Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Short Communication

Risk factors of post-COVID-19 conditions attributed to COVID-19 disease in people aged ≥50 years in Europe and Israel

T. Bovila,*, C.T. Westera, L.L. Scheel-Hincke, K. Andersen-Ranberg

A Unit for Epidemiology, Biostatistics and Biodemography, Department of Public Health, University of Southern Denmark, 5000 Odense, Denmark
b Department of Clinical Research, University of Southern Denmark, 5000 Odense, Denmark
c Department of Geriatric Medicine, Odense University Hospital, 5000 Odense, Denmark

Abstract

Objectives: High age, male sex and pre-existing comorbidities are risk factors for a more severe development of COVID-19, and individuals surviving COVID-19 may experience persistent symptoms afterwards referred to as ‘post-COVID-19 condition’, which represents a range of symptoms after recovering from COVID-19. This study aims at identifying risk factors of post-COVID-19 conditions among people aged ≥50 years.

Study design: We conducted a cross-sectional study based on data from the Survey of Health, Ageing and Retirement in Europe.

Methods: A multiple logistic regression model was used to investigate age, sex, education, comorbidities, smoking, body mass index, and COVID-19 hospitalisation as risk factors of post-COVID-19 condition.

Results: Participants aged ≥70 years (odds ratio [OR] 1.61) with medium (OR 2.38) and lower (OR 2.14) educational levels have a higher risk of post-COVID-19 conditions. In addition, when considering the severity of the COVID-19 disease, those who were hospitalised due to COVID-19 had a 26 times higher risk of post-COVID-19 conditions compared with those who were only tested positive (OR 25.9).

Conclusions: This study supports that health inequalities exist across educational levels with respect to post-COVID-19 conditions, although misclassification may be more common among lower educated participants. The results suggest that policy makers should increase educational interventions towards increasing health literacy.

© 2022 The Author(s). Published by Elsevier Ltd on behalf of The Royal Society for Public Health. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

Key points

- This study examines the risk factors of post-COVID-19 conditions among Europeans aged ≥50 years who tested positive for COVID-19.
- Higher age, low and medium educational level and prior COVID-19-related hospitalisation are risk factors of post-COVID-19 conditions.
- This study suggests policy makers to increase their focus on educational interventions towards increasing health literacy.

Introduction

By fall 2022, the COVID-19 pandemic has been present for more than 2 years, and repercussions of COVID-19 may well be observed. Although COVID-19 strikes at all ages, older people are at increased risk of a critical course of disease, as are people with pre-existing comorbidities.1 Following COVID-19 disease, lingering symptoms lasting from weeks to months may be experienced. The World Health Organisation has recently coined this as ‘post-COVID-19 condition’, defined as a condition that “occurs in individuals with a history of probable or confirmed SARS-CoV-2 infection, usually 3 months from the onset of COVID-19 with symptoms that last for at least 2 months and cannot be explained by an alternative diagnosis.”2

Studies describing the risk factors of post-COVID-19 health conditions are limited and show conflicting results, but increasing age, female gender, multimorbidity, high body mass index (BMI),
lower educational level, having several symptoms during COVID-19 infection, and a more severe acute phase of COVID-19 disease, have all been associated with post-COVID-19 condition.\textsuperscript{2,4} Full recovery from COVID-19 is important to keep people's work capacity, productivity, and ability to return to normal everyday activities, and thus, risk factors of post-COVID-19 must be explored. To our knowledge, no previous studies have explored the possible risk factors in a large population-based sample of middle-aged and older adults comparing several countries. Thus, the aim of the study was to investigate risk factors of post-COVID-19 conditions among people aged ≥50 years within 27 European countries and Israel.

Methods

We used data from the second wave of the Survey of Health, Ageing and Retirement in Europe (SHARE) COVID-19 survey (SCS2) conducted from June to August 2021.\textsuperscript{3} Participants, who had tested positive with COVID-19 (Supplementary figure F1), were asked, “Have you experienced any long-term or lingering effects that you attribute to your Covid Illness?” with the following answer options: ‘fatigue’, ‘cough, congestion, shortness of breath’, ‘loss of taste or smell’, ‘headache’, ‘body aches, joint pain’, ‘chest or abdominal pain’, ‘diarrhoea, nausea’, ‘confusion’, and ‘other’. Based on this question, an outcome variable was created and dichotomised, indicating whether the respondents had ‘no symptoms’ or ‘one or more’. The following variables were selected as the primary potential risk factors for post-COVID-19 conditions: age (50–69 and ≥70 years), sex (male, female), educational level (according to the International Standardized Classification of Education [ISCED] classified into lower [ISCED groups 0–2], medium [ISCED groups 3–4] and higher [ISCED groups 5–6]), comorbidity (‘no diseases’, ‘one or two diseases’, and ‘three or more diseases’), smoking (‘not smoking’, ‘smoking now’, ‘previous smoker’), BMI (‘normal weight’ (BMI <18.5 and <25 kg/m\textsuperscript{2}), ‘underweight’ (BMI <18.5 kg/m\textsuperscript{2}), ‘overweight’ (BMI ≥25 and <30 kg/m\textsuperscript{2}) and ‘obese’ (BMI ≥30 kg/m\textsuperscript{2}) and a COVID-19 hospitalisation variable indicating if respondents have been hospitalised due to COVID-19 (‘yes’ or ‘no’) and serve as a proxy of the severity of the COVID-19 disease. Moreover, the variable ‘country’, representing the 28 SHARE countries, was included (Germany, The Netherlands, Belgium, Luxembourg, Switzerland, Austria, France, Spain, Portugal, Malta, Italy, Greece, Cyprus, Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Slovenia, Hungary, Croatia, Romania, Bulgaria, Denmark, Sweden, Finland, and Israel; Supplementary Table S2).

Age, sex, diseases, and COVID-19 hospitalisation were drawn from SCS2, and all other variables were drawn from SHARE wave 8 (conducted in 2020)\textsuperscript{5} or the latest wave possible. Multiple logistic regression models were used to study the risk factors of post-COVID-19 conditions, and the analyses were performed in three steps. First, we included age, gender, education, comorbidity, smoking and BMI (model 1); second, we added a ‘country’ variable (model 2); and finally, we included the ‘COVID-19-hospitalisation’ variable (model 3). In all analyses, the cross-sectional individual weights supplied by SHARE were applied to yield a representative sample.

Results

Of all SCS2 participants aged ≥50 years (n = 49,044), 6.5% (n = 3156) reported having tested positive for COVID-19 and were thus included in the final analysis (Supplementary figure F1). In the final sample, 42.4% were aged ≥70 years, and 61.6% were females. The proportion of people with a high educational level was 19.2%, 45.1% with a medium level, and 30.4% had a lower educational level (10% were missing). Among the respondents, 19.4% had three or more comorbidities and 24.1% had none, 39.1% were overweight, and 28.4% had a normal BMI. Only 7.9% reported to be smokers, and 16.4% were hospitalised due to COVID-19 disease (Supplementary Table S3).

Of those who tested positive, almost one-quarter (23.5%) reported at least one post-COVID-19 condition, the most common being ‘fatigue’ (18.8%), followed by ‘cough, congestion or shortness of breath’ (13.5%) and ‘body aches or joint pain’ (13.2%; Supplementary Table S4). In the crude analysis, respondents with higher age (≥70 years), medium or low education, multimorbidity, and obesity were at higher risk of post-COVID-19 conditions. However, in the adjusted model (model 1), only older participants (≥70 years; odds ratio [OR] 1.58, 95% confidence interval [CI] 1.06–2.34), and those with a medium (OR 2.46, 95% CI 1.46–4.16) or low education (OR 2.42, 95% CI 1.37–4.25) had a higher risk of post-COVID-19 condition. When adding the country variable to the model (model 2), the risk persisted for those aged ≥70 years (OR 1.61, 95% CI 1.08–2.41), with a medium (OR 2.38, 95% CI 1.39–4.09) or lower (OR 2.14, 95% CI 1.18–3.86) educational level, but the effect attenuated. In addition, when considering the severity of the COVID-19 disease (model 3), those who were hospitalised due to COVID-19 had a 26 times higher risk of post-COVID-19 conditions compared with those who were not hospitalised (OR 25.9, 95% CI 15.64–42.79), and the effect of educational level persisted (medium (OR 2.69, 95% CI 1.48–4.89), lower (OR 2.30, 95% CI 1.22–4.35; Table 1). Sex, comorbidity, BMI and smoking did not show any association with post-COVID-19 conditions.

Discussion

Post-COVID-19 conditions are common among COVID-19-infected people aged ≥50 years living in the 28 SHARE countries and affects, in particular, older people and those with lower educational level. The association to lower educational level has not been described previously in a European population. However, educational attainment is a social determinant of health, as well as a predictor of the severity of COVID-19 disease.\textsuperscript{6} Low educational level is also associated with low health literacy,\textsuperscript{7} that is, the ability to reflect upon one's illness and understand how to distinguish between symptoms from chronic disease and symptoms related to COVID-19, and poorer health literacy may explain an overreporting of symptoms.

Not only is increasing age associated with COVID-19 disease severity,\textsuperscript{8} but it is also associated with higher risk of post-COVID-19 conditions,\textsuperscript{9} and in line with our findings. This may be explained by an age-associated adverse immunological response, as specific cell changes persist longer in older compared with younger individuals,\textsuperscript{9} and therefore, the symptoms may be more persistent.

The most salient predictor of post-COVID-19 conditions in our study was the COVID-19 hospitalisation, which may represent the severity of the COVID-19 disease and is in keeping with other studies.\textsuperscript{4} However, as intensive treatment during hospital stay can cause similar symptoms,\textsuperscript{10} it may be difficult to determine if the symptoms are attributed to the in-hospital treatment, COVID-19, or a combination.

The strength of this study was the large and representative sample of 28 countries using standardised methods for data collection. Also, this study comprised both hospitalised and non-hospitalised participants. However, it is a weakness that SHARE did not collect information on the duration of the post-COVID-19 symptoms to account for the extent of the post-COVID-19 condition. A time frame for long-term or lingering symptoms would have improved the comparability across individuals. In general, we cannot exclude residual confounding; for instance, both hospitalisations and post-COVID-19 conditions may be correlated with
**Table 1**

The risk of having post-COVID-19 condition.

| Variables                  | Crude OR (95% CI) | Model 1a OR (95% CI) | Model 2a b OR (95% CI) | Model 3a b c OR (95% CI) |
|----------------------------|------------------|----------------------|-----------------------|------------------------|
| Age 50–69                  |                  |                      |                       |                        |
| ≥70 Age                   | 1.57*            | 1.05–2.35            | 1.58*                 | 1.06–2.34              |
| Male                      |                  |                      |                       |                        |
| Female                    |                  |                      |                       |                        |
| Education High             |                  |                      |                       |                        |
| Low                       | 3.13***          | 1.77–5.56            | 2.46***               | 1.46–4.16              |
| Smoking                   |                  |                      |                       |                        |
| Not smoking               |                  |                      |                       |                        |
| Previous smoker           | 1.16             | 0.75–1.81            | 1.11                  | 0.74–1.66              |
| BMI                       |                  |                      |                       |                        |
| Normal                    |                  |                      |                       |                        |
| Underweight               | 0.28             | 0.04–1.88            | 0.27                  | 0.04–1.76              |
| Overweight                | 1.15             | 0.68–1.93            | 1.18                  | 0.76–1.83              |
| Obese                     | 1.86**           | 1.17–2.94            | 1.59                  | 0.98–2.59              |
| COVID-19 hospitalisation  |                  |                      |                       |                        |
| No                        |                  |                      |                       |                        |
| Yes                       |                  |                      |                       |                        |
| Pseudo R²                 | 0.059            | 0.081                | 0.274                 |                        |
| Observations              | 2817             | 2817                 | 2817                  |                        |

BMI: body mass index; CI, confidence interval; OR, odds ratio.

a: adjusted for age, sex, education, comorbidity, smoking, BMI; b: adjusted for country (Germany used as reference); c: adjusted for COVID-19 hospitalisation.

***P < 0.001, **P < 0.01, *P < 0.05.

vaccination status. Finally, as a self-reported questionnaire, the post-COVID-19 conditions may be over- or under-reported due to information bias.

**Conclusion**

The results indicate that lower educational level, higher age, and prior hospitalisation for COVID-19 disease increase the risk of post-COVID-19 conditions. Although biological mechanisms may explain the adverse effects of higher age and disease severity, the effect of a lower educational level for post-COVID-19 conditions is more likely explained by lower health literacy. In conclusion, these findings have implications for public policies in Europe and Israel, as we shed light on the social inequalities in health, which still exist at large. We encourage policy makers to increase their focus on educational interventions and implement programmes and policies to increase health literacy and hereby reduce inequalities in health.

**Author statements**

**Ethical approval**

None required.

**Funding**

The SHARE data collection has been funded by the European Commission, DG RTD through FP5 (QLG6-CT-2001-00360), FP6 (SHARE-13: RII-CT-2006-062,193, COMPARE: CIT5-CT-2005-028,857, SHARELIFE: CIT4-CT-2008-028,812), FP7 (SHARE-PREP: GA N°211,909, SHARE-LEAP: GA N°227,822, SHARE M4: GA N°261,982, DASISH: GA N°283,646) and Horizon 2020 (SHARE-DEV3: GA N°676,536, SHARE-COHESION: GA N°870,628, SERISS: GA N°654,221, SSHOC: GA N°823,782, SHARE-COVID19: GA N°101,015,924) and by DG Employment, Social Affairs & Inclusion through VS 2015/0195, VS 2016/0135, VS 2018/0285, VS 2019/0332, and VS 2020/0313. Additional funding from the German Ministry of Education and Research, the Max Planck Society for the Advancement of Science, the U.S. National Institute on Aging (U01_AG09740-13S2, P01_AG005842, P01_AG08291, P30_AG12815, R21_AG025169, Y1-AG-4553-01, IAG_BSR06-11, ORHA_04028,800, 10.6103/SHARE.w8ca.800, 10.6103/SHARE.w9ca800), see (DOIs: 10.6103/SHARE.w1.800, 10.6103/SHARE.w2.800, 10.6103/SHARE.w3.800, 10.6103/SHARE.w4.800, 10.6103/SHARE.w5.800, 10.6103/SHARE.w6.800, 10.6103/SHARE.w7.800, 10.6103/SHARE.w8.800, 10.6103/SHARE.w8ca800, 10.6103/SHARE.w9ca800), see Börsch-Supan et al. (2013) for methodological details.

**Competing interests**

None declared.

**Data source**

This article uses data from SHARE Waves 1, 2, 3, 4, 5, 6, 7, 8 and 9 (DOIs: 10.6103/SHARE.w1.800, 10.6103/SHARE.w2.800, 10.6103/SHARE.w3.800, 10.6103/SHARE.w4.800, 10.6103/SHARE.w5.800, 10.6103/SHARE.w6.800, 10.6103/SHARE.w7.800, 10.6103/SHARE.w8.800, 10.6103/SHARE.w8ca800, 10.6103/SHARE.w9ca800), see Börsch-Supan et al. (2013) for methodological details.

**Appendix A. Supplementary data**

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2022.09.017.
References

1. Liu B, Spokes P, He W, Kaldor J. High risk groups for severe COVID-19 in a whole of population cohort in Australia. BMC Infect Dis 2021;21(1):685. https://doi.org/10.1186/s12879-021-06378-z.

2. Soriano JB, Murthy S, Marshall JC, Relan P, Diaz JV. A clinical case definition of post-COVID-19 condition by a Delphi consensus. Lancet Infect Dis 2022;22(4):e102–7. https://doi.org/10.1016/S1473-3099(21)00703-9.

3. Crankson S, Pokhrel S, Anokye NK. Determinants of COVID-19-related length of hospital stays and long COVID in Ghana: a cross-sectional analysis. Int J Environ Res Publ Health 2022;19(1). https://doi.org/10.3390/ijerph19010527.

4. Crook H, Raza S, Nowell J, Young M, Edison P. Long covid-mechanisms, risk factors, and management. BMJ 2021;374:n1648. https://doi.org/10.1136/bmj.n1648.

5. Börsch-Supan A, Survey of Health. Ageing and retirement in Europe (SHARE) wave 9. COVID-19 survey 2. Release version: 8.0.0. SHARE-ERIC. Data set; 2022. https://doi.org/10.6103/SHARE.w9ca.800.

6. Börsch-Supan A, Brandt M, Hunkler C, Kneip T, Korbmacher J, Malter F, et al. Data resource profile: the survey of health, ageing and retirement in Europe (SHARE). Int J Epidemiol 2013. https://doi.org/10.1093/ije/dyt088.

7. Jian Z, Wang M, Jin X, Wei X. Genetically predicted higher educational attainment decreases the risk of COVID-19 susceptibility and severity: a mendelian randomization study. Front Public Health 2021;9:731962. https://doi.org/10.3389/fpubh.2021.731962.

8. Van der Heide I, Wang J, Droomers M, Spreeuwenberg P, Rademakers J, Uiters E. The relationship between health, education, and health literacy: results from the Dutch adult literacy and life skills survey. J Health Commun 2013;18(sup1):172–84. https://doi.org/10.1080/10810730.2013.825666.

9. Townsend I, Dyer AH, Naughton A, Kiersley R, Holden D, Gardner M, et al. Longitudinal analysis of COVID-19 patients shows age-associated T cell changes independent of ongoing ill-health. Front Immunol 2021;12. https://doi.org/10.3389/fimmu.2021.676932.

10. Vrettou CS, Mantziou V, Vassiliou AG, Orfanos SE, Kotanidou A, Dimopoulou I. Post-intensive care syndrome in survivors from critical illness including COVID-19 patients: a narrative review. Life (Basel) 2022;12(1). https://doi.org/10.3390/life12010107.