

1 A global systematic analysis of the occurrence, severity, and recovery 2 pattern of long COVID in 2020 and 2021

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160 Key Points

161 **Question:** What are the extent and nature of the most common long COVID symptoms by country in

162 2020 and 2021?

163 **Findings:** Globally, 144.7 million people experienced one or more of three symptom clusters (fatigue;

164 cognitive problems; and ongoing respiratory problems) of long COVID three months after infection, in

165 2020 and 2021. Most cases arose from milder infections. At 12 months after infection, 15.1% of these

166 cases had not yet recovered.

167 **Meaning:** The substantial number of people with long COVID are in need of rehabilitative care and

168 support to transition back into the workplace or education when symptoms start to wane.

169 Abstract

170 **Importance:** While much of the attention on the COVID-19 pandemic was directed at the daily counts of
171 cases and those with serious disease overwhelming health services, increasingly, reports have appeared
172 of people who experience debilitating symptoms after the initial infection. This is popularly known as
173 long COVID.

174 **Objective:** To estimate by country and territory of the number of patients affected by long COVID in
175 2020 and 2021, the severity of their symptoms and expected pattern of recovery

176 **Design:** We jointly analyzed ten ongoing cohort studies in ten countries for the occurrence of three
177 major symptom clusters of long COVID among representative COVID cases. The defining symptoms of
178 the three clusters (fatigue, cognitive problems, and shortness of breath) are explicitly mentioned in the
179 WHO clinical case definition. For incidence of long COVID, we adopted the minimum duration after
180 infection of three months from the WHO case definition. We pooled data from the contributing studies,
181 two large medical record databases in the United States, and findings from 44 published studies using a
182 Bayesian meta-regression tool. We separately estimated occurrence and pattern of recovery in patients
183 with milder acute infections and those hospitalized. We estimated the incidence and prevalence of long
184 COVID globally and by country in 2020 and 2021 as well as the severity-weighted prevalence using
185 disability weights from the Global Burden of Disease study.

186 **Results:** Analyses are based on detailed information for 1906 community infections and 10526
187 hospitalized patients from the ten collaborating cohorts, three of which included children. We added
188 published data on 37262 community infections and 9540 hospitalized patients as well as ICD-coded
189 medical record data concerning 1.3 million infections. Globally, in 2020 and 2021, 144.7 million (95%
190 uncertainty interval [UI] 54.8–312.9) people suffered from any of the three symptom clusters of long
191 COVID. This corresponds to 3.69% (1.38–7.96) of all infections. The fatigue, respiratory, and cognitive

192 clusters occurred in 51.0% (16.9–92.4), 60.4% (18.9–89.1), and 35.4% (9.4–75.1) of long COVID cases,
193 respectively. Those with milder acute COVID-19 cases had a quicker estimated recovery (median
194 duration 3.99 months [IQR 3.84–4.20]) than those admitted for the acute infection (median duration
195 8.84 months [IQR 8.10–9.78]). At twelve months, 15.1% (10.3–21.1) continued to experience long COVID
196 symptoms.

197 **Conclusions and relevance:** The occurrence of debilitating ongoing symptoms of COVID-19 is common.
198 Knowing how many people are affected, and for how long, is important to plan for rehabilitative services
199 and support to return to social activities, places of learning, and the workplace when symptoms start to
200 wane.

201 Introduction

202 Much of the attention of disease surveillance of the coronavirus disease 2019 (COVID-19) pandemic has
203 concentrated on the number of infections, the large number of cases requiring hospital care for severe
204 infection, and those who have died from the disease. Less attention has been given to the quantification
205 of those who continue to experience symptoms past the acute infection stage. Terms such as long
206 COVID, COVID long haulers, brain fog, post-COVID-19 condition, or post-acute sequelae of COVID-19
207 have been used to describe a diverse array of ongoing symptoms. In October 2021, the World Health
208 Organization released a clinical case definition for post-COVID-19 condition as symptoms that are
209 present at three months after SARS-CoV-2 infection with a minimum duration of 2 months and cannot
210 be explained by an alternative diagnosis.¹⁻⁶ We will use the term long COVID in this paper.

211 Post-acute infection fatigue syndromes have been described for other viruses and bacteria.⁷⁻¹⁰ An
212 ongoing low-grade inflammation has been postulated to cause these symptoms, but the pathology
213 remains largely unknown and treatments are based on symptom relief.^{2,11,12} The impact on affected
214 individuals is substantial, and special clinics dealing with patients of long COVID have arisen to respond
215 to an increasing need for supportive and rehabilitative care.¹³⁻¹⁶

216 A meta-analysis of 45 follow-up studies of COVID patients, of which only three had a follow-up time
217 greater than three months, found 84 long-term effects of COVID-19, with shortness of breath, fatigue,
218 and sleep disorders or insomnia as the most common symptoms.¹⁷ Studies have most frequently just
219 reported on individual symptoms or counts of symptoms but less on severity, overlap of symptoms and
220 pattern of recovery.^{1,18-22}

221 In this paper, we have collated the information on long COVID into three common clusters of symptoms
222 largely based on joint analyses with custodians of follow-up studies after COVID-19 diagnosis in ten
223 countries, supplemented by published data and medical record databases. From this pooled information

224 on the occurrence of these three symptom clusters, their severity, and the limited information on
225 duration, we derived estimates of incidence, prevalence, and severity-weighted prevalence for 204
226 countries and territories for the years 2020 and 2021.

227 This analysis complies with the Guidelines for Accurate and Transparent Health Estimates Reporting
228 (GATHER).²³ The full GATHER checklist is provided in eTable 1.

229 Methods

230 Incidence of SARS-CoV-2 infection

231 We derived estimates of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection from
232 the IHME COVID model, a statistical Susceptible-Exposed-Infected-Removed (SEIR) compartmental
233 model fit to data on daily reported deaths, hospitalizations, and infections; seroprevalence; and excess
234 mortality data. Greater detail of the relevant aspects of this model and its data and assumptions is
235 available in the Supplement eSection 3.^{24–26}

236 Incidence of symptomatic infection

237 We took estimates of new, daily infections from this COVID model and assumed that long COVID only
238 occurs in those with symptomatic infection. From a published review, we selected studies that
239 estimated the proportion of asymptomatic infections in representative screened samples with antibody
240 testing (Supplementary Appendix Data Inputs).²⁷ We pooled the logit-transformed proportions of
241 asymptomatic cases from six studies in a random effects meta-analysis (eFigure 5) and multiplied one
242 minus the predicted proportion by infections to estimate the incidence of symptomatic infection.

243 Incidence and prevalence of long COVID

244 *Case definition*

245 We define the incidence of long COVID as newly onset or persisting symptoms three months after an
246 acute episode of COVID-19 which impact daily functioning and were not preexisting symptoms before
247 SARS-CoV-2 infection. This aligns with the WHO clinical case definition of post-COVID condition, their
248 preferred term for long COVID.⁵

249 *Input data*

250 From the long list of persisting symptoms reported by a proportion of COVID-19 cases after the acute
251 phase, we selected three major symptom clusters based on frequency and the ability to quantify their
252 relative severity using health state descriptions and corresponding disability weights (DWs) from the
253 Global Burden of Disease (GBD) study. GBD uses 236 health states and DWs to quantify the non-fatal
254 consequences of diseases and injuries.²⁸ Table 1 shows the health states, lay descriptions, and disability
255 weights used for long COVID. The three symptom clusters were a) fatigue with bodily pains and/or
256 symptoms of depression or anxiety; b) cognitive problems such as forgetfulness or difficulty in
257 concentrating, commonly referred to as “brain fog”; and c) ongoing respiratory problems with shortness
258 of breath and persistent cough as the main symptoms. We decided to distinguish between two severity
259 levels for cognitive problems and three levels of severity for the ongoing respiratory symptoms. From
260 here on, we refer to the “fatigue”, “respiratory”, and “cognitive” clusters.

261 We conducted a systematic review of published papers on the long-term consequences of COVID-19 but
262 found that no published study provided enough detail for our quantification purposes. From 7362
263 unique search hits and additions screened from a living systematic review²⁹, we included 46 published
264 articles from 44 studies that contain follow-up data of at least one defining symptom included in our
265 defined symptom clusters (Supplementary Appendix Data Inputs). We used the Preferred Reporting
266 Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines;³⁰ our PRISMA checklist is in the
267 appendix (eSection 5), and the search protocol was registered with the International Prospective
268 Register of Systematic Reviews (PROSPERO, CRD42020210101).³¹

269 Instead of relying on published reports only, we contacted study authors of published studies and
270 ongoing COVID-19 follow-up studies that were registered at the ISRCTN registry.³² From 23 positive
271 responses of 42 study authors contacted, ten were able to share symptom cluster data in time for
272 inclusion in our study (Table 2). With researchers from the ten follow-up studies, we developed

273 algorithms to define the three symptom clusters by severity level by choosing symptom questions and
274 measures employed in each study that would most closely match the wording of the lay descriptions
275 that were presented to respondents of the GBD DW surveys (Table 1). In the Supplement eSection 5, we
276 present details of the algorithms for each of the included studies. We utilized the cohort data with
277 explicit questions comparing current symptoms to those pre-COVID to adjust the remainder of the
278 cohort data lacking pre-COVID comparisons (Table 2, Supplementary Appendix Data Inputs).

279 In addition, we received analyses from collaborators at the Veterans Affairs Health Administration and
280 from PRA Health Sciences, a data collection of private health insurance plans, based on ICD codes for the
281 primary symptoms belonging to the three symptom clusters of interest among COVID patients
282 compared to matched non-COVID patients (Supplementary Appendix Data Inputs).^{33–35} ICD codes are
283 provided in the Supplement eTable 4.

284 *Modelled symptom cluster recovery patterns and proportions*

285 We first undertook a meta-regression of studies with multiple follow-up measurements to determine
286 the recovery pattern of symptoms. Given the relative scarcity of data, we assumed a similar pattern of
287 recovery for all three symptom clusters. We used separate models for community cases and hospitalized
288 cases using a Bayesian meta-regression tool, MR-BRT (meta-regression—Bayesian, regularized,
289 trimmed), to pool the logit-transformed proportions of cases with any of the three symptom clusters by
290 follow-up time since the end of the acute episode (eFigure 10).^{36,37} For community cases, we used data
291 from the Zürich and Faroe studies supplemented with data derived from three published studies.^{18–20,38–}

292 ⁴⁰ With a dummy in the meta-regression, we adjusted the Cirulli, United Kingdom COVID Symptom
293 Study (CSS), and United Kingdom COVID-19 Infection Survey (CIS) studies as proportions were reported
294 for aggregates of many individual symptoms, rather than only the symptom clusters of our interest.^{18–}

295 ^{20,40} For hospitalized cases, we used data from the COVID-19 Follow-up care paths and Long-term
296 Outcomes Within the Dutch health care system (CO-FLOW), Sechenov StopCOVID, PronMed ICU, and

297 the Zürich SARS-CoV-2 Cohort studies supplemented with data derived from two published studies in
298 Switzerland and Spain, both adjusted as in the community cases duration model.^{38,41} The longest follow-
299 up from these studies was 12 months in the Zürich, Co-FLOW and Sechenov studies. In both models, an
300 exponential decline was assumed in the proportion of cases affected by long COVID. The coefficients on
301 the rate of decline in these initial models were then entered as priors into the models that used all
302 available follow-up data, described below.

303 Next, we used all the data in models of long COVID in community and hospitalized cases separately. We
304 ran separate models for each of the three clusters and the overlap between clusters and adjusted their
305 outputs proportionally to sum to the values of the models for any of the three clusters of long COVID
306 (eFigures 11-15). We had too few data points to run separate models for ICU-admitted cases; in the
307 hospital models for each symptom cluster, we used a dummy variable for those admitted to ICU in order
308 to predict their proportions, with the coefficient informed by the observed relationship between ICU
309 and non-ICU hospitalized data.^{33,35} We also included variables for sex, whether the data were from an
310 administrative source, and indicator variables for individual symptoms reported in the published articles
311 (cognitive dysfunction, shortness of breath, fatigue).

312 To estimate the severity distributions, we pooled data from cohorts that had enough detail to determine
313 the two levels of severity of cognitive symptoms and the three levels of severity of ongoing respiratory
314 problems using a random effects meta-analysis with a fixed effect on hospitalized data (eFigures 16–17).

315 *Incidence, prevalence, and severity-weighted prevalence of long COVID*

316 To estimate the incidence of long COVID, we first subtracted deceased patients from the incidence
317 numbers of symptomatic COVID infection and then multiplied these surviving patients by the estimated
318 proportions of cases with each symptom cluster at 3 months.^{42,43(p19),44–46} Daily incident cases of long
319 COVID at three months post-infection were multiplied by the average duration, estimated separately for

320 community cases and hospitalized cases. We then summed the prevalent days of long COVID for each of
321 the symptom clusters and their overlap by level of severity where applicable across the years 2020 and
322 2021. Each of these was multiplied by the corresponding DW to get severity-weighted prevalence,
323 equivalent to the GBD metric of years lived with disability (YLDs). For overlapping clusters, we assumed a
324 multiplicative function to constrain the combined DW to a value between zero and one.⁴⁷

325 We present uncertainty intervals (UIs) for all estimates based on the 25th and 975th values of the ordered
326 1000 draws of the posterior distributions.

327

328 Results

329 Globally within 2020 and 2021, of 3.92 billion (95% UI 3.77–4.05) infections with SARS-CoV-2 through
330 the end of 2021, 3.7% (1.4–8.0) or 144.7 million (54.7–312.6) persons developed long COVID defined as
331 experiencing one or more of the three symptom clusters three months after infection (Table 3). Of
332 these, 130 million (42.1–301) had experienced mild to moderate acute infections in the community,
333 11.5 million (4.91–20.5) developed long COVID after severe disease needing hospitalization, and 3.03
334 million (0.892–7.48) after critical acute disease needing ICU care. We estimated that 6.17% (2.43–
335 13.31) of symptomatic SARS-CoV-2 infections who survived the acute episode developed long COVID.
336 This proportion was greater in those who were admitted to intensive care units (ICU) (43.1% [22.6–
337 65.2]) and general hospital wards (27.5% [12.1–47.8]) than in those with less severe symptomatic
338 infections in the community (5.68% [1.85–13.1]). Note that our estimate of the number of global
339 infections is much higher than reported as diagnosed cases because excess deaths, infection-to-death
340 ratios and seroprevalence surveys suggest many more cases must have occurred. We estimated a
341 median duration of long COVID of 3.99 months (IQR 3.84–4.20) in community infections, while
342 hospitalized cases were estimated to experience a longer median duration of 8.84 months (IQR 8.10–
343 9.78) (eFigure 10). The global prevalence of long COVID in 2020-2021 was 5.11 million (2.31–8.72) cases
344 among more severe, hospitalized patients and 31.4 million (10.2–73.5) cases among those who had
345 milder infections.

346 The fatigue, respiratory, and cognitive clusters occurred in 51.0% (16.9–92.4), 60.4% (18.9–89.1), and
347 35.4% (9.4–75.1) cases of long COVID, respectively. In 38.4% (7.94–96.0) of long COVID cases, two or all
348 three of the clusters overlapped (Figure 1).

349 Globally, among prevalent long COVID cases, 63.2% (59.7–66.3) were female. The risk of long COVID at 3
350 months follow-up under the age of 20 was lower than in adults in milder community infections, 2.73%

351 (0.808–6.65) in children versus 4.76% (1.53–11.3) in adult males and 9.88% (3.38–21.2) in adult females
352 (eTable 15a). The peak ages of long COVID cases were between 20 and 29 (Figure 2).

353 The average level of disability among long COVID cases, estimated as the ratio of overall long COVID
354 severity-weighted prevalence to prevalence, was 0.231 (0.134–0.370)—equivalent to the GBD DWs for
355 severe neck pain, Crohn’s disease, or long-term consequences of moderately severe traumatic brain
356 injury.²⁸

357 The age and geographical pattern of incidence and prevalence of long COVID closely follows that of
358 SARS-CoV-2 infections, as we assumed the same risk among survivors of acute infection, severity
359 distributions, and duration in all locations. The counts of incident and prevalent cases of long COVID by
360 country are provided in Table 4.

361 Among COVID patients who develop long COVID in 2020 and 2021, 15.1% (10.3–21.1) continued to have
362 persistent symptoms at 12 months after COVID infection, or 21.0 million (9.19–41.7) people. In the
363 United States, the Social Security Administration is mandated to financially assist those who are still
364 unable to work after 12 months, corresponding to 946,000 (365,000–2,130,000) people aged 20-64 in
365 the US in 2021 and 2022.

366

367 Discussion

368 A substantial proportion of COVID-19 patients do not recover after the initial infection. We estimated
369 that 144.7 million (54.7–312.6) cases globally in 2020 and 2021 suffered from one or more of three
370 common symptom clusters of long COVID. The risk of long COVID is greater in females and in those with
371 more severe initial infection. The peak ages of those experiencing long COVID were between 20 and 29
372 years. This pattern by age and sex is distinct from that of severe acute infection, which affects more
373 males and increases with age.⁴⁸ From seventeen follow-up studies that included children, we also know
374 that long COVID affects a lower but substantial number of children, while severe acute infection is very
375 uncommon at younger ages.^{49–51} These differences suggests that the underlying mechanism of long
376 COVID may be different from that of the severity of acute infection.

377 A prolonged state of low-grade infection with a hyperimmune response, coagulation/vasculopathy,
378 endocrine and autonomic dysregulation, and a maladaptation of the angiotensin converting enzyme-2
379 (ACE-2) pathway have been postulated as the underlying pathophysiology of long COVID.⁵²
380 Deconditioning due to prolonged immobilization during hospitalization may compound these
381 problems.⁵³ Direct tissue damage due to COVID-19 has been demonstrated in many parts of the body,
382 including the lung, heart, kidney, and brain.^{54–59} Due to the large reserves in capacity of most body
383 organs, tissue damage does not immediately lead to symptomatic disease. It may, however, become
384 apparent over time that COVID-19 will contribute to an earlier onset and greater occurrence of long-
385 term symptomatic major organ disease with increasing age or if these organs become diseased by other
386 mechanisms. The rate of recovery from long COVID, moreover, suggests that less permanent factors
387 may underlie these debilitating symptoms.

388 We have adopted the WHO case definition which stipulates a minimum period of three months after
389 infection before calling ongoing symptoms long COVID or post-COVID-19 condition. Others have

390 suggested a threshold of three weeks to define a case of long COVID, arguing that no competent virus
391 has been replicated beyond three weeks of infection, but a period of up to 12 weeks has been suggested
392 to define the start of long COVID.^{12,52,60} This analysis accounts for COVID infections through the end of
393 2021 and therefore does not cover the omicron wave, and it is currently unclear what the risk of long
394 COVID is after infection with omicron. The large proportion of asymptomatic infections with omicron
395 and the fact that if symptoms arise they mostly affect the upper airways suggests that the risk of long
396 COVID will be much smaller.

397 The recovery pattern among community cases for the three symptom clusters quantified suggests that
398 the majority of cases resolve, a sign of hope for those experiencing these debilitating symptoms. It is not
399 yet clear if there is a smaller proportion of patients, especially among those with more severe acute
400 episodes, who develop a more chronic course of long COVID. Given that the longest follow-up time
401 among the studies we examined was 12 months, the true long-term pattern of recovery will only be
402 revealed as studies conduct longer follow-up periods. The time-limited course of long COVID in most
403 cases has led to the advice to provide rehabilitative support in the community, with specialist
404 rehabilitation services required only for those with protracted and more severe problems, particularly
405 when compounded by post-intensive care syndrome.^{12,61} Important to patients is that they feel empathy
406 and recognition from health-care workers even if they can only provide symptomatic and supportive
407 care.⁶² Quantifying the number of incident and prevalent cases of long COVID will help policy makers
408 ensure adequate access to services to guide patients towards recovery, return to the workplace or
409 schooling, and restoration of their mental health and social life. The attention given to long COVID may
410 also provide greater recognition to patients who suffer from the longer-term consequences of other
411 infectious diseases and who may have received less attention from health services. The large number of
412 people affected by long COVID should also create new opportunities to unravel phenotypical and
413 genotypical characteristics, with an aim to find new treatments and predictors of post-acute disease

414 syndromes including those known to occur after other infectious disease and intensive care for other
415 critical illness.

416 The main strength of this study is the willingness of researchers from ten follow-up studies to share data
417 and analyses with consistent approaches to deal with the diverse study methods and instruments. This
418 collaborative effort also allowed us to go beyond the reporting of individual symptoms or counts of
419 symptoms reported in the literature. With access to individual patient data, we were able to define
420 clusters of symptoms that frequently occur together and to quantify the overlap among symptom
421 clusters. Importantly, we were able to correct for over-reporting from studies that did not have a
422 comparison with previous health status, leveraging information from the cohort studies that explicitly
423 asked respondents to recall their pre-COVID health status or existence of symptoms. In addition, the
424 very large health insurance databases from the USA allowed us to identify controls matched on
425 demographic and disease characteristics and thus correct for the occurrence of these symptoms
426 unrelated to SARS-CoV-2 infection. This may in part explain why our estimates of long COVID are lower
427 than often reported in the literature. Direct comparisons are not easy, as we have defined clusters of
428 symptoms that are not reported by others. However, we think this is a strength of this analysis in
429 comparison to studies reporting individual symptoms or counts of symptoms.

430 There are also important limitations to our analysis. First, the uncertainty intervals around the estimates
431 are wide, reflecting as yet limited and heterogeneous data. Second, we had to derive separate
432 algorithms for each contributing study to achieve consistency in case definitions of the three chosen
433 symptom clusters. Efforts to achieve standardization of questions and instruments for studies of long
434 COVID are underway.^{5,63} This would make pooling estimates among studies less prone to measurement
435 bias. Third, we assumed that long COVID follows a similar course in all countries and territories. We used
436 data from western European countries, Iran, Russia, India, China, South Africa, Turkey, Saudi Arabia,
437 Israel, Australia, and the USA. Additional reports from Brazil and Bangladesh suggest that long COVID

438 similarly affects other parts of the world.^{21,22} As more information becomes available, we can explore
439 whether there is geographical variation in the occurrence or severity of long COVID. We also note that
440 the duration estimates relied on studies from high income countries only. With repeated follow-up
441 being planned in many of the studies and with new studies appearing, it will become clearer over time
442 how generalizable our findings on duration are. Fourth, apart from symptoms and symptom clusters,
443 new diseases have been reported to occur more frequently in patients after COVID-19 diagnosis,
444 including cardiovascular complications like myocarditis, acute myocardial infarction, and thrombo-
445 embolic events as well as kidney, liver, gastrointestinal, endocrine, and skin disorders.⁶⁴⁻⁶⁶ The data
446 sources to quantify these COVID-19-related changes may not yet be sufficient due to lags in reporting of
447 clinical informatics data, disease registries, or surveys, which form the basis of estimation for such
448 diseases. Fifth, with limited follow-up time available, the pattern of recovery cannot yet be fully
449 described. Importantly, longer follow-up can reveal if there is a subset of cases that go on to have a
450 protracted course of long COVID and need longer care. Sixth, we made the assumption that long COVID
451 only affects those with a symptomatic course of the initial infection. The participating cohorts included
452 few asymptomatic cases: the Faroe Islands, Zurich SARS-CoV-2 Cohort, HAARVI, Rome ISARIC pediatrics
453 and adults cohorts observed 22, 182, 9, 27, and 26 asymptomatic COVID cases, respectively. Long
454 COVID was not identified among asymptomatic cases that were followed in HAARVI and Rome ISARIC
455 cohorts. In the Faroe Islands and Zurich SARS-CoV-2 cohorts, three and five of their asymptomatic cases,
456 respectively, developed at least one long COVID symptom cluster at follow-up. The total number of
457 asymptomatic cases followed in these studies is very low and we chose to be cautious and exclude them
458 from our calculations. In a review of medical records in the University of California COvid Research Data
459 Set (UC CORDS), 32% of those with long COVID symptoms at two months after a positive PCR test
460 reported no symptoms at testing, but it is not clear how many of these developed acute symptoms after
461 testing.⁶⁰ Seventh, we chose three commonly reported symptom clusters but have not quantified other

462 common symptoms. The main symptoms of our three symptom clusters are those that reached the
463 highest degree of consensus in the Delphi process WHO used to create a clinical case definition for post
464 COVID-19 condition.⁵ In the most complete cohort, the Sechenov StopCOVID cohort, we had information
465 on a wide range of symptoms and general health status with explicit comparison with the pre-COVID-19
466 status (eSection 5). Among 1309 respondents with PCR-confirmed COVID-19 needing hospitalization,
467 136 qualified for at least one of our three symptom clusters of long COVID at six months follow-up.
468 Another 62 respondents reported not having fully recovered. Of these, 48 reported at least one
469 symptom of our three symptom clusters but had failed to meet all criteria by reporting either no or
470 slight problems with usual activities or no worsening of this item compared to before COVID-19. Other
471 more common symptoms that were reported by this group included problems with vision, sleep
472 problems, loss of smell, palpitations, and hair loss. Quantifying vision loss requires measurement of
473 visual acuity, which is not measured in long COVID studies. There are no DWs for loss of smell, hair loss,
474 or palpitations. While there is a disability weight for insomnia, it has not been used in any GBD study as
475 sleep disorders are not (yet) included in the GBD cause list. Estimates therefore do not reflect the
476 burden of the full range of long COVID outcomes.

477 Conclusion

478 We have quantified the frequency at which common symptom clusters of long COVID have occurred
479 across the world and made an estimate of their severity and expected duration. Many countries and
480 territories have already responded by setting up specialized treatment centers for those affected.^{67,68}
481 Understanding the magnitude of the problem will help other countries and territories to respond
482 likewise. Early studies indicate that for most patients with long COVID, there is hope for recovery, but
483 time will tell if all patients recover. The attention given to long COVID during this pandemic should
484 trigger research into the underlying pathology and potential treatment or prevention, the long-term
485 trajectory of long COVID, the potential transition from long COVID into chronic fatigue syndrome, the

486 level of protection from vaccination and the risk of long COVID following more recent omicron variants.
487 Such research may also benefit those who experience similar outcomes following a range of other
488 infectious diseases, an issue that has not received much attention from clinical and global health
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536 [Author access to data](#)

537 TV and SWH had full access to all the data in the study and took responsibility for the integrity of the
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541 [Data sharing](#)

542 All tabulated input data are available upon publication as Supplementary Appendix Data Inputs.
543 Proposals to access de-identified individual-level data up to one year after publication for researchers
544 who provide a methodologically sound proposal for individual participant data meta-analysis should be
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906 **Main text figures and tables**

907 Figure 1. Proportions of incident long COVID symptom clusters and their overlap in 2020 and 2021

908 globally

909 Figure 2. Global incident cases, prevalent cases, and severity-weighted prevalence of long COVID by age,

910 sex, symptom cluster, and overlap of symptom clusters in 2020 and 2021

911

912 Table 1. Health states, lay descriptions, and disability weights used for the three symptom clusters of

913 long COVID.

Outcome	Health State	Lay description	DW (95% UI)
Mild respiratory symptoms	Chronic respiratory problems, mild	has cough and shortness of breath after heavy physical activity but is able to walk long distances and climb stairs.	0.019 (0.011 – 0.039)
Moderate respiratory symptoms	Chronic respiratory problems, moderate	has cough, wheezing and shortness of breath, even after light physical activity. The person feels tired and can walk only short distances or climb only a few stairs.	0.225 (0.153 – 0.310)
Severe respiratory symptoms	Chronic respiratory problems, severe	has cough, wheezing and shortness of breath all the time. The person has great difficulty walking even short distances or climbing any stairs, feels tired when at rest, and is anxious.	0.408 (0.273 – 0.556)
Mild cognitive symptoms	Cognitive problems, mild	has some trouble remembering recent events and finds it hard to concentrate and make decisions and plans.	0.069 (0.046 – 0.099)
Severe cognitive symptoms	Cognitive problems, moderate	has memory problems and confusion, feels disoriented, at times hears voices that are not real, and needs help with some daily activities.	0.377 (0.252 – 0.508)
Fatigue syndrome	Infectious disease, post-acute consequences	is always tired and easily upset. The person feels pain all over the body and is depressed.	0.219 (0.148 – 0.308)

GBD disability weights (DWs) quantify health loss as a fraction of time lived within a health state. For severe cognitive symptoms of long COVID we use the health state of moderate cognitive problems that is also used in GBD for moderate dementia.

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916 Table 2. Follow-up studies of long COVID, their inclusion of community and/or hospitalized cases,
917 sample size, follow-up period, comparison method, and reported symptoms

Follow-up study	Community sample size	Hospital/ICU sample size	Follow-up since end of acute episode (days)	Comparison group	Outcomes
Cohort studies with individual-level data					
CO-FLOW (Netherlands) ⁴¹		285 adults	81, 171	Self-reported health status one year prior to survey	Fatigue cluster, respiratory cluster by severity, cognitive cluster
Faroe Islands ³⁹	362 all ages	8 all ages	0, 16, 46, 76	None	Fatigue cluster, respiratory cluster, cognitive cluster
Helbok et al. (Austria) ⁶⁹	17 adults	68 adults	81	Self-reported health status one year prior to survey	Fatigue cluster, cognitive cluster
Isfahan COVID Cohort (Iran) ⁷⁰		1938 all ages	120	Self-reported pre-COVID health status	Fatigue cluster, respiratory cluster, cognitive cluster
pa-COVID (Germany) ^{71,72}	29 adults	145 adults	42, 90, 180, 365	None	Fatigue cluster, respiratory cluster by severity, cognitive cluster
PronMed ICU (Sweden) ^{73,74}		158 adults	121, 166, 346	None	Fatigue cluster, respiratory cluster, cognitive cluster
Rome ISARIC (Italy) ⁴⁹	82 children, 52 adults		42 (adults); 56 (children)	Self-reported pre-COVID health status	Fatigue cluster, respiratory cluster, cognitive cluster
StopCOVID Cohort (Russia) ^{51,75}		885 children, 6908 adults	171, 247, 351	Self-reported pre-COVID health status	Fatigue cluster, respiratory cluster by severity, cognitive cluster
US Longitudinal COVID-19 Cohort HAARVI (USA) ⁷⁶	160 adults	17 adults	164 (comm); 143 (hosp)	None	Fatigue cluster, respiratory cluster, cognitive cluster
Zürich SARS-CoV-2 Cohort (Switzerland) ³⁸	Prospective 888 adults; retrospective 316 adults	Prospective 40 adults; retrospective 74 adults	7, 23, 83, 173, 263, 353 (comm); 3, 63, 153, 243, 333 (hosp/ICU)	Self-reported pre-COVID health status	Fatigue cluster, respiratory cluster by severity, cognitive by severity cluster

Follow-up study	Community sample size	Hospital/ICU sample size	Follow-up since end of acute episode (days)	Comparison group	Outcomes
Administrative data sources					
PRA administrative data (USA) ³³	772,611 all ages	237,274 all ages	87 (comm); 73 (hosp); 101 (ICU)	Matched 1:1 to non-COVID controls	ICD codes for fatigue, respiratory, and cognitive symptoms
Veterans Affairs administrative data (USA) ^{34,35}	73,435 adults	13,654 adults	143 (comm); 123 (hosp); 150 (ICU)	Matched to 4,990,835 non-COVID controls	ICD codes for fatigue, respiratory, and cognitive symptoms
Published articles					
Anastasio et al. (Italy) ⁷⁷		379 adults	135	None	Dyspnoea, memory loss
ANOSVID (France) ⁷⁸	233 adults	121 adults	259	None	Fatigue, dyspnoea, any symptom from their symptom list
Arnold D et al. (UK) ⁷⁹		110 adults	60 (hosp); 53 (ICU)	None	Fatigue, cough, shortness of breath
Asadi-Pooya et al. (Iran) ⁸⁰		58 children	246	None	Fatigue, dyspnoea
Becker et al. (Switzerland) ⁸¹		90 adults	90, 365	None	Fatigue, concentration difficulties, shortness of breath, any symptom from their symptom list
Bellan et al. (Italy) ⁸²		238 adults	96	None	Dyspnoea
Berg et al. (Denmark) ⁸³	5106 children		53, 83, 173, 263, 353	Matched COVID-free control group (either not tested or tested negative)	Fatigue, trouble breathing, trouble concentrating
Carfi A et al. (Italy) ⁸⁴		143 adults	27	None	Fatigue, dyspnoea
Carvalho-Schneider C et al. (France) ⁸⁵	116 adults	34 adults	30	None	Dyspnoea
Chopra N et al. (India) ⁸⁶		53 all ages	21	None	Fatigue, exertional dyspnoea
Chopra V et al. (USA) ⁸⁷		488 adults	51	None	Cough, shortness of breath, chest tightness, wheezing
Cirulli et al. (USA) ¹⁸	225 adults	8 adults	28, 58, 88	None	Fatigue, cough, dyspnoea.

Follow-up study	Community sample size	Hospital/ICU sample size	Follow-up since end of acute episode (days)	Comparison group	Outcomes
Published articles (cont.)					
CLoCk (England) ⁸⁸	3065 children		83	Matched to COVID test-negative controls	Tiredness, shortness of breath, confusion/disorientation/drowsiness, any symptom
COD19 (Italy) ⁸⁹	114 adults	189 adults	366	None	Fatigue, respiratory disorders
COMEBAC (France) ⁹⁰		478 adults	104	None	Memory loss, mental slowness, concentration problems, fatigue, dyspnoea, cough
Coronavirus Infection Survey (CIS) (UK) ^{19,91}	3489 children, 21,622 adults		26, 75 (children); 26, 33, 40, 47, 54, 61, 68, 75, 82, 89, 96, 103, 110 (adults)	Matched 1:1 to non-COVID controls	Fatigue, cough
COVID Symptom Study (CSS) App (UK) ^{20,40}	1734 children, 4182 adults		19, 47, 75	None	Fatigue, cough, shortness of breath
Darcis et al. (Belgium) ⁹²		101 adults (3-month follow-up), 78 adults (6-month follow-up)	85, 171	None	Fatigue, exertional dyspnoea, confusion
Dryden et al. (South Africa) ⁹³		1258 adults	19	None	Fatigue, confusion, dyspnoea
Elkan et al. (Israel) ⁹⁴		66 adults	261	None	Fatigue, dyspnoea, memory/concentration impairment
García-Abellán et al. (Spain) ⁹⁵		104 adults (2-month follow-up), 116 adults (6-month follow-up)	51, 171	None	Fatigue, dyspnoea, respiratory symptoms, any symptom from their symptom list
Garrigues et al. (France) ⁹⁶		120 all ages	88 (hosp); 81 (ICU)	None	Fatigue, cough, dyspnoea, memory loss

Follow-up study	Community sample size	Hospital/ICU sample size	Follow-up since end of acute episode (days)	Comparison group	Outcomes
Published articles (cont.)					
Halpin S et al. (UK) ⁹⁷		100 adults	39 (hosp); 38 (ICU)	None	Fatigue, breathlessness, concentration problems, short-term memory problems
Heesakkers et al. (Netherlands) ⁹⁸		246 young adults and adults	365	None	Fatigue, cognitive failure, dyspnea
Horwitz et al. (USA) ⁹⁹		126 adults	171	None	Fatigue, dyspnoea, cognitive fuzziness/brain fog/difficulty concentrating
Huang et al. (China) ⁵⁴		1655 adults	171 (hosp); 170 (ICU)	None	Fatigue or muscle weakness, dyspnoea
Jacobson et al. (USA) ¹⁰⁰	96 all ages	22 all ages	112 (comm); 92 (hosp/ICU)	None	Memory problems, fatigue, dyspnoea
Kayaaslan et al. (Turkey) ¹⁰¹	591 adults	416 adults	113	None	Fatigue, dyspnoea, concentration or memory problems
Klein et al. (Israel) ¹⁰²	103 adults		171	None	Fatigue, breathing difficulties
Lerum et al. (Norway) ¹⁰³		69 adults	59 (hosp), 55 (ICU)	None	Dyspnoea
Mandal S et al. (UK) ¹⁰⁴		217 all ages	45	None	Fatigue, breathlessness, cough
Moreno-Pérez et al. (Spain) ¹⁰⁵		277 adults	77	None	Fatigue, dyspnoea, cough, amnesic complaints
Naik et al. (India) ¹⁰⁶	523 adults	711 adults	63, 84	None	Fatigue, dyspnea
Peghin et al. (Italy) ¹⁰⁷	502 adults	39 adults	182 (comm); 161 (hosp); 191 (ICU)	None	Fatigue, dyspnoea
Say et al. (Australia) ¹⁰⁸	97 children		128	None	Fatigue
Sibila et al. (Spain) ¹⁰⁹		172 all ages	81	None	Dyspnoea
Sigfrid et al. (UK) ¹¹⁰		327 adults	192	None	Fatigue, shortness of breath, any symptom

Follow-up study	Community sample size	Hospital/ICU sample size	Follow-up since end of acute episode (days)	Comparison group	Outcomes
Published articles (cont.)					
Søraas et al. (Norway) ¹¹¹	676 adults		119	COVID test-negative group	Fatigue, dyspnoea, any symptom
Suárez-Robles et al. (Spain) ¹¹²		134 all ages	81	None	Fatigue, dyspnoea
Taboada et al. (Spain) ¹¹³		183 adults	171 (hosp); 170 (ICU)	None	Dyspnoea
Tleyjeh et al. (Saudi Arabia) ¹¹⁴		222 adults	122	None	Fatigue, shortness of breath, concentration issues, memory impairment, any persistent symptoms
Venturelli et al. (Italy) ¹¹⁵		767 adults	72	None	Confusion, dyspnoea
Wanga et al. (USA) ¹¹⁶	417 adults	48 adults	21	COVID test-negative group	Fatigue, dyspnoea, cognitive problems
Xiong et al. (China) ¹¹⁷		538 adults	81	COVID-free control group (n=184) with similar demographic attributes	Fatigue, dyspnoea

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920 Table 3. Incident and prevalent cases of long COVID by sex and severity of initial infection in 2020-2021,
 921 in millions.

	Males	Females	Both males and females
<i>Incident cases</i>			
Post-acute fatigue syndrome	26.8 (4.51–84.4)	52.1 (9.60–157)	78.9 (14.4–242)
Respiratory symptoms	33.5 (8.04–84.0)	55.8 (12.7–139)	89.3 (21.1–222)
Cognitive symptoms	18.6 (2.49–61.6)	36.6 (4.93–121)	55.2 (7.40–180)
Any long COVID	52.2 (19.7–115)	92.4 (34.9–199)	145 (55.0–312)
among community cases	45.8 (14.0–109)	84.3 (27.8–190)	130 (42.1–301)
among cases needing hospitalization	4.99 (1.97–9.35)	6.47 (2.92–10.8)	11.5 (4.91–20.5)
among cases needing ICU care	1.39 (0.381–3.54)	1.64 (0.517–3.96)	3.03 (0.892–7.48)
<i>Prevalent cases</i>			
Post-acute fatigue syndrome	6.95 (1.49–20.5)	13.1 (2.91–37.4)	20.0 (4.35–57.7)
Respiratory symptoms	8.55 (2.34–21.0)	13.8 (3.51–34.1)	22.4 (6.08–54.9)
Cognitive symptoms	4.77 (0.798–14.9)	9.05 (1.50–28.9)	13.8 (2.32–43.3)
Any long COVID	13.4 (5.66–28.5)	23.1 (9.55–48.5)	36.5 (15.4–76.6)

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924 Table 4. Incident and prevalent cases of long COVID by country, 2020 and 2021.

Location	Incident cases of Long COVID during 2020 (in thousands)	Incident cases of Long COVID during 2021 (in thousands)	Prevalent cases of Long COVID during 2020 (in thousands)	Prevalent cases of Long COVID during 2021 (in thousands)
Global	40500 (15500–88200)	104000 (39400–225000)	6410 (2510–14000)	30100 (12800–63000)
Central Europe, Eastern Europe, and Central Asia	2400 (973–5120)	10400 (4270–22000)	383 (160–807)	2890 (1320–5860)
Central Asia	727 (271–1660)	1790 (678–4060)	106 (41.1–239)	457 (192–1000)
Armenia	31.2 (11.2–72.1)	82.9 (29.7–182)	5.51 (2.01–12.6)	25.3 (10.3–52.5)
Azerbaijan	42.2 (14.3–100)	310 (95.3–738)	7.33 (2.54–17.1)	79.0 (26.5–181)
Georgia	2.96 (0.737–6.86)	124 (33.1–293)	0.247 (0.0534–0.688)	30.1 (8.27–66.9)
Kazakhstan	107 (27.1–278)	363 (97.7–930)	18.2 (4.66–46.6)	77.3 (22.2–190)
Kyrgyzstan	87.2 (30.5–192)	130 (43.9–307)	15.3 (5.33–33.9)	39.6 (15.7–90.7)
Mongolia	0.276 (0.0401–0.917)	61.2 (21.8–141)	0.0621 (0.00862–0.209)	7.89 (2.84–18.8)
Tajikistan	54.7 (18.2–120)	195 (66.7–431)	8.69 (2.97–18.9)	47.1 (17.9–102)
Turkmenistan	30.7 (10.7–68.9)	108 (37.5–243)	4.90 (1.74–10.9)	26.6 (10.5–58.2)
Uzbekistan	371 (99.2–888)	415 (111–1040)	46.2 (12.5–111)	124 (33.8–286)
Central Europe	281 (118–584)	2700 (1130–5710)	39.1 (16.8–81.2)	819 (376–1650)
Albania	22.2 (7.82–48.4)	94.1 (35.2–204)	2.96 (1.03–6.33)	28.9 (12.1–59.3)
Bosnia and Herzegovina	17.6 (6.64–38.9)	103 (41.1–227)	2.32 (0.882–5.16)	30.9 (13.7–66.1)
Bulgaria	15.9 (6.03–34.1)	219 (72.2–500)	2.35 (0.894–5.00)	62.0 (23.4–130)
Croatia	6.53 (2.63–14.7)	90.7 (37.9–197)	0.892 (0.378–1.99)	27.4 (12.3–54.5)
Czechia	25.0 (9.75–54.0)	317 (129–684)	2.28 (0.929–4.93)	103 (46.3–210)
Hungary	13.4 (5.23–28.9)	211 (81.9–456)	1.57 (0.596–3.37)	66.7 (28.6–140)
Montenegro	3.04 (1.20–6.46)	24.5 (9.81–51.8)	0.294 (0.119–0.622)	6.70 (2.93–13.7)
North Macedonia	14.0 (5.48–31.3)	76.3 (29.2–167)	2.19 (0.854–4.93)	21.9 (9.35–46.8)
Poland	60.2 (25.4–129)	794 (322–1750)	8.60 (3.68–18.4)	250 (114–518)
Romania	79.5 (32.0–177)	415 (158–931)	11.2 (4.60–24.7)	121 (50.9–248)
Serbia	18.8 (6.81–42.8)	222 (83.5–478)	3.83 (1.42–8.70)	58.1 (24.0–120)
Slovakia	3.19 (1.05–8.08)	103 (37.2–228)	0.325 (0.102–0.856)	32.2 (12.9–68.4)
Slovenia	1.40 (0.425–3.81)	34.1 (11.6–79.4)	0.211 (0.0620–0.582)	10.1 (3.71–23.4)
Eastern Europe	1390 (577–2930)	5870 (2410–12300)	238 (101–503)	1620 (753–3290)
Belarus	58.5 (14.8–155)	194 (51.1–498)	11.5 (3.09–28.2)	52.9 (14.3–128)
Estonia	0.661 (0.236–1.68)	14.7 (5.74–34.5)	0.144 (0.0526–0.369)	4.08 (1.75–9.58)
Latvia	1.03 (0.295–2.53)	35.4 (11.0–88.0)	0.209 (0.0567–0.513)	10.1 (3.27–24.9)

Location	Incident cases of Long COVID during 2020 (in thousands)	Incident cases of Long COVID during 2021 (in thousands)	Prevalent cases of Long COVID during 2020 (in thousands)	Prevalent cases of Long COVID during 2021 (in thousands)
Lithuania	1.87 (0.584–4.36)	74.4 (23.9–182)	0.326 (0.100–0.773)	20.8 (7.14–48.8)
Republic of Moldova	34.8 (10.5–79.1)	92.7 (29.4–215)	5.22 (1.59–12.1)	30.8 (11.3–67.6)
Russian Federation	1130 (461–2380)	4450 (1790–9230)	200 (86.0–426)	1200 (555–2400)
Ukraine	161 (50.0–390)	1010 (336–2300)	19.9 (5.92–50.0)	299 (105–688)
High-income	2180 (899–4500)	7720 (3170–15900)	429 (187–877)	2270 (1050–4540)
Australasia	3.62 (1.36–7.80)	6.40 (2.72–13.1)	0.591 (0.242–1.24)	0.940 (0.441–1.86)
Australia	3.49 (1.31–7.54)	6.28 (2.67–12.9)	0.560 (0.231–1.17)	0.917 (0.429–1.81)
New Zealand	0.125 (0.0498–0.272)	0.126 (0.0524–0.256)	0.0307 (0.0133–0.0665)	0.0229 (0.0111–0.0449)
High-income Asia Pacific	40.3 (17.0–82.6)	319 (137–651)	7.34 (3.31–14.8)	79.1 (37.7–153)
Brunei Darussalam	0.0743 (0.0237–0.176)	0.894 (0.318–2.12)	0.0205 (0.00637–0.0492)	0.0618 (0.0234–0.144)
Japan	29.7 (12.9–60.1)	284 (122–576)	5.06 (2.32–10.1)	71.1 (33.6–138)
Republic of Korea	4.57 (1.58–10.9)	31.0 (12.3–67.9)	0.905 (0.326–2.16)	7.03 (2.90–15.1)
Singapore	5.92 (2.20–13.7)	3.47 (1.46–7.25)	1.36 (0.514–3.15)	0.867 (0.398–1.69)
High-income North America	1050 (436–2210)	3780 (1550–7830)	190 (81.4–397)	1100 (506–2210)
Canada	27.9 (10.7–58.3)	167 (66.8–345)	6.01 (2.31–12.5)	47.4 (20.4–95.5)
Greenland	0.00685 (0.00211–0.0157)	0.0622 (0.0225–0.139)	0.00171 (0.000516–0.00406)	0.00726 (0.00281–0.0156)
United States of America	1020 (425–2160)	3620 (1480–7490)	184 (78.5–384)	1050 (485–2130)
Southern Latin America	183 (70.6–393)	533 (202–1180)	22.9 (9.13–48.5)	160 (65.7–334)
Argentina	130 (48.9–286)	388 (140–861)	13.9 (5.44–29.8)	116 (45.5–253)
Chile	52.1 (19.5–114)	112 (42.2–243)	8.89 (3.46–18.9)	35.4 (14.8–73.4)
Uruguay	0.450 (0.142–1.06)	33.1 (13.3–71.3)	0.0931 (0.0290–0.225)	8.64 (3.67–17.8)
Western Europe	898 (371–1840)	3080 (1280–6310)	208 (91.0–423)	928 (436–1820)
Andorra	0.564 (0.206–1.22)	1.21 (0.457–2.86)	0.116 (0.0425–0.250)	0.415 (0.172–0.872)
Austria	7.59 (3.03–16.6)	67.0 (24.9–143)	1.43 (0.607–3.02)	20.6 (8.85–42.5)
Belgium	40.7 (16.4–88.8)	108 (43.3–228)	9.64 (3.97–20.7)	34.0 (15.3–70.4)
Cyprus	0.292 (0.107–0.683)	7.64 (3.11–16.0)	0.0644 (0.0240–0.152)	1.88 (0.822–3.87)
Denmark	6.14 (2.26–13.0)	23.8 (9.61–48.8)	1.44 (0.537–3.05)	7.25 (3.23–14.3)
Finland	3.73 (1.50–7.90)	13.6 (5.53–28.7)	0.935 (0.382–1.95)	3.65 (1.65–7.33)
France	175 (65.0–378)	513 (203–1090)	40.5 (15.3–89.7)	159 (69.6–326)
Germany	55.8 (23.2–114)	424 (173–874)	13.2 (5.67–27.2)	129 (59.3–254)

Location	Incident cases of Long COVID during 2020 (in thousands)	Incident cases of Long COVID during 2021 (in thousands)	Prevalent cases of Long COVID during 2020 (in thousands)	Prevalent cases of Long COVID during 2021 (in thousands)
Greece	3.11 (1.12–7.10)	56.7 (22.7–120)	0.486 (0.168–1.14)	14.4 (6.40–28.8)
Iceland	0.292 (0.115–0.621)	0.627 (0.256–1.31)	0.0605 (0.0240–0.130)	0.153 (0.0710–0.301)
Ireland	9.48 (3.30–21.3)	30.0 (11.3–65.8)	2.29 (0.819–5.09)	8.23 (3.31–17.7)
Israel	25.7 (10.4–53.8)	67.2 (26.8–146)	2.84 (1.20–6.00)	19.3 (8.79–40.5)
Italy	107 (44.8–219)	433 (180–907)	28.0 (12.3–57.2)	138 (65.1–269)
Luxembourg	1.18 (0.455–2.54)	5.21 (2.07–11.0)	0.253 (0.0976–0.537)	1.62 (0.707–3.28)
Malta	0.349 (0.149–0.743)	2.72 (1.15–5.62)	0.0450 (0.0192–0.0942)	0.823 (0.386–1.61)
Monaco	0.0293 (0.0126–0.0620)	0.268 (0.118–0.541)	0.00534 (0.00225–0.0115)	0.0779 (0.0368–0.152)
Netherlands	42.0 (16.1–92.1)	145 (57.4–302)	9.87 (3.73–21.7)	43.8 (19.5–89.3)
Norway	4.15 (1.57–9.26)	16.3 (6.67–34.5)	1.04 (0.409–2.31)	4.34 (1.94–8.61)
Portugal	13.8 (5.23–30.7)	94.1 (38.0–198)	2.85 (1.10–6.31)	29.3 (13.2–59.7)
San Marino	0.183 (0.0728–0.390)	0.460 (0.188–0.976)	0.0511 (0.0222–0.106)	0.156 (0.0707–0.313)
Spain	168 (73.2–348)	373 (153–797)	35.7 (15.6–73.5)	118 (55.2–228)
Sweden	30.4 (12.0–64.5)	73.7 (31.1–154)	7.50 (3.13–15.6)	25.2 (11.7–49.1)
Switzerland	9.81 (3.93–21.4)	63.0 (25.4–133)	2.25 (0.941–4.76)	18.3 (8.32–36.2)
United Kingdom	191 (78.6–398)	560 (233–1160)	47.1 (20.0–96.7)	150 (69.9–297)
Latin America and Caribbean	5200 (1990–11200)	10100 (3870–22000)	861 (345–1860)	3160 (1360–6650)
Andean Latin America	906 (340–1960)	1090 (409–2480)	152 (59.5–331)	399 (164–857)
Bolivia (Plurinational State of)	223 (79.1–485)	257 (85.5–590)	34.0 (12.5–74.6)	94.2 (36.4–206)
Ecuador	218 (77.8–469)	332 (116–742)	39.6 (14.8–84.6)	111 (43.2–233)
Peru	466 (166–1050)	498 (177–1130)	78.7 (29.7–177)	194 (76.5–424)
Caribbean	147 (48.3–342)	325 (121–747)	24.9 (8.29–57.6)	81.9 (33.2–180)
Antigua and Barbuda	0.0491 (0.0155–0.131)	0.622 (0.209–1.40)	0.0112 (0.00362–0.0291)	0.0969 (0.0352–0.222)
Bahamas	1.22 (0.387–2.85)	3.46 (1.11–8.02)	0.116 (0.0379–0.269)	0.766 (0.260–1.70)
Barbados	0.0779 (0.0290–0.172)	0.964 (0.390–2.11)	0.0199 (0.00756–0.0433)	0.151 (0.0650–0.316)
Belize	0.683 (0.190–1.72)	4.49 (1.11–10.9)	0.0553 (0.0159–0.136)	1.13 (0.305–2.68)
Bermuda	0.0384 (0.0144–0.0842)	0.409 (0.168–0.847)	0.0101 (0.00386–0.0217)	0.0675 (0.0302–0.133)
Cuba	1.67 (0.581–3.97)	88.0 (33.4–197)	0.345 (0.126–0.815)	12.2 (4.84–27.3)

Location	Incident cases of Long COVID during 2020 (in thousands)	Incident cases of Long COVID during 2021 (in thousands)	Prevalent cases of Long COVID during 2020 (in thousands)	Prevalent cases of Long COVID during 2021 (in thousands)
Dominica	0.0121 (0.00227–0.0349)	0.419 (0.138–1.02)	0.00302 (0.000517–0.00876)	0.0366 (0.0131–0.0817)
Dominican Republic	68.2 (18.5–170)	75.3 (20.6–185)	11.5 (3.20–28.2)	28.4 (8.50–67.5)
Grenada	0.00863 (0.00183–0.0248)	0.999 (0.297–2.53)	0.00231 (0.000499–0.00671)	0.0630 (0.0201–0.156)
Guyana	2.40 (0.632–5.95)	10.3 (2.59–26.6)	0.235 (0.0665–0.569)	2.31 (0.617–5.60)
Haiti	56.9 (10.8–151)	69.8 (10.8–190)	10.5 (2.05–28.1)	20.2 (3.74–52.2)
Jamaica	2.83 (0.938–6.71)	19.4 (5.86–45.9)	0.236 (0.0778–0.591)	4.23 (1.39–9.97)
Puerto Rico	4.42 (1.68–10.2)	16.4 (6.47–35.8)	0.569 (0.218–1.23)	4.91 (2.18–10.3)
Saint Kitts and Nevis	0.0138 (0.00201–0.0482)	0.242 (0.0831–0.601)	0.00384 (0.000527–0.0136)	0.0274 (0.00983–0.0640)
Saint Lucia	0.0179 (0.00450–0.0450)	1.79 (0.581–4.00)	0.00447 (0.00104–0.0111)	0.319 (0.113–0.696)
Saint Vincent and the Grenadines	0.0296 (0.00765–0.0753)	0.606 (0.218–1.47)	0.00692 (0.00181–0.0168)	0.0952 (0.0372–0.215)
Suriname	1.87 (0.537–4.37)	10.1 (2.88–23.9)	0.262 (0.0774–0.624)	1.88 (0.545–4.34)
Trinidad and Tobago	1.43 (0.452–3.53)	9.68 (2.81–22.5)	0.153 (0.0493–0.381)	2.02 (0.637–4.44)
United States Virgin Islands	0.314 (0.106–0.781)	0.796 (0.274–1.99)	0.0459 (0.0145–0.112)	0.190 (0.0767–0.437)
Central Latin America	2110 (798–4480)	4460 (1690–9520)	337 (134–713)	1320 (562–2780)
Colombia	252 (94.0–563)	714 (258–1590)	33.2 (12.8–72.7)	219 (88.7–474)
Costa Rica	18.3 (6.13–41.5)	76.1 (25.4–170)	1.78 (0.596–4.14)	19.1 (7.15–41.8)
El Salvador	24.1 (8.46–53.2)	64.6 (21.3–146)	3.62 (1.35–8.01)	17.1 (6.23–38.0)
Guatemala	149 (51.8–348)	316 (99.6–754)	23.5 (8.42–54.2)	81.3 (29.1–188)
Honduras	99.7 (35.9–231)	254 (92.0–588)	14.5 (5.32–34.5)	67.4 (26.3–152)
Mexico	1290 (496–2750)	2430 (927–5240)	219 (86.6–465)	746 (324–1540)
Nicaragua	44.3 (16.8–98.7)	104 (39.8–230)	6.67 (2.58–14.8)	29.1 (12.1–63.6)
Panama	28.3 (10.3–61.9)	41.9 (15.5–91.5)	4.71 (1.74–10.5)	15.2 (6.24–32.4)
Venezuela (Bolivarian Republic of)	199 (75.6–434)	463 (172–1010)	30.1 (11.8–64.8)	131 (54.4–274)
Tropical Latin America	2040 (779–4430)	4270 (1620–9450)	348 (140–751)	1350 (588–2830)
Brazil	2020 (769–4390)	4110 (1550–9050)	346 (140–747)	1310 (563–2740)
Paraguay	22.7 (8.39–50.1)	165 (57.3–378)	1.79 (0.660–3.99)	45.7 (17.9–103)
North Africa and Middle East	4830 (1800–10900)	9410 (3630–21000)	868 (327–1940)	2740 (1140–5970)

Location	Incident cases of Long COVID during 2020 (in thousands)	Incident cases of Long COVID during 2021 (in thousands)	Prevalent cases of Long COVID during 2020 (in thousands)	Prevalent cases of Long COVID during 2021 (in thousands)
Afghanistan	428 (118–996)	881 (276–2180)	87.3 (24.2–205)	239 (82.4–555)
Algeria	118 (37.8–297)	194 (56.9–485)	20.5 (6.84–51.2)	56.5 (19.8–135)
Bahrain	9.17 (3.28–20.4)	24.3 (8.27–55.0)	1.35 (0.490–2.97)	7.46 (2.72–16.7)
Egypt	1240 (182–3160)	1330 (193–3380)	243 (35.6–624)	475 (73.3–1150)
Iran (Islamic Republic of)	552 (214–1200)	1750 (673–3730)	97.9 (39.3–209)	447 (187–937)
Iraq	657 (194–1460)	946 (324–2120)	86.5 (25.0–191)	292 (112–641)
Jordan	8.45 (2.88–19.2)	282 (95.5–636)	0.356 (0.116–0.844)	76.1 (27.8–169)
Kuwait	27.4 (7.12–67.9)	57.4 (16.9–129)	4.42 (1.19–11.0)	17.8 (5.61–40.8)
Lebanon	20.8 (7.05–57.6)	137 (48.7–320)	2.92 (0.728–13.1)	41.4 (16.5–93.2)
Libya	45.5 (17.3–100)	211 (76.0–472)	4.12 (1.54–9.23)	54.2 (21.1–117)
Morocco	224 (74.3–506)	933 (273–2240)	26.5 (8.76–64.6)	228 (74.0–515)
Oman	25.8 (8.84–62.9)	49.6 (15.8–119)	3.75 (1.28–9.35)	14.8 (5.20–33.8)
Palestine	21.7 (7.38–50.7)	142 (47.9–325)	2.14 (0.711–4.97)	38.3 (13.9–87.2)
Qatar	37.5 (12.6–86.6)	33.0 (10.7–77.9)	7.46 (2.61–17.1)	12.7 (4.65–28.9)
Saudi Arabia	226 (70.3–542)	104 (29.9–274)	41.5 (13.7–99.6)	49.5 (16.9–126)
Sudan	415 (78.1–1080)	306 (75.6–767)	86.1 (17.5–221)	126 (36.6–306)
Syrian Arab Republic	12.9 (3.64–33.9)	79.9 (19.8–231)	1.31 (0.381–3.32)	20.4 (5.14–56.2)
Tunisia	22.7 (6.88–54.2)	437 (144–1030)	1.40 (0.378–3.62)	108 (37.9–247)
Turkey	475 (105–1360)	1240 (426–2820)	99.8 (20.3–298)	348 (121–784)
United Arab Emirates	22.9 (7.15–53.0)	74.3 (22.8–173)	4.37 (1.37–10.2)	22.4 (7.43–50.8)
Yemen	231 (28.1–574)	179 (31.4–584)	44.1 (5.14–110)	62.2 (14.2–169)
South Asia	15700 (5810–34000)	36700 (13500–79300)	2130 (811–4630)	11200 (4670–23800)
Bangladesh	1550 (508–3700)	3850 (1390–8660)	248 (83.7–603)	1010 (388–2220)
Bhutan	0.145 (0.0299–0.401)	0.664 (0.245–1.54)	0.0253 (0.00505–0.0720)	0.173 (0.0667–0.384)
India	11900 (4500–25800)	27900 (10400–59600)	1430 (556–3160)	8830 (3720–18600)
Nepal	138 (51.9–307)	840 (305–1900)	11.6 (4.42–26.1)	211 (84.2–468)
Pakistan	2100 (726–4800)	4150 (1410–9360)	437 (155–984)	1180 (432–2630)
Southeast Asia, East Asia, and Oceania	1340 (519–2890)	8860 (3360–19100)	188 (76.4–403)	1900 (806–3980)
East Asia	106 (42.3–225)	9.78 (3.86–21.3)	33.0 (13.9–69.4)	8.56 (4.10–16.2)
China	104 (41.8–223)	3.69 (1.49–7.85)	32.6 (13.7–68.8)	7.01 (3.38–13.5)
Democratic People's Republic of Korea	1.06 (0.308–2.70)	2.06 (0.767–4.74)	0.318 (0.0954–0.796)	0.546 (0.214–1.25)

Location	Incident cases of Long COVID during 2020 (in thousands)	Incident cases of Long COVID during 2021 (in thousands)	Prevalent cases of Long COVID during 2020 (in thousands)	Prevalent cases of Long COVID during 2021 (in thousands)
Taiwan (Province of China)	0.506 (0.0824–1.83)	4.04 (1.46–9.48)	0.133 (0.0222–0.469)	1.00 (0.364–2.40)
Oceania	4.27 (1.31–11.2)	105 (32.9–262)	0.503 (0.157–1.33)	22.9 (7.69–57.2)
American Samoa	0.00352 (0.000102–0.0150)	0.00645 (0.000398–0.0241)	0 (0–0)	0.00197 (0.000102–0.00800)
Cook Islands	0.0211 (0.00760–0.0471)	0.0707 (0.0249–0.165)	0.00236 (0.000851–0.00530)	0.0178 (0.00704–0.0387)
Fiji	0.0831 (0.0221–0.242)	11.0 (3.40–26.1)	0.0185 (0.00436–0.0565)	1.59 (0.509–3.73)
Guam	0.803 (0.293–1.89)	2.02 (0.699–4.66)	0.0865 (0.0292–0.211)	0.491 (0.193–1.08)
Kiribati	0 (0–0)	0.0215 (0.00160–0.0659)	0 (0–0)	0.00474 (0.000353–0.0146)
Marshall Islands	0 (0–0)	0.0183 (0.00264–0.0537)	0 (0–0)	0.00546 (0.000798–0.0155)
Micronesia (Federated States of)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Nauru	0.0103 (0.00355–0.0240)	0.0346 (0.0116–0.0795)	0.00113 (0.000389–0.00272)	0.00820 (0.00310–0.0187)
Niue	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Northern Mariana Islands	0.0440 (0.0159–0.0989)	0.0324 (0.0116–0.0747)	0.0102 (0.00388–0.0219)	0.0110 (0.00447–0.0248)
Palau	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Papua New Guinea	3.09 (0.782–8.91)	86.3 (25.3–219)	0.359 (0.0921–1.01)	19.6 (6.28–49.5)
Samoa	0 (0–0)	0.0136 (0.00186–0.0423)	0 (0–0)	0.00427 (0.000602–0.0132)
Solomon Islands	0 (0–0)	0.0857 (0.00858–0.330)	0 (0–0)	0.0232 (0.00256–0.0869)
Tokelau	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Tonga	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
Tuvalu	0.0121 (0.00424–0.0277)	0.0403 (0.0138–0.0911)	0.00134 (0.000470–0.00303)	0.00979 (0.00378–0.0216)
Vanuatu	0 (0–0)	0.0947 (0.0189–0.299)	0 (0–0)	0.0257 (0.00528–0.0809)
Southeast Asia	1230 (472–2670)	8750 (3310–18800)	155 (62.0–335)	1870 (790–3920)
Cambodia	0.261 (0.0389–0.899)	127 (39.8–318)	0.0582 (0.00843–0.206)	19.8 (6.58–48.6)
Indonesia	770 (300–1680)	5370 (2010–11700)	95.7 (38.0–208)	1250 (527–2630)
Lao People's Democratic Republic	0.121 (0.00958–0.439)	12.8 (3.18–38.1)	0.0321 (0.00246–0.117)	1.32 (0.278–4.08)
Malaysia	4.71 (1.37–12.1)	343 (124–783)	0.887 (0.259–2.40)	52.5 (19.6–117)

Location	Incident cases of Long COVID during 2020 (in thousands)	Incident cases of Long COVID during 2021 (in thousands)	Prevalent cases of Long COVID during 2020 (in thousands)	Prevalent cases of Long COVID during 2021 (in thousands)
Maldives	1.29 (0.372–3.55)	5.20 (1.82–12.1)	0.189 (0.0568–0.522)	1.38 (0.512–3.22)
Mauritius	0.227 (0.0591–0.614)	2.14 (0.819–4.87)	0.0633 (0.0170–0.169)	0.238 (0.0890–0.547)
Myanmar	53.9 (17.8–127)	585 (177–1360)	1.96 (0.634–4.77)	112 (38.1–252)
Philippines	389 (144–833)	1610 (605–3470)	54.2 (21.2–115)	343 (141–726)
Seychelles	0.0280 (0.00837–0.0684)	1.95 (0.742–4.29)	0.00562 (0.00164–0.0137)	0.433 (0.174–0.933)
Sri Lanka	2.03 (0.302–6.59)	123 (45.8–267)	0.415 (0.0604–1.39)	20.6 (7.59–46.3)
Thailand	2.70 (0.360–9.02)	284 (94.7–693)	0.723 (0.0937–2.43)	36.0 (12.3–89.2)
Timor-Leste	0.0407 (0.00537–0.130)	13.9 (4.17–36.2)	0.00987 (0.00126–0.0319)	2.10 (0.654–5.30)
Viet Nam	1.37 (0.426–3.59)	249 (81.6–578)	0.262 (0.0686–0.755)	26.3 (9.08–60.3)
Sub-Saharan Africa	8840 (3240–19200)	21000 (7610–46400)	1560 (584–3360)	5880 (2390–12700)
Central Sub-Saharan Africa	1350 (465–2980)	2690 (958–6060)	249 (87.7–556)	780 (296–1710)
Angola	189 (61.0–439)	817 (266–1820)	17.8 (5.73–41.2)	190 (68.0–415)
Central African Republic	75.3 (23.8–187)	55.5 (17.8–146)	15.4 (5.01–37.5)	21.6 (8.04–51.4)
Congo	51.0 (17.4–121)	70.1 (24.4–162)	9.44 (3.39–22.1)	21.2 (8.39–47.5)
Democratic Republic of the Congo	987 (319–2260)	1710 (565–3870)	198 (63.2–457)	536 (188–1190)
Equatorial Guinea	25.0 (8.45–58.1)	11.9 (3.24–29.5)	5.12 (1.81–11.8)	4.44 (1.76–9.66)
Gabon	17.7 (4.99–42.2)	25.3 (6.33–62.9)	3.81 (1.09–9.05)	7.23 (2.20–16.4)
Eastern Sub-Saharan Africa	2410 (858–5180)	9470 (3410–20700)	337 (122–738)	2460 (982–5360)
Burundi	8.62 (2.89–19.6)	55.8 (18.3–133)	1.48 (0.495–3.43)	15.1 (5.16–36.4)
Comoros	2.26 (0.404–7.53)	16.2 (5.98–36.2)	0.453 (0.0865–1.46)	5.29 (2.07–11.7)
Djibouti	11.2 (3.67–26.1)	17.2 (5.45–41.9)	2.52 (0.856–5.80)	4.98 (1.70–12.0)
Eritrea	2.86 (0.164–10.2)	57.4 (19.3–126)	0.530 (0.0280–1.95)	14.0 (4.57–30.6)
Ethiopia	845 (308–1860)	2700 (981–5970)	93.4 (34.9–205)	719 (283–1600)
Kenya	375 (134–826)	1430 (518–3140)	53.8 (20.2–119)	363 (146–785)
Madagascar	325 (113–755)	510 (168–1180)	48.4 (16.9–112)	175 (64.1–389)
Malawi	64.0 (18.0–154)	539 (184–1220)	10.3 (2.94–24.7)	129 (47.1–289)
Mozambique	82.7 (25.0–200)	967 (337–2170)	7.69 (2.29–20.0)	231 (85.3–523)
Rwanda	9.69 (2.91–23.4)	212 (62.9–506)	1.30 (0.387–3.36)	43.4 (13.6–101)
Somalia	137 (35.9–341)	478 (154–1120)	31.6 (9.20–75.9)	118 (42.5–266)
South Sudan	88.3 (26.2–230)	107 (30.2–276)	18.2 (5.48–47.5)	38.1 (12.5–95.6)
Uganda	59.5 (20.2–133)	714 (231–1630)	4.60 (1.56–10.5)	164 (60.0–370)

Location	Incident cases of Long COVID during 2020 (in thousands)	Incident cases of Long COVID during 2021 (in thousands)	Prevalent cases of Long COVID during 2020 (in thousands)	Prevalent cases of Long COVID during 2021 (in thousands)
United Republic of Tanzania	282 (102–606)	1150 (417–2530)	45.9 (16.9–99.0)	303 (119–657)
Zambia	119 (38.1–283)	511 (179–1190)	16.7 (5.41–40.2)	131 (49.4–304)
Southern Sub-Saharan Africa	492 (184–1070)	1820 (664–4000)	71.8 (27.4–154)	470 (193–996)
Botswana	1.14 (0.414–2.51)	61.0 (16.1–150)	0.111 (0.0414–0.245)	12.1 (3.21–29.6)
Eswatini	6.20 (2.18–14.3)	26.1 (6.57–68.6)	0.886 (0.318–2.04)	6.40 (1.79–16.8)
Lesotho	7.06 (2.42–16.3)	46.5 (11.0–112)	0.882 (0.305–2.00)	12.1 (3.19–29.3)
Namibia	6.49 (2.28–14.7)	59.0 (17.9–138)	0.734 (0.267–1.66)	13.8 (4.77–32.1)
South Africa	419 (157–898)	1170 (437–2520)	62.1 (24.2–132)	323 (136–686)
Zimbabwe	51.7 (16.4–125)	460 (134–1100)	7.11 (2.26–17.2)	103 (32.8–242)
Western Sub-Saharan Africa	4580 (1680–9970)	6970 (2520–15600)	900 (341–1970)	2170 (887–4710)
Benin	36.7 (10.3–102)	112 (32.1–261)	6.92 (1.98–19.5)	24.5 (7.02–60.1)
Burkina Faso	136 (42.3–350)	378 (134–860)	28.0 (8.14–71.4)	120 (45.6–281)
Cabo Verde	4.69 (1.45–11.8)	10.4 (3.55–24.8)	0.600 (0.164–1.53)	3.22 (1.17–7.57)
Cameroon	189 (19.4–462)	465 (29.9–1320)	40.6 (4.11–98.3)	126 (8.46–355)
Chad	153 (38.5–412)	145 (38.8–356)	32.6 (7.92–88.4)	56.9 (16.6–137)
Côte d'Ivoire	280 (81.3–671)	424 (138–977)	56.6 (17.2–139)	111 (42.6–247)
Gambia	27.8 (9.19–62.7)	44.3 (13.4–106)	3.37 (1.17–7.38)	12.7 (4.51–28.0)
Ghana	273 (94.6–624)	541 (186–1320)	47.2 (17.0–109)	155 (58.9–368)
Guinea	143 (45.2–351)	266 (76.9–628)	26.9 (8.77–66.4)	67.9 (23.9–149)
Guinea-Bissau	27.9 (9.00–67.7)	18.9 (3.13–57.1)	6.00 (1.90–15.0)	5.87 (1.89–15.4)
Liberia	49.2 (15.7–114)	68.5 (21.5–178)	10.2 (3.34–23.2)	17.0 (6.33–39.6)
Mali	195 (52.5–478)	369 (125–886)	43.8 (11.8–107)	121 (43.7–289)
Mauritania	27.1 (9.17–66.0)	75.4 (23.3–180)	5.52 (1.86–13.8)	20.1 (6.66–46.8)
Niger	115 (27.2–295)	233 (76.0–530)	29.4 (6.83–76.0)	78.5 (26.2–182)
Nigeria	2700 (992–5980)	3240 (1160–7100)	519 (192–1160)	1100 (449–2390)
Sao Tome and Principe	2.12 (0.670–5.43)	1.95 (0.396–5.38)	0.487 (0.158–1.25)	0.539 (0.201–1.16)
Senegal	110 (40.1–253)	394 (144–891)	19.1 (7.23–43.9)	105 (40.6–232)
Sierra Leone	87.3 (28.7–211)	39.6 (13.9–94.4)	19.3 (6.27–47.0)	16.5 (6.60–36.6)
Togo	27.9 (9.29–65.4)	145 (49.7–331)	4.27 (1.46–9.71)	32.8 (12.4–72.8)

Figure 1. Proportions of incident long COVID symptom clusters and their overlap in 2020 and 2021 globally

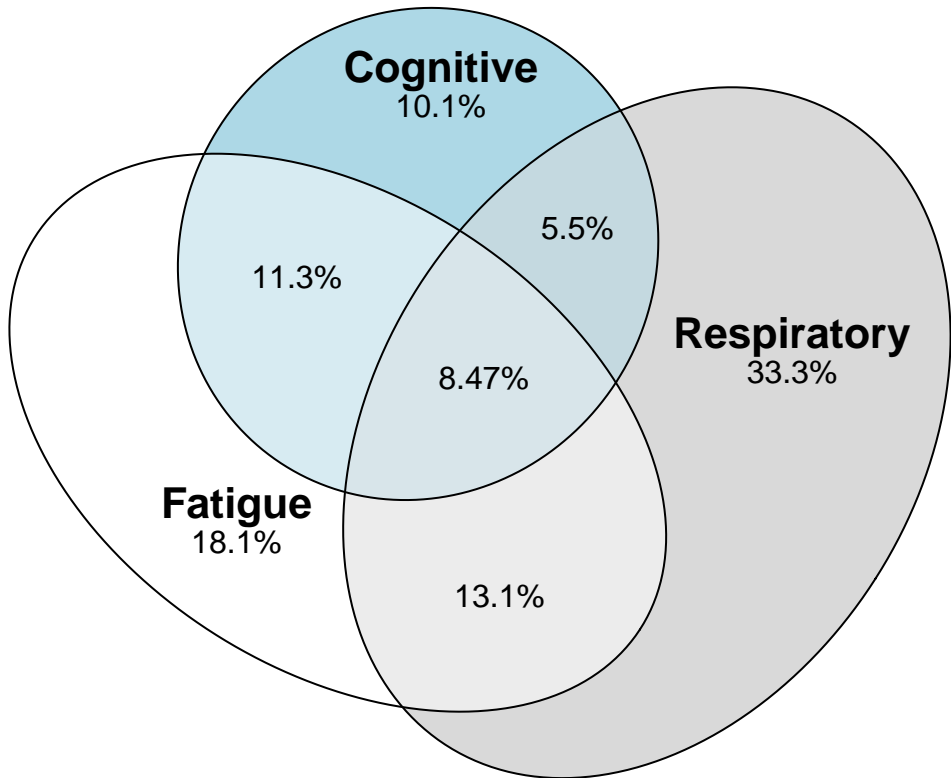


Figure 2. Global prevalence of COVID-19 symptom clusters in 2020 and 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a [CC-BY-NC 4.0 International license](https://creativecommons.org/licenses/by-nc/4.0/).

