.6%)	<0.001	22 (3.9%)	21 (15.2%)	<0.001	27 (5.1%)	36 (13.5%)	<0.001	19 (4.2%)	23 (9.1%)	0.009

Outcomes taken from the same visit as reported visit or swallow problems. Unless otherwise specified, numbers are reported as count (percentage) and p values are the result of a  $\chi^2$  test. P<0.05 are bolded.

<sup>x</sup>The denominators vary for most variables, the number of excluded records due to missing data are recorded in online supplemental table S1.

<sup>‡</sup>Values are shown as median (IQR) and Kruskal-Wallis test is used.

<sup>§</sup>Normal cognitive function score >25, mild cognitive impairment score 18–25, moderate or severe cognitive impairment score <18.

<sup>¶</sup>Frail defined as RCF  $\geq$ 5.

ICU, intensive care unit; MoCA, Montreal Cognitive Assessment; PCL-5, Post-traumatic Checklist for DSM-5; RCF, Rockwood Clinical Frailty.

a fever (88% vs 80%) and to have experienced a sore throat (18% vs 11%) than those without (table 3).

Respondents with voice problems spent on average 2 weeks longer in hospital than those without (median length of stay: 28 vs 14 days) and were more likely to report a worsening of their mobility, self-care, usual activities, pain or discomfort, anxiety or depression and have a lower health score (table 5). They had a higher overall score on the Dyspnoea 12 questionnaire (both physical and affective), had a higher PCL-5 overall score and were more likely to be classified as clinically frail. Variables included in the final model chosen by cross-validation are detailed in online supplemental data 1.2. Voice problems were only collected at one time point so it is not possible to comment on how long these problems lasted.

## Communication issues

### Visit 1

Approximately one in four experienced communication issues at visit 1 (527/2375, 23%), they were younger (median: 56 vs 60 years), a higher proportion were female (48% vs 36%), came from more deprived areas (27% vs 22%), were healthcare workers (17% vs 13%) and had been shielding prior to admission (34% vs 28%) (table 2). This is important clinical information, identifying those who recognised deterioration in their ability to communicate. They were more likely to report COVID-19 symptoms; fever (81% vs 77%,  $p=0.023$ ), shortness of breath (88% vs 83%,  $p=0.014$ ), sore throat (19% vs 13%  $p=0.003$ ) and confusion (18% vs 11%,  $p=0.001$ ) (online supplemental table 6). They reported worse; mobility (51% vs 29%), self-care (64% vs 40%), usual activities (57% vs 35%), pain or discomfort (40% vs 25%) anxiety or depression (49% vs 35%) on the EQ-5D-5L, and worse overall health (online supplemental table 7) than pre-COVID-19. Their MRC Dyspnoea Scale was also worse (61% vs 50%) and they had higher Dyspnoea 12 (9 vs 2) scores, PCL-5 (25 vs 7), with more classed as frail (12% vs 4%). Respondents were also more likely to have mild cognitive impairment (42% vs 34%) or moderate/severe impairment (4% vs 3%) according to the MoCA. Variables included in the final model chosen by cross-validation are detailed in online supplemental data 1.3.

### Visit 2

Just under one in four identified as having communication issues ( $n=399/1771$ , 23%), they were more likely to have been admitted to ICU (42% vs 36%), and to report headache (33% vs 26%) or sore throat (20% vs 14%) as COVID-19 symptoms (online supplemental table 6). They had significantly worse outcomes, with the exception of MoCA where there did not appear to be a significant difference (online supplemental table 7). Variables included in the final model chosen by cross-validation are detailed in online supplemental data 1.4

## Cognitive issues

### Visit 1

Over two-thirds reported cognitive issues at visit 1 ( $n=1598/2275$ , 70%) and were more likely to have been female (44% vs 27%), white (78% vs 68%), not educated beyond secondary school level (32% vs 25%) to have been shielding (32% vs 24%), to have more comorbidities at baseline (online supplemental table 8) median: 2 vs 1, but with no difference in age (table 2). There were no significant difference in treatments, respiratory support, additional diagnoses, admission to ICU nor the overall length of stay between respondents who did or did not state they had cognitive issues except those with cognitive issues at visit 2 were more likely to have received NIV (6% vs 3%).

Respondents with cognitive issues were more likely to report worsening mobility (42% vs 16%), self-care (56% vs 23%), usual activities (49% vs 20%), pain or discomfort (35% vs 13%), anxiety or depression (46% vs 20%), overall health (65% vs 52%) and MRC Dyspnoea Scale (58% vs 37%) compared with pre-COVID-19. The Dyspnoea 12 overall score was significantly higher for respondents with cognitive issues (median: 5 vs 0), as was the PCL-5 summary score (median 14 vs 3). There were slightly more respondents with self-reported cognitive issues classified as having moderate or severe cognitive impairment on the MoCA (4% vs 2%) and were significantly more likely to have been deemed clinically frail at the follow-up visit (8% vs 2%). Variables included in the final model chosen by cross-validation are detailed in online supplemental data 1.5.

### Visit 2

A similar proportion of respondents self-reported cognitive issues at visit 2 (1231/1768, 70%), more likely to be female (43% vs 26%), white (80% vs 71%), shielding (32% vs 25%) and to have come from a more deprived area (Q1 24% vs 19%) (table 2). Significantly more respondents with cognitive issues at visit 2 were treated via CPAP (29% vs 24%) and had longer length of stay (8 vs 7 days). As with respondents who identified as having cognitive issues at visit 1, worsening in mobility (38% vs 14%), self-care (53% vs 20%), usual activities (46% vs 18%), pain or discomfort (33% vs 13%) and anxiety or depression (44% vs 18%) and overall worsening in their health (67% vs 50%) were identified (online supplemental table 8). They were also more likely to have worsening in breathing according to the MRC Dyspnoea Scale (49% vs 23%) and Dyspnoea 12 (4 vs 0), and more respondents were classed as frail (7% vs 1%). Significantly fewer respondents were classified as having normal cognitive function according to the MoCA (68% vs 75%). Variables included in the final model chosen by cross-validation are detailed in online supplemental data 1.6.

## DISCUSSION

This is the first large-scale prospective analysis of swallowing, communication, voice and cognitive function



following hospitalisation with COVID-19 in the UK, with prevalent and persistent compromise identified. These data raise important questions about management and potential rehabilitation requirements for those individuals with complex symptoms and their recovery.

Swallow compromise following an ICU stay was associated with variables inherently linked to increased illness severity and treatment burden, specifically proning and mechanical ventilation, rather than pre-existing factors such as sociodemographics or number of comorbidities. This is reported in critical illness data predating COVID-19 and may reflect iatrogenic impact of ventilation on the upper airway,<sup>7 21 35–37</sup> reiterating the importance of identification of swallow and voice problems and their aetiology post-ICU admission, to facilitate differential diagnosis and rehabilitation to improve function and positively influence bed stay.<sup>38</sup> Patients with swallow/voice problems stayed in hospital over a week and 2 weeks longer than those without, respectively. They also had resultant frailty, poor mobility and worse quality of life scores.

Associations between swallow/voice symptoms and previous mental health problems were identified. Concurrent mental and physical health compromise are complex and costly for the individual, and for the economy if left untreated. Conservative estimates suggest<sup>39</sup> poor mental health costing the UK economy £74–94 billion a year as a result of lost output. Given our findings regarding associations with physiological symptoms and mental health, devising interventions where the whole person and their symptoms are supported and rehabilitated must be prioritised.<sup>40</sup> The ‘unknown illness’ of the pandemic, insufficient ‘medical spaces’<sup>41</sup> and until now, under-recognised symptomatology described in this paper require urgent and collective attention from clinicians and commissioners to reduce physical, emotional and economic burden.

Nearly one in four participants reported communication issues at visits 1 and 2, with worse mobility, self-care, pain, anxiety or depression and overall health scores compared with pre-COVID-19. These people were more likely to be younger, female, health workers, from areas of social deprivation and have cognitive compromise. These are concerning conglomerate issues, with overt self-limiting realities regarding the ability to self-manage and seek support when cognition and communication skills are compromised. Early diagnosis and assessment may be challenged by this unusual profile or presentation for an individual reporting communication issues, so healthcare professionals may overlook this symptom in a clinical setting. The mechanism of injury, rehabilitation needs and recovery trajectory is not yet understood and future studies require detailed culturally appropriate assessments to fully uncover language pathology to determine appropriate, effective treatment interventions.

There are conflicting perspectives regarding associations between compromised cognition following COVID-19<sup>15 42</sup> with severity of disease,<sup>43 44</sup> severity of

respiratory compromise<sup>45</sup> and being female<sup>46</sup> reported as independent variables by some groups, with others not identifying these relationships.<sup>47 48</sup> Methodological variation and limitations of existing outcome measures are important factors to consider when comparing findings, along with the novel nature of this disease, reiterating the importance of creating core datasets.<sup>49</sup> In our analysis, associations between worse self-reported cognition and social deprivation at visit 2 were identified. In the context of public health, social deprivation is linked to worse global health outcomes and mortality<sup>50 51</sup> and is of practical importance when considering health literacy, access to health services and the individual’s ability to broadly navigate health systems to support their own recovery, perhaps without the appropriate tools or facilities.<sup>52</sup> In context of the UK health system, finding solutions to these problems is challenged by conglomerate social and political drivers affecting identification, management and implementation of all health interventions. We offer suggestions from the insights generated in this analysis, while acknowledging the healthcare landscape and its realities.

### Strengths and limitations

This analysis was not set-up as a formal prevalence study. There is acquisition bias in the cohort and therefore we can only report what is observed in the study rather than assuming this is representative of the wider population. We have not reported on incidence, the frequency or rate of occurrence of new self-reported functional compromise, as we sought to explore all cases reported in the time frame and their persistence over a specific time frame. Notwithstanding this limitation, it is the biggest study to date and therefore a rich dataset and a valuable observation. For the first time, we have been able to detail the prevalence of self-reported swallow, communication, voice and cognitive symptoms, defining associations and independent variables which may influence these outcomes. Triangulating these findings with intelligence around clinical provision will support understanding around how to design and commission services to support patients experiencing these issues.

Limitations include the following: only people admitted to ICU were asked to report on their swallowing and voice. We could therefore only report on this subgroup, and so are likely to be over-representing the prevalence but under-representing the total burden. In addition, lack of detail within the communication and swallow assessments means we are able to report on overall (self-reported) symptoms only. Direct laryngoscopy and assessment of swallow was not undertaken. We do not have the fine-grained information on swallow, or communication compromise required to identify what specific aspects of swallow, speech, language and/or communication have been impacted (and how), or if these were pre-existing and/or exacerbated. Data were collected over the first year post hospitalisation, but not beyond that point, so we

do not yet know how these symptoms progress or change over time. Similarly, some data points, such as BMI, were only collected at visit 1 so comparisons of index scores cannot be made between visits. Missing data, as described in the ‘Methods’ section, is an important limitation of this study.

## CONCLUSION

This is the first study to explore prevalence of swallow, communication, voice and cognitive issues post hospitalisation with COVID-19. These data are fundamental to identify and understand the complex functional compromise people experienced, and to determine what future interventions are required to reduce the burden of these symptoms. The individuals with greatest functional compromise were frequently those who had been most acutely unwell, women, from areas of social deprivation. We recommend; ring-fenced research funding to identify mechanism of injury and rehabilitation requirements, culturally appropriate communication and swallowing assessments to help understand the impact on the individual rehabilitation required and trajectories of recovery and access to dedicated swallow, communication, voice and cognitive evaluation within long COVID clinics.

Swallow, voice, communication and cognition are the cornerstones of human interaction and existence. Their compromise following COVID-19 has significant and far-reaching potential impact on the individual, their communities and the economy. There is a time-specific opportunity to research these challenges, to provide practical approaches to help people improve these key functions.

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