Original Article

The Impact of the COVID-19 Pandemic on Self-Reported Health

Early Evidence From the German National Cohort

Annette Peters, Susanne Rospleszcz, Karin H. Greiser, Marco Dallavalle, Klaus Berger*

Summary

Background: The pandemic caused by the coronavirus SARS-CoV-2 and the countermeasures taken to protect the public are having a substantial effect on the health of the population. In Germany, nationwide protective measures to halt the spread of the virus were implemented in mid-March for 6 weeks.

Methods: In May, the impact of the pandemic was assessed in the German National Cohort (NAKO). A total of 113 928 men and women aged 20 to 74 years at the time of the baseline examination conducted 1 to 5 years earlier (53%) answered, within a 30-day period, a follow-up questionnaire on SARS-CoV-2 test status, COVID-19-associated symptoms, and self-perceived health status.

Results: The self-reported SARS-CoV-2 test frequency among the probands was 4.6%, and 344 participants (0.3%) reported a positive test result. Depressive and anxiety-related symptoms increased relative to baseline only in participants under 60 years of age, particularly in young women. The rate of moderate to severe depressive symptoms increased from 6.4% to 8.8%. Perceived stress increased in all age groups and both sexes, especially in the young. The scores for mental state and self-rated health worsened in participants tested for SARS-CoV-2 compared with those who were not tested. In 32% of the participants, however, self-rated health improved.

Conclusion: The COVID-19 pandemic and the protective measures during the first wave had effects on mental health and on self-rated general health.

Cite this as
Peters A et al.: The impact of the COVID-19 pandemic on self-reported health—early evidence from the German National Cohort. Dtsch Arztebl Int 2020; 117: 861–7. DOI: 10.3238/arztebl.2020.0861

*The authors are listed in full in *Box – Authors* at the end of the article.

Institute for Epidemiology, Helmholtz Center Munich: Prof. Dr. rer. biol. hum. Annette Peters, Dr. rer. biol. hum. Susanne Rospleszcz, Dr. rer. nat. Marco Dallavalle

Chair of Epidemiology, Institute for Medical Information Processing, Biometry and Epidemiology, Medical Faculty, Ludwig-Maximilians-Universität München, Munich: Prof. Dr. rer. biol. hum. Annette Peters, Dr. rer. biol. hum. Susanne Rospleszcz

Department of Environmental Health, Harvard T. H. Chan School of Public Health, Boston, MA, USA: Prof. Dr. rer. biol. hum. Annette Peters

Department of Cancer Epidemiology, German Cancer Research Center (DKFZ), Heidelberg: Dr. med. Karin H. Greiser

Institute of Epidemiology and Social Medicine, University of Münster: Prof. Dr. med. Klaus Berger

The very first case of COVID-19 in Germany was detected on 27 January 2020 (1). The German health authorities isolated the first cases and traced and tested their contacts, but by mid-March 2020 community spread had become apparent in many regions. Testing capacities and dedicated medical care structures were set up to limit the spread and safeguard care of the general population. Within 2 weeks, nationwide countermeasures were introduced for a 6-week period. The goal was to contain the short- and long-term health impact of infection. However, concerns were raised regarding potential health consequences due to social isolation, increased stress and negative socioeconomic effects.

Large population-based cohort studies offer the opportunity to study emerging new diseases and their effects on health. Thus, they are ideal for measuring the spread of COVID-19 in the general population (2) and to evaluate the health impacts of protective measures (3). In the study presented here we analyzed data on more than 100 000 individuals from the German National Cohort (NAKO) (4). The following parameters were considered:

- Regional differences in COVID-19 occurrence among NAKO participants in comparison with the official statistics in spring 2020
- The frequency of COVID-19-associated symptoms
- Changes in mental health and self-rated general health status compared with a baseline assessment 1 to 5 years earlier.

Methods

Between 2014 and 2019, the NAKO recruited 205 219 randomly selected persons aged 20 to 74 years for the baseline examination at 18 study centers (4). Approval had been given by all study centers' local ethics committees, and all participants had provided written consent for study participation and repeat contact. The first follow-up examination started in 2019, but had to be halted in mid-March 2020 because of the COVID-19 pandemic and the Germany-wide protective countermeasures. Within a short time a new COVID-NAKO questionnaire was developed to collect information on SARS-CoV-2 tests and COVID-19-related symptoms and psychosocial factors. Further details can be found in *eBox 1*. The findings reported here rest on data

TABLE

Description of the study sample of the German National Cohort and the frequency of SARS-CoV-2 testing as self-reported in the COVID-NAKO questionnaire

	Study region characteristics		Sample characteristics				SARS-CoV-2 infections			
	Population, N*1	COVID-19 cases per 100 000*2	Baseline	COVID-19 follow-up	% women	Age in years, mean	(Number of) SARS-CoV-2 tests	(Number) observed to be positive	(Number) expected to be positive*3	p-value*4
	Age range 15–79 years	Age range 15–79 years								
All study centers	5 741 000	227	205 219	113 928	51.8	50	5245	344	257	< 0.001

*1 Sum of all study centers. The numbers of inhabitants in the respective districts were obtained from the official records of the Federal Statistical Office (www.genesis.destatis.de/genesis/online). Numbers are given for all inhabitants in the age range 15–79 years (as of 31 December 2019) (see *eTable 4*).

*2 Unweighted mean of all study centers. The numbers of COVID-19 cases per 100 000 inhabitants in the period 1–30 March 2020 were obtained from the official data of the Robert Koch Institute [https://npgeo-corona-npgeo-de.hub.arcgis.com/, 02.06.2020]. Cumulative incidences were calculated as weighted mean based on the age groups 15–34 years, 35–59 years and 60–79 years, weighted by the number of inhabitants in the respective age group in each district (see *eTable 4*).

*3 The number of expected SARS-CoV-2 infections was calculated, based on the number of participants and the cumulative COVID-19 incidence, as the weighted mean across the age groups 15–34 years, 35–59 years and 60–79 years, weighted by the number of participants in the respective age group in each district (see *eTable 4*).

*4 Comparison of numbers of expected vs observed SARS-CoV-2 infections, based on a goodness-of-fit chi-squared test for probabilities, with the probabilities given by the expected number of infections.

collected from questionnaires completed during in the first 30 days (30 April to 29 May) by 113 928 COVID-NAKO participants *(Table)*. Questionnaire participants had the same age as non-participants (mean 50 years) and a slim majority were women (52%, against 49% in non-participants). Participation varied among the study regions, from 34% in the northeast to 67% in the southwest (*eTable 1* and *eTable 2*).

Numbers of expected COVID-19 cases were calculated on the basis of official records from the Robert Koch Institute and the Federal Statistical Office, as described in *eBox 2*. The frequencies of COVID-19-related symptoms and their co-occurrence were graphically evaluated by means of bar plots and Euler diagrams.

The NAKO baseline examination included (4):

- Physical examinations
- A standardized personal interview
- Self-administered questionnaires and tests
- Acquisition of biological samples.

Several modules from the German version of the Patient Health Questionnaire (PHQ) (5, 6) for the assessment of mental health were included in the questionnaires to assess the severity of depressive symptoms (PHQ-9), anxiety symptoms (GAD-7), and perceived psychosocial strains (PHQ-stress).

The assessment of mental health in the COVID-NAKO questionnaire comprised the same scales (PHQ-9, GAD-7 and PHQ-stress). Summary scores for all three mental health scales were calculated according to the PHQ manual. The respective minimum and maximum scores are 0 to 27 points for PHQ-9, 0 to 21 points for GAD-7 and 0 to 20 points for PHQ-stress. The test-retest reliability of PHQ-9 and GAD-7 is high (7, 8). Differences between the COVID-NAKO questionnaire and the baseline examination were analyzed for all participants with data available at both time points. Student´s t-test was used to assess differences in mental health scores according to study center, age group, and sex. Multivariable linear regression models were applied with the difference in score between the COVID-NAKO questionnaire and baseline for each scale as dependent variable and age at baseline, sex, and baseline score as independent variables.

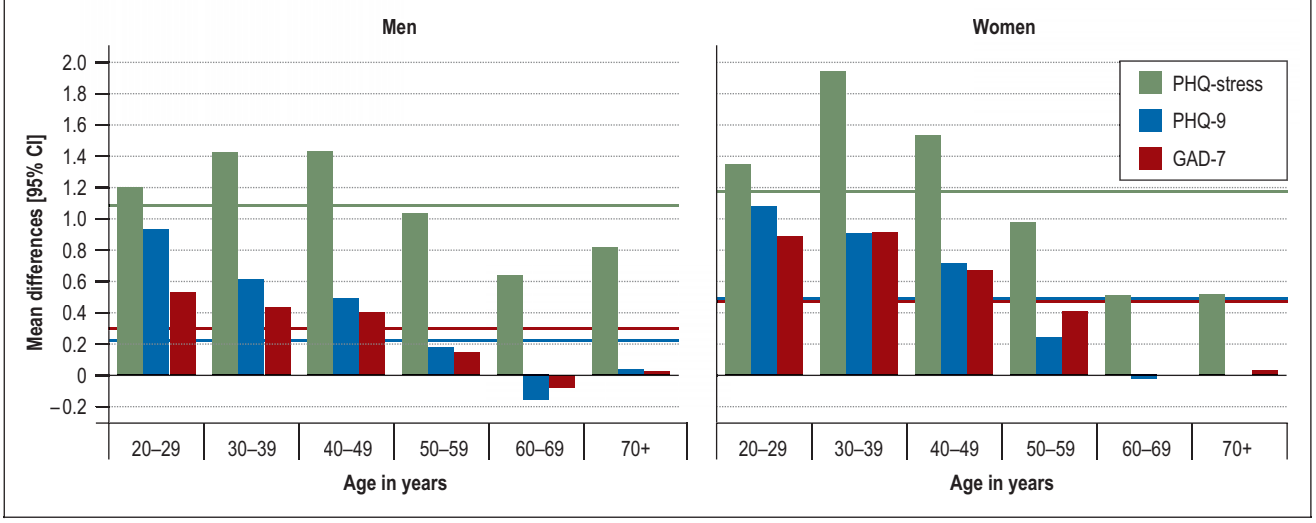
Self-rated health was assessed using the first question from the Short Form Health Questionnaire (SF-12). Changes in subjective state of health between the baseline examination and the time of the COVID-NAKO questionnaire were evaluated graphically and by means of adjusted logistic regression models. The binary outcome was worsening of self-rated health compared with baseline.

Results

Cumulative incidence of SARS-CoV-2-positive test results

Overall, 4.6% of NAKO participants reported having been tested for SARS-CoV-2 since 1 February 2020. Of the 5245 tested participants, 344 (6.6%) were positive

FIGURE 1



Mean differences in mental health summary scores between the time of the COVID-NAKO questionnaire and the NAKO baseline examination, stratified by age group and sex

PHQ-stress; PHQ-9, depressive symptoms; GAD-7, anxiety symptoms; CI, confidence interval

for SARS-CoV-2, yielding an overall cumulative incidence of 0.3%. The mean age of participants who were tested for SARS CoV-2 was higher than for than those who were not tested (50 years vs 47 years) and the proportion of women among the tested participants was slightly higher (57%). The number of cases tested positive in our study was 34% ($p < 0.001$) higher than was predicted on the basis of the official statistics. More than 80% of the cases that tested positive had been detected by mid-April *(eFigure 1a)*. A higher cumulative incidence was observed in the more strongly affected southern study centers (Freiburg, Saarbrücken, Regensburg) than in the north and east (Neubrandenburg, Leipzig, Kiel) *(eFigure 1b, eTable 2)*.

Frequency and distribution of symptoms

Across all regions, upper and lower respiratory tract symptoms were reported by 31% and 8% of the participants, respectively *(eTable 3)*. Of the 36 609 participants with either upper or lower respiratory tract symptoms in the preceding 4 months, 8.3% had been tested for SARS-CoV-2 infection. Among those tested, the rate of respiratory tract symptoms was much higher (59%). Specifically, 39% reported upper respiratory tract symptoms only, 3% lower respiratory tract symptoms only, and 17% reported symptoms in both segments *(eFigure 2)*. Persons who tested positive constituted only a minor fraction (0.93%) of all participants with respiratory tract symptoms *(eFigure 2)*. However, those with a positive test result reported on average more symptoms—such as fatigue, non-specific pain, loss of taste and smell—than those with a negative result *(eFigure 3)*. Thirty-six percent of participants with a positive test result reported no symptoms at all.

Changes in mental health

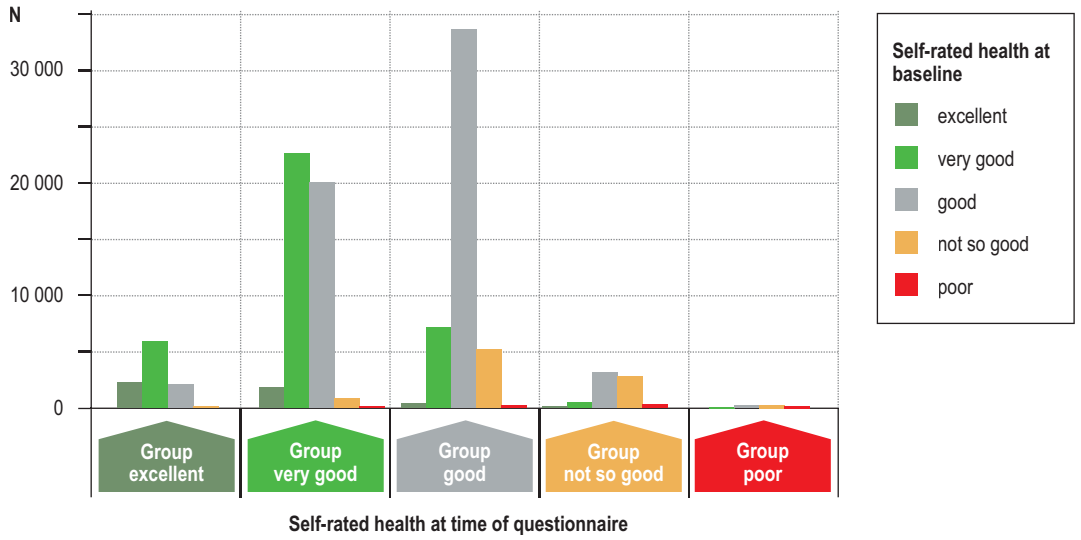
Figure 1 and *eTable 5* illustrate the changes in mental health scores between the NAKO baseline examination and the time of the COVID-NAKO questionnaire. *Figure 1* shows the mean increase in summary scores for self-perceived stress (1.14 ± 0.02) and for the severity of depressive (0.38 ± 0.02) and anxiety symptoms (0.36 ± 0.02), stratified by age and sex.

Increases in perceived stress were observed across all age groups, while increases in depressive symptoms and anxiety symptoms were limited to those below the age of 60 years. The most pronounced increases on all three scales were seen in the younger age groups. Women showed much higher increases than men, e.g., a rise of 1.94 points on the stress scale (minimum 0, maximum 20) in the age group 30–39 years.

On all three scales for mental health, the differences from baseline were somewhat less pronounced in the NAKO regions with a low cumulative incidence than in the regions with intermediate or high incidence *(eFigure 4)*. This pattern was apparent for all scales regardless of the absolute increase in score.

Participants who reported having been tested for SARS-CoV-2, regardless of whether the test result was positive or negative, had higher scores on all scales for mental health than those who had not been tested *(eFigure 5)*. The increase in mean severity of both depressive symptoms and anxiety symptoms raised the proportion of those who were above the cut-off points on these two scales (≥10 points): from 6.4% to 8.8% (depression) and from 4.3% to 5.7% (anxiety). The cut-off value shows symptoms of depression or anxiety with clinical relevance (9).

FIGURE 2



Self-rated health during the pandemic (x-axis) compared with the NAKO baseline examination (color coding). Y-axis: Number of participants. Overall, 56% of participants reported their health status as unchanged, 32% rated it as better during the pandemic, and 12% stated that it was worse during the pandemic than at the time of the NAKO baseline examination.

Changes in self-rated health status

Thirty-two percent of the participants stated an improvement in self-rated state of health since baseline *(Figure 2)*, while 12% reported deterioration. Worsening was reported predominantly by persons who had been tested (odds ratio for those tested negative: 1.68, 95% confidence interval [1.54; 1.82], odds ratio for those tested positive: 2.38 [1.83; 3.10]), after adjustment for age, sex, study center, and self-rated health at baseline *(eTable 6)*. Furthermore, there was a relationship between deterioration in self-rated health and worsening of mental health *(eFigure 6)*.

Discussion

Consistently with official figures from local health offices, the results of this large, population-based cohort study indicate that up to the end of May 2020, a low proportion of infections with SARS-CoV-2 were self-reported (0.3%). Nevertheless, the NAKO data revealed 34% more positive test results than predicted on the basis of official reporting statistics. Selection bias may be at work here, as persons who tested positive may have been more likely to participate in the survey. The data cover the time from the start of the pandemic until it reached its peak in Europe (10). Early on, the epidemic was driven mainly by people coming back from abroad. This group tended to be of higher socio-economic status, a stratum which is also overrepresented in the NAKO. Furthermore, the higher cumulative incidence could also be due to increased health consciousness on the part of the NAKO participants. The implementation of a test-based case identification strategy along with countermeasures such as social distancing could have contributed to the decline in new SARS-CoV-2 infections in the NAKO study regions observed in our sample (11–13).

Most of the persons with positive test results described their symptoms as mild, with 36% reporting no symptoms and 12% requiring hospitalization. Our data confirm that loss of smell and taste is associated with a higher likelihood of a positive SARS-CoV-2 test (14,15).

Participants reported more perceived stress and more symptoms of depression and anxiety during the pandemic than at the time of the baseline examination, conducted 1 to 5 years earlier. While various factors may have contributed to this change over time, the fact that NAKO participants living in regions of low SARS-CoV-2 incidence reported fewer mental problems than those from regions of higher incidence supports a relation with the pandemic. Greater severity of depressive and anxiety symptoms was restricted to those younger than 60, with a focus on young adults between the ages of 20 and 39 years. Similar findings have recently been reported in the UK (16) and in a small follow-up survey conducted in April 2020 at Johns Hopkins University. The latter found a clear increase in severe psychological distress compared with a prior assessment in 2018, particularly in young adults aged 18 to 29 years (17).

A study with Dutch students showed that the lockdown in March 2020 negatively affected the students' ability to stabilize their mood through familiar activities (18). Young and middle-aged adults were under particular pressure, having to manage various tasks in a situation of limited services and multiple challenges

associated with the advice to stay at home. This included, for example, the coordination of working from home or other changes in working conditions with home schooling, childcare, or care for the elderly.

Very recent commentaries and recommendations (3, 19) emphasize the urgent necessity to collect high-quality data on the mental health effects of the COVID-19 pandemic across the whole population and in vulnerable groups (3) and point to the fact that the pandemic may have considerable implications for individual and collective health as well as for emotional and social functioning (19). They also address the need to provide mental health services that target patients' health needs and reduce (social) disparities (20).

Self-rated health deteriorated in participants who underwent testing, especially in those with a positive test result. However, self-rated health also improved in a considerable number of participants. Given that this is self-perceived health, subjective changes in health consciousness rather than objective improvements may be responsible for this observation. While contact restrictions were in place, beginning in mid-March, essential shopping, access to the workplace (in the absence of reduced hours or working from home), and outdoor exercising were allowed at all times in the NAKO study regions. The national government and the individual federal states implemented a wide range of support programs to lessen the socioeconomic burden.

While working conditions became much worse for some employees, such as those in the health care sector, other population groups gained additional leisure time and experienced a slower pace of life, increased health consciousness, and neighborhood support. The results were not adjusted for individual socioeconomic factors; future analyses should specifically examine their potential role as modifiers.

A major strength of the results presented here is that they are derived from a large, population-based cohort with a defined sampling frame from 16 geographic regions of Germany. The baseline data supply a detailed characterization of the health status of the participants before the outbreak of the COVID-19 pandemic. The COVID-NAKO questionnaire offered a timely longitudinal follow-up and included several questions and scales previously employed in the baseline assessment. This provided the opportunity to analyze changes in health scores over time. Limitations arise from the fact that all responses are based on self-reports. Changes in the scores for mental health could be attributable to the pandemic, to the countermeasures, or to other unrelated factors. The mental health scores were analyzed on the dimensional scale only; in other words, no (subtype) diagnoses, e.g., major depressive disorder, were applied. The reported SARS-CoV-2 test results are only a snapshot, reflecting the situation at the time of filling in the questionnaire.

The worsening of results regarding mental health was stronger in regions with a higher background cumulative incidence. Moreover, it was slightly more pronounced among participants who had undergone the baseline examination only 1 or 2 years previously. This speaks for an association between worsening of mental health and the pandemic. Because the population was confronted with constantly changing regulations concerning health and general behavior, the results need to be discussed within the context of the dynamics of the pandemic. Repeated assessments are required to determine whether the consequences of the countermeasures will persist for a longer period.

Conclusion

Although the cumulative incidence of detected SARS-CoV-2 infections was low on the population level in Germany in spring 2020, we observed a deterioration in mental health scores during the nationwide 6-week period of protective measures in the entire NAKO cohort, irrespective of test or infection status. Our results indicate health consequences at population level that go substantially beyond the direct health impact of COVID-19.

Funding and support
The German National Cohort (NAKO) (www.nako.de) is funded by the Federal Ministry of Education and Research (project numbers: 01ER1301A/B/C and 01ER1511D), the federal states, and the Helmholtz Association, with additional financial support from the participating universities and the participating institutes of the Leibniz Association and the Helmholtz Association.

Acknowledgments
We thank all staff at the study centers, the NAKO data management center, and the NAKO head office who made this study possible. Furthermore, we thank Maren Albrecht and Dr. Barbara Bohn for their committed work and their valuable contributions to the implementation of the questionnaire, as well as Dr. Susanne Göttlicher for her assistance in finalizing the manuscript.

Conflict of interest statement
Prof. Lieb owns shares in Biontech.
The remaining authors declare that no conflict of interest exists.

Manuscript received on 6 October 2020, revised version accepted on 18 November 2020.

References

1. Rothe C, Schunk M, Sothmann P, et al.: Transmission of 2019-nCoV infection from an asymptomatic contact in Germany. N Engl J Med 2020; 382: 970–1.
2. Lipsitch M, Swerdlow DL, Finelli L: Defining the epidemiology of Covid-19—studies needed. N Engl J Med 2020; 382: 1194–6.
3. Holmes EA, O'Connor RC, Perry VH, et al.: Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science. Lancet Psychiatry 2020; 7: 547–60.
4. German National Cohort Consortium: The German National Cohort: aims, study design and organization. Eur J Epidemiol 2014; 29: 371–82.
5. Spitzer RL, Kroenke K, Williams JB: Validation and utility of a self-report version of PRIME-MD: the PHQ primary care study. Primary care evaluation of mental disorders. Patient health questionnaire. JAMA 1999; 282: 1737–44.
6. Lowe B, Grafe K, Zipfel S, et al.: Detecting panic disorder in medical and psychosomatic outpatients: comparative validation of the hospital anxiety and depression scale, the patient health questionnaire, a screening question, and physicians' diagnosis. J Psychosom Res 2003; 55: 515–9.
7. Lowe B, Unutzer J, Callahan CM, Perkins AJ, Kroenke K: Monitoring depression treatment outcomes with the Patient Health Questionnaire-9. Med Care 2004; 42: 1194–201.

BOX – AUTHORS

Complete list of authors and affiliations

Annette Peters[1,2,3]; Susanne Rospleszcz[1,2]; Karin H. Greiser[4]; Marco Dallavalle[1]; André Karch[5]; Rafael Mikolajczyk[6]; Gérard Krause[7]; Stefanie Castell[7]; Alexandra Nieters[8]; Daniel Kraft[9]; Robert Wolff[10]; Gunthard Stübs[10]; Olga Lang[1]; Leo Panreck[11]; Marcella Rietschel[12]; Dan Rujescu[13]; Nico Dragano[14]; Börge Schmidt[15]; Heiko Becher[16]; Hermann Brenner[17]; Antje Damms-Machado[4]; Beate Fischer[18]; Claus-Werner Franzke[19]; Sylvia Gastell[20]; Kathrin Günther[21]; Anne Hermes[22]; Bernd Holleczek[23,24]; Lina Jaeschke[25]; Karl-Heinz Jöckel[15]; Rudolf Kaaks[4]; Thomas Keil[26,27,28]; Yvonne Kemmling[29]; Alexander Kluttig[6]; Oliver Kuß[30]; Nicole Legath[5]; Michael Leitzmann[18]; Wolfgang Lieb[22]; Markus Loeffler[31, 32]; Claudia Meinke-Franze[10]; Karin B. Michels[19]; Nadia Obi[16]; Tobias Pischon[25]; Tamara Schikowski[33]; Matthias B. Schulze[34,35]; Andreas Stang[15]; Sigrid Thierry[1, 36]; Henry Völzke[10]; Stefan N. Willlich[37]; Kerstin Wirkner[31,32]; Kathrin Wolf[1]; Hajo Zeeb[38, 39]; Klaus Berger[5]

[1] Institute of Epidemiology, Helmholtz Center Munich, Germany

[2] Department of Epidemiology, Institute for Medical Information Processing, Biometry and Epidemiology, Medical Faculty, Ludwig-Maximilians-Universität München, Munich, Germany

[3] Department of Environmental Health, Harvard T. H. Chan School of Public Health, Boston, MA, USA

[4] Department of Cancer Epidemiology, German Cancer Research Center (DKFZ), Heidelberg, Germany

[5] Institute of Epidemiology and Social Medicine, University of Münster, Germany

[6] Institute of Medical Epidemiology, Biometrics and Informatics, University of Halle-Wittenberg, Halle (Saale), Germany

[7] Department of Epidemiology, Helmholtz Center for Infection Research, Braunschweig, Germany

[8] Center for Chronic Immunodeficiency (CCI), University of Freiburg Medical Center, Germany

[9] Medical Informatics for Translational Oncology, German Cancer Research Center (DKFZ), Heidelberg, Germany

[10] Institute of Community Medicine, University of Greifswald, Germany

[11] NAKO e.V., Heidelberg, Germany

[12] Department of Genetic Epidemiology in Psychiatry, Central Institute of Mental Health), Mannheim, Germany

[13] Department of Psychiatry, Psychotherapy, and Psychosomatics, University of Halle-Wittenberg, Halle (Saale), Germany

[14] Institute of Medical Sociology, University Hospital of Düsseldorf, Germany

[15] Institute for Medical Informatics, Biometry and Epidemiology, University Hospital of Essen, Germany

[16] Institute of Medical Biometry and Epidemiology, University Medical Center Hamburg-Eppendorf, Hamburg, Germany

[17] Division of Clinical Epidemiology and Aging Research, German Cancer Research Center (DKFZ), Heidelberg, Germany

[18] Department of Epidemiology and Preventive Medicine, Regensburg University Medical Center, Germany

[19] Institute for Prevention and Cancer Epidemiology, Faculty of Medicine, University of Freiburg Medical Center, Germany

[20] NAKO Study Center South Berlin/Brandenburg, German Institute for Nutritional Research Potsdam-Rehbruecke, Nuthetal, Germany

[21] Leibniz Institute for Prevention Research and Epidemiology—BIPS, Bremen, Germany

[22] Institute of Epidemiology, Kiel University, Germany

[23] Saarland Cancer Registry, Saarbrücken, Germany

[24] Division of Clinical Epidemiology and Aging Research, German Cancer Research Center (DKFZ), Heidelberg, Germany

[25] Molecular Epidemiology Research Group, Max Delbrück Center for Molecular Medicine (MDC), Berlin, Germany

[26] Institute for Social Medicine, Epidemiology, and Health Economics, Charité—University Medical Center Berlin, Germany

[27] Institute for Clinical Epidemiology and Biometry, University of Wuerzburg, 97080 Würzburg, Germany

[28] Bavarian State Office of Health, Health and Food Safety, Bad Kissingen, Germany

[29] Department of Epidemiology, Helmholtz Center for Infection Research, Braunschweig, Germany

[30] Institute for Biometrics and Epidemiology, German Diabetes Center, Leibniz Center for Diabetes Research, University of Düsseldorf, Germany

[31] Institute for Medical Informatics, Statistics and Epidemiology (IMISE), University of Leipzig, Germany

[32] Leipzig Research Center for Civilization Diseases (LIFE), University of Leipzig, Germany

[33] IUF—Leibniz Institute for Environmental Medicine, Düsseldorf, Germany

[34] Department of Molecular Epidemiology, German Institute of Human Nutrition Potsdam-Rehbruecke, Nuthetal, Germany

[35] German Institute for Nutritional Research Potsdam-Rehbruecke, University of Potsdam, Germany

[36] NAKO Study Center, University Hospital Augsburg, Germany

[37] Institute for Social Medicine, Epidemiology, and Health Economics, Charité – University Medical Center Berlin, Germany

[38] Leibniz Institute for Prevention Research and Epidemiology—BIPS, Bremen, Germany

[39] Human and Health Sciences, University of Bremen, Germany

8. Spitzer RL, Kroenke K, Williams JB, Lowe B: A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med 2006; 166: 1092–7.
9. Gilbody S, Richards D, Brealey S, Hewitt C: Screening for depression in medical settings with the Patient Health Questionnaire (PHQ): a diagnostic meta-analysis. J Gen Intern Med 2007; 22: 1596–602.
10. Wiersinga WJ, Rhodes A, Cheng AC, Peacock SJ, Prescott HC: Pathophysiology, transmission, diagnosis, and treatment of coronavirus disease 2019 (COVID-19): a review. JAMA 2020; 324: 782–93.
11. Auger KA, Shah SS, Richardson T, et al.: Association between statewide school closure and COVID-19 incidence and mortality in the US. JAMA 2020; 324: 859–70.
12. Chu DK, Akl EA, Duda S, et al.: Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. Lancet 2020; 395: 1973–87.
13. Cowling BJ, Ali ST, Ng TWY, et al.: Impact assessment of non-pharmaceutical interventions against coronavirus disease 2019 and influenza in Hong Kong: an observational study. The Lancet Public Health 2020; 5: e279–e88.
14. Menni C, Valdes AM, Freidin MB, et al.: Real-time tracking of self-reported symptoms to predict potential COVID-19. Nat Med 2020; 26: 1037–40.
15. Spinato G, Fabbris C, Polesel J, et al.: Alterations in smell or taste in mildly symptomatic outpatients with SARS-CoV-2 infection. JAMA 2020; 323: 2089–90.
16. Pierce M, Hope H, Ford T, et al.: Mental health before and during the COVID-19 pandemic: a longitudinal probability sample survey of the UK population. Lancet Psychiatry 2020; 7: 883–92.
17. McGinty EE, Presskreischer R, Han H, Barry CL: Psychological distress and loneliness reported by US adults in 2018 and April 2020. JAMA 2020; 324: 93–4.
18. Taquet M, Quoidbach J, Fried EI, Goodwin GM: Mood homeostasis before and during the coronavirus disease 2019 (COVID-19) lockdown among students in the Netherlands. JAMA Psychiatry 2020; e202389. doi: 10.1001/jamapsychiatry.2020.2389. Epub ahead of print.
19. Pfefferbaum B, North CS: Mental health and the Covid-19 pandemic. N Engl J Med 2020; 383: 510–2.
20. Moreno C, Wykes T, Galderisi S, et al.: How mental health care should change as a consequence of the COVID-19 pandemic. Lancet Psychiatry 2020; 7: 813–24.

Corresponding author
Prof. Dr. rer. biol. hum. Annette Peters
Institut für Epidemiologie, Helmholtz Zentrum München
Deutsches Zentrum für Gesundheit und Umwelt GmbH
Ingolstädter Landstr. 1
85764 Neuherberg, Germany
peters@helmholtz-muenchen.de

Cite this as:
Peters A et al.: The impact of the COVID-19 pandemic on self-reported health—early evidence from the German National Cohort.
Dtsch Arztebl Int 2020; 117: 861–7. DOI: 10.3238/arztebl.2020.0861

► **Supplementary material**

eFigures, eTables, eBoxes:
www.aerzteblatt-international.de/20m0861

Supplementary material to:

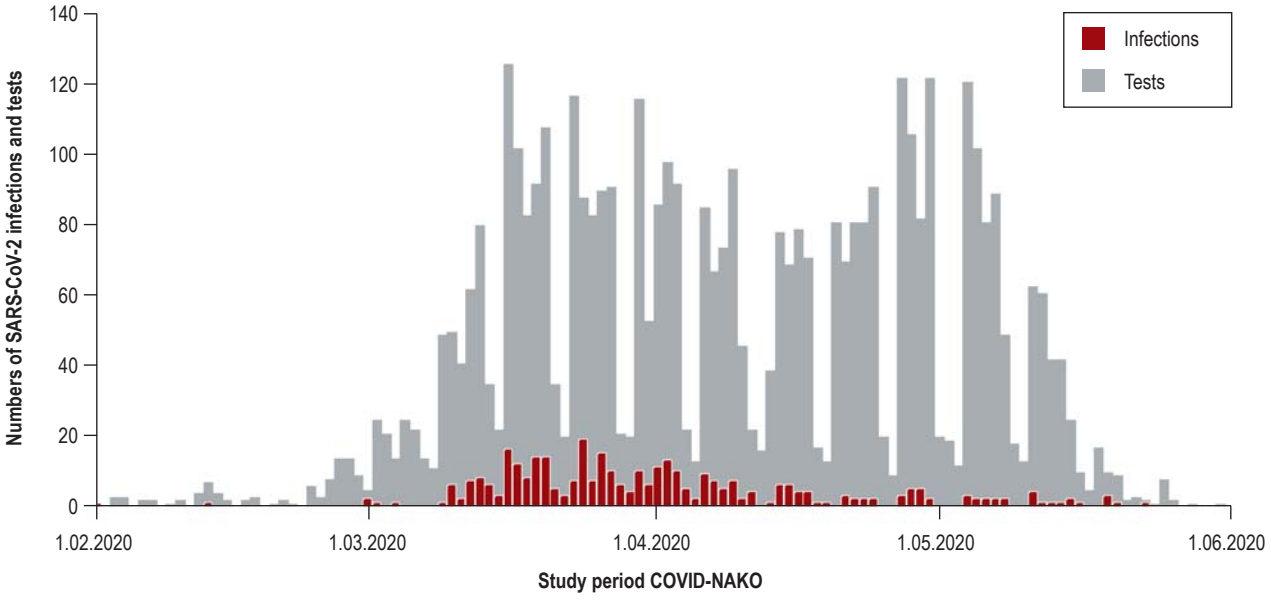
The Impact of the COVID-19 Pandemic on Self-Reported Health

Early Evidence From the German National Cohort

by Annette Peters, Susanne Rospleszcz, Karin H. Greiser, Marco Dallavalle, and Klaus Berger*

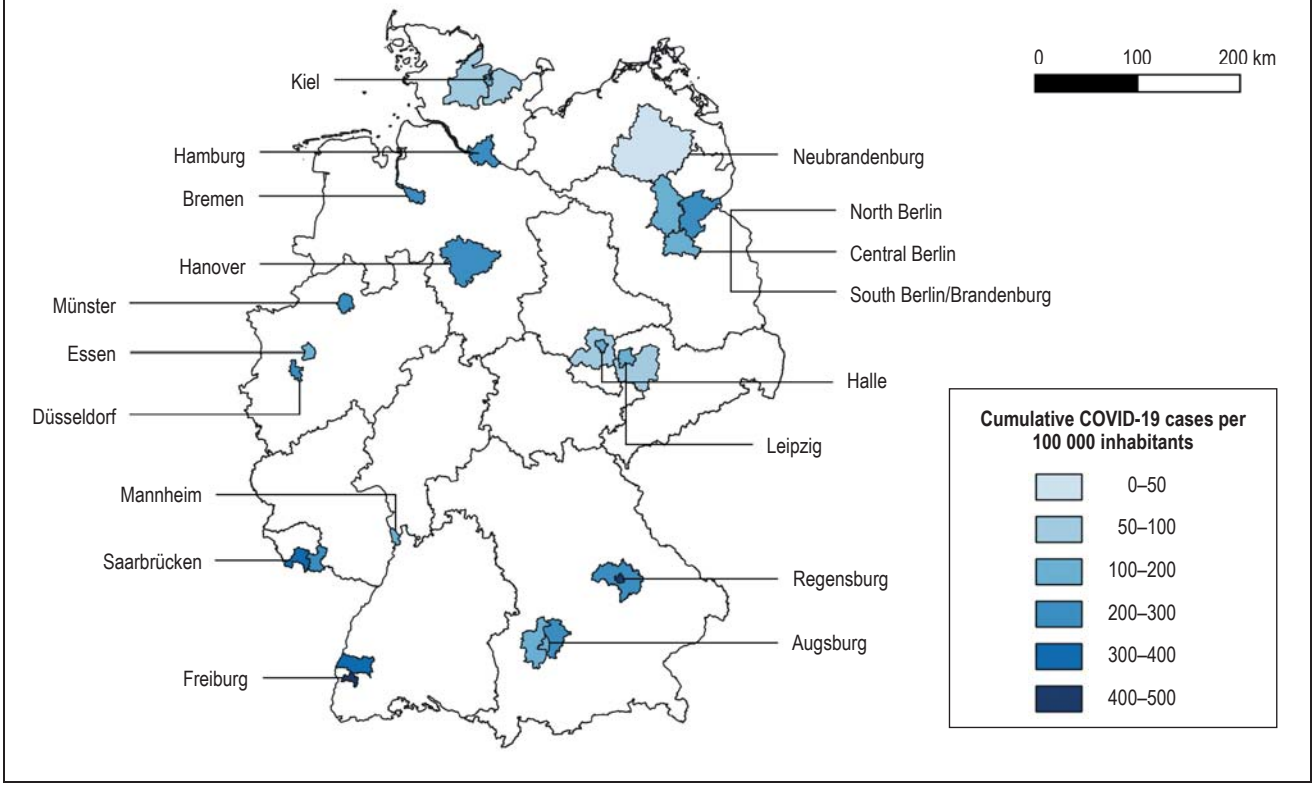
Dtsch Arztebl Int 2020; 117: 861–7. DOI: 10.3238/arztebl.2020.0861

eFIGURE 1a



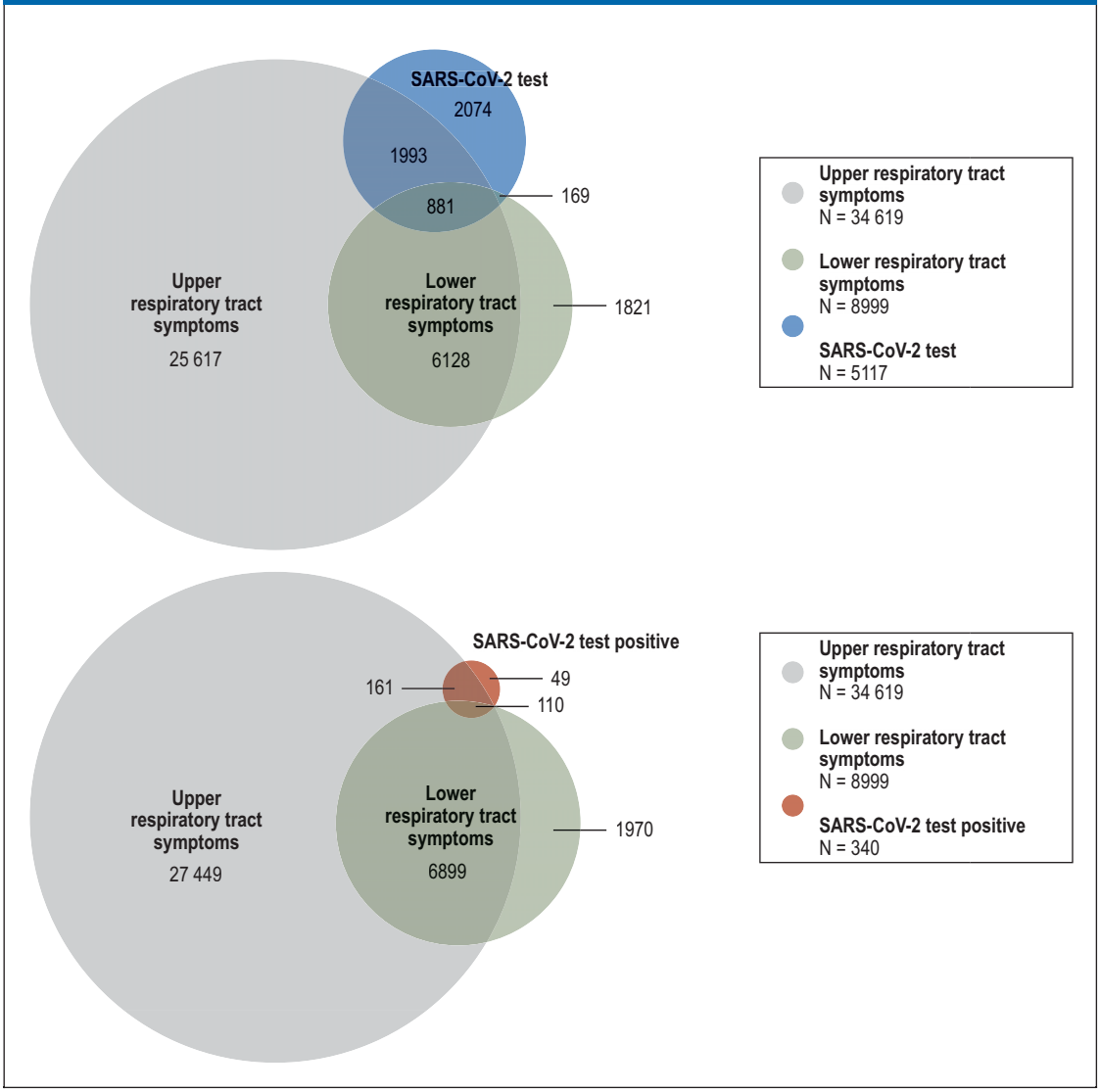
Numbers of SARS-CoV-2 infections and tests, as self-reported in COVID-NAKO questionnaires

eFIGURE 1b



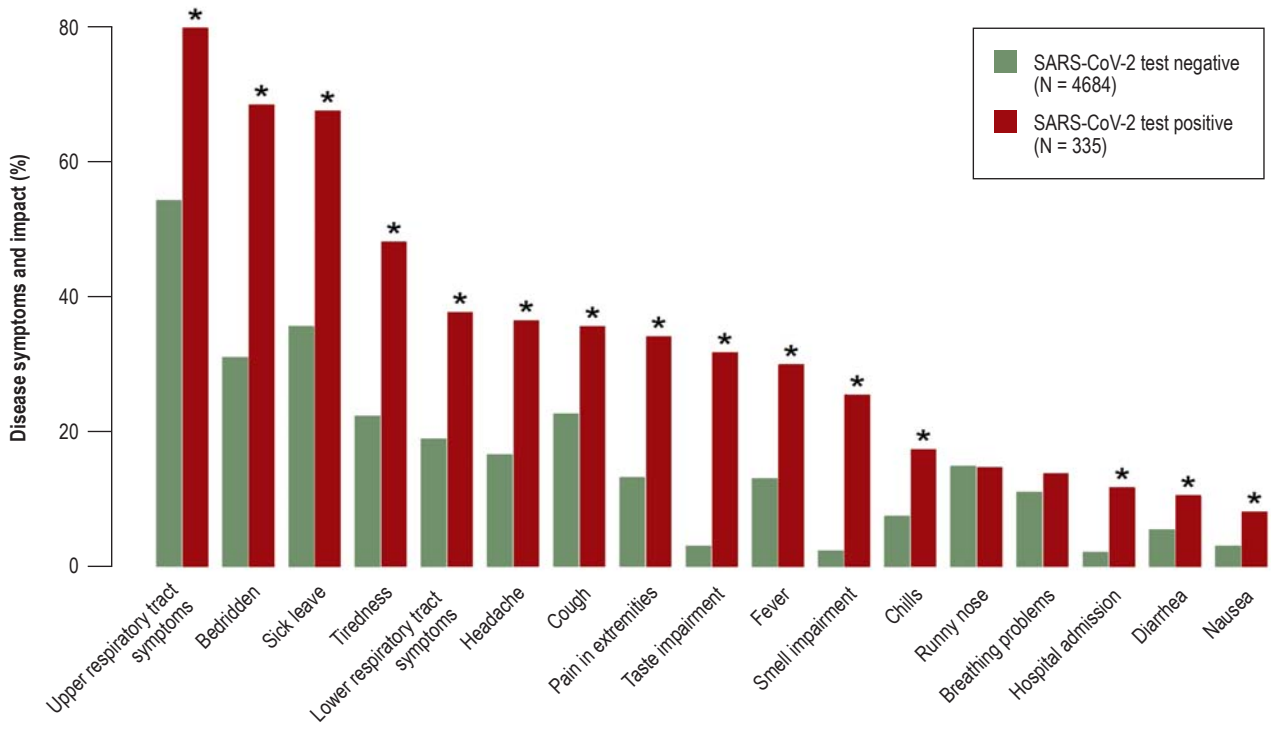
NAKO study regions and cumulative COVID-19 incidence as of 29 May 2020

eFIGURE 2



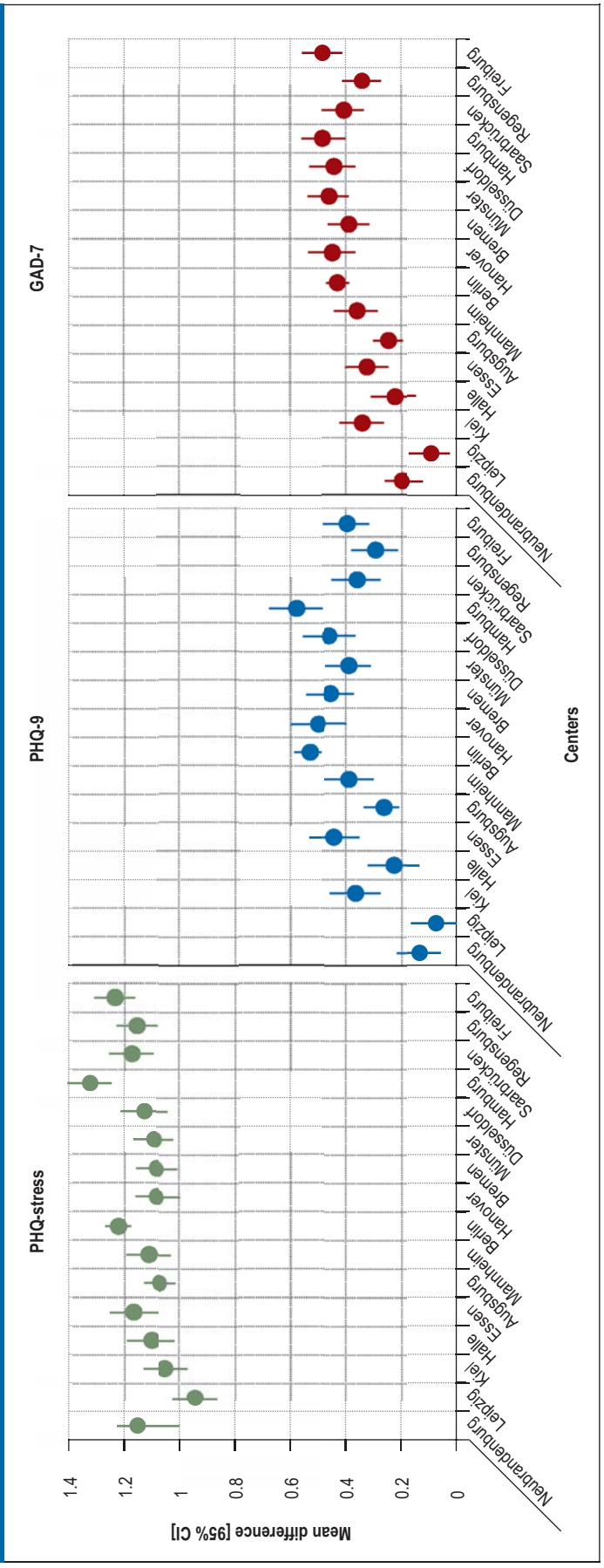
Prevalence of symptoms of upper and lower respiratory tract infections in persons with available data on such symptoms, SARS-CoV-2 test, and result of SARS-CoV-2 test (N=111 582)

eFIGURE 3



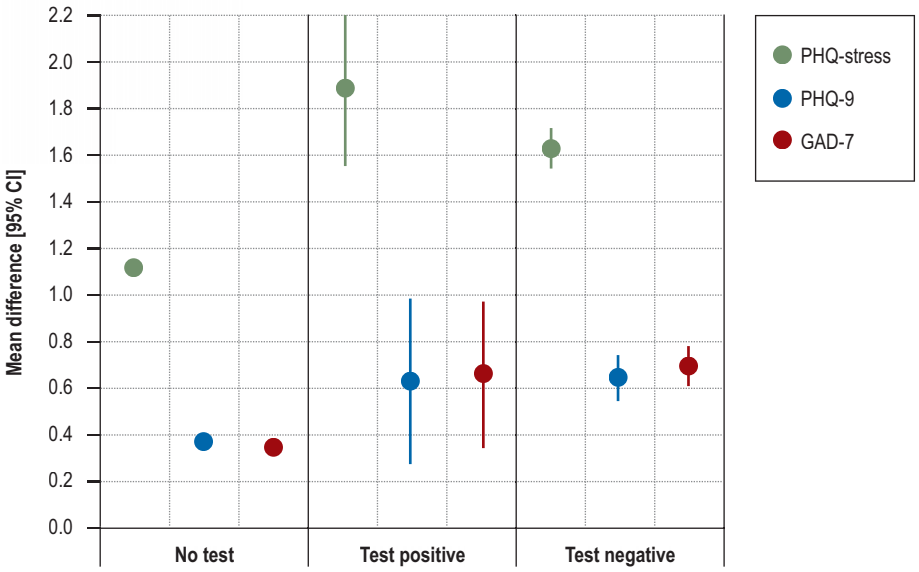
Prevalence of disease symptoms and consequences (bedridden, sick leave, hospital admission) in persons with positive SARS-CoV-2 test results and in those with negative SARS-CoV-2 test results. Statistically significant differences (p-value from chi-squared test < 0.0005) are indicated by *. The graph is based on the data of all persons who received a SARS-CoV-2 test and provided information on the result of the test and on all symptoms and measures of disease impact.

eFIGURE 4



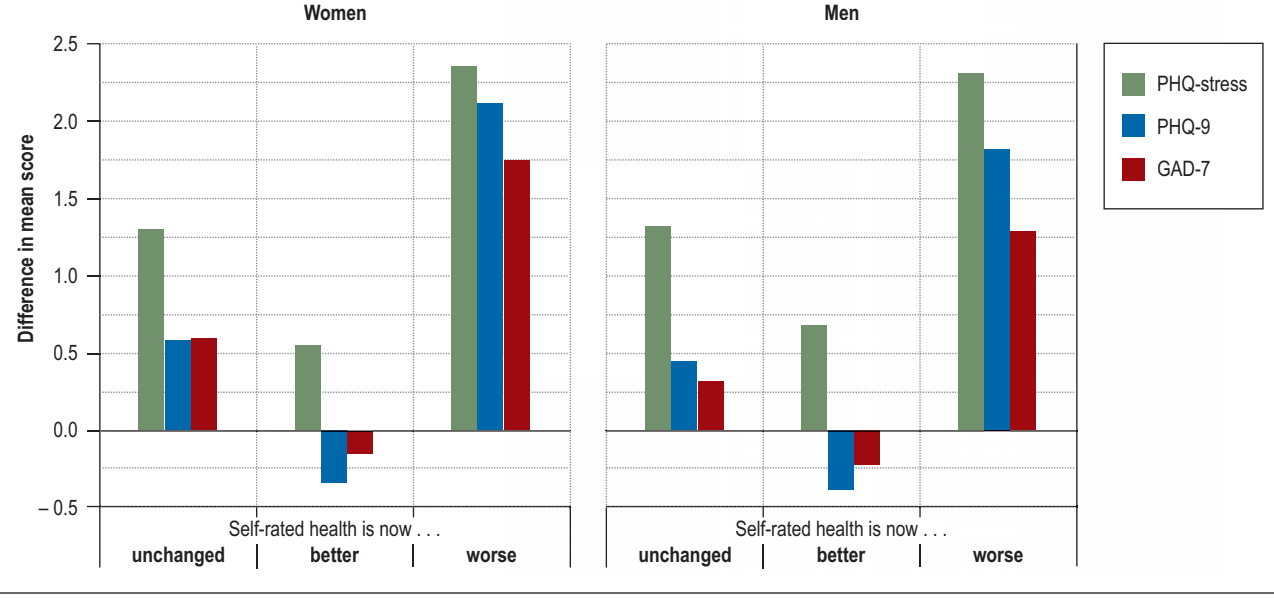
Differences in mean summary scores for mental health, stratified by study center (in increasing order of background infection rate) and adjusted for sex, age at baseline, and summary score at baseline. PHQ-stress; PHQ-9, depressive symptoms; GAD-7, anxiety symptoms; CI, confidence interval

eFIGURE 5



Increase in summary scores for mental health, stratified by SARS-CoV-2 test status. Mean differences in summary scores, with 95% confidence interval, between the NAKO baseline examination and the COVID-NAKO questionnaire, adjusted for sex, age at baseline, and summary score at baseline
PHQ-stress; PHQ-9, depressive symptoms; GAD-7, anxiety symptoms

eFIGURE 6



Description of change in self-rated health status between baseline examination and COVID-NAKO questionnaire with changes in summary scores for mental health
X-axis: Change in self-rated health between baseline examination and questionnaire, categorized into unchanged/better/worse
Y-axis: Difference in mean summary scores between time of questionnaire and baseline.
PHQ-stress; PHQ-9, depressive symptoms; GAD-7, anxiety symptoms

eTABLE 1

Age and sex distribution of COVID-NAKO questionnaire respondents by study region

	Participants	Sex				Age group (years)											
		Male		Female		20–29		30–39		40–49		50–59		60–69		70 +	
	N	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
All	**113 928**	**54 954**	**48.2**	**58 974**	**51.8**	**10 330**	**9.1**	**11 670**	**10.2**	**30 407**	**26.7**	**31 009**	**27.2**	**28 306**	**24.8**	**2206**	**1.9**
Neubrandenburg	7433	3624	48.8	3809	51.2	624	8.4	923	12.4	1958	26.3	2084	28.0	1756	23.6	88	1.2
Leipzig	5968	2823	47.3	3145	52.7	508	8.5	572	9.6	1584	26.5	1628	27.3	1518	25.4	158	2.6
Kiel	5641	2700	47.9	2941	52.1	490	8.7	567	10.1	1441	25.5	1576	27.9	1503	26.6	64	1.1
Halle	5346	2482	46.4	2864	53.6	441	8.2	513	9.6	1460	27.3	1551	29.0	1289	24.1	92	1.7
Essen	5382	2613	48.6	2769	51.4	561	10.4	671	12.5	1443	26.8	1388	25.8	1244	23.1	75	1.4
Augsburg	11 740	5810	49.5	5930	50.5	1061	9.0	1175	10.0	3138	26.7	3166	27.0	2926	24.9	274	2.3
Mannheim	5521	2760	50.0	2761	50.0	536	9.7	635	11.5	1473	26.7	1523	27.6	1265	22.9	89	1.6
Berlin	19 650	9316	47.4	10 334	52.6	1787	9.1	1872	9.5	5392	27.4	5337	27.2	4750	24.2	512	2.6
Hanover	4686	2306	49.2	2380	50.8	434	9.3	432	9.2	1238	26.4	1233	26.3	1251	26.7	98	2.1
Bremen	6150	3010	48.9	3140	51.1	565	9.2	648	10.5	1588	25.8	1669	27.1	1577	25.6	103	1.7
Münster	6514	3121	47.9	3393	52.1	542	8.3	577	8.9	1696	26.0	1792	27.5	1841	28.3	66	1.0
Düsseldorf	5253	2458	46.8	2795	53.2	541	10.3	561	10.7	1337	25.5	1381	26.3	1337	25.5	96	1.8
Hamburg	5300	2525	47.6	2775	52.4	541	10.2	613	11.6	1477	27.9	1393	26.3	1168	22.0	108	2.0
Saarbrücken	5992	2857	47.7	3135	52.3	472	7.9	657	11.0	1583	26.4	1588	26.5	1638	27.3	54	0.9
Regensburg	6545	3276	50.1	3269	49.9	592	9.0	592	9.0	1758	26.9	1818	27.8	1583	24.2	202	3.1
Freiburg	6807	3273	48.1	3534	51.9	635	9.3	662	9.7	1841	27.0	1882	27.6	1660	24.4	127	1.9

eTABLE 2

Description of the 16 study areas of the German National Cohort and the frequency of SARS-CoV-2 testing as reported in the COVID-NAKO questionnaire

	Study region characteristics							Sample characteristics				SARS-CoV-2 infections			
	# counties	Inhabitants, in 1000 *1		urban	rural	COVID-19 cases per 100 000 inhabitants *2		Baseline	COVID-19 Follow-up	% women	Age, years mean	SARS-CoV-2 Tested	# observed positive	# expected*3	p-value*4
		all	Age range 15–79y			all	Age range 15–79y								
All study centers								**205 219**	**113 928**	**51.8**	**50.0**	**5245**	**344**	**257**	**< 0.001**
Neubrandenburg	1	259	190		x	47	57	22 006	7433	51.2	49.5	277	9	4	0.02
Leipzig	2	846	627	x	x	88	117	10 874	5968	52.7	50.5	277	13	7	0.02
Kiel	3	649	488	x	x	100	120	9504	5641	52.1	50.4	253	9	7	0.46
Halle	2	424	310	x	x	109	124	10 139	5346	53.6	50.2	362	12	7	0.05
Essen	1	583	435	x		145	163	10 623	5382	51.4	48.8	155	15	9	0.05
Augsburg	3	680	517	x	x	170	178	20 621	11 740	50.5	50.2	400	40	22	< 0.001
Mannheim	1	309	240	x		156	186	10 287	5521	50.0	49.2	321	17	10	0.03
Berlin *5	3	4040	3064	x	x	186	215	31 202	19 650	52.6	50.1	916	53	42	0.08
Hanover	1	1158	863	x	x	211	242	10 049	4686	50.8	50.4	177	12	11	0.83
Bremen	1	569	427	x		227	259	10 486	6150	51.1	50.0	266	13	15	0.66
Münster	1	314	246	x		226	268	10 031	6514	52.1	50.7	309	23	18	0.24
Düsseldorf	1	619	471	x		231	272	9146	5253	53.2	49.7	250	21	14	0.06
Hamburg	1	1841	1399	x		277	315	10 083	5300	52.4	49.1	256	11	17	0.15
Saarbrücken	2	472	355	x	x	294	345	10 038	5992	52.3	50.4	345	26	21	0.29
Regensburg	2	346	268	x	x	329	373	10 030	6545	49.9	50.3	302	34	24	0.04
Freiburg	2	396	304	x	x	367	399	10 100	6807	51.9	50.0	379	36	29	0.18

*1 The numbers of inhabitants in the respective districts were obtained from the official records of the Federal Statistical Office (www.genesis.destatis.de/genesis/online). Numbers are given for all inhabitants (as of 31 December 2018), as well as for all inhabitants in the age range of 15–79 years (as of 31 December 2019) (see *eTable 4*).

*2 The numbers of COVID-19 cases per 100 000 inhabitants in the period 1–30 March 2020 were obtained from the official data of the Robert Koch Institute [https://npgeo-corona-npgeo-de.hub.arcgis.com/, 02.06.2020]. The cumulative incidences were calculated as arithmetic mean of all age groups, as well as averaged based on the age groups 15–34 years, 35–59 years and 60–79 years, weighted by the number of inhabitants in the respective age group in the counties (see *eTable 4*).

*3 The number of expected positive tests/SARS-CoV-2 infections was calculated as weighted mean, based on the number of participants and the cumulative COVID-19 incidence, for the total population and for the age groups 15–34 years, 35–59 years and 60–79 years, weighted by the number of participants in the respective age group in each district (see *eTable 4*).

*4 Comparison of numbers of expected vs observed SARS-CoV-2 infections, based on a goodness-of-fit chi-squared test for probabilities, with the probabilities given by the expected number of infections. Since the absolute numbers of cases are sometimes very small, the resulting p-values have to be interpreted with caution.

*5 Three NAKO study centers jointly cover the Berlin NAKO study region.

eTABLE 3

Distribution of respiratory tract symptoms and disease impact in the 16 NAKO study regions

	Participants	Respiratory tract symptoms				Disease impact					
		Upper respiratory tract		Lower respiratory tract		Bedridden		Sick leave		Hospital admission	
	N	n	%	n	%	n	%	n	%	n	%
All study centers	**113 928**	**34 929**	**30.7**	**9242**	**8.1**	**15 627**	**13.7**	**16 141**	**14.2**	**617**	**0.5**
Neubrandenburg	7433	1960	26.4	545	7.3	827	11.1	944	12.7	42	0.6
Leipzig	5968	1561	26.2	380	6.4	558	9.3	648	10.9	26	0.4
Kiel	5641	1805	32.0	458	8.1	810	14.4	827	14.7	26	0.5
Halle	5346	1372	25.7	317	5.9	516	9.7	643	12.0	25	0.5
Essen	5382	1664	30.9	448	8.3	779	14.5	784	14.6	26	0.5
Augsburg	11 740	3468	29.5	999	8.5	1640	14.0	1708	14.5	63	0.5
Mannheim	5521	1675	30.3	449	8.1	765	13.9	753	13.6	28	0.5
Berlin	19 650	6143	31.3	1482	7.5	2748	14.0	2877	14.6	120	0.6
Hanover	4686	1483	31.6	349	7.4	648	13.8	638	13.6	32	0.7
Bremen	6150	1957	31.8	456	7.4	891	14.5	921	15.0	19	0.3
Münster	6514	2067	31.7	573	8.8	961	14.8	961	14.8	35	0.5
Düsseldorf	5253	1630	31.0	429	8.2	749	14.3	706	13.4	27	0.5
Hamburg	5300	1719	32.4	425	8.0	775	14.6	764	14.4	20	0.4
Saarbrücken	5992	1973	32.9	618	10.3	887	14.8	914	15.3	38	0.6
Regensburg	6545	2135	32.6	623	9.5	932	14.2	914	14.0	49	0.7
Freiburg	6807	2317	34.0	691	10.2	1141	16.8	1139	16.7	41	0.6

eTABLE 4

Age group-specific cumulative incidences* and observed and expected case numbers

	Age group (years)	Population	COVID-19 cases per 100 000	Participants	SARS-CoV-2 positive	
					Observed (n)	Expected (n)
All study centers	**15–34**	**3 435 142**	**230**	**16 322**	**48**	**36**
	35–59	**4 672 133**	**235**	**67 094**	**252**	**155**
	60–79	**2 095 850**	**218**	**30 512**	**44**	**66**
Neubrandenburg	15–34	43 430	74	1045	0	1
	35–59	90 073	59	4544	8	3
	60–79	56 742	41	1844	1	1
Leipzig	15–34	211 238	116	774	1	1
	35–59	281 408	128	3518	12	4
	60–79	134 047	98	1676	0	2
Kiel	15–34	154 987	99	756	1	1
	35–59	222 087	115	3318	5	4
	60–79	110 632	157	1567	3	2
Halle	15–34	91 664	108	695	1	1
	35–59	139 541	140	3270	10	5
	60–79	79 202	115	1381	1	2
Essen	15–34	143 102	138	925	4	1
	35–59	194 927	178	3138	10	6
	60–79	96 833	170	1319	1	2
Augsburg	15–34	169 685	148	1674	3	2
	35–59	239 483	191	6866	31	13
	60–79	107 730	196	3200	6	6
Mannheim	15–34	90 495	188	875	3	2
	35–59	105 056	200	3292	12	7
	60–79	44 576	148	1354	2	2
Berlin	15–34	1 032 897	224	2727	9	6
	35–59	1 425 486	215	11 661	37	25
	60–79	605 183	200	5262	7	11
Hanover	15–34	279 960	241	693	0	2
	35–59	398 418	259	2644	11	7
	60–79	184 410	205	1349	1	3
Bremen	15–34	147 443	327	923	2	3
	35–59	189 949	243	3547	10	9
	60–79	89 629	182	1680	1	3
Münster	15–34	102 805	249	855	3	2
	35–59	100 386	291	3752	18	11
	60–79	42 803	259	1907	2	5
Düsseldorf	15–34	160 799	281	861	5	2
	35–59	220 553	277	2959	11	8
	60–79	89 857	240	1433	5	3

	Age group (years)	Population	COVID-19 cases per 100 000	Participants	SARS-CoV-2 positive	
					Observed (n)	Expected (n)
Hamburg	15–34	494 366	301	854	1	3
	35–59	654 050	315	3170	9	10
	60–79	250 439	341	1276	1	4
Saarbrücken	15–34	107 896	309	774	3	2
	35–59	156 771	355	3526	22	13
	60–79	90 160	370	1692	1	6
Regensburg	15–34	92 180	400	911	6	4
	35–59	121 691	378	3849	20	15
	60–79	53 922	313	1785	8	6
Freiburg	15–34	112 195	330	980	6	3
	35–59	132 254	431	4040	26	17
	60–79	59 685	457	1787	4	8

*Obtained from the data of the Robert Koch Institute (https://npgeo-corona-npgeo-de.hub.arcgis.com/. 02.06.2020)
n, Number

eTABLE 5

Mental health summary scores at baseline and at the time of the COVID-NAKO questionnaire

	PHQ-9		GAD-7		PHQ-stress	
	Mean (SD) baseline	Mean (SD) COVID questionnaire	Mean (SD) baseline	Mean (SD) COVID questionnaire	Mean (SD) baseline	Mean (SD) COVID questionnaire
All study centers	**3.68 (3.50)**	**4.05 (3.91)**	**3.01 (3.06)**	**3.36 (3.42)**	**3.36 (2.91)**	**4.49 (3.48)**
Neubrandenburg	3.47 (3.44)	3.73 (3.82)	2.90 (3.03)	3.16 (3.35)	3.31 (2.96)	4.50 (3.59)
Leipzig	3.61 (3.40)	3.70 (3.75)	2.97 (3.05)	3.07 (3.35)	3.34 (2.85)	4.29 (3.41)
Kiel	3.59 (3.54)	3.97 (3.88)	2.85 (3.02)	3.25 (3.37)	3.24 (2.87)	4.32 (3.44)
Halle	3.50 (3.39)	3.81 (3.78)	2.91 (2.99)	3.19 (3.33)	3.34 (2.85)	4.45 (3.41)
Essen	3.94 (3.79)	4.31 (4.11)	3.15 (3.20)	3.46 (3.52)	3.41 (2.93)	4.58 (3.51)
Augsburg	3.53 (3.34)	3.85 (3.84)	2.99 (2.97)	3.23 (3.40)	3.35 (2.92)	4.42 (3.52)
Mannheim	3.78 (3.55)	4.15 (3.98)	3.00 (3.10)	3.38 (3.47)	3.35 (2.96)	4.48 (3.46)
Berlin	3.72 (3.50)	4.24 (3.99)	3.04 (3.07)	3.45 (3.45)	3.39 (2.92)	4.60 (3.47)
Hanover	3.58 (3.43)	4.10 (3.83)	2.86 (2.90)	3.36 (3.38)	3.24 (2.78)	4.35 (3.36)
Bremen	3.78 (3.49)	4.19 (3.95)	3.06 (3.08)	3.42 (3.39)	3.40 (2.93)	4.46 (3.42)
Münster	3.42 (3.29)	3.90 (3.72)	2.78 (2.88)	3.32 (3.29)	3.12 (2.74)	4.29 (3.37)
Düsseldorf	3.84 (3.63)	4.27 (4.06)	3.09 (3.15)	3.53 (3.61)	3.39 (2.94)	4.53 (3.51)
Hamburg	3.87 (3.69)	4.39 (4.00)	3.08 (3.17)	3.55 (3.42)	3.33 (2.88)	4.69 (3.52)
Saarbrücken	3.90 (3.65)	4.15 (4.04)	3.28 (3.26)	3.56 (3.62)	3.59 (3.06)	4.67 (3.61)
Regensburg	3.76 (3.56)	4.00 (3.90)	3.14 (3.10)	3.41 (3.45)	3.39 (2.97)	4.52 (3.58)
Freiburg	3.65 (3.39)	4.06 (3.81)	2.98 (2.91)	3.48 (3.37)	3.38 (2.87)	4.61 (3.46)

PHQ-stress; PHQ-9, depressive symptoms; GAD-7, anxiety symptoms; SD, standard deviation

eTABLE 6

Associations of baseline characteristics. study center and SARS-CoV-2 testing status with deterioration in self-rated health from baseline to time of COVID-NAKO questionnaire*[1,2]

	OR	[95% CI]	p-value
Characteristics at baseline examination			
Age, per 5 years	1.11	[1.10; 1.11]	< 0.001
Women	1.30	[1.25; 1.35]	< 0.001
Self-rated health, continuous	0.22	[0.21; 0.23]	< 0.001
Study center: reference Neubrandenburg			
Leipzig	0.93	[0.83; 1.05]	0.25
Kiel	0.99	[0.88; 1.11]	0.84
Halle	0.99	[0.88; 1.11]	0.82
Essen	1.00	[0.89; 1.13]	0.97
Augsburg	0.91	[0.82; 1.00]	0.05
Mannheim	0.91	[0.81; 1.02]	0.10
Berlin	1.03	[0.95; 1.13]	0.46
Hanover	1.05	[0.93; 1.19]	0.39
Bremen	0.99	[0.89; 1.11]	0.90
Münster	0.99	[0.89; 1.11]	0.93
Düsseldorf	0.80	[0.70; 0.90]	< 0.001
Hamburg	0.84	[0.75; 0.95]	< 0.001
Saarbrücken	1.03	[0.92; 1.16]	0.58
Regensburg	0.95	[0.85; 1.07]	0.41
Freiburg	0.87	[0.78; 0.97]	0.01
SARS-CoV-2 test result: reference "not tested"			
Negative test result	1.68	[1.54; 1.82]	< 0.001
Positive test result	2.38	[1.83; 3.10]	< 0.001

*[1]The parameters investigated were age, sex, self-rated health status at baseline examination, study center, and SARS-CoV-2 test status.

*[2]Results from a logistic regression model with the dichotomous outcome: "self-rated health status at the time of the COVID-NAKO questionnaire is worse than at the baseline examination". Self-rated health at the baseline examination was regarded in the model as continuous, with 1 meaning "excellent" and 5 signifying "poor".

OR, Odds ratio; CI, confidence interval

eBOX 1

Content and distribution of the COVID-NAKO questionnaire

The questionnaire was designed by a committee of NAKO scientists. It comprises 42 questions that derive mainly from validated instruments. Self-rated health was assessed by means of the first question from the Short Form Health Survey (SF-12) ("In general, how would you rate your health?"). Mental health was assessed by means of modules from the Patient Health Questionnaire (depressive symptoms: PHQ-9; anxiety symptoms: GAD-7; stress: PHQ-stress).

Participants were asked whether they had undergone at least one test for coronavirus at a physician's office, test center, or hospital. The exact type of test was not elucidated. If the participants answered "yes", they were asked whether at least one test result was positive, with possible answers "yes" and "no." Furthermore, the reasons for testing were relevant (e.g., contact with a person tested positive, returning from a high-risk area, suspicious symptoms). Symptoms were presented as a list of 12 items (plus the option "other"), and participants were asked to check what applied. The 12 symptoms were tiredness, breathing problems, headache, nausea, fever, chills, pain in extremities, cough, runny nose, diarrhea, and impairments of the senses of smell and taste.

Participants who had given an an e-mail address received the questionnaire electronically through a web-based survey tool with specific links; otherwise, a paper questionnaire was sent through the mail . All questionnaires were sent between 30 April and 15 May 2020, and participants received one reminder. Overall, 199 001 persons were eligible; 6218 individuals had died, had left Germany for good, declined to be contacted with the COVID-NAKO questionnaire, or had not consented to be recontacted at all.

eBOX 2

Calculation of observed and expected COVID-19 cases

Official data on COVID-19 cases reported by local health authorities were obtained from the website "National Platform for Geographic Data (NPGEO) Corona Hub 2020" of the Robert Koch Institute (www.npgeo-corona-npgeo-de.hub.arcgis.com/; last accessed on 2 June 2020). The populations of the respective districts were obtained from the official records of the Federal Statistical Office (www.genesis.destatis.de/genesis/online). Numbers were retrieved for all inhabitants (as of 31 December 2018) and for inhabitants in the age range of 15–79 years (as of 31 December 2019) (see *eTable 4*). Cumulative incidences were calculated as weighted mean, based on the overall population and on the age groups 15–34 years, 35–59 years, and 60–79 years, weighted by the number of inhabitants in the respective age group in each district (see *eTable 4*). The number of expected positive tests/SARS-CoV-2 infections was calculated, based on the number of participants and the cumulative COVID-19 incidence, for the whole population and as weighted mean across the age groups 15–34 years, 35–59 years and 60–79 years, weighted by number of participants in the respective age group for each district (see *eTable 4*). For comparison of the expected versus observed numbers of SARS-CoV-2 infections we used a chi-squared goodness-of-fit test for probabilities, with the probabilities given by the expected number of infections.