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SARS-CoV-2 antibody prevalence and determinants of six ethnic groups living in Amsterdam, the Netherlands: a population-based cross-sectional study, June-October 2020

Running title

SARS-CoV-2 seroprevalence and ethnicity

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ABSTRACT

Background

It has been suggested that ethnic minorities have been disproportionally affected by the coronavirus disease 2019 (COVID-19). We aimed to determine whether prevalence and determinants of past SARS-CoV-2 exposure varied between six ethnic groups in Amsterdam, the Netherlands.

Methods

Participants aged 25-79 years enrolled in a population-based prospective cohort were randomly selected within ethnic groups and invited to test for SARS-CoV-2-specific antibodies and answer COVID-19 related questions. We estimated prevalence and determinants of SARS-CoV-2 exposure within ethnic groups using survey-weighted logistic regression adjusting for age, sex and calendar time.

Results

Between June 24-October 9, 2020, we included 2497 participants. Adjusted SARS-CoV-2 seroprevalence was comparable between ethnic-Dutch (25/498; 5.5%, 95%CI=3.2-7.9), South-Asian Surinamese (22/451; 4.8%, 95%CI=2.1-7.5), African Surinamese (22/400; 8.2%, 95%CI=3.0-13.4), Turkish (30/408; 7.8%, 95%CI=4.3-11.2) and Moroccan (32/391; 7.0%, 95%CI=4.0-9.9) participants, but higher among Ghanaians (95/327; 26.5%, 95%CI=18.7-34.4). 57.1% of SARS-CoV-2-positive participants did not suspect or were unsure of being infected, which was lowest in African Surinamese (18.2%) and highest in Ghanaians (90.5%). Determinants of SARS-CoV-2 exposure varied across ethnic groups, while the most common determinant was having a household member suspected of infection. In Ghanaians, seropositivity was associated with older age, larger household sizes, living with small children, leaving home to work and attending religious services.

Conclusions

No remarkable differences in SARS-CoV-2 seroprevalence were observed between the largest ethnic groups in Amsterdam after the first wave of infections. The higher infection seroprevalence observed among Ghanaians, which passed mostly unnoticed, warrants wider prevention efforts and opportunities for non-symptom-based testing.

ARTICLE SUMMARY

Strengths and limitations of the study

- Our study used data from a large population-based sample, including participants belonging to most major ethnic groups in Amsterdam.
- Most studies on ethnic disparities used routine surveillance data on SARS-CoV-2 notifications, which are biased by differential testing uptake and lack information on determinants of infection, such as socio-economic characteristics and potential routes of SARS-CoV-2 transmission. We measured SARS-CoV-2 antibodies in participants regardless of COVID-19-related symptoms and obtained individual-level data on determinants of infection.
- The studied sample was nested in a large prospective cohort study (HELIUS) and response rates varied between ethnic groups. However, the characteristics of included individuals were largely similarly distributed to those non-included, with varying levels of socioeconomic status.
- Our study did not include undocumented people and people from other ethnic groups.

INTRODUCTION

Data from the United Kingdom (UK) and United States (US) suggest that certain ethnic minority populations have been disproportionally affected by the coronavirus disease 2019 (COVID-19), caused by SARS-CoV-2. In both countries, a relatively higher number of SARS-CoV-2 polymerase chain reaction (PCR)-positive or clinically-diagnosed COVID-19 cases were observed among ethnic minority groups, particularly people of African and Asian descent.[1-3] The underlying causes for these disparities might include work-related exposure, housing conditions, access to healthcare, help-seeking behavior, and language proficiency.[4-6]

Little is known about ethnic differences in SARS-CoV-2 infections outside the UK and US. This is of particular concern for larger cities in Europe, including the Dutch capital Amsterdam, where half the population comprises migrants, including people with foreign-born parents.[7] Amsterdam witnessed its first confirmed case of SARS-CoV-2 on February 29, 2020 and by December 31, 2020, there were more than 50,000 confirmed infections, 1300 COVID-19-related hospitalizations and 500 COVID-19-related deaths.[8] If SARS-CoV-2 infection prevalence is increased in specific ethnic groups, targeted prevention measures could be instated to help minimize the risk of further transmission.

Ethnic differences in SARS-CoV-2 infection prevalence could be studied using COVID-19 notification registries. However, since the testing policy in the Netherlands has changed several times and until June 1, 2020, testing was largely restricted to symptomatic health care workers or those living or working in long-term care facilities, these data are prone to differential testing uptake. Ethnic differences in testing uptake could be further exacerbated by testing access, willingness to test and disease perceptions. Another limitation of registries is that migration background is often missing. Other data are therefore needed to estimate seroprevalence within specific ethnic groups in Amsterdam.

The Healthy life in an Urban Setting (HELIUS) study is a large, population-based cohort study among six different ethnic groups, which was established with the aim to investigate mechanisms underlying the impact of ethnicity on communicable and non-communicable diseases.[9] From individuals actively enrolled in this study, we determined the prevalence and determinants of exposure to SARS-CoV-2 between the largest ethnic groups in Amsterdam.

METHODS

Study design and population

The HELIUS study is a multiethnic cohort study conducted in Amsterdam, the Netherlands, which focuses on cardiovascular disease, mental health, and infectious diseases. Detailed procedures have been previously described.[9] Briefly, HELIUS includes persons of Dutch, South-Asian Surinamese, African Surinamese, Ghanaian, Moroccan, and Turkish origin, aged between 18 and 70 years at inclusion. A random sample of persons, stratified by ethnic origin, was taken from the municipality register of Amsterdam and subjects were invited to participate. Between January 2011 and December 2015, a total of 24,789 individuals were included.[9] Participants filled in a self-administered questionnaire and underwent a physical examination during which biological samples were obtained. Ethical approval for the HELIUS study was obtained from the Academic Medical Center Ethical Review Board. All participants provided written informed consent.

Ethnicity was defined according to the country of birth of the participant and their parents.[9] Participants were considered to be of non-Dutch ethnic origin if (i) they were born abroad and had at least one parent born abroad (first generation) or (ii) they were born in Netherlands but both their parents were born abroad (second generation). Participants of Dutch origin were born in the Netherlands with both parents who were born in the Netherlands. Surinamese participants were further classified as African Surinamese, South-Asian Surinamese, and Javanese/other/unknown Surinamese, based on self-reporting.

A cross-sectional, serological substudy was performed in participants of the HELIUS study from 24 June to 9 October 2020. Participants were randomly selected within each ethnic group and asked to participate in the substudy. Serum samples for assessment of SARS-CoV-2 antibodies were collected by venipuncture and stored at -20°C. Trained interviewers asked participants questions on uptake of COVID-19-related prevention measures, potential exposure, infection, symptoms and disease.

Outcomes

SARS-CoV-2 exposure was determined by the presence of SARS-CoV-2 antibodies. SARS-CoV-2-specific antibodies were determined using the WANTAI SARS-CoV-2 Ab Elisa (Wantai Biological Pharmacy Enterprise Co., Beijing, China) according to the manufacturer's instructions. This Elisa detects IgA, IgM and IgG against the receptor binding domain of the S-protein of SARS-CoV-2.[10]

Determinants

We defined the following potential determinants: *from the baseline visit of the HELIUS study*– demographics (i.e. age, sex, ethnicity, migration generation, city district), socio-economic factors (i.e. educational level, working status, occupational level, number of people in household), access-to-healthcare indicators (i.e. proficiency with Dutch language, health literacy); *from the COVID-19 substudy visit*–job setting, household members, suspected being infected, thinking household member/steady partner was infected, household member hospitalized for COVID-19, type of people living in household, travelling abroad in 2020 and COVID-19 behaviors in the past week (i.e. number of times leaving the house, type of locations visited, number of visitors, frequency of using public transportation).

Statistical analysis

SARS-CoV-2 seroprevalence, along with 95% confidence intervals (CI), was modeled per ethnic group using univariable logistic regression. Seroprevalence was then modeled per ethnic group while correcting for sampling, accounting for the population structure of ethnic groups in Amsterdam (i.e. post-stratification), and adjusting for differences in age, sex and calendar time (before/after 15 August 2020, based on the onset of the second wave of SARS-CoV-2 infections in the Netherlands[8]) between ethnic groups (Supplementary Materials). The mean and 95%CI of predicted seroprevalence was plotted over age in years.

To identify determinants of past SARS-CoV-2 infection within ethnic groups, univariable associations between potential determinants and SARS-CoV-2 seropositivity were evaluated. The

odds ratios (OR) comparing the odds of seroprevalence across levels of each determinant, and their 95% confidence intervals (CI), were estimated using logistic regression. P-values were obtained using the Wald χ^2 test. All covariates with a *P*-value≤0.2 in univariable analyses were then included in a multivariable model and after assessing covariate distributions and collinearity, variables with a *P*-value≥0.05 above this threshold were removed in backwards-stepwise fashion until only variables with a *P*-value<0.05 were retained in a final multivariable model. All models included sampling and post-stratification weights. We forced calendar time in all models.

Statistical significance was defined at a *P*-value<0·05. All analyses were conducted using Stata 15.1 (StataCorp, College Station, TX, USA).

Patient and public involvement

There was no patient or public involvement in the development of the research questions, outcome measures, study design and recruitment/conduct for the current study. However, the parent HELIUS study employed several recruitment strategies to enhance enrolment of all eligible ethnic groups, e.g. by involving faith communities (churches and mosques) and community leaders to endorse the study, conducting at-home visits to non-Dutch persons who did not respond to the written invitation letter, and by providing, upon request, additional information or assistance in completing the questionnaire from a trained ethnically matched same-sex interviewer who spoke their preferred language. Results of the current study were disseminated to the involved communities following preliminary results to improve prevention and care. HELIUS study participants were invited for online seminars during which results were presented and discussed. Meetings were held with community leaders, general practitioners serving the population at risk, and local prevention teams. The prevention teams in turn developed prevention measures in co-creation with the community and met with key stakeholders such as employers to discuss their role.

RESULTS

Study population

Of the 16,889 HELIUS participants who were in active follow-up in 2019-2020, 11,080 (65.6%) were invited (Supplementary Figure 1). Of these, 2497 (22.5%) were included in the COVID-19 substudy. The response rate varied across ethnic groups, from 15.3-17.2% among Ghanaian, Turkish or Moroccan participants to 49.9% among Dutch participants. Detailed information on differences between HELIUS participants who were and were not invited, and between invited participants who were and were not included, are presented in Supplementary Table 1. Briefly, invited individuals who were included had obtained a slightly higher educational level, were more likely to be employed and were more likely to have adequate health literacy level compared to those who were invited but not included.

Number included per month within ethnic groups is presented in Supplementary Figure 3. Of 2497 included participants, 503 (20.1%) were of Dutch origin, 453 (18.1%) South-Asian Surinamese, 407 (16.3%) African Surinamese, 331 (13.3%) Ghanaian, 409 (16.4%) Turkish and 394 (15.8%) Moroccan (Supplementary Table 1, Table 1). The median age of included participants was 54 (interquartile range [IQR]: 44-61) and 56.6% were female. In the 1994 participants of non-Dutch origin, the percentage of first-generation migrants was lowest in the Turkish group (74.8%) and highest in the Ghanaian group (98.2%). Dutch participants were the most likely to have a higher vocational or university degree (67.0%) and be employed (75.5%) compared to other ethnicities.

Table 1. Characteristics of the HELIUS participants included in the COVID-19 study, by ethnic group (N=2497), Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	Dutch (n=503)	South-Asian Surinamese (n=453)	African Surinamese (n=407)	Ghanaian (n=331)	Turkish (n=409)	Moroccan (n=392)	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	*P*-value
Sex							
Male	237 (47.1%)	179 (39.5%)	165 (40.5%)	145 (43.8%)	184 (45.0%)	173 (43.9%)	0.19
Female	266 (52.9%)	274 (60.5%)	242 (59.5%)	186 (56.2%)	225 (55.0%)	221 (56.1%)	
Age in years on 1 January 2020							
Median [IQR]	57 [45-66]	56[47-63]	59 [50-65]	54 [47-59]	48 [40-56]	49 [39-56]	<0.001
Migration generation							
1st	N.A.	370 (81.7%)	355 (87.2%)	325 (98.2%)	306 (74.8%)	300 (76.1%)	<0.001
2nd	N.A	83 (18.3%)	52 (12.8%)	6 (1.8%)	103 (25.2%)	94 (23.9%)	
City district[a]							
Centre	88 (17.5%)	18 (4.0%)	15 (3.7%)	5 (1.5%)	4 (1.0%)	12 (3.0%)	<0.001
East	99 (19.7%)	53 (11.7%)	84 (20.6%)	25 (7.6%)	66 (16.1%)	94 (23.9%)	
West	89 (17.7%)	6 (1.3%)	34 (8.4%)	19 (5.7%)	66 (16.1%)	83 (21.1%)	
South	112 (22.3%)	32 (7.1%)	28 (6.9%)	8 (2.4%)	30 (7.3%)	38 (9.6%)	
New-West	45 (8.9%)	111 (24.5%)	51 (12.5%)	18 (5.4%)	231 (56.5%)	147 (37.3%)	
Southeast	65 (12.9%)	229 (50.6%)	192 (47.2%)	254 (76.7%)	6 (1.5%)	19 (4.8%)	
Other/missing	5 (1.0%)	4 (0.9%)	3 (0.7%)	2 (0.6%)	6 (1.5%)	1 (0.3%)	
Educational level[a]							
No school/elementary school	10 (2.0%)	56 (12.4%)	15 (3.7%)	78 (23.6%)	78 (19.1%)	90 (22.8%)	<0.001
Lower vocational/lower secondary school	56 (11.1%)	156 (34.4%)	124 (30.5%)	128 (38.7%)	84 (20.5%)	64 (16.2%)	
Intermediary vocational/intermediary secondary school	99 (19.7%)	137 (30.2%)	142 (34.9%)	73 (22.1%)	124 (30.3%)	125 (31.7%)	
Higher vocational/university	337 (67.0%)	103 (22.7%)	124 (30.5%)	26 (7.9%)	108 (26.4%)	94 (23.9%)	
Missing	1 (0.2%)	1 (0.2%)	2 (0.5%)	26 (7.9%)	15 (3.7%)	21 (5.3%)	
Labor participation[b]							
Employed	380 (75.5%)	308 (68.0%)	292 (71.7%)	203 (61.3%)	247 (60.4%)	229 (58.1%)	<0.001

Not in workforce	90 (17.9%)	47 (10.4%)	40 (9.8%)	10 (3.0%)	59 (14.4%)	63 (16.0%)	
Unemployed/on benefits	21 (4.2%)	53 (11.7%)	47 (11.5%)	60 (18.1%)	62 (15.2%)	57 (14.5%)	
Disabled	11 (2.2%)	39 (8.6%)	24 (5.9%)	28 (8.5%)	27 (6.6%)	22 (5.6%)	
Unknown/missing	1 (0.2%)	6 (1.3%)	4 (1.0%)	30 (9.0%)	14 (3.4%)	23 (5.8%)	
Occupational level[a]							
Elementary occupations	5 (1.0%)	36 (7.9%)	22 (5.4%)	162 (48.9%)	52 (12.7%)	46 (11.7%)	<0.001
Lower occupations	46 (9.1%)	127 (28.0%)	101 (24.8%)	69 (20.8%)	102 (24.9%)	92 (23.4%)	
Intermediary occupations	107 (21.3%)	143 (31.6%)	146 (35.9%)	21 (6.3%)	88 (21.5%)	94 (23.9%)	
Higher occupations	203 (40.4%)	79 (17.4%)	91 (22.4%)	11 (3.3%)	51 (12.5%)	65 (16.5%)	
Scientific occupations	115 (22.9%)	20 (4.4%)	19 (4.7%)	6 (1.8%)	32 (7.8%)	10 (2.5%)	
Missing	27 (5.4%)	48 (10.6%)	28 (6.9%)	62 (18.7%)	84 (22.5%)	87 (22.1%)	
Job setting[b]							
No job / caretaker only	117 (23.3%)	144 (31.8%)	120 (29.5%)	90 (27.2%)	138 (33.7%)	132 (33.5%)	<0.001
Job with no contact within 1.5 meter	96 (19.1%)	65 (14.3%)	39 (9.6%)	66 (19.9%)	67 (16.4%)	54 (13.7%)	
Other job with contact within 1.5 meter	145 (28.8%)	154 (34.0%)	131 (32.2%)	115 (34.7%)	130 (31.8%)	114 (28.9%)	
Child care/schools/higher education	62 (12.3%)	27 (6.0%)	43 (10.6%)	10 (3.0%)	25 (6.1%)	48 (12.2%)	
Bar/restaurant	12 (2.4%)	10 (2.2%)	11 (2.7%)	23 (6.9%)	6 (1.5%)	7 (1.8%)	
Hospital/long-term care facility/Health care worker elsewhere	71 (14.1%)	51 (11.3%)	63 (15.5%)	26 (7.9%)	41 (10.0%)	36 (9.1%)	
Missing	0 (0.0%)	2 (0.4%)	0 (0.0%)	1 (0.3%)	2 (0.5%)	3 (0.8%)	
Difficulty with Dutch language[a]							
No	N.A.	348 (76.8%)	359 (88.2%)	41 (12.4%)	189 (46.2%)	211 (53.6%)	<0.001
Yes	N.A.	104 (23.0%)	46 (11.3%)	264 (79.8%)	206 (50.4%)	162 (41.1%)	
Missing	N.A.	1 (0.2%)	2 (0.5%)	26 (7.9%)	14 (3.4%)	21 (5.3%)	
Health literacy (SBSQ)[a]							
Adequate	500 (99.4%)	437 (96.5%)	400 (98.3%)	209 (63.1%)	310 (75.8%)	308 (78.2%)	<0.001
Low	3 (0.6%)	16 (3.5%)	7 (1.7%)	97 (29.3%)	87 (21.3%)	64 (16.2%)	
Missing	0 (0.0%)	0 (0.0%)	0 (0.0%)	25 (7.6%)	12 (2.9%)	22 (5.6%)	
Diabetes mellitus[c]							
No	478 (95.0%)	358 (79.0%)	362 (88.9%)	297 (89.7%)	366 (89.5%)	345 (87.6%)	<0.001

Yes	18 (3.6%)	88 (19.4%)	42 (10.3%)	30 (9.1%)	35 (8.6%)	41 (10.4%)	
Missing	7 (1.4%)	7 (1.5%)	3 (0.7%)	4 (1.2%)	8 (2.0%)	8 (2.0%)	
High blood pressure[d]							
No	370 (73.6%)	261 (57.6%)	198 (48.6%)	143 (43.2%)	321 (78.5%)	305 (77.4%)	<0.001
Yes	127 (25.2%)	185 (40.8%)	207 (50.9%)	181 (54.7%)	82 (20.0%)	81 (20.6%)	
Missing	6 (1.2%)	7 (1.5%)	2 (0.5%)	7 (2.1%)	6 (1.5%)	8 (2.0%)	
Body Mass Index (kg/m2), median (IQR)[a]	24 [22-27]	25 [23-28]	27 [24-29]	28 [25-31]	27 [24-32]	27 [24-30]	<0.001
Month of study visit[b]							
June	86 (17.1%)	44 (9.7%)	31 (7.6%)	0 (0.0%)	0 (0.0%)	32 (8.1%)	<0.001
July	265 (52.7%)	233 (51.4%)	203 (49.9%)	38 (11.5%)	151 (36.9%)	170 (43.1%)	
August	108 (21.5%)	98 (21.6%)	110 (27.0%)	135 (40.8%)	88 (21.5%)	85 (21.6%)	
September	39 (7.8%)	75 (16.6%)	56 (13.8%)	125 (37.8%)	127 (31.1%)	74 (18.8%)	
October	5 (1.0%)	3 (0.7%)	7 (1.7%)	33 (10.0%)	43 (10.5%)	33 (8.4%)	

Abbreviations: BMI, body mass index; HELIUS, Healthy Life in an Urban Setting; IQR, interquartile range; N.A., not applicable; SBSQ, Set of Brief Screening Question [a] Presumed higher exposure categories had priority, i.e. if someone was working in a school and as a health care worker, they were categorized as a health care worker. Caretakers were not included as a category because many had other jobs.

[a] Measured at baseline (2011-2015) [b] Measured at COVID-1 visit (2020) [c] Based on self-report, increased fasting glucose (≥7 mmol/l) or use of glucose-lowering medication [d] Based on self-report, SBP ≥140 mmHg, DBP ≥90 or blood pressure-lowering medication

SARS-CoV-2 seroprevalence

Of 2497 included, 2483 (99.4%) participants had a SARS-CoV-2 antibody test result. Of these 2483, 226 were positive, 2249 negative and 8 had an equivocal test result. The distribution of signal-to-cutoff ratios for positive test results is shown per ethnic group in Supplementary Figure 3. The proportion with a positive result did not increase over time in any of the ethnic groups, except for the South-Asian Surinamese group (Supplementary Figure 2).

Unadjusted and adjusted seroprevalence estimates per ethnic group are provided in Figure 1 and Supplementary Table 2. Adjusted seroprevalence was comparable between the Dutch (5.5%, 95%CI=3.2-7.9), South-Asian Surinamese (4.8%, 95%CI=2.1-7.5), African Surinamese (8.2%, 95%CI=3.0-13.4), Turkish (7.8%, 95%CI=4.3-11.2) and Moroccan (7.0%, 95%CI=4.0-9.9) groups, but higher in the Ghanaian group compared to all other groups (26.5%, 95%CI=18.7-34.4, P<0.001).

Figure 2 shows adjusted seroprevalence estimates as a function of age in years for each ethnic group. In the African Surinamese group, seroprevalence decreased with age. In the Ghanaian group, the highest seroprevalence was observed between the ages of 50-55 years.

COVID-19-related symptoms

Table 2 describes SARS-CoV-2-related characteristics of included participants. Of 2497 participants, 348 (13.9%) suspected being infected with SARS-CoV-2, 2144 (85.9%) did not suspect or were unsure of being infected. 90.5% of Ghanaian participants who tested positive did not suspect or were unsure of being infected, mainly because most of these individuals had not experienced symptoms (58.7%). SARS-CoV-2 positive individuals from other ethnic groups more frequently suspected being infected (range 59.1% to 81.8%).

Table 2. SARS-CoV-2-related characteristics of the HELIUS participants included in the COVID-19 study, by ethnicity (N=2497), Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	Dutch (n=503)	South-Asian Surinamese (n=453)	African Surinamese (n=407)	Ghanaian (n=331)	Turkish (n=409)	Moroccan (n=392)	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	P-value
Do you think you have been infected? (among all respondents)							
Yes, this was confirmed by a PCR test	1 (0.2%)	4 (0.9%)	5 (1.2%)	2 (0.6%)	5 (1.2%)	9 (2.3%)	<0.001
Yes, this was confirmed by a Ab test	6 (1.2%)	1 (0.2%)	1 (0.2%)	0 (0.0%)	1 (0.2%)	2 (0.5%)	
Yes, but this was not confirmed by a test	67 (13.3%)	46 (10.2%)	51 (12.5%)	16 (4.8%)	63 (15.4%)	68 (17.3%)	
No, this was confirmed by a PCR test	28 (5.6%)	22 (4.9%)	22 (5.4%)	14 (4.2%)	26 (6.4%)	17 (4.3%)	
No, this was confirmed by a Ab test	6 (1.2%)	4 (0.9%)	5 (1.2%)	2 (0.6%)	5 (1.2%)	9 (2.3%)	
No, I do not think so, but this was not confirmed by a test	178 (35.4%)	181 (40.0%)	139 (34.2%)	90 (27.2%)	112 (27.4%)	108 (27.4%)	
No, I know for certain, because I did not have any symptoms	178 (35.4%)	152 (33.6%)	144 (35.4%)	182 (55.0%)	134 (32.8%)	144 (36.5%)	
I do not know	39 (7.8%)	41 (9.1%)	40 (9.8%)	25 (7.6%)	61 (14.9%)	36 (9.1%)	
Missing	0 (0.0%)	2 (0.4%)	0 (0.0%)	0 (0.0%)	2 (0.5%)	1 (0.3%)	
Do you think you have been infected? (among SARS-CoV-2 antibody positive individuals)							<0.001
No/do not know	6 (24.0%)	9 (40.9%)	4 (18.2%)	86 (90.5%)	11 (36.7%)	13 (40.6%)	
Yes	19 (76.0%)	13 (59.1%)	18 (81.8%)	9 (9.5%)	19 (63.3%)	19 (59.4%)	
Thinks household member/steady partner was infected							<0.001
N.A.	93 (18.5%)	89 (19.6%)	104 (25.6%)	40 (12.1%)	50 (12.2%)	58 (14.7%)	
No	352 (70.0%)	321 (70.9%)	270 (66.3%)	275 (83.1%)	310 (75.8%)	281 (71.3%)	
Yes	53 (10.5%)	38 (8.4%)	33 (8.1%)	15 (4.5%)	46 (11.2%)	51 (12.9%)	
Missing	5 (1.0%)	5 (1.1%)	0 (0.0%)	1 (0.3%)	3 (0.7%)	4 (1.0%)	
Household member hospitalized for COVID-19							<0.001
N.A.	93 (18.5%)	89 (19.6%)	104 (25.6%)	40 (12.1%)	50 (12.2%)	58 (14.7%)	
No	401 (79.7%)	356 (78.6%)	302 (74.2%)	290 (87.6%)	352 (86.1%)	329 (83.5%)	
Yes	4 (0.8%)	3 (0.7%)	1 (0.2%)	0 (0.0%)	4 (1.0%)	3 (0.8%)	

Missing	5 (1.0%)	5 (1.1%)	0 (0.0%)	1 (0.3%)	3 (0.7%)	4 (1.0%)	
Number of times left home in the past week							<0.001
0-7	59 (11.7%)	144 (31.8%)	145 (35.6%)	122 (36.9%)	106 (25.9%)	101 (25.6%)	
8-11	82 (16.3%)	134 (29.6%)	99 (24.3%)	120 (36.3%)	97 (23.7%)	90 (22.8%)	
12-16	141 (28.0%)	103 (22.7%)	80 (19.7%)	58 (17.5%)	103 (25.2%)	88 (22.3%)	
17+	221 (43.9%)	70 (15.5%)	83 (20.4%)	30 (9.1%)	101 (24.7%)	113 (28.7%)	
Missing	0 (0.0%)	2 (0.4%)	0 (0.0%)	1 (0.3%)	2 (0.5%)	2 (0.5%)	
Number of unique visitors at home in the past week							
0	216 (42.9%)	218 (48.1%)	192 (47.2%)	239 (72.2%)	207 (50.6%)	209 (53.0%)	<0.001
1	89 (17.7%)	80 (17.7%)	84 (20.6%)	43 (13.0%)	48 (11.7%)	45 (11.4%)	
2-4	146 (29.0%)	120 (26.5%)	97 (23.8%)	41 (12.4%)	110 (26.9%)	102 (25.9%)	
5+	49 (9.7%)	30 (6.6%)	32 (7.9%)	6 (1.8%)	41 (10.0%)	34 (8.6%)	
Missing	3 (0.6%)	5 (1.1%)	2 (0.5%)	2 (0.6%)	3 (0.7%)	4 (1.0%)	

239 **Abbreviations:** HELIUS, Healthy Life in an Urban Setting

Determinants of SARS-CoV-2 seropositivity per ethnic group

Univariable analysis of determinants of SARS-CoV-2 seropositivity is presented per ethnic group in Supplementary Tables 2-7. In multivariable analysis (Figure 3), having a household member suspected of infection was associated with SARS-CoV-2 seropositivity in Dutch, South-Asian Surinamese, Turkish and Moroccan participants. Recently traveling abroad was associated with seropositivity in Dutch and South-Asian Surinamese participants. In Ghanaian participants, older age, increasing household size, living with children ≤3 years old, and leaving home to work and attending religious services were associated with SARS-CoV-2 seropositivity. Increased odds for SARS-CoV-2 seropositivity were also observed for leaving home to pick up medication or visiting a doctor in the past week (Dutch participants), living with other adults (African Surinamese), having had ≥2 unique visitors in the past week (African Surinamese), leaving home to walk or exercise outside and using public transportation in the past week (Turkish participants) and occupational level (Moroccan participants).

DISCUSSION

After the first wave of the SARS-CoV-2 epidemic, we observed no evidence of ethnic disparities in past SARS-CoV-2 infection between the six largest ethnic groups residing in Amsterdam, The Netherlands, with the noteworthy exception of individuals of Ghanaian origin. We estimated that 26% of the adult Ghanaian group had developed SARS-COV-2 antibodies, compared to 5-8% of the other adult ethnic groups. Increased risk of past infection was present among individuals who reported a household member suspected of infection in four of the six groups. Amongst other factors, leaving home to work and attending religious services were associated with seropositivity in Ghanaian individuals, while using public transportation was associated with seropositivity in Turkish individuals. Determinants differed between ethnicities, hence demonstrating that broad generalizations of some SARS-CoV-2-related determinants might not be appropriate for individual ethnic groups.

Among the determinants of SARS-CoV-2 seropositivity, work and travelling to work, most likely via public transportation, represents a common theme in individuals of non-Dutch origin. Working from home was one of the first preventive measures introduced in the Netherlands to mitigate spread of SARS-CoV-2.[11] However, this was not feasible for individuals with lower professional levels and jobs requiring physical presence, many of whom were of non-Dutch origin. Interestingly, Moroccan individuals in the missing occupation category appeared to be more often seropositive. Previous research suggests that the health of individuals in this category resembles that of individuals with elementary or intermediary professions,[12] implying that working conditions could put these individuals at risk of infection.

Although attending religious services was asked only for the past week and infections may have occurred as early as in March 2020, exposure to SARS-CoV-2 during attendance at religious services might have driven many of the past infections observed in the Ghanaian group. Religious services, along with demonstrations, were allowed to continue without a maximum number of attendees, as

stipulated by Dutch law,[13] which could have fostered further spread of SARS-CoV-2. Many places of worship did, however, implement social distancing measures. A nationwide study demonstrated similar findings in that Orthodox-Reformed Protestants were at increased risk for SARS-CoV-2 seropositivity during the first wave of the pandemic.[14] Increased infection risk for people attending religious services has also been demonstrated in studies from other countries.[15-17]

Strikingly, 91% of Ghanaians with SARS-CoV-2 antibodies did not suspect or were unsure of being infected, many because they did not report experiencing any COVID-19-related symptoms. This is in stark contrast to other ethnic groups in which most SARS-CoV-2 positive individuals had suspected of being infected. If these infections were indeed asymptomatic in Ghanaians, many could have been completely unaware of their infection and as a result, might have carried out their normal routines despite unknowingly continuing transmission. The dense clustering of Ghanaians in the South-East city district of Amsterdam might have also accelerated transmission, as we unknowingly may have sampled a cluster of infections within a specific neighbourhood or religious center. Nevertheless, there were no infection clusters within Ghanaian individuals identified during the first wave by the local Public Health Service (personal communication T. Leenstra, January 27, 2021), when SARS-CoV-2 PCR testing was restricted. Our study clearly indicates that to reduce ongoing and unnoticed transmission of SARS-CoV-2, expanded testing needs to include those groups in which the proportion of asymptomatic individuals might be high, such as the Ghanaian residents of Amsterdam.

Since data from Ghana on SARS-CoV-2 seroprevalence and proportion of asymptomatic infection are limited, we cannot make any distinction on whether our finding reflects the epidemiology in the country of origin or is specific to Ghanaian individuals in the Netherlands. One modelling study suggests that Ghana is one of the four most affected African countries in terms of cases, but has a relatively low death rate.[18] A study among Kenyan blood donors found a surprisingly high seroprevalence (4.3%) from what can be inferred by the low number of COVID-19-related

hospitalisations and deaths.[19] Further research is needed to clarify the role of symptom burden, earlier exposure to coronaviruses, or differences in genetic vulnerability to symptoms in explaining the seemingly high proportion of asymptomatic cases in Ghanaians.[20,21]

Having a household member suspected of being infected was the most common and consistent determinant of seropositivity. This finding supports observations that during periods of more extensive lock-downs, most transmissions occur in household settings and is related to symptomatic infection, age distribution and social interactions within households.[22-24] Other household determinants of seropositivity were observed in specific ethnic groups and included living with other adults, living with children ≤3 years old, and larger household sizes.

In the Netherlands, a series of restrictions was introduced in mid-March, when the spread of SARS-CoV-2 was still limited.[11] The finding that seroprevalence did not differ between ethnic groups, other than Ghanaian, implies that these restrictive measures were able to prevent the spread of infection equally across ethnicities. Furthermore, additional data from individuals participating in the parent HELIUS study showed that non-ethnic Dutch groups in general were as likely as ethnic-Dutch to adhere to prevention measures (personal communication F. Chilunga, January, 27 2021). It should be mentioned that our results also stem from a setting where economic inequalities are not prohibitive to healthcare access.[25]

In comparison to the seroprevalence estimates, people from large ethnic groups (Netherlands Antilles, Morocco, Surinam, Turkey, Ghana) had increased hospitalisation rates compared to ethnic Dutch individuals living in Amsterdam between February and May 2020,[26] as shown in other settings.[2,3] In addition, individuals with a migration background living in the Netherlands had a higher excess mortality during the first six weeks of the COVID-19 pandemic.[27] Our data suggest that, apart from Ghanaians, the increased rates of hospitalisations and deaths in non-Dutch ethnic groups during this period cannot be explained by a higher infection rate. The severity of COVID-19 can be impacted to a large extent by underlying comorbidities,[28] which vary across ethnic

groups[9] and could explain differences in severity.[29] Healthcare inequalities, racism, stigmatisation and discrimination witnessed by ethnic minorities and differences in healthcare seeking-behaviour may provide additional explanations for these disparities.[30-34]

Strengths of our study include population-based sampling, with a large number of participants from the major ethnic groups living in Amsterdam, representing various levels of socioeconomic status; measuring seroprevalence via antibodies in individuals with and without previous COVID-19-related symptoms; and obtaining individual-level determinants of infection. Nonetheless, there are several limitations. First, our study includes a random subsample of HELIUS participants and there may be selection bias. Undocumented people and other ethnic groups living in Amsterdam were not included in the parent study. Second, participants in our substudy may have been more concerned about their health compared to non-participants. Notwithstanding the differential response rate between ethnicities in this substudy, the distribution of characteristics was largely similar between included and non-included HELIUS participants. Our estimates, corrected for sampling and post-stratification, were also close to those from a nationwide study that included mainly people of Dutch origin and revealed a 6% seroprevalence among the Amsterdam population in June 2020.[35] Data were also collected over a span of 4 months, which reflects different points of the epidemic, and thus the timing of testing could bias estimates. We attempted to mitigate this issue by adjusting for calendar time. Furthermore, prevention measures remained mostly the same and nationwide incidence was quite stable during this period, thereby limiting the effect of this bias.[8,36] Third, as this study was cross-sectional and infection occurred in the past, it is difficult to make any causal inference with respect to determinants. Fourth, fear of stigmatization or consequences for work might have led to an underreporting of suspected past infection and symptoms, particularly among Ghanaians. Finally, circulating SARS-CoV-2 antibodies could have disappeared after infection,[37,38] although this was probably limited during the study period,[39,40] and individuals could not participate in this substudy if they were experiencing COVID-19-related symptoms, both of which likely led to underestimated seroprevalence.

In conclusion, most ethnic groups displayed comparable seroprevalence after the first SARS-CoV-2 wave in Amsterdam, yet the substantially higher prevalence among the smaller Ghanaian population, possibly infections without symptoms, is of concern. Targeted prevention campaigns addressing the needs of specific ethnic groups and expanding testing opportunities are urgently warranted. In addition, prevention measures for those who cannot work from home should be intensified, also by bringing to light the employer's role in reducing COVID-19 transmissions.

STATEMENTS

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Competing interests

The authors declare that they have no competing interests related to the project.

Data sharing

The HELIUS data are owned by the Amsterdam UMC, location AMC, in Amsterdam, The Netherlands. Any researcher can request the data by submitting a proposal to the HELIUS Executive Board as outlined at http://www.heliusstudy.nl/en/researchers/collaboration, by email: heliuscoordinator@amsterdamumc.nl. The HELIUS Executive Board will check proposals for compatibility with the general objectives, ethical approvals and informed consent forms of the HELIUS study. There are no other restrictions to obtaining the data and all data requests will be processed in the same manner.

Contributors

MP, KS, JS and CA conceived, designed or oversaw the study. HG, AK and JS were involved in the acquisition of data. LC and AB conducted the statistical analysis. LC, AB and MP drafted the manuscript. All authors contributed to interpretation of the data, provided feedback on the initial draft for revision, and approved the final manuscript.

Ethics approval

Ethical approval for the HELIUS study was obtained from the Academic Medical Center Ethical Review Board.

Consent to participate

All participants provided written informed consent.

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Figures

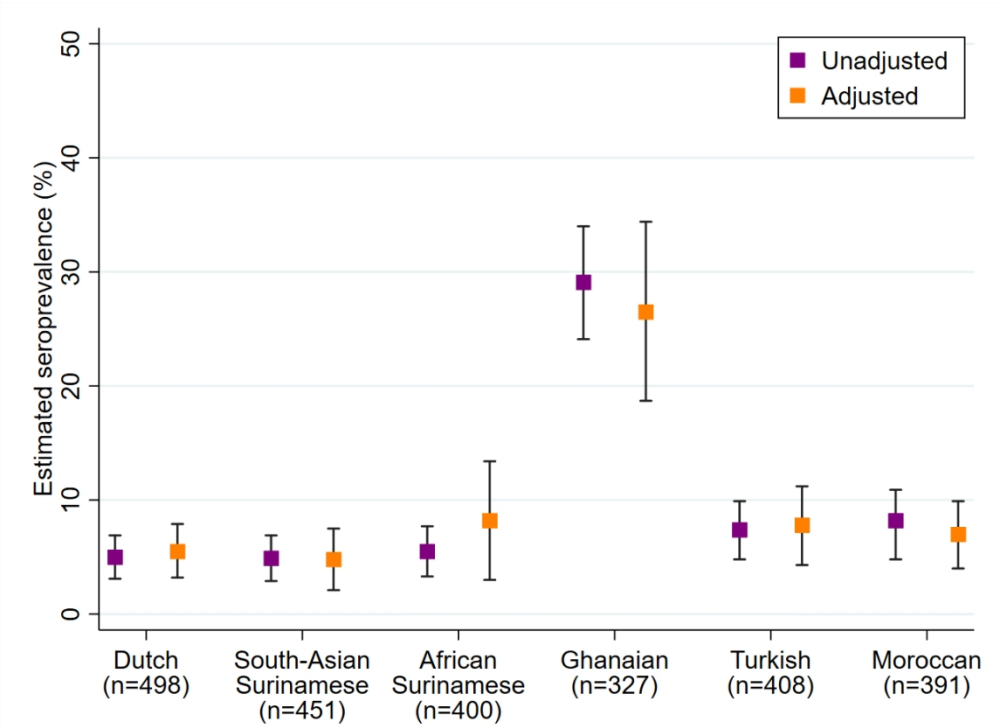
Figure 1. Unadjusted and adjusted SARS-CoV-2 seroprevalence per ethnic group (N=2475), Amsterdam, the Netherlands, 24 June - 9 October 2020

Legend: We excluded individuals with an equivocal result (n=8) from the seroprevalence calculation. Boxes represent the seroprevalence estimate, bands the corresponding 95% confidence interval. Adjusted seroprevalence estimates were corrected for sampling, accounted for the population structure of ethnic groups in Amsterdam (i.e. post-stratification), and adjusted for differences in age, sex and calendar time (before/after 15 August 2020) between ethnic groups.

Figure 2. SARS-CoV-2 seroprevalence and age by ethnic group, Amsterdam, the Netherlands, 24 June - 9 October 2020

Legend: Seroprevalence was regressed on age (in restricted cubic splines with 3 knots) with sample and post-stratification weights, within subpopulations of ethnic groups.

Figure 3. Determinants of SARS-CoV-2 seropositivity by ethnic group, HELIUS COVID-19 study, 24 June - 9 October 2020 (multivariable analysis)



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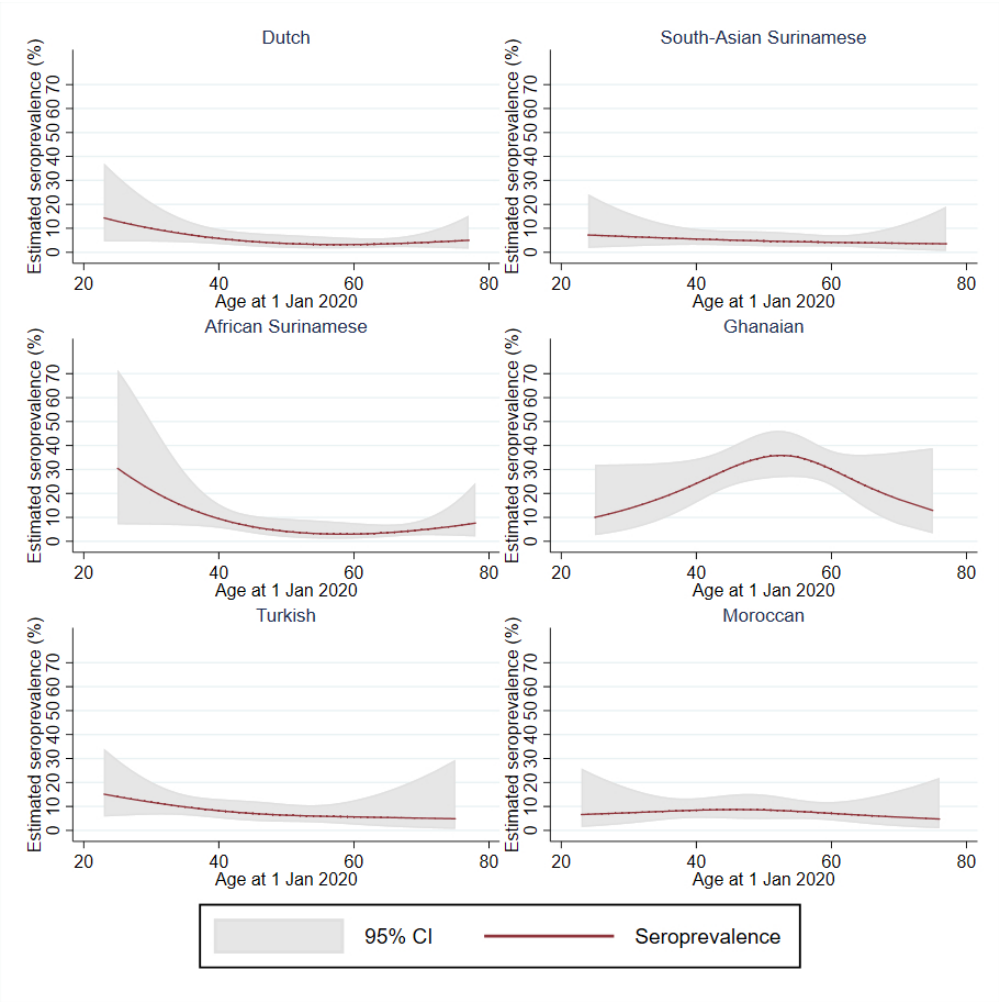

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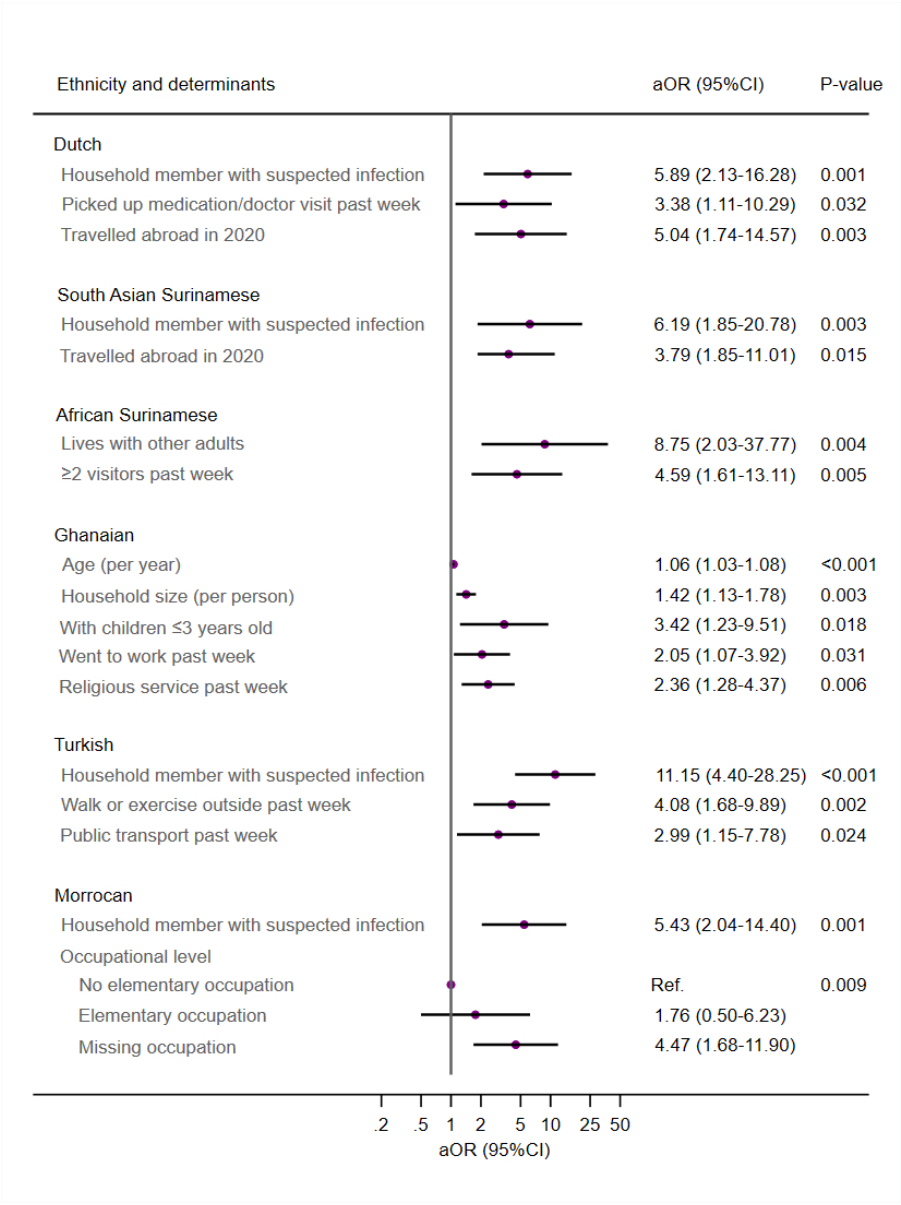

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Supplement to:
SARS-CoV-2 antibody prevalence and determinants of six ethnic groups living in Amsterdam, the Netherlands: a population-based cross-sectional study, June-October 2020

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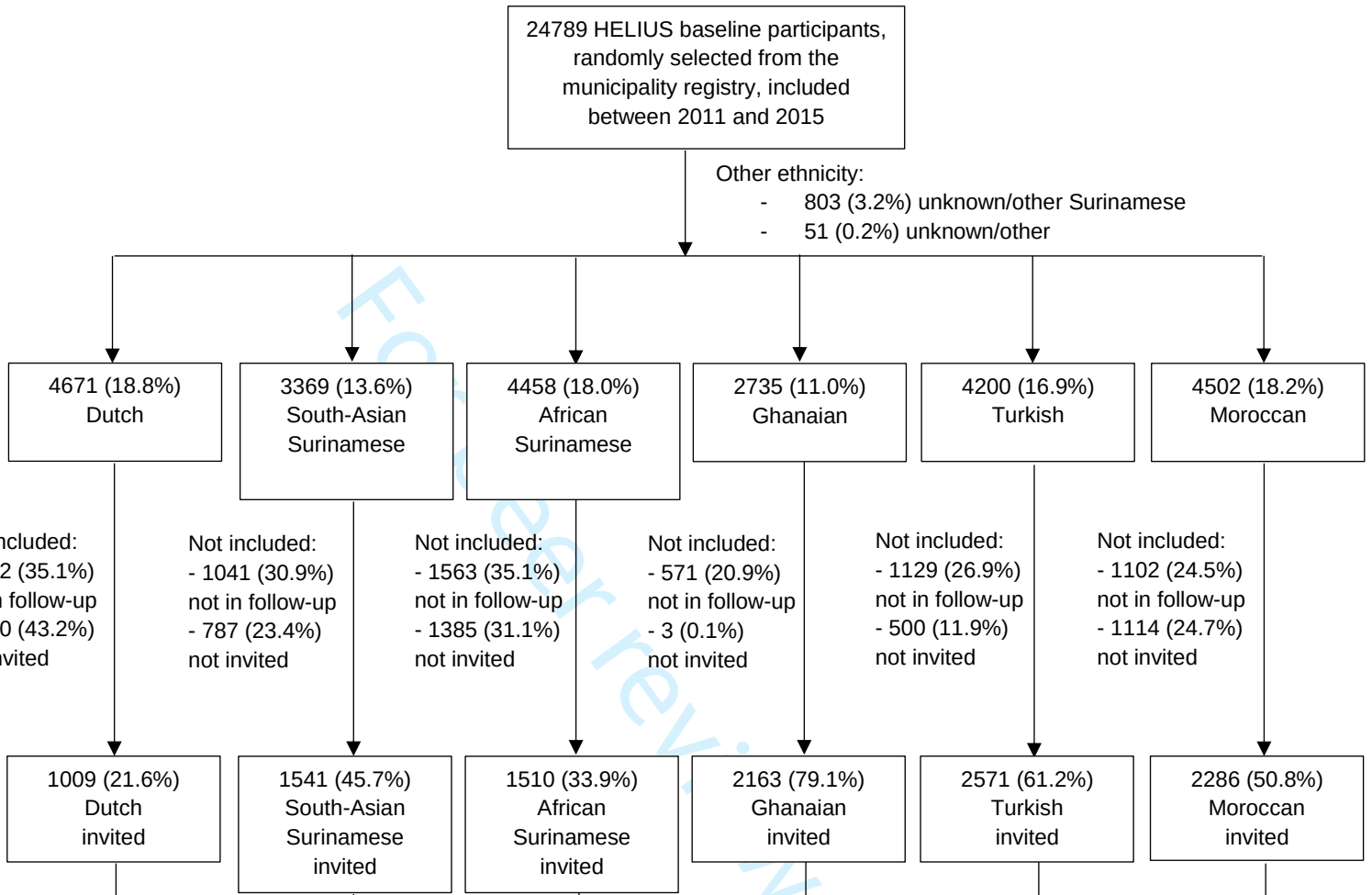
Figure S1. Flowchart depicting the selection of HELIUS participants in the COVID-19 study, Amsterdam, the Netherlands, 24 June - 9 October 2020



Information on seroprevalence estimation corrected for sampling, post-stratification and adjusting for differences in age, sex and calendar time between ethnic groups.

For sampling, the probability of being invited for the COVID-19 substudy (as the proportion of participants invited among those in active follow-up in the parent study) was calculated, as was the conditional probability of participating in the COVID-19 substudy (given the participant's ethnicity, age, educational level, working status and health literacy). The product of the two probabilities was taken and the inverse of this result, standardized to one, was used as a sampling weight. For post-stratification, a weight was assigned corresponding to the proportion representing the Amsterdam population of each stratum of age (20-44, 45-54, 55-59, 60-79 years), sex (male, female) and ethnicity (Surinamese, Ghanaian, Moroccan, Turkish, Dutch). Sampling and post-stratification weights were placed in a multivariable logistic regression model with covariates ethnicity, age, sex, and calendar time. Given the weighting scheme of this study, variance was calculated with the designed-based Taylor series linearization method using the 'svy' commands in STATA. Differences between ethnic groups were tested in the model using the Wald $\chi 2$ test.

Table S1. Characteristics of three inclusion groups (invited and included in COVID-19 study invited not included not invited) within the HELIUS population (N=16889), Amsterdam, the Netherlands, 24 June - 9 October 2020

To identify potential selection bias among HELIUS participants who were still in active follow-up, demographic, socio-economic factors and access to health care indicators were compared between those who were invited versus not invited for the COVID-19 substudy. To assess the reasons for nonresponse among invited HELIUS participants, these variables were also compared between those who participated versus not participated in the COVID-19 substudy. Pearson's $\chi 2$ or Fisher exact test were used for categorical data and Kruskal-Wallis rank test for continuous variables.

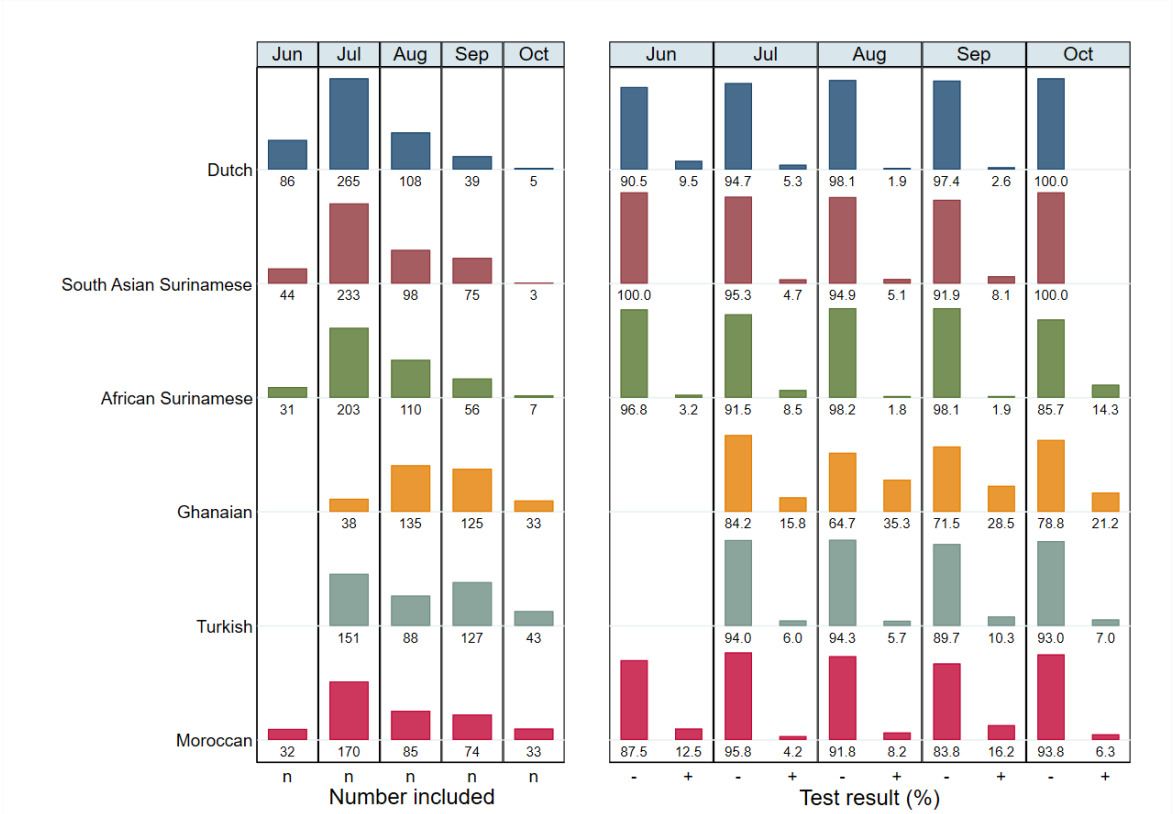
Characteristic	All HELIUS participants in follow-up[a] (N= 16889)	Invited included (n=2497)	Invited not included (n=8583)	Not invited (n=5809)	*Invited and included vs. invited not included*	*Invited (included and not included) vs. not invited*
	n (%)	n (%)	n (%)	n (%)	*P*-value	*P*-value
Ethnicity					<0.001	<0.001
Dutch	3029 (17.9%)	503 (20.1%)	506 (5.9%)	2020 (34.8%)		
South-Asian Surinamese	2328 (13.8%)	453 (18.1%)	1088 (12.7%)	787 (13.5%)		
African Surinamese	2895 (17.1%)	407 (16.3%)	1103 (12.9%)	1385 (23.8%)		
Ghanaian	2166 (12.8%)	331 (13.3%)	1832 (21.3%)	3 (0.1%)		
Turkish	3071 (18.2%)	409 (16.4%)	2162 (25.2%)	500 (8.6%)		
Moroccan	3400 (20.1%)	394 (15.8%)	1892 (22.0%)	1114 (19.2%)		
Sex					0.095	0.94
Male	7077 (41.9%)	1083 (43.4%)	3562 (41.5%)	2432 (41.9%)		
Female	9812 (58.1%)	1414 (56.6%)	5021 (58.5%)	3377 (58.1%)		
Age in years on 1 January 2020					<0.001	<0.001
Median [IQR]	52 [41-61]	54 [44-61]	51 [39-59]	54 [42-63]		
Migration generation					<0.001	<0.001
N.A. (Dutch group)	3029 (17.9%)	503 (20.1%)	506 (5.9%)	2020 (34.8%)		
1st	10978 (65.0%)	1656 (66.3%)	6339 (73.9%)	2983 (51.4%)		
2nd	2882 (17.1%)	338 (13.5%)	1738 (20.2%)	806 (13.9%)		
City district[b]					<0.001	<0.001
Centre	783 (4.6%)	142 (5.7%)	222 (2.6%)	419 (7.2%)		
East	2550 (15.1%)	421 (16.9%)	1302 (15.2%)	827 (14.2%)		
West	2361 (14.0%)	297 (11.9%)	1205 (14.0%)	859 (14.8%)		
South	1382 (8.2%)	248 (9.9%)	524 (6.1%)	610 (10.5%)		
New-West	4893 (29.0%)	603 (24.1%)	2571 (30.0%)	1719 (29.6%)		
Southeast	4803 (28.4%)	765 (30.6%)	2722 (31.7%)	1316 (22.7%)		
Other	16 (0.1%)	3 (0.1%)	7 (0.1%)	6 (0.1%)		
Missing	101 (0.6%)	18 (0.7%)	30 (0.3%)	53 (0.9%)		
Educational level[b]					<0.001	<0.001
No school/elementary school	3286 (19.5%)	327 (13.1%)	2175 (25.3%)	784 (13.5%)		
Lower vocational/ lower secondary school	4324 (25.6%)	612 (24.5%)	2358 (27.5%)	1354 (23.3%)		
Intermediary vocational/ intermediary secondary school	4715 (27.9%)	700 (28.0%)	2393 (27.9%)	1622 (27.9%)		

Higher vocational/university	3993 (23.6%)	792 (31.7%)	1243 (14.5%)	1958 (33.7%)		
Missing	571 (3.4%)	66 (2.6%)	414 (4.8%)	91 (1.6%)		
Labor participation[b]					<0.001	<0.001
Employed	9585 (56.8%)	1659 (66.4%)	4274 (49.8%)	3652 (62.9%)		
Not in workforce	2992 (17.7%)	309 (12.4%)	1645 (19.2%)	1038 (17.9%)		
Unemployed/on benefits	2372 (14.0%)	300 (12.0%)	1416 (16.5%)	656 (11.3%)		
Disabled	1309 (7.8%)	151 (6.0%)	792 (9.2%)	366 (6.3%)		
Missing	631 (3.7%)	130 (3.1%)	774 (8.7%)	154 (2.7%)		
Occupational level[b]					<0.001	<0.001
Elementary occupations	2454 (14.5%)	323 (12.9%)	1739 (20.3%)	392 (6.7%)		
Lower occupations	4177 (24.7%)	537 (21.5%)	2280 (26.6%)	1360 (23.4%)		
Intermediary occupations	3549 (21.0%)	599 (24.0%)	1515 (17.7%)	1435 (24.7%)		
Higher occupations	2565 (15.2%)	500 (20.0%)	783 (9.1%)	1282 (22.1%)		
Scientific occupations	928 (5.5%)	202 (8.1%)	223 (2.6%)	503 (8.7%)		
Missing	3216 (19.0%)	336 (13.5%)	2043 (23.8%)	837 (14.4%)		
Difficulty with Dutch language[b]					<0.001	<0.001
N.A. (Dutch group)	3029 (17.9%)	503 (20.1%)	506 (5.9%)	2020 (34.8%)		
No	7467 (44.2%)	1148 (46.0%)	3751 (43.7%)	2568 (44.2%)		
Yes	5891 (34.9%)	782 (31.3%)	3950 (46.0%)	1159 (20.0%)		
Missing	502 (3.0%)	64 (2.6%)	376 (4.4%)	62 (1.1%)		
Difficulty with Dutch language[b] **(excluding Dutch group)**					<0.001	<0.001
No	7467 (53.9%)	1148 (57.6%)	3751 (46.4%)	2568 (67.8%)		
Yes	5891 (42.5%)	782 (39.2%)	3950 (48.9%)	1159 (30.6%)		
Missing	502 (3.6%)	64 (3.2%)	376 (4.7%)	62 (1.6%)		
Health literacy (SBSQ)[b]					<0.001	<0.001
Adequate	5329 (31.6%)	971 (38.9%)	2058 (24.0%)	2300 (39.6%)		
Low	1927 (11.4%)	265 (10.6%)	1110 (12.9%)	552 (9.5%)		
Missing	9633 (57.0%)	1261 (50.5%)	5415 (63.1%)	2957 (50.9%)		

Abbreviations: HELIUS Healthy Life in an Urban Setting; IQR interquartile range; N.A. not applicable; SBSQ Set of Brief Screening Question

[a] Excluding participants not belonging to one of the six ethnic groups included in the COVID-19 study [b] Measured at baseline (2011-2015)

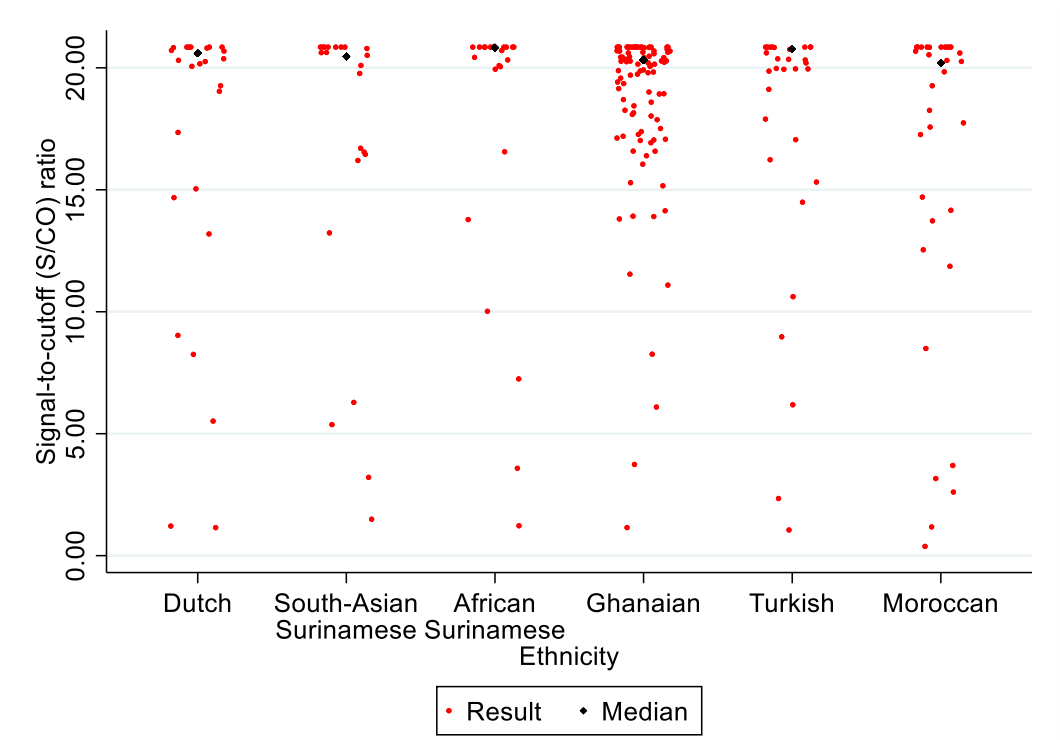
Figure S2 Inclusion numbers and test results per month by ethnicity, Amsterdam, the Netherlands, 24 June - 9 October 2020



The left side of the graph shows the number of individuals included in the substudy per month by ethnic group. The right side of the graph shows the distribution of test results per inclusion month by ethnic group, excluding people without a test result (n=14) or equivocal test result (n=8).

We tested whether the seroprevalence changed over months in survey-weighted logistic regression models per ethnic group. Odds of a positive test did not change in the Dutch (*P*=0.91), Ghanaian (*P*=0.33), Turkish (*P*=0.67) and Moroccan groups (*P*=0.33), but increased in the South-Asian Surinamese group (OR=1.87 per month increase, 95%CI=1.12-3.12, *P*=0.016) and decreased in the African Surinamese group (OR=0.56 per month increase, 95%CI=0.34-0.94, *P*=0.028).

Figure S3 Distribution of signal-to-cutoff (S/CO) ratios for positive test results (N=226) by ethnicity, Amsterdam, the Netherlands, 24 June - 9 October 2020



Kruskall Wallis test for difference between ethnic groups: *P*=0.50

Table S2. Univariable analysis of potential determinants of SARS-CoV-2 seropositivity in Dutch participants, Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	Number per category	Number with antibodies (%)	OR (95% CI)[a]	*P*-value
Sex				0.26
Male	234	10 (4.3%)	1	
Female	264	15 (5.7%)	1.79 (0.65-4.88)	
Per year increase in age in years on 1 January 2020[c]			0.97 (0.93-1.00)	0.087
Migration generation				
1st	N.A.	N.A.		
2nd	N.A.	N.A.		
Month of study visit[b]				0.55
June	84	8 (9.5%)	1	
July	262	14 (5.3%)	0.78 (0.26-2.33)	
August	108	2 (1.9%)	0.32 (0.06-1.63)	
September	39	1 (2.6%)	0.46 (0.05-4.07)	
October	5	0 (0%)	Omitted	
City district[c]				0.88
Centre	86	7 (8.1%)	1	
East	99	2 (2.0%)	1.11 (0.21-5.92)	
West	89	5 (5.6%)	1.11 (0.27-4.63)	
South	112	8 (7.1%)	1.78 (0.58-5.49)	
New-West	44	3 (6.8%)	1.64 (0.30-8.85)	
Southeast	63	0 (0%)	Omitted	
Other	1	0 (0%)	Omitted	
Has obesity (BMI≥30.0)[c]				0.66
No	442	22 (5.0%)	1	
Yes	51	3 (5.9%)	0.75 (0.21-2.72)	
Educational level[c]				0.32
No school/elementary school	10	0 (0%)	Omitted	
Lower vocational/ lower secondary school	53	0 (0%)	Omitted	
Intermediary vocational/ intermediary secondary school	99	1 (1.0%)	1	
Higher vocational/university	335	24 (7.2%)	2.78 (0.37-20.97)	
Missing	1	0 (0%)	Omitted	
Labor participation[c]				0.19
Employed	377	19 (5.0%)	1	
Not in workforce	88	6 (6.8%)	2.12 (0.69-6.55)	
Unemployed/on benefits	21	0 (0%)	Omitted	
Disabled	11	0 (0%)	Omitted	
Unknown/missing	1	0 (0%)	Omitted	
Elementary occupation[c]				0.20
No	467	23 (4.9%)	1	
Yes	4	0 (0%)	Omitted	
Missing	27	2 (7.4)	2.71 (0.58-12.64)	
Health literacy (SBSQ)[c]				
Adequate	495	25 (5.1%)	Omitted	
Low	3	0 (0%)	Omitted	
Job setting[b,e]				
No job / caretaker only	115	2 (1.7%)	1	

Job with no contact within 1.5 meter	96	3 (3.1%)	3.40 (0.44-25.99)	
Other job with contact within 1.5 meter	142	10 (7.0%)	6.22 (1.25-30.86)	
Child care/schools/higher education	62	4 (6.5%)	8.23 (1.26-53.64)	
Bar/restaurant	12	1 (8.3%)	2.51 (0.20-32.41)	
Hospital/long-term care facility/Care worker elsewhere	71	5 (7.0%)	8.51 (1.37-52.99)	
Caretaker [b]				0.46
No	424	20 (4.7%)	1	
Yes	74	5 (6.8)	1.68 (0.43-6.6)	
Number of people in household [c]				0.067
1 (Lives alone)	125	6 (4.8%)	1	
2	222	12 (5.4%)	0.61 (0.18-2.06)	
3	63	1 (1.6%)	0.07 (0.01-0.63)	
4	76	4 (5.3%)	0.56 (0.14-2.31)	
≥5	12	2 (16.7%)	3.45 (0.44-27.16)	
Lives with other people [b]	375	20 (5.3%)	0.76 (0.22-2.61)	0.66
Partner	334	19 (5.7%)	0.79 (0.26-2.41)	0.68
Children up to 3 years old	38	1 (2.6%)	0.36 (0.05-2.85)	0.33
Children 4 through 12 years old	55	2 (3.6%)	0.52 (0.11-2.43)	0.41
Children 13 through 17 years old	31	0 (0%)	Omitted	
Children 18+ years old	50	1 (2.0%)	0.23 (0.03-1.77)	0.16
Parents or parents-in-law	4	0 (0%)	Omitted	
Other adults	18	1 (5.6%)	2.17 (0.26-18.01)	0.47
Household member/steady partner with suspected infection [b]				0.001
N.A./No	440	12 (2.7%)	1	
Yes	53	13 (24.5%)	6.26 (2.16-18.13)	
Number of times left home in the past week [b,d]				0.19
0-7	59	1 (1.7%)	1	
8-11	81	4 (4.9%)	4.22 (0.42-42.42)	
12-16	140	6 (4.3%)	4.51 (0.44-46.04)	
17+	218	14 (6.4%)	8.42 (1.07-66.63)	
In the past week, left home to [b]**:**				
Work	237	16 (6.8%)	1.72 (0.60-4.93)	0.32
Do groceries	473	23 (4.9%)	1.64 (0.35-7.72)	0.53
Visit family or friends	335	20 (6.0%)	1.68 (0.48-5.93)	0.42
Walk the dog or go outside with kids	125	8 (6.4%)	1.34 (0.46-3.85)	0.59
Walk or exercise outside	396	19 (4.8%)	1.01 (0.30-3.39)	0.99
Take care of someone	75	6 (8.0%)	1.12 (0.39-3.20)	0.83
Pick up prescription medicines or visit	99	10 (10.1%)	3.97 (1.38-11.43)	0.01
Attend religious service	5	0 (0%)	Omitted	
Visit cultural place	80	5 (6.3%)	1.24 (0.38-4.02)	0.72
Visit bar or restaurant	279	15 (5.4%)	1.61 (0.59-4.35)	0.35
Indoor sports	63	4 (6.3%)	1.56 (0.40-6.11)	0.52
Visit recreational park	210	11 (5.2%)	1.01 (0.36-2.83)	0.98
Frequency of using public transportation in the past week [b]				0.79
0 days	321	17 (5.3%)	1	
1-2 days	130	6 (4.6%)	0.64 (0.18-2.32)	
3-4 days	36	2 (5.6%)	0.84 (0.14-4.87)	
5-7 days	10	0 (0%)	Omitted	
Number of unique visitors at home in the past week [b]				0.50

0	213	9 (4.2%)	1	
1	88	4 (4.5%)	1.21 (0.24-6.24)	
2-4	145	6 (4.1%)	0.72 (0.21-2.44)	
5+	49	6 (12.2%)	2.20 (0.56-8.71)	
Travelled abroad in 2020 [b]				0.021
No	259	8 (3.1%)	1	
Yes	239	17 (7.1%)	3.43 (1.21-9.75)	

Abbreviations: CI, confidence interval; HELIUS, Healthy Life in an Urban Setting; N.A., not applicable; OR, odds ratio
[a] Those with an equivocal test result were excluded from this analysis [b] Measured at COVID-1 visit (2020) [c] Measured at baseline (2011-2015) [d] Quartiles [e] Presumed higher exposure categories had priority, i.e. if someone was working in a school and as a careworker, they were categorized as a health worker. Caretakers were not included as a category because many had other jobs.

In multivariable analysis, the distribution of educational level and labor participation were skewed to mostly one group and hence were not included. The following variables were removed as they were no longer significant in the multivariable model: dichotomized household size (*P*=0.80), age (0.53), occupational level (0.36), number of times left home (0.40), living with child 18+ years old (0.19), job setting (0.12).

Table S3. Univariable analysis of potential determinants of SARS-CoV-2 seropositivity in South-Asian Surinamese participants, Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	Number per category	Number with antibodies (%)	OR (95% CI)[a]	*P*-value
Sex				0.84
Male	178	7 (3.9%)	1	
Female	273	15 (5.5%)	1.13 (0.34-3.77)	
Per year increase in age in years on 1 January 2020[c]			0.98 (0.95-1.02)	0.44
Migration generation				0.36
1st	368	17 (4.6%)	1	
2nd	83	5 (6.0%)	1.68 (0.56-5.05)	
Month of study visit[b]				0.16
June	44	0 (0%)	Omitted	
July	232	11 (4.7%)	1	
August	98	5 (5.1%)	1.79 (0.46-7.04)	
September	74	6 (8.1%)	3.22 (0.95-10.91)	
October	3	0 (0%)	Omitted	
City district[c]				0.48
Centre	17	0 (0%)	Omitted	
East	53	2 (3.8%)	1	
West	6	0 (0%)	Omitted	
South	32	1 (3.1%)	1.05 (0.09-12.53)	
New-West	111	5 (4.5%)	1.43 (0.25-8.24)	
Southeast	228	14 (6.1%)	2.81 (0.56-14.10)	
Other	0	0 (0%)	Omitted	
Has obesity (BMI≥30.0)[c]				0.55
No	369	20 (5.4%)	1	
Yes	76	2 (2.6%)	0.58 (0.10-3.42)	
Educational level[c]				0.62
No school/elementary school	55	2 (3.6%)	1	
Lower vocational/ lower secondary school	156	11 (7.1%)	2.64 (0.53-13.21)	
Intermediary vocational/ intermediary secondary school	136	5 (3.7%)	1.41 (0.22-9.14)	
Higher vocational/university	103	4 (3.9%)	2.06 (0.28-14.89)	
Missing	1	0 (0%)	Omitted	
Labor participation[c]				0.53
Employed	306	16 (5.2%)	1	
Not in workforce	47	1 (2.1%)	0.84 (0.1-6.77)	
Unemployed/on benefits	53	3 (5.7%)	2.66 (0.56-12.59)	
Disabled	39	1 (2.6%)	0.55 (0.07-4.38)	
Unknown/missing	6	1 (16.7%)	3.43 (0.37-31.95)	
Elementary occupation[c]				0.12
No	367	18 (4.9%)	1	
Yes	36	3 (8.3%)	1.19 (0.30-4.69)	
Missing	48	1 (2.1%)	0.12 (0.02-0.98)	
Difficulty with Dutch language[c]				0.48
No	347	13 (3.7%)	1	
Yes	103	9 (8.7%)	1.45 (0.52-4.04)	
Health literacy (SBSQ)[c]				0.94
Adequate	435	21 (4.8%)	1	

Low	16	1 (6.3%)	0.93 (0.11-7.8)	
Job setting[b,e]				0.06
No job / caretaker only	144	5 (3.5%)	1	
Job with no contact within 1.5 meter	65	1 (1.5%)	0.27 (0.03-2.42)	
Other job with contact within 1.5 meter	153	12 (7.8%)	3.35 (0.99-11.32)	
Child care/schools/higher education	27	1 (3.7%)	1.19 (0.12-11.38)	
Bar/restaurant	10	1 (10.0%)	1.28 (0.12-13.30)	
Hospital/long-term care facility/Care worker elsewhere	50	2 (4.0%)	0.46 (0.08-2.61)	
Caretaker [b]			0.27 (0.03-2.42)	
No	380	20 (5.3%)	3.35 (0.99-11.32)	
Yes	69	2 (2.9%)	1.19 (0.12-11.38)	
Number of people in household [c]				0.02
1 (Lives alone)	98	1 (1.0%)	1	
2	126	7 (5.6%)	4.55 (0.53-39.15)	
3	102	10 (9.8%)	16.85 (1.99-142.58)	
4	77	3 (3.9%)	2.96 (0.30-29.11)	
≥5	44	1 (2.3%)	1.69 (0.10-28.05)	
Lives with other people [b]	333	18 (5.4%)	1.91 (0.57-6.46)	0.29
Partner	224	13 (5.8%)	1.11 (0.35-3.47)	0.86
Children up to 3 years old	19	1 (5.3%)	0.91 (0.11-7.49)	0.93
Children 4 through 12 years old	51	0 (0%)	Omitted	
Children 13 through 17 years old	40	2 (5.0%)	0.68 (0.14-3.24)	0.63
Children 18+ years old	146	7 (4.8%)	0.85 (0.30-2.42)	0.76
Parents or parents-in-law	32	3 (9.4%)	2.03 (0.50-8.19)	0.32
Other adults	32	0 (0%)	Omitted	
Household member/steady partner with suspected infection [b]				0.002
N.A./No	408	13 (3.2%)	1	
Yes	38	9 (23.7%)	7.05 (2.07-24.04)	
Number of times left home in the past week [b,d]				0.02
0-7	144	9 (6.3%)	1	
8-11	134	9 (6.7%)	2.12 (0.64-6.98)	
12-16	102	2 (2.0%)	0.18 (0.04-0.94)	
17+	69	2 (2.9%)	0.49 (0.09-2.56)	
In the past week, left home to [b]**:**				
Work	195	9 (4.6%)	0.62 (0.19-2.09)	0.44
Do groceries	422	20 (4.7%)	1.28 (0.25-6.56)	0.77
Visit family or friends	247	12 (4.9%)	1.01 (0.34-3.03)	0.98
Walk the dog or go outside with kids	34	1 (2.9%)	0.55 (0.07-4.46)	0.58
Walk or exercise outside	266	12 (4.9%)	1.86 (0.68-5.03)	0.22
Take care of someone	63	1 (2.9)	0.23 (0.03-1.79)	0.16
Pick up prescription medicines or visit	120	12 (4.5%)	1.77 (0.57-5.54)	0.33
Attend religious service	20	1 (1.6%)	0.73 (0.09-6.09)	0.77
Visit cultural place	17	7 (5.8%)	0.89 (0.1-7.57)	0.91
Visit bar or restaurant	87	1 (5.0%)	0.48 (0.06-3.79)	0.49
Indoor sports	77	4 (5.2%)	1.26 (0.29-5.47)	0.75
Visit recreational park	66	3 (4.5%)	1.45 (0.31-6.76)	0.64
Frequency of using public transportation in the past week [b]				0.95
0 days	316	16 (5.1%)	1	
1-2 days	76	3 (3.9%)	0.81 (0.20-3.26)	
3-4 days	29	0 (0%)	Omitted	

5-7 days	27	3 (11.1%)	1.06 (0.25-4.42)	
Number of unique visitors at home in the past week [b]				0.27
0	217	12 (5.5%)	1	
1	80	2 (2.5%)	0.37 (0.07-1.92)	
2-4	119	6 (5.0%)	1.07 (0.31-3.68)	
5+	30	2 (6.7%)	3.68 (0.53-25.58)	
Travelled abroad in 2020 [b]				0.010
No	332	15 (4.5%)	1	
Yes	117	7 (6.0%)	4.06 (1.40-11.76)	

Abbreviations: CI, confidence interval; HELIUS, Healthy Life in an Urban Setting; OR, odds ratio

[a] Those with an equivocal test result were excluded from this analysis [b] Measured at COVID-1 visit (2020) [c] Measured at baseline (2011-2015) [d] Quartiles [e] Presumed higher exposure categories had priority, i.e. if someone was working in a school and as a careworker, they were categorized as a health worker. Caretakers were not included as a category because many had other jobs.

In multivariable analysis, the distribution of occupational level and number of times left home were skewed to mostly one group and hence were not included. The following variables were removed as they were no longer significant in the multivariable model: job setting (P=0.84), leaving home to care for someone (0.32), else dichotomized household size (0.18).

Table S4. Univariable analysis of potential determinants of SARS-CoV-2 seropositivity in African Surinamese participants, Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	Number per category	Number with antibodies (%)	OR (95% CI)[a]	*P*-value
Sex				0.70
Male	163	7 (4.3%)	1	
Female	237	15 (6.3%)	0.76 (0.20-2.98)	
Per year increase in age in years on 1 January 2020[c]			0.94 (0.88-1.00)	0.063
Migration generation				0.030
1st			1	
2nd			3.97 (1.11-14.28)	
Month of study visit[b]				0.020
June	31	1 (3.2%)	1	
July	199	17 (8.5%)	4.80 (0.57-40.24)	
August	109	2 (1.8%)	0.35 (0.03-4.03)	
September	54	1 (1.9%)	0.83 (0.05-13.72)	
October	7	1 (14.3%)	3.42 (0.18-64.59)	
City district[c]				0.50
Centre	15	1 (6.7%)	1	
East	81	5 (6.2%)	0.93 (0.10-8.7)	
West	34	1 (2.9%)	0.25 (0.02-4.36)	
South	28	1 (3.6%)	2.04 (0.12-35.25)	
New-West	49	3 (6.1%)	0.92 (0.09-9.58)	
Southeast	190	11 (5.8%)	2.04 (0.22-19.04)	
Other	1	0 (0%)	Omitted	
Has obesity (BMI≥30.0)[c]				0.88
No	312	15 (4.8%)	1	
Yes	87	7 (8.0%)	0.92 (0.3-2.81)	
Educational level[c]				0.78
No school/elementary school	14	1 (7.1%)	1	
Lower vocational/ lower secondary school	118	7 (5.9%)	2.66 (0.24-28.99)	
Intermediary vocational/ intermediary secondary school	142	9 (6.3%)	1.54 (0.16-14.82)	
Higher vocational/university	124	5 (4.0%)	1.22 (0.12-12.53)	
Missing	2	0 (0%)	Omitted	
Labor participation[c]				0.016
Employed	289	14 (4.8%)	1	
Not in workforce	37	4 (10.8%)	8.09 (1.85-35.42)	
Unemployed/on benefits	46	2 (4.3%)	0.41 (0.09-2.02)	
Disabled	24	2 (8.3%)	1.26 (0.25-6.47)	
Unknown/missing	3	0 (0%)	Omitted	
Elementary occupation[c]				0.081
No	350	18 (5.1%)	1	
Yes	22	2 (9.1%)	1.83 (0.38-8.82)	
Missing	28	2 (7.1%)	6.64 (1.25-35.31)	
Difficulty with Dutch language[c]				0.21
No	353	20 (5.7%)	1	
Yes	45	2 (4.4%)	0.36 (0.07-1.78)	
Health literacy (SBSQ)[c]				0.98
Adequate	393	21 (5.3%)	1	
Low	7	1 (14.3%)	1.03 (0.10-10.43)	

Job setting[b,e]				0.046
No job / caretaker only	117	5 (4.3%)	1	
Job with no contact within 1.5 meter	39	1 (2.6%)	0.21 (0.02-1.93)	
Other job with contact within 1.5 meter	130	7 (5.4%)	2.20 (0.48-10.06)	
Child care/schools/higher education	42	1 (2.4%)	0.31 (0.03-2.78)	
Bar/restaurant	11	0 (0%)	Omitted	
Hospital/long-term care facility/Care worker elsewhere	61	8 (13.1%)	3.09 (0.81-11.7)	
Caretaker [b]				0.81
No	336	18 (5.4%)	1	
Yes	64	4 (6.3%)	0.85 (0.23-3.14)	
Number of people in household [c]				
1 (Lives alone)	143	2 (1.4%)	1	0.039
2	88	7 (8.0%)	12.95 (2.21-76.01)	
3	75	5 (6.7%)	17.30 (2.45-122.24)	
4	63	5 (7.9%)	6.26 (1.11-35.42)	
≥5	26	3 (11.5%)	8.09 (1.19-55.04)	
Lives with other people [b]	255	18 (7.1%)	2.19 (0.43-11.24)	0.35
Partner	163	11 (6.7%)	0.78 (0.23-2.66)	0.69
Children up to 3 years old	19	2 (10.5%)	2.09 (0.38-11.54)	0.40
Children 4 through 12 years old	44	1 (2.3%)	0.12 (0.01-0.95)	0.039
Children 13 through 17 years old	41	2 (4.9%)	0.32 (0.07-1.58)	0.16
Children 18+ years old	110	11 (10.0%)	1.22 (0.41-3.64)	0.72
Parents or parents-in-law	11	2 (18.2%)	1.63 (0.3-9.04)	0.57
Other adults	27	4 (14.8%)	9.34 (1.7-51.41)	0.010
Household member/steady partner with suspected infection [b]				<0.001
N.A./No	367	11 (3.0%)	1	
Yes	33	11 (33.3%)	20.08 (4.98-80.9)	
Number of times left home in the past week [b,d]				0.38
0-7	143	10 (7.0%)	1.52 (0.32-7.21)	
8-11	96	7 (7.3%)	0.40 (0.08-2.07)	
12-16	78	3 (3.8%)	0.34 (0.05-2.27)	
17+	83	2 (2.4%)	1.52 (0.32-7.21)	
In the past week, left home to [b]**:**				
Work	187	11 (5.9%)	2.51 (0.81-7.73)	0.11
Do groceries	364	17 (4.7%)	0.22 (0.05-1.00)	0.049
Visit family or friends	190	11 (5.8%)	2.53 (0.86-7.43)	0.092
Walk the dog or go outside with kids	58	2 (3.4%)	0.68 (0.13-3.55)	0.64
Walk or exercise outside	234	6 (2.6%)	0.08 (0.03-0.26)	<0.001
Take care of someone	51	2 (3.9%)	0.35 (0.07-1.74)	0.20
Pick up prescription medicines or visit	97	7 (7.2%)	0.90 (0.28-2.95)	0.86
Attend religious services	13	2 (15.4%)	1.26 (0.23-6.86)	0.79
Visit cultural place	16	1 (6.3%)	0.29 (0.03-2.49)	0.26
Visit bar or restaurant	88	3 (3.4%)	0.17 (0.05-0.67)	0.011
Indoor sports	51	2 (3.9%)	0.75 (0.15-3.72)	0.73
Visit recreational park	67	3 (4.5%)	0.65 (0.12-3.47)	0.61
Frequency of using public transportation in the past week [b]				0.13
0 days	211	12 (5.7%)	1	
1-2 days	111	5 (4.5%)	0.29 (0.08-1.04)	
3-4 days	45	3 (6.7%)	0.44 (0.10-1.98)	
5-7 days	32	2 (6.3%)	1.88 (0.27-13.04)	

Number of unique visitors at home in the past week [b]				0.029
0	189	10 (5.3%)	1	
1	81	3 (3.7%)	0.54 (0.13-2.20)	
2-4	97	6 (6.2%)	4.68 (1.32-16.65)	
5+	31	3 (9.7%)	2.86 (0.54-15.15)	
Travelled abroad in 2020 [b]				0.12
No	269	12 (4.5%)	1	
Yes	129	10 (7.8%)	2.76 (0.77-9.89)	

Abbreviations: CI, confidence interval; HELIUS, Healthy Life in an Urban Setting; OR, odds ratio

[a] Those with an equivocal test result were excluded from this analysis [b] Measured at COVID-1 visit (2020) [c] Measured at baseline (2011-2015) [d] Quartiles [e] Presumed higher exposure categories had priority, i.e. if someone was working in a school and as a careworker, they were categorized as a health worker. Caretakers were not included as a category because many had other jobs.

In multivariable analysis, the distribution of migration generation was skewed to mostly one group and hence were not included. The ORs for having a household member suspected of infection, walk or exercise outside, living with a child 4-12 years old, leaving home to visit bar or restaurant, and household size were extremely high with overinflated 95%CI, and hence were not included. The following variables were removed as they were no longer significant in the multivariable model: leaving home to work (*P*=0.97), traveling with public transport (0.71), leaving home to care for someone (0.63), visiting friends or family (0.53), occupational level (0.28), travelling abroad (0.22), leaving home to do groceries (0.14), labor participation (0.091), age (0.058), living with a child 13-17 years old (0.054).

Table S5. Univariable analysis of potential determinants of SARS-CoV-2 seropositivity in Ghanaian participants, Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	Number per category	Number with antibodies (%)	OR (95% CI)[a]	*P*-value
Sex				0.46
Male	143	40 (28.0%)	1	
Female	184	55 (29.9%)	1.25 (0.69-2.29)	
Per year increase in age in years on 1 January 2020[c]			1.02 (0.99-1.05)	0.12
Migration generation				
1st	321	95 (29.6%)	Omitted	
2nd	6	0 (0%)	Omitted	
Month of study visit[b]				0.026
June	0		Omitted	
July	38	6 (15.8%)	1	
August	133	47 (35.3%)	4.13 (1.43-11.9)	
September	123	35 (28.5%)	2.06 (0.72-5.92)	
October	33	7 (21.2%)	1.57 (0.41-5.99)	
City district[c]	38	6 (15.8%)		0.10
Centre	5	0 (0%)	Omitted	
East	25	4 (16.0%)	1.02 (0.19-5.41)	
West	19	4 (21.1%)	3.74 (0.52-26.92)	
South	8	2 (25.0%)	1.49 (0.27-8.38)	
New-West	17	4 (23.5%)	3.33 (1-11.11)	
Southeast	251	81 (32.3%)	1.02 (0.19-5.41)	
Other	0		Omitted	
Has obesity (BMI≥30.0)[c]				0.77
No	225	66 (29.3%)	1	
Yes	97	28 (28.9%)	0.90 (0.45-1.81)	
Educational level[c]				0.23
No school/elementary school	78	26 (33.3%)	1	
Lower vocational/ lower secondary school	127	36 (28.3%)	0.70 (0.33-1.50)	
Intermediary vocational/ intermediary secondary school	72	20 (27.8%)	0.39 (0.18-0.86)	
Higher vocational/university	26	7 (26.9%)	0.75 (0.23-2.47)	
Missing	24	6 (25.0%)		
Labor participation[c]				0.82
Employed	202	60 (29.7%)	1	
Not in workforce	10	2 (20.0%)	0.51 (0.09-3.08)	
Unemployed/on benefits	59	17 (28.8%)	1.34 (0.61-2.95)	
Disabled	28	8 (28.6%)	0.8 (0.32-2.01)	
Unknown/missing	28	8 (28.6%)	1.01 (0.39-2.58)	
Elementary occupation[c]				0.33
No	107	36 (33.6%)	1	
Yes	162	43 (26.5%)	1.29 (0.68-2.44)	
Missing	58	16 (27.6%)	0.75 (0.31-1.81)	
Difficulty with Dutch language[c]				0.010
No	40	9 (22.5%)	1	
Yes	263	80 (30.4%)	3.21 (1.32-7.78)	
Health literacy (SBSQ)[c]				0.74
Adequate	207	59 (28.5%)	1	
Low	97	30 (30.9%)	1.12 (0.58-2.15)	

Job setting[b,e]				0.85
No job / caretaker only	89	20 (22.5%)	1	
Job with no contact within 1.5 meter	65	19 (29.2%)	1.66 (0.69-3.99)	
Other job with contact within 1.5 meter	114	36 (31.6%)	1.56 (0.71-3.43)	
Child care/schools/higher education	10	3 (30.0%)	1.93 (0.25-15.1)	
Bar/restaurant	23	7 (30.4%)	1.49 (0.44-4.96)	
Hospital/long-term care facility/Care worker elsewhere	25	9 (36.0%)	1.11 (0.37-3.28)	
Caretaker [b]				0.71
No	307	89 (29.0%)	1	
Yes	19	5 (26.3%)	0.80 (0.25-2.59)	
Number of people in household [c]				0.06
1 (Lives alone)	46	6 (13%)	1	
2	61	18 (30%)	1.85 (0.63-5.50)	
3	69	19 (28%)	1.88 (0.62-5.70)	
4	69	23 (33%)	2.86 (0.96-8.48)	
≥5	55	21 (38%)	5.02 (1.59-15.86)	
Lives with other people [b]	268	77 (28.7%)	0.94 (0.47-1.91)	0.87
Partner	124	38 (30.6%)	1.28 (0.68-2.39)	0.45
Children up to 3 years old	26	11 (42.3%)	2.54 (1.00-6.46)	0.050
Children 4 through 12 years old	81	25 (30.9%)	1.17 (0.59-2.33)	0.65
Children 13 through 17 years old	76	28 (36.8%)	1.97 (1.02-3.80)	0.045
Children 18+ years old	114	37 (32.5%)	1.52 (0.84-2.73)	0.16
Parents or parents-in-law	8	0 (0%)	Omitted	
Other adults	58	19 (32.8%)	1.08 (0.51-2.30)	0.83
Household member/steady partner with suspected infection [b]				0.79
N.A./No	311	75 (28.0%)	1	
Yes	15	4 (26.7%)	1.20 (0.30-4.78)	
Number of times left home in the past week [b,d]				0.87
0-7	120	34 (28.3%)	1	
8-11	118	33 (28.0%)	0.90 (0.45-1.77)	
12-16	58	16 (27.6%)	1.07 (0.43-2.63)	
17+	30	11 (36.7%)	0.67 (0.24-1.89)	
In the past week, left home to [b]**:**				
Work	192	66 (34.4%)	1.91 (1.01-3.60)	0.045
Do groceries	294	84 (28.6%)	1.29 (0.54-3.09)	0.56
Visit family or friends	81	21 (25.9%)	0.40 (0.21-0.78)	0.007
Walk the dog or go outside with kids	22	10 (45.5%)	2.27 (0.87-5.95)	0.09
Walk or exercise outside	207	58 (28.0%)	0.75 (0.40-1.40)	0.37
Take care of someone	14	4 (28.6%)	1.22 (0.36-4.08)	0.75
Pick up prescription medicines or visit	70	20 (28.6%)	0.82 (0.39-1.74)	0.61
Attend religious service	128	49 (38.3%)	2.76 (1.49-5.11)	0.001
Visit cultural place	3	1 (33.3%)	0.51 (0.04-5.91)	0.59
Visit bar or restaurant	19	4 (21.1%)	0.35 (0.11-1.15)	0.082
Indoor sports	27	10 (37.0%)	0.79 (0.30-2.10)	0.63
Visit recreational park	17	4 (23.5%)	0.79 (0.14-4.45)	0.79
Frequency of using public transportation in the past week [b]				0.90
0 days	116	31 (26.7%)	1	
1-2 days	73	20 (27.4%)	0.73 (0.31-1.72)	
3-4 days	38	13 (34.2%)	1.01 (0.40-2.56)	
5-7 days	98	30 (30.6%)	0.91 (0.43-1.93)	

Number of unique visitors at home in the past week [b]				0.29
0	238	71 (29.8%)	1	
1	41	7 (17.1%)	0.47 (0.19-1.20)	
2-4	40	14 (35.0%)	0.57 (0.25-1.29)	
5+	6	2 (33.3%)	1.02 (0.17-5.93)	
Travelled abroad in 2020 [b]				0.020
No	252	76 (30.2%)	1	
Yes	72	18 (25.0%)	0.44 (0.22-0.88)	

Abbreviations: CI, confidence interval; HELIUS, Healthy Life in an Urban Setting; OR, odds ratio

[a] Those with an equivocal test result were excluded from this analysis [b] Measured at COVID-1 visit (2020) [c] Measured at baseline (2011-2015) [d] Quartiles [e] Presumed higher exposure categories had priority, i.e. if someone was working in a school and as a careworker, they were categorized as a health worker. Caretakers were not included as a category because many had other jobs.

In multivariable analysis, the following variables were removed as they were no longer significant in the multivariable model: living with a child 18+ years old (*P*=0.92), leaving home to visit bar or restaurant (0.91), travelling abroad (0.66), living with a child 13-17 years old (0.51), visiting friends or family (0.22), walk the dog or go outside with kids (0.15), difficulty with Dutch language (0.11), district (0.09).

Table S6. Univariable analysis of potential determinants of SARS-CoV-2 seropositivity in Turkish participants, Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	Number per category	Number with antibodies (%)	OR (95% CI)[a]	*P*-value
Sex				0.63
Male	183	14 (7.7%)	1	
Female	225	16 (7.1%)	1.23 (0.53-2.90)	
Per year increase in age in years on 1 January 2020[c]			0.97 (0.93-1.01)	0.15
Migration generation				0.24
1st	306	20 (6.5%)	1	
2nd	102	10 (9.8%)	1.67 (0.71-3.89)	
Month of study visit[b]				0.40
June	0		Omitted	
July	151	9 (6.0%)	1	
August	88	5 (5.7%)	0.38 (0.10-1.45)	
September	126	13 (10.3%)	1.11 (0.41-2.99)	
October	43	3 (7.0%)	1.18 (0.27-5.13)	
City district[c]				0.056
Centre	3	0 (0%)	1	
East	66	10 (15.2%)	0.87 (0.27-2.75)	
West	66	8 (12.1%)	0.40 (0.06-2.79)	
South	30	2 (6.7%)	0.23 (0.08-0.67)	
New-West	231	9 (3.9%)	1.22 (0.12-12.99)	
Southeast	6	1 (16.7%)	0.87 (0.27-2.75)	
Other	0		Omitted	
Has obesity (BMI≥30.0)[c]				0.41
No	288	22 (7.6%)	1	
Yes	114	7 (6.1%)	1.5 (0.58-3.92)	
Educational level[c]				0.95
No school/elementary school	78	6 (7.7%)	1	
Lower vocational/ lower secondary school	84	8 (9.5%)	1.41 (0.41-4.85)	
Intermediary vocational/ intermediary secondary school	124	9 (7.3%)	1.17 (0.36-3.83)	
Higher vocational/university	107	7 (6.5%)	1.39 (0.38-5.06)	
Missing	15	0 (0%)	Omitted	
Labor participation[c]				0.76
Employed	246	17 (6.9%)	1	
Not in workforce	59	8 (13.6%)	1.68 (0.63-4.46)	
Unemployed/on benefits	62	4 (6.5%)	1.23 (0.37-4.09)	
Disabled	27	1 (3.7%)	0.82 (0.10-6.71)	
Unknown/missing	14	0 (0%)	Omitted	
Elementary occupation[c]				0.47
No	272	17 (6.3%)	1	
Yes	52	4 (7.7%)	2.08 (0.61-7.15)	
Missing	84	9 (10.7%)	1.41 (0.54-3.66)	
Difficulty with Dutch language[c]				0.96
No	188	12 (6.4%)	1	
Yes	206	17 (8.3%)	1.02 (0.42-2.46)	
Health literacy (SBSQ)[c]				0.88
Adequate	309	21 (6.8%)	1	
Low	87	9 (10.3%)	1.07 (0.43-2.66)	

Job setting[b,e]				1.00
No job / caretaker only	138	9 (6.5%)	1	
Job with no contact within 1.5 meter	67	5 (7.5%)	1.01 (0.27-3.69)	
Other job with contact within 1.5 meter	129	8 (6.2%)	0.87 (0.30-2.57)	
Child care/schools/higher education	25	2 (8.0%)	1.02 (0.14-7.45)	
Bar/restaurant	6	1 (16.7%)	0.99 (0.10-10.17)	
Hospital/long-term care facility/Care worker elsewhere	41	5 (12.2%)	1.18 (0.32-4.38)	
Caretaker [b]				0.076
No	362	23 (6.4%)	1	
Yes	44	7 (15.9%)	2.63 (0.9-7.67)	
Number of people in household [c]				0.43
1 (Lives alone)	53	2 (3.8%)	1	
2	67	2 (3.0%)	1.45 (0.19-11.11)	
3	81	5 (6.2%)	2.17 (0.37-12.65)	
4	113	10 (8.8%)	2.71 (0.53-13.80)	
≥5	81	10 (12.3%)	4.11 (0.82-20.64)	
Lives with other people [b]	345	27 (7.8%)	1.00 (0.26-3.77)	1.00
Partner	269	21 (7.8%)	0.98 (0.40-2.38)	0.96
Children up to 3 years old	38	3 (7.9%)	1.46 (0.40-5.32)	0.56
Children 4 through 12 years old	84	6 (7.1%)	0.67 (0.23-2.00)	0.48
Children 13 through 17 years old	76	6 (7.9%)	0.92 (0.32-2.66)	0.88
Children 18+ years old	172	14 (8.1%)	1.29 (0.55-3.00)	0.56
Parents or parents-in-law	31	3 (9.7%)	0.76 (0.21-2.81)	0.68
Other adults	18	2 (11.1%)	1.58 (0.32-7.89)	0.58
Household member/steady partner with suspected infection [b]				<0.001
N.A./No	359	16 (4.5%)	1	
Yes	46	14 (30.4%)	9.15 (3.7-22.63)	
Number of times left home in the past week [b,d]				0.73
0-7	106	6 (5.7%)	1	
8-11	97	10 (10.3%)	1.69 (0.51-5.57)	
12-16	103	7 (6.8%)	0.92 (0.25-3.40)	
17+	100	7 (7.0%)	1.20 (0.33-4.37)	
In the past week, left home to [b]**:**				
Work	190	19 (10.0%)	1.59 (0.66-3.83)	0.30
Do groceries	360	27 (7.5%)	2.21 (0.56-8.73)	0.26
Visit family or friends	215	17 (7.9%)	1.14 (0.48-2.67)	0.77
Walk the dog or go outside with kids	79	5 (6.3%)	0.41 (0.13-1.27)	0.12
Walk or exercise outside	264	23 (8.7%)	3.53 (1.41-8.83)	0.007
Take care of someone	37	5 (13.5%)	2.07 (0.66-6.46)	0.21
Pick up prescription medicines or visit	84	8 (9.5%)	1.38 (0.53-3.61)	0.51
Attend religious service	62	5 (8.1%)	0.73 (0.26-2.10)	0.56
Visit cultural place	14	3 (21.4%)	3.81 (0.77-18.83)	0.10
Visit bar or restaurant	127	9 (7.1%)	0.76 (0.29-2.02)	0.58
Indoor sports	42	6 (14.3%)	1.81 (0.58-5.67)	0.31
Visit recreational park	81	7 (8.6%)	0.97 (0.35-2.68)	0.95
Frequency of using public transportation in the past week [b]				0.13
0 days	307	19 (6.2%)	1	
1-2 days	72	7 (9.7%)	2.76 (1.01-7.51)	
3-4 days	14	2 (14.3%)	3.35 (0.64-17.39)	
5-7 days	13	2 (15.4%)	2.72 (0.47-15.72)	

Number of unique visitors at home in the past week [b]				0.055
0	207	18 (8.7%)	1	
1	48	1 (2.1%)	0.09 (0.01-0.69)	
2-4	109	8 (7.3%)	0.96 (0.34-2.68)	
5+	41	3 (7.3%)	0.33 (0.09-1.25)	
Travelled abroad in 2020 [b]				0.73
No	234	17 (7.3%)	1	
Yes	172	13 (7.6%)	1.17 (0.49-2.78)	

Abbreviations: CI, confidence interval; HELIUS, Healthy Life in an Urban Setting; OR, odds ratio

[a] Those with an equivocal test result were excluded from this analysis [b] Measured at COVID-1 visit (2020) [c] Measured at baseline (2011-2015) [d] Quartiles [e] Presumed higher exposure categories had priority, i.e. if someone was working in a school and as a careworker, they were categorized as a health worker. Caretakers were not included as a category because many had other jobs.

In multivariable analysis, the following variables were removed as they were no longer significant in the multivariable model: visit cultural place (P=0.89), walk the dog or go outside with kids (0.38), being a caretaker (0.27), number of unique visitors past week (0.26), age (0.20), household size (0.12), district (0.11)

Table S7. Univariable analysis of potential determinants of SARS-CoV-2 seropositivity in Moroccan participants, Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	Number per category	Number with antibodies (%)	OR (95% CI)[a]	*P*-value
Sex				0.093
Male	172	11 (6.4%)	1	
Female	219	21 (9.6%)	2.26 (0.87-5.86)	
Per year increase in age in years on 1 January 2020[c]			1.00 (0.96-1.03)	0.90
Migration generation				0.23
1st	297	23 (7.7%)	1	
2nd	94	9 (9.6%)	1.74 (0.71-4.25)	
Month of study visit[b]				0.24
June	32	4 (12.5%)	1	
July	168	7 (4.2%)	0.41 (0.09-1.79)	
August	85	7 (8.2%)	0.72 (0.17-3.06)	
September	74	12 (16.2%)	1.66 (0.4-6.85)	
October	32	2 (6.3%)	0.78 (0.12-5.00)	
City district[c]				0.040
Centre	12	2 (16.7%)	1	
East	94	10 (10.6%)	0.83 (0.15-4.76)	
West	82	10 (12.2%)	1.77 (0.30-10.35)	
South	38	2 (5.3%)	0.32 (0.03-2.98)	
New-West	145	8 (5.5%)	0.34 (0.06-1.99)	
Southeast	19	0 (0%)	Omitted	
Other	1	0 (0%)	Omitted	
Has obesity (BMI≥30.0)[c]				0.96
No	288	25 (8.7%)		
Yes	96	7 (7.3%)	1.03 (0.37-2.90)	
Educational level[c]				0.072
No school/elementary school	89	6 (6.7%)	1	
Lower vocational/ lower secondary school	64	4 (6.3%)	1.30 (0.34-5.00)	
Intermediary vocational/ intermediary secondary school	123	11 (8.9%)	1.47 (0.48-4.47)	
Higher vocational/university	94	7 (7.4%)	1.39 (0.41-4.72)	
Missing	21	4 (19.0%)	8.52 (1.92-37.78)	
Labor participation[c]				0.011
Employed	227	16 (7.0%)	1	
Not in workforce	63	5 (7.9%)	1.48 (0.49-4.47)	
Unemployed/on benefits	56	4 (7.1%)	1.03 (0.3-3.48)	
Disabled	22	2 (9.1%)	1.01 (0.19-5.5)	
Unknown/missing			9.2 (2.68-31.54)	
Elementary occupation[c]				0.003
No	259	16 (6.2%)	1	
Yes	46	4 (8.7%)	1.49 (0.45-4.99)	
Missing	86	12 (14.0%)	4.69 (1.93-11.43)	
Difficulty with Dutch language[c]				0.33
No	210	14 (6.7%)	1	
Yes	160	14 (8.8%)	1.53 (0.65-3.62)	
Health literacy (SBSQ)[c]				0.50
Adequate	305	21 (6.9%)	1	
Low	64	7 (10.9%)	1.39 (0.54-3.58)	

Job setting[b,e]				0.017
No job / caretaker only	131	12 (9.2%)	1	
Job with no contact within 1.5 meter	54	7 (13.0%)	0.82 (0.27-2.47)	
Other job with contact within 1.5 meter	113	3 (2.7%)	0.15 (0.04-0.64)	
Child care/schools/higher education	48	8 (16.7%)	2.15 (0.68-6.80)	
Bar/restaurant	7	1 (14.3%)	0.88 (0.09-8.16)	
Hospital/long-term care facility/Care worker elsewhere	35	1 (2.9%)	0.13 (0.02-1.08)	
Caretaker [b]				0.42
No	335	26 (7.8%)	1	
Yes	53	6 (11.3%)	1.59 (0.51-4.90)	
Number of people in household [c]				0.41
1 (Lives alone)	52	4 (7.7%)	1	
2	64	1 (1.6%)	0.24 (0.03-2.26)	
3	40	3 (7.5%)	0.56 (0.11-2.76)	
4	71	8 (11.3%)	1.47 (0.39-5.51)	
≥5	142	12 (8.5%)	1.20 (0.34-4.17)	
Lives with other people [b]	318	27 (8.5%)	1.09 (0.32-3.72)	0.90
Partner	256	22 (8.6%)	0.85 (0.34-2.12)	0.72
Children up to 3 years old	48	5 (10.4%)	1.19 (0.41-3.45)	0.74
Children 4 through 12 years old	104	10 (9.6%)	1.16 (0.47-2.84)	0.75
Children 13 through 17 years old	114	11 (9.6%)	1.06 (0.44-2.53)	0.90
Children 18+ years old	149	15 (10.1%)	0.94 (0.41-2.15)	0.89
Parents or parents-in-law	21	2 (9.5%)	1.76 (0.36-8.69)	0.49
Other adults	22	3 (13.6%)	2.99 (0.74-12.08)	0.12
Household member/steady partner with suspected infection [b]				<0.001
N.A./No	336	18 (5.4%)	1	
Yes	51	14 (27.5%)	5.14 (2.06-12.82)	
Number of times left home in the past week [b,d]				0.020
0-7	99	15 (15.2%)	1	
8-11	89	5 (5.6%)	0.20 (0.06-0.65)	
12-16	88	7 (8.0%)	0.33 (0.11-0.97)	
17+	113	5 (4.4%)	0.28 (0.08-1.00)	
In the past week, left home to [b]**:**				
Work	171	9 (5.3%)	0.46 (0.17-1.28)	0.14
Do groceries	363	28 (7.7%)	0.40 (0.11-1.37)	0.14
Visit family or friends	226	15 (6.6%)	0.50 (0.21-1.19)	0.12
Walk the dog or go outside with kids	77	6 (7.8%)	0.98 (0.31-3.13)	0.97
Walk or exercise outside	268	19 (7.1%)	1.02 (0.43-2.4)	0.96
Take care of someone	57	5 (8.8%)	0.90 (0.30-2.68)	0.84
Pick up prescription medicines or visit	89	9 (10.1%)	1.25 (0.44-3.56)	0.68
Attend religious service	32	2 (6.3%)	0.58 (0.12-2.82)	0.50
Visit cultural place	15	0 (0%)	Omitted	
Visit bar or restaurant	130	9 (6.9%)	0.90 (0.33-2.44)	0.84
Indoor sports	42	4 (9.5%)	1.32 (0.29-6.10)	0.72
Visit recreational park	94	5 (5.3%)	0.55 (0.19-1.60)	0.27
Frequency of using public transportation in the past week [b]				0.18
0 days	256	22 (8.6%)	1	
1-2 days	90	6 (6.7%)	0.41 (0.15-1.13)	
3-4 days	25	3 (12.0%)	0.58 (0.15-2.19)	
5-7 days	18	1 (5.6%)	0.20 (0.03-1.66)	

Number of unique visitors at home in the past week [b]				0.11
0	206	22 (10.7%)	1	
1	45	1 (2.2%)	0.13 (0.02-1.02)	
2-4	102	7 (6.9%)	1.08 (0.39-3.01)	
5+	34	2 (5.9%)	0.29 (0.06-1.35)	
Travelled abroad in 2020 [b]				0.11
No	228	15 (6.6%)	1	
Yes	160	16 (10.0%)	1.99 (0.85-4.67)	

Abbreviations: CI, confidence interval; HELIUS, Healthy Life in an Urban Setting; OR, odds ratio

[a] Those with an equivocal test result were excluded from this analysis [b] Measured at COVID-1 visit (2020) [c] Measured at baseline (2011-2015) [d] Quartiles [e] Presumed higher exposure categories had priority, i.e. if someone was working in a school and as a careworker, they were categorized as a health worker. Caretakers were not included as a category because many had other jobs.

In multivariable analysis, the distribution of district was skewed to mostly one group and hence were not included. The following variables were removed as they were no longer significant in the multivariable model: sex (*P*=0.93), living with other adults (0.83), number of unique visitors past week (0.82), leaving home to work (0.54), labor participation (0.57), visiting friends or family (0.87), education level (0.88), job setting (0.56), travelling abroad (0.28), groceries (0.30), number of time left house (0.12).

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*9, 10*
Bias	9	Describe any efforts to address potential sources of bias	8,9,10
Study size	10	Explain how the study size was arrived at	8,11
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9,10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9,10
		(*b*) Describe any methods used to examine subgroups and interactions	n.a.
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	9
		(*e*) Describe any sensitivity analyses	n.a.
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11
		(b) Give reasons for non-participation at each stage	11
		(c) Consider use of a flow diagram	11
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11
		(b) Indicate number of participants with missing data for each variable of interest	Table 1,2
Outcome data	15*	Report numbers of outcome events or summary measures	15
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	15,18

		(*b*) Report category boundaries when continuous variables were categorized	17
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n.a.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	n.a.
Discussion			
Key results	18	Summarise key results with reference to study objectives	19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	22
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	19-23
Generalisability	21	Discuss the generalisability (external validity) of the study results	22
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	24

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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SARS-CoV-2 antibody prevalence and correlates of six ethnic groups living in Amsterdam, the Netherlands: a population-based cross-sectional study, June-October 2020

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SARS-CoV-2 antibody prevalence and correlates of six ethnic groups living in Amsterdam, the Netherlands: a population-based cross-sectional study, June-October 2020

Running title

SARS-CoV-2 seroprevalence and ethnicity

Authors

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Keywords

HELIUS study; SARS-CoV-2; COVID-19; infection, seroprevalence; serology, antibody; ethnicity

ABSTRACT

Objectives

It has been suggested that ethnic minorities have been disproportionally affected by the coronavirus disease 2019 (COVID-19). We aimed to determine whether prevalence and correlates of past SARS-CoV-2 exposure varied between six ethnic groups in Amsterdam, the Netherlands.

Design, setting, participants

Participants aged 25-79 years enrolled in the HELIUS population-based prospective cohort (N=16,889) were randomly selected within ethnic groups and invited to participate in a cross-sectional COVID-19 seroprevalence substudy.

Outcome measures

We tested participants for SARS-CoV-2-specific antibodies and collected information on SARS-CoV-2 exposures. We estimated prevalence and correlates of SARS-CoV-2 exposure within ethnic groups using survey-weighted logistic regression adjusting for age, sex and calendar time.

Results

Between June 24-October 9, 2020, we included 2497 participants. Adjusted SARS-CoV-2 seroprevalence was comparable between ethnic-Dutch (24/498; 5.1%, 95%CI=2.8-7.4), South-Asian Surinamese (22/451; 4.9%, 95%CI=2.2-7.7), African Surinamese (22/400; 8.3%, 95%CI=3.1-13.6), Turkish (30/408; 7.9%, 95%CI=4.4-11.4) and Moroccan (32/391; 7.2%, 95%CI=4.2-10.1) participants, but higher among Ghanaians (95/327; 26.3%, 95%CI=18.5-34.0). 57.1% of SARS-CoV-2-positive participants did not suspect or were unsure of being infected, which was lowest in African Surinamese (18.2%) and highest in Ghanaians (90.5%). Correlates of SARS-CoV-2 exposure varied across ethnic groups, while the most common correlate was having a household member suspected

of infection. In Ghanaians, seropositivity was associated with older age, larger household sizes, living with small children, leaving home to work and attending religious services.

Conclusions

No remarkable differences in SARS-CoV-2 seroprevalence were observed between the largest ethnic groups in Amsterdam after the first wave of infections. The higher infection seroprevalence observed among Ghanaians, which passed mostly unnoticed, warrants wider prevention efforts and opportunities for non-symptom-based testing.

ARTICLE SUMMARY

Strengths and limitations of the study

- Our study used data from a large population-based sample, including participants belonging to most major ethnic groups in Amsterdam (i.e. South-Asian Surinamese, African Surinamese, Ghanaian, Turkish, Moroccan).
- We measured SARS-CoV-2 antibodies in participants regardless of COVID-19-related symptoms and obtained individual-level data on correlates of infection.
- Although response rates varied between ethnic groups, the characteristics of included individuals were largely similarly distributed to thlose non-included.
- Our study did not include undocumented people and people from other ethnic groups.

INTRODUCTION

Data from the United Kingdom (UK) and United States (US) suggest that certain ethnic minority populations have been disproportionally affected by the coronavirus disease 2019 (COVID-19), caused by SARS-CoV-2. In both countries, a relatively higher number of SARS-CoV-2 polymerase chain reaction (PCR)-positive or clinically-diagnosed COVID-19 cases were observed among ethnic minority groups, particularly people of African and Asian descent.[1-3] The underlying causes for these disparities might include work-related exposure, housing conditions, access to healthcare, help-seeking behavior, and language proficiency.[4-6]

Little is known about ethnic differences in SARS-CoV-2 infections outside the UK and US. This is of particular concern for larger cities in Europe, including the Dutch capital Amsterdam, where half the population comprises migrants, including people with foreign-born parents.[7] Amsterdam witnessed its first confirmed case of SARS-CoV-2 on February 29, 2020 and by December 31, 2020, there were more than 50,000 confirmed infections, 1300 COVID-19-related hospitalizations and 500 COVID-19-related deaths.[8] During the first wave of COVID-19, COVID-19-related hospitalization rates were higher in individuals who have migrated from lower and middle income countries compared to ethnic-Dutch individuals in Amsterdam, with the highest rates observed in individuals of Ghanaian or Turkish ethnic origin.[9] However, it was unclear if these differences resulted from differences in acquiring infection, differences in disease severity after infection, or both. If SARS-CoV-2 infection prevalence is increased in specific ethnic groups, targeted prevention measures could be instated or improved to help minimize the risk of further transmission.

Ethnic differences in SARS-CoV-2 infection prevalence could be studied using COVID-19 notification registries.[10] However, since the testing policy in the Netherlands has changed several times and until June 1, 2020, testing was largely restricted to symptomatic health care workers or those living or working in long-term care facilities, these data are prone to differential testing uptake.[9] Ethnic differences in testing uptake could be further exacerbated by testing access,

willingness to test and disease perceptions.[4,11-13] Another limitation of registries is that migration background is often missing. Other data are therefore needed to estimate seroprevalence within specific ethnic groups in Amsterdam.

The Healthy life in an Urban Setting (HELIUS) study is a large, population-based cohort study among six different ethnic groups, which was established with the aim to investigate mechanisms underlying the impact of ethnicity on communicable and non-communicable diseases.[14] From individuals actively enrolled in this study, we determined the prevalence and correlates of exposure to SARS-CoV-2 between the largest ethnic groups in Amsterdam.

METHODS

Study design and population

The HELIUS study is a multiethnic cohort study conducted in Amsterdam, the Netherlands, which focuses on cardiovascular disease, mental health, and infectious diseases. Detailed procedures have been previously described.[14] Briefly, HELIUS includes persons of Dutch, South-Asian Surinamese, African Surinamese, Ghanaian, Moroccan, and Turkish origin, aged between 18 and 70 years at inclusion. A random sample of persons, stratified by ethnic origin, was taken from the municipality register of Amsterdam and subjects were invited to participate. Between January 2011 and December 2015, a total of 24,789 individuals were included.[14] Participants filled in a self-administered questionnaire and underwent a physical examination during which biological samples were obtained. Ethical approval for the HELIUS study was obtained from the Academic Medical Center Ethical Review Board. All participants provided written informed consent.

Ethnicity was defined according to the country of birth of the participant and their parents.[14] Participants were considered to be of non-Dutch ethnic origin if (i) they were born abroad and had at least one parent born abroad (first generation) or (ii) they were born in Netherlands but both their parents were born abroad (second generation). Participants of Dutch origin were born in the Netherlands with both parents who were born in the Netherlands. Surinamese participants were further classified as African Surinamese, South-Asian Surinamese, and Javanese/other/unknown Surinamese, based on self-reporting.

A cross-sectional, serological substudy was performed in participants of the HELIUS study from 24 June to 9 October 2020. HELIUS participants who were still in follow-up and belonged to one of the six ethnic groups included in the substudy (N=16,889) were randomly selected within each ethnic group and asked to participate in the substudy. Assuming a seroprevalence of 5% in the Dutch ethnic origin group, a sample size of 430 per group (N=2580) would be required to detect at least a two times higher prevalence between Dutch and a given ethnic minority group, with Type I error at

5% and power at 80%. Recruitment into the substudy continued until the target sample size of 430 per group was achieved for all groups or the recruitment period ended (October 2020). Serum samples for assessment of SARS-CoV-2 antibodies were collected by venipuncture and stored at -20°C. Trained interviewers asked participants questions on uptake of COVID-19-related prevention measures, potential exposure, infection, symptoms and disease.

Outcomes

SARS-CoV-2 exposure was determined by the presence of SARS-CoV-2 antibodies. SARS-CoV-2-specific antibodies were determined using the WANTAI SARS-CoV-2 Ab Elisa (Wantai Biological Pharmacy Enterprise Co., Beijing, China) according to the manufacturer's instructions. This Elisa detects IgA, IgM and IgG against the receptor binding domain of the S-protein of SARS-CoV-2.[15]

Correlates

We defined the following potential correlates: *from the baseline visit of the HELIUS study*– demographics (i.e. age, sex, ethnicity, migration generation, city district), socio-economic factors (i.e. educational level, working status, occupational level, number of people in household), access-to-healthcare indicators (i.e. proficiency with Dutch language, health literacy); *from the COVID-19 substudy visit*–job setting, household members, suspected being infected, thinking household member/steady partner was infected, household member hospitalized for COVID-19, type of people living in household, travelling abroad in 2020 and COVID-19 behaviors in the past week (i.e. number of times leaving the house, type of locations visited, number of visitors, frequency of using public transportation).

Statistical analysis

SARS-CoV-2 seroprevalence, along with 95% confidence intervals (CI), was modeled per ethnic group using univariable logistic regression. Seroprevalence was then modeled per ethnic group while correcting for sampling, accounting for the population structure of ethnic groups in Amsterdam (i.e. post-stratification), and adjusting for differences in age, sex and calendar time

(before/after 15 August 2020, based on the onset of the second wave of SARS-CoV-2 infections in the Netherlands[8]) between ethnic groups (Supplementary Materials). The mean and 95%CI of predicted seroprevalence was plotted over age in years.

To identify correlates of past SARS-CoV-2 infection within ethnic groups, univariable associations between potential correlates and SARS-CoV-2 seropositivity were evaluated. The odds ratios (OR) comparing the odds of seroprevalence across levels of each determinant, and their 95% confidence intervals (CI), were estimated using logistic regression. P-values were obtained using the Wald χ^2 test. All covariates with a *P*-value≤0.2 in univariable analyses were then included in a multivariable model and after assessing covariate distributions and collinearity, variables with a *P*-value≥0.05 above this threshold were removed in backwards-stepwise fashion until only variables with a *P*-value<0.05 were retained in a final multivariable model. All models included sampling and post-stratification weights. We forced calendar time in all models.

Statistical significance was defined at a *P*-value<0·05. We did not correct for multiple testing and results should be considered exploratory.[16] All analyses were conducted using Stata 15.1 (StataCorp, College Station, TX, USA).

Patient and public involvement

There was no patient or public involvement in the development of the research questions, outcome measures, study design and recruitment/conduct for the current study. However, the parent HELIUS study employed several recruitment strategies to enhance enrolment of all eligible ethnic groups, e.g. by involving faith communities (churches and mosques) and community leaders to endorse the study, conducting at-home visits to non-Dutch persons who did not respond to the written invitation letter, and by providing, upon request, additional information or assistance in completing the questionnaire from a trained ethnically matched same-sex interviewer who spoke their preferred language. Results of the current study were disseminated to the involved communities following preliminary results to improve prevention and care. HELIUS study

participants were invited for online seminars during which results were presented and discussed. Meetings were held with community leaders, general practitioners serving the population at risk, and local prevention teams. The prevention teams in turn developed prevention measures in co-creation with the community and met with key stakeholders such as employers to discuss their role.

RESULTS

Study population

Of the 16,889 HELIUS participants who were in active follow-up in 2019-2020, 11,080 (65.6%) were invited (Supplementary Figure S1). Of these, 2497 (22.5%) were included in the COVID-19 substudy. The response rate varied across ethnic groups, from 15.3-17.2% among Ghanaian, Turkish or Moroccan participants to 49.9% among Dutch participants. Detailed information on differences between HELIUS participants who were and were not invited, and between invited participants who were and were not included, are presented in Supplementary Table S1. Briefly, invited individuals who were included had obtained a slightly higher educational level, were more likely to be employed and were more likely to have adequate health literacy level compared to those who were invited but not included.

Number included per month within ethnic groups is presented in Supplementary Figure S2. Of 2497 included participants, 503 (20.1%) were of Dutch origin, 453 (18.1%) South-Asian Surinamese, 407 (16.3%) African Surinamese, 331 (13.3%) Ghanaian, 409 (16.4%) Turkish and 394 (15.8%) Moroccan (Supplementary Table S1, Table 1). The median age of included participants was 54 (interquartile range [IQR]: 44-61) and 56.6% were female. In the 1994 participants of non-Dutch origin, the percentage of first-generation migrants was lowest in the Turkish group (74.8%) and highest in the Ghanaian group (98.2%). Dutch participants were the most likely to have a higher vocational or university degree (67.0%) and be employed (75.5%) compared to other ethnicities.

Table 1. Characteristics of the HELIUS participants included in the COVID-19 study, by ethnic group (N=2497), Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	Dutch (n=503)	South-Asian Surinamese (n=453)	African Surinamese (n=407)	Ghanaian (n=331)	Turkish (n=409)	Moroccan (n=394)
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Sex						
Male	237 (47.1%)	179 (39.5%)	165 (40.5%)	145 (43.8%)	184 (45.0%)	173 (43.9%)
Female	266 (52.9%)	274 (60.5%)	242 (59.5%)	186 (56.2%)	225 (55.0%)	221 (56.1%)
Age in years on 1 January 2020, median [IQR]	57 [45-66]	56[47-63]	59 [50-65]	54 [47-59]	48 [40-56]	49 [39-56]
Migration generation						
1st	N.A.	370 (81.7%)	355 (87.2%)	325 (98.2%)	306 (74.8%)	300 (76.1%)
2nd	N.A	83 (18.3%)	52 (12.8%)	6 (1.8%)	103 (25.2%)	94 (23.9%)
City district*						
Centre	87 (17.3%)	18 (4.0%)	15 (3.7%)	5 (1.5%)	3 (0.7%)	12 (3.0%)
East	99 (19.7%)	53 (11.7%)	85 (20.9%)	25 (7.6%)	66 (16.1%)	94 (23.9%)
West	89 (17.7%)	5 (1.1%)	34 (8.4%)	19 (5.7%)	66 (16.1%)	81 (20.6%)
South	112 (22.3%)	32 (7.1%)	26 (6.4%)	8 (2.4%)	30 (7.3%)	38 (9.6%)
New-West	45 (8.9%)	111 (24.5%)	52 (12.8%)	18 (5.4%)	233 (57.0%)	147 (37.3%)
Southeast	65 (12.9%)	228 (50.3%)	190 (46.7%)	253 (76.4%)	5 (1.2%)	19 (4.8%)
Other/missing	7 (1.4%)	6 (1.3%)	5 (1.2%)	3 (0.9%)	6 (1.5%)	3 (0.8%)
Educational level*						
No school/elementary school	10 (2.0%)	56 (12.4%)	15 (3.7%)	78 (23.6%)	78 (19.1%)	90 (22.8%)
Lower vocational/lower secondary school	56 (11.1%)	156 (34.4%)	124 (30.5%)	128 (38.7%)	84 (20.5%)	64 (16.2%)
Intermediary vocational/intermediary secondary school	99 (19.7%)	137 (30.2%)	142 (34.9%)	73 (22.1%)	124 (30.3%)	125 (31.7%)
Higher vocational/university	337 (67.0%)	103 (22.7%)	124 (30.5%)	26 (7.9%)	108 (26.4%)	94 (23.9%)
Missing	1 (0.2%)	1 (0.2%)	2 (0.5%)	26 (7.9%)	15 (3.7%)	21 (5.3%)
Labor participation†						
Employed	380 (75.5%)	308 (68.0%)	292 (71.7%)	203 (61.3%)	247 (60.4%)	229 (58.1%)
Not in workforce	90 (17.9%)	47 (10.4%)	40 (9.8%)	10 (3.0%)	59 (14.4%)	63 (16.0%)
Unemployed/on benefits	21 (4.2%)	53 (11.7%)	47 (11.5%)	60 (18.1%)	62 (15.2%)	57 (14.5%)
Disabled	11 (2.2%)	39 (8.6%)	24 (5.9%)	28 (8.5%)	27 (6.6%)	22 (5.6%)
Unknown/missing	1 (0.2%)	6 (1.3%)	4 (1.0%)	30 (9.0%)	14 (3.4%)	23 (5.8%)
Occupational level*						

Elementary occupations	5 (1.0%)	36 (7.9%)	22 (5.4%)	162 (48.9%)	52 (12.7%)	46 (11.7%)
Lower occupations	46 (9.1%)	127 (28.0%)	101 (24.8%)	69 (20.8%)	102 (24.9%)	92 (23.4%)
Intermediary occupations	107 (21.3%)	143 (31.6%)	146 (35.9%)	21 (6.3%)	88 (21.5%)	94 (23.9%)
Higher occupations	203 (40.4%)	79 (17.4%)	91 (22.4%)	11 (3.3%)	51 (12.5%)	65 (16.5%)
Scientific occupations	115 (22.9%)	20 (4.4%)	19 (4.7%)	6 (1.8%)	32 (7.8%)	10 (2.5%)
Missing	27 (5.4%)	48 (10.6%)	28 (6.9%)	62 (18.7%)	84 (22.5%)	87 (22.1%)
Job setting[†,‡]						
No job / caretaker only	117 (23.3%)	144 (31.8%)	120 (29.5%)	90 (27.2%)	138 (33.7%)	132 (33.5%)
Job with no contact within 1.5 meter	96 (19.1%)	65 (14.3%)	39 (9.6%)	66 (19.9%)	67 (16.4%)	54 (13.7%)
Other job with contact within 1.5 meter	145 (28.8%)	154 (34.0%)	131 (32.2%)	115 (34.7%)	130 (31.8%)	114 (28.9%)
Child care/schools/higher education	62 (12.3%)	27 (6.0%)	43 (10.6%)	10 (3.0%)	25 (6.1%)	48 (12.2%)
Bar/restaurant	12 (2.4%)	10 (2.2%)	11 (2.7%)	23 (6.9%)	6 (1.5%)	7 (1.8%)
Hospital/long-term care facility/Health care worker elsewhere	71 (14.1%)	51 (11.3%)	63 (15.5%)	26 (7.9%)	41 (10.0%)	36 (9.1%)
Missing	0 (0.0%)	2 (0.4%)	0 (0.0%)	1 (0.3%)	2 (0.5%)	3 (0.8%)
Difficulty with Dutch language*						
No	N.A.	348 (76.8%)	359 (88.2%)	41 (12.4%)	189 (46.2%)	211 (53.6%)
Yes	N.A.	104 (23.0%)	46 (11.3%)	264 (79.8%)	206 (50.4%)	162 (41.1%)
Missing	N.A.	1 (0.2%)	2 (0.5%)	26 (7.9%)	14 (3.4%)	21 (5.3%)
Health literacy (SBSQ)*						
Adequate	500 (99.4%)	437 (96.5%)	400 (98.3%)	209 (63.1%)	310 (75.8%)	308 (78.2%)
Low	3 (0.6%)	16 (3.5%)	7 (1.7%)	97 (29.3%)	87 (21.3%)	64 (16.2%)
Missing	0 (0.0%)	0 (0.0%)	0 (0.0%)	25 (7.6%)	12 (2.9%)	22 (5.6%)
Diabetes mellitus[§]						
No	478 (95.0%)	358 (79.0%)	362 (88.9%)	297 (89.7%)	366 (89.5%)	345 (87.6%)
Yes	18 (3.6%)	88 (19.4%)	42 (10.3%)	30 (9.1%)	35 (8.6%)	41 (10.4%)
Missing	7 (1.4%)	7 (1.5%)	3 (0.7%)	4 (1.2%)	8 (2.0%)	8 (2.0%)
High blood pressure[¶]						
No	370 (73.6%)	261 (57.6%)	198 (48.6%)	143 (43.2%)	321 (78.5%)	305 (77.4%)
Yes	127 (25.2%)	185 (40.8%)	207 (50.9%)	181 (54.7%)	82 (20.0%)	81 (20.6%)
Missing	6 (1.2%)	7 (1.5%)	2 (0.5%)	7 (2.1%)	6 (1.5%)	8 (2.0%)
Body Mass Index (kg/m2), median (IQR)*	24 [22-27]	25 [23-28]	27 [24-29]	28 [25-31]	27 [24-31]	27 [24-30]

Abbreviations: BMI, body mass index; HELIUS, Healthy Life in an Urban Setting; IQR, interquartile range; N.A., not applicable; SBSQ, Set of Brief Screening Question * Measured at baseline (2011-2015) † Measured at COVID-1 visit (2020) ‡ Presumed higher exposure categories had priority, i.e. if someone was working in a school and as a health care worker, they were categorized as a health care worker. Caretakers were not included as a category because many had other jobs. § Based on self-report, increased fasting glucose (≥7 mmol/l) or use of glucose-lowering medication ¶ Based on self-report, SBP ≥140 mmHg, DBP ≥90 or blood pressure-lowering medication. # Pearson's $\chi 2$ or Kruskal-Wallis test, as appropriate.

SARS-CoV-2 seroprevalence

Of 2497 included, 2483 (99.4%) participants had a SARS-CoV-2 antibody test result. Of these 2483, 225 were positive, 2248 negative and 8 had an equivocal test result. The distribution of signal-to-cutoff ratios for positive test results is shown per ethnic group in Supplementary Figure S3. The proportion with a positive result did not increase over time in any of the ethnic groups, except for the South-Asian Surinamese group (Supplementary Figure S2).

Unadjusted and adjusted seroprevalence estimates per ethnic group are provided in Figure 1. Adjusted seroprevalence was comparable between the Dutch (24/498; 5.1%, 95%CI=2.8-7.4), South-Asian Surinamese (22/451; 4.9%, 95%CI=2.2-7.7), African Surinamese (22/400; 8.3%, 95%CI=3.1-13.6), Turkish (30/408; 7.9%, 95%CI=4.4-11.4) and Moroccan (32/391; 7.2%, 95%CI=4.2-10.1) groups, but higher in the Ghanaian group compared to all other groups (95/327; 26.3%, 95%CI=18.5-34.0, P<0.001).

Figure 2 shows adjusted seroprevalence estimates as a function of age in years for each ethnic group. In the African Surinamese group, seroprevalence decreased with age. In the Ghanaian group, the highest seroprevalence was observed between the ages of 50-55 years.

COVID-19-related symptoms

Supplementary Table S2 describes SARS-CoV-2-related characteristics of included participants. Of 2497 participants, 348 (13.9%) suspected being infected with SARS-CoV-2, 2144 (85.9%) did not suspect or were unsure of being infected. 90.5% of Ghanaian participants who tested positive did not suspect or were unsure of being infected, and of them, 51.2% reported not experiencing any COVID-19-related symptoms. SARS-CoV-2 positive individuals from other ethnic groups more frequently suspected being infected (range 59.1% to 81.8%).

Correlates of SARS-CoV-2 seropositivity per ethnic group

Univariable analysis of correlates of SARS-CoV-2 seropositivity is presented per ethnic group in Supplementary Table S3. In multivariable analysis (Table 2), having a household member suspected of infection was associated with SARS-CoV-2 seropositivity in Dutch, South-Asian Surinamese, Turkish and Moroccan participants. Recently traveling abroad was associated with seropositivity in Dutch and South-Asian Surinamese participants. In Ghanaian participants, older age, increasing household size, living with children ≤3 years old, and leaving home to work and attending religious services were associated with SARS-CoV-2 seropositivity. Increased odds for SARS-CoV-2 seropositivity were also observed for living with other adults (African Surinamese), having had ≥2 unique visitors in the past week (African Surinamese), leaving home to walk or exercise outside and using public transportation in the past week (Turkish participants) and occupational level (Moroccan participants).

Table 2. Correlates of SARS-CoV-2 seropositivity per ethnic group, Amsterdam, the Netherlands, 24 June - 9 October 2020 (multivariable analysis)

Characteristic	Dutch	South-Asian Surinamese	African Surinamese	Ghanaian	Turkish	Moroccan
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)§	aOR (95% CI)	aOR (95% CI)
Per year increase in age in years on 1 January 2020	-	-	-	1.06 (1.03-1.08)	-	-
COVID-19 substudy visit after 15 August 2020*	0.40 (0.07-2.38)	1.82 (0.51-6.48)	0.36 (0.08-1.57)	1.11 (0.57-2.15)	1.04 (0.40-2.72)	3.11 (1.18-8.23)
Elementary occupation†						
No	-	-	-		-	1
Yes	-	-	-		-	2.13 (0.59-7.67)
Missing	-	-	-		-	4.54 (1.72-11.98)
Per person increase in household†	-	-	-	1.40 (1.11-1.76)		
Lives with a child or children ≤3 years old*	-	-	-	3.20 (1.14-9.06)		
Lives with other adults*	-	-	8.07 (1.75-37.15)		-	-
Household member/steady partner with suspected infection*	9.16 (2.95-28.43)	6.27 (1.67-23.50)	-		11.20 (4.40-28.50)	6.00 (2.14-16.78)
Went to work*,‡	-	-	-	2.09 (1.10-3.99)	-	-
Walked or exercised outside*,‡	-	-	-		4.04 (1.66-9.86)	-
Attended religious service*,‡	-	-	-	2.26 (1.20-4.25)	-	-
Used public transportation*,‡	-	-	-		3.02 (1.16-7.84)	-
≥2 unique visitors at home*,‡	-	-	4.59 (1.61-13.09)		-	-
Travelled abroad in 2020*	4.00 (1.44-11.15)	4.05 (1.31-12.48)	-		-	-

Abbreviations: CI, confidence interval; HELIUS, Healthy Life in an Urban Setting; N.A., not applicable; aOR, adjusted odds ratio. Participants with an equivocal test result were excluded from this analysis. Univariable ORs are provided in Supplementary Table S3. Models are adjusted for all other covariates found within the same column.

* Measured at COVID-1 visit (2020) † Measured at baseline (2011-2015) ‡ In the past week. §As prevalence in the Ghanaian group was >10%, odds ratios could be much greater than their corresponding relative risks. The differences between these estimates are given for the univariable analysis in Supplementary Table S4 for reference.

DISCUSSION

After the first wave of the SARS-CoV-2 epidemic, we observed no evidence of ethnic disparities in past SARS-CoV-2 infection between the six largest ethnic groups residing in Amsterdam, The Netherlands, with the noteworthy exception of individuals of Ghanaian origin. We estimated that 26% of the adult Ghanaian group had developed SARS-COV-2 antibodies, compared to 5-8% of the other adult ethnic groups. Increased risk of past infection was present among individuals who reported a household member suspected of infection in four of the six groups. Amongst other factors, leaving home to work and attending religious services were associated with seropositivity in Ghanaian individuals, while using public transportation was associated with seropositivity in Turkish individuals. Correlates differed between ethnicities, hence demonstrating that broad generalizations of some SARS-CoV-2-related correlates might not be appropriate for individual ethnic groups.

Among the correlates of SARS-CoV-2 seropositivity, work and travelling to work, most likely via public transportation, represents a common theme in individuals of non-Dutch origin. Working from home was one of the first preventive measures introduced in the Netherlands to mitigate spread of SARS-CoV-2.[17] However, this was not feasible for individuals with lower professional levels and jobs requiring physical presence, many of whom were of non-Dutch origin. Interestingly, Moroccan individuals in the missing occupation category appeared to be more often seropositive. Previous research suggests that the health of individuals in this category resembles that of individuals with elementary or intermediary professions,[18] implying that working conditions could put these individuals at risk of infection.

Although attending religious services was asked only for the past week and infections may have occurred as early as in March 2020, exposure to SARS-CoV-2 during attendance at religious services might have driven many of the past infections observed in the Ghanaian group. Religious services, along with demonstrations, were allowed to continue without a maximum number of attendees, as

stipulated by Dutch law,[19] which could have fostered further spread of SARS-CoV-2. Many places of worship did, however, implement social distancing measures. A nationwide study demonstrated similar findings in that Orthodox-Reformed Protestants were at increased risk for SARS-CoV-2 seropositivity during the first wave of the pandemic.[20] Increased infection risk for people attending religious services has also been demonstrated in studies from other countries.[21-23]

Strikingly, 91% of Ghanaians with SARS-CoV-2 antibodies did not suspect or were unsure of being infected, many because they reported not experiencing any COVID-19-related symptoms. This is in stark contrast to other ethnic groups in which most SARS-CoV-2 positive individuals had suspected of being infected. If these infections were indeed asymptomatic in Ghanaians, many could have been completely unaware of their infection and as a result, might have carried out their normal routines despite unknowingly continuing transmission. The dense clustering of Ghanaians in the South-East city district of Amsterdam might have also accelerated transmission, as we unknowingly may have sampled a cluster of infections within a specific neighbourhood or religious center. Nevertheless, there were no infection clusters within Ghanaian individuals identified during the first wave by the local Public Health Service (personal communication T. Leenstra, January 27, 2021), when SARS-CoV-2 PCR testing was restricted. Our study clearly indicates that to reduce ongoing and unnoticed transmission of SARS-CoV-2, expanded testing needs to include those groups in which the proportion of asymptomatic individuals might be high or recognition of infection might be low, such as the Ghanaian residents of Amsterdam.

Since data from Ghana on SARS-CoV-2 seroprevalence and proportion of asymptomatic infection are limited, we cannot make any distinction on whether our finding reflects the epidemiology in the country of origin or is specific to Ghanaian individuals in the Netherlands. One modelling study suggests that Ghana is one of the four most affected African countries in terms of cases, but has a relatively low death rate.[24] A study among Kenyan blood donors found a surprisingly high seroprevalence (4.3%) from what can be inferred by the low number of COVID-19-related

hospitalisations and deaths.[25] Further research is needed to clarify the role of symptom burden, earlier exposure to coronaviruses, or differences in genetic vulnerability to symptoms in explaining the seemingly high proportion of asymptomatic cases in Ghanaians.[26-29] Alternatively, recall of symptoms, particularly mild symptoms, could have been lower in this group, which might be explained by lower levels of health literacy, knowledge of COVID-19 symptomatology, and possibly education when compared to other groups. Furthermore, self-assessment of infection might have been underreported during the face-to-face interview due to fear of stigmatization or social desirability bias.

Having a household member suspected of being infected was the most common and consistent determinant of seropositivity. This finding supports observations that during periods of more extensive lock-downs, most transmissions occur in household settings and is related to symptomatic infection, age distribution and social interactions within households.[30-32] Other household correlates of seropositivity were observed in specific ethnic groups and included living with other adults, living with children ≤3 years old, and larger household sizes.

In the Netherlands, a series of restrictions was introduced in mid-March, when the spread of SARS-CoV-2 was still limited.[17] The finding that seroprevalence did not differ between ethnic groups, other than Ghanaian, implies that these restrictive measures were able to prevent the spread of infection equally across ethnicities. Furthermore, additional data from individuals participating in the parent HELIUS study showed that non-ethnic Dutch groups in general were as likely as ethnic-Dutch to adhere to prevention measures (personal communication F. Chilunga, January, 27 2021). It should be mentioned that our results also stem from a setting where economic inequalities are not prohibitive to healthcare access.[33]

In comparison to the seroprevalence estimates, people from large ethnic groups (Netherlands Antilles, Morocco, Surinam, Turkey, Ghana) had increased hospitalisation rates compared to ethnic Dutch individuals living in Amsterdam between February and May 2020,[9] as shown in other

settings.[2,3] In addition, individuals with a migration background living in the Netherlands had a higher excess mortality during the first six weeks of the COVID-19 pandemic.[34] Our data suggest that, apart from Ghanaians, the increased rates of hospitalisations and deaths in non-Dutch ethnic groups during this period cannot be explained by a higher infection rate. The severity of COVID-19 can be impacted to a large extent by underlying comorbidities,[35] which vary across ethnic groups[14] and could explain differences in severity.[36] Healthcare inequalities, racism, stigmatisation and discrimination witnessed by ethnic minorities and differences in healthcare seeking-behaviour may provide additional explanations for these disparities.[37-41]

Strengths of our study include population-based sampling, with a large number of participants from the major ethnic groups living in Amsterdam, representing various levels of socioeconomic status; measuring seroprevalence via antibodies in individuals with and without previous COVID-19-related symptoms; and obtaining individual-level correlates of infection. Nonetheless, there are several limitations. First, our study includes a random subsample of HELIUS participants and there may be selection bias. Undocumented people and other ethnic groups living in Amsterdam were not included in the parent study. Moreover, the differential rates of lost to follow-up between ethnic groups in the parent HELIUS study might have influenced the initial selection of invited participants for the substudy. Second, participants in our substudy may have been more concerned about their health compared to non-participants. Notwithstanding the differential response rate between ethnicities in this substudy, the distribution of characteristics was largely similar between included and non-included HELIUS participants. Our estimates, corrected for sampling and post-stratification, were also close to those from a nationwide study that included mainly people of Dutch origin and revealed a 6% seroprevalence among the Amsterdam population in June 2020.[42] Data were also collected over a span of 4 months, which reflects different points of the epidemic, and thus the timing of testing could bias estimates. We attempted to mitigate this issue by adjusting for calendar time. Furthermore, prevention measures remained mostly the same and nationwide incidence was quite stable during this period, thereby limiting the effect of this

bias.[8,43] Third, as this study was cross-sectional and infection occurred in the past, it is difficult to make any causal inference with respect to correlates. Fourth, fear of stigmatization or consequences for work might have led to an underreporting of suspected past infection and symptoms, particularly among Ghanaians. Fifth, circulating SARS-CoV-2 antibodies could have disappeared after infection,[44,45] although this was probably limited during the study period,[46,47] and individuals could not participate in this substudy if they were experiencing COVID-19-related symptoms, both of which likely led to underestimated seroprevalence. Finally, we used stepwise selection procedures to determine correlates of SARS-CoV-2 seropositivity, which has several limitations, including underestimated standard errors.[48]

In conclusion, most ethnic groups displayed comparable seroprevalence after the first SARS-CoV-2 wave in Amsterdam, yet the substantially higher prevalence among the smaller Ghanaian population, possibly infections without symptoms, is of concern. Targeted prevention campaigns addressing the needs of specific ethnic groups and expanding testing opportunities are urgently warranted. In addition, prevention measures for those who cannot work from home should be intensified, also by bringing to light the employer's role in reducing COVID-19 transmissions.

STATEMENTS

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Competing interests

The authors declare that they have no competing interests related to the project.

Data sharing

The HELIUS data are owned by the Amsterdam UMC, location AMC, in Amsterdam, The Netherlands. Any researcher can request the data by submitting a proposal to the HELIUS Executive Board as outlined at http://www.heliusstudy.nl/en/researchers/collaboration, by email: heliuscoordinator@amsterdamumc.nl. The HELIUS Executive Board will check proposals for compatibility with the general objectives, ethical approvals and informed consent forms of the HELIUS study. There are no other restrictions to obtaining the data and all data requests will be processed in the same manner.

Contributors

MP, KS, JS and CA conceived, designed or oversaw the study. HG, AK and JS were involved in the acquisition of data. LC and AB conducted the statistical analysis. LC, AB and MP drafted the manuscript. LC, AB, JS, CA, HG, AK, TL, EC, BB, AL, AV, AZ, SJ, LV, KS and MP all contributed to

interpretation of the data, provided feedback on the initial draft for revision, and approved the final manuscript.

Ethics approval

Ethical approval for the HELIUS study was obtained from the Academic Medical Center Ethical Review Board (METC number 10/100, NL32251.018.10).

Consent to participate

All participants provided written informed consent.

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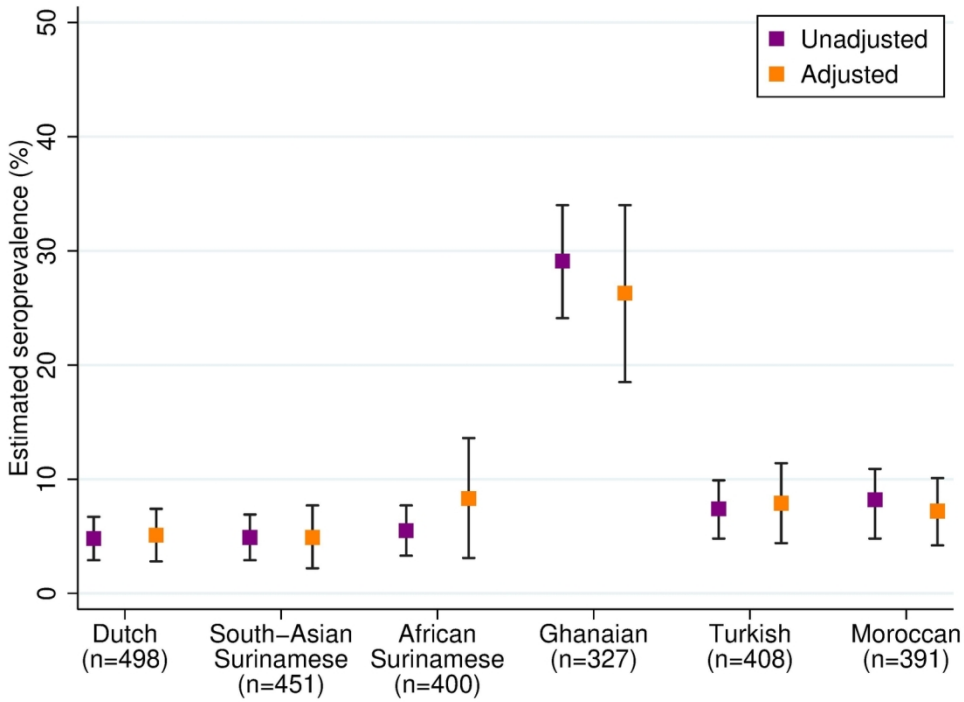
Figures

Figure 1. Unadjusted and adjusted SARS-CoV-2 seroprevalence per ethnic group (N=2475), Amsterdam, the Netherlands, 24 June - 9 October 2020

Legend: We excluded individuals with an equivocal result (n=8) from the seroprevalence calculation. Boxes represent the seroprevalence estimate, bands the corresponding 95% confidence interval. Adjusted seroprevalence estimates were corrected for sampling, accounted for the population structure of ethnic groups in Amsterdam (i.e. post-stratification), and adjusted for differences in age, sex and calendar time (before/after 15 August 2020) between ethnic groups.

Figure 2. SARS-CoV-2 seroprevalence and age by ethnic group, Amsterdam, the Netherlands, 24 June - 9 October 2020

Legend: Seroprevalence was regressed on age (in restricted cubic splines with 3 knots) with sample and post-stratification weights, within subpopulations of ethnic groups.



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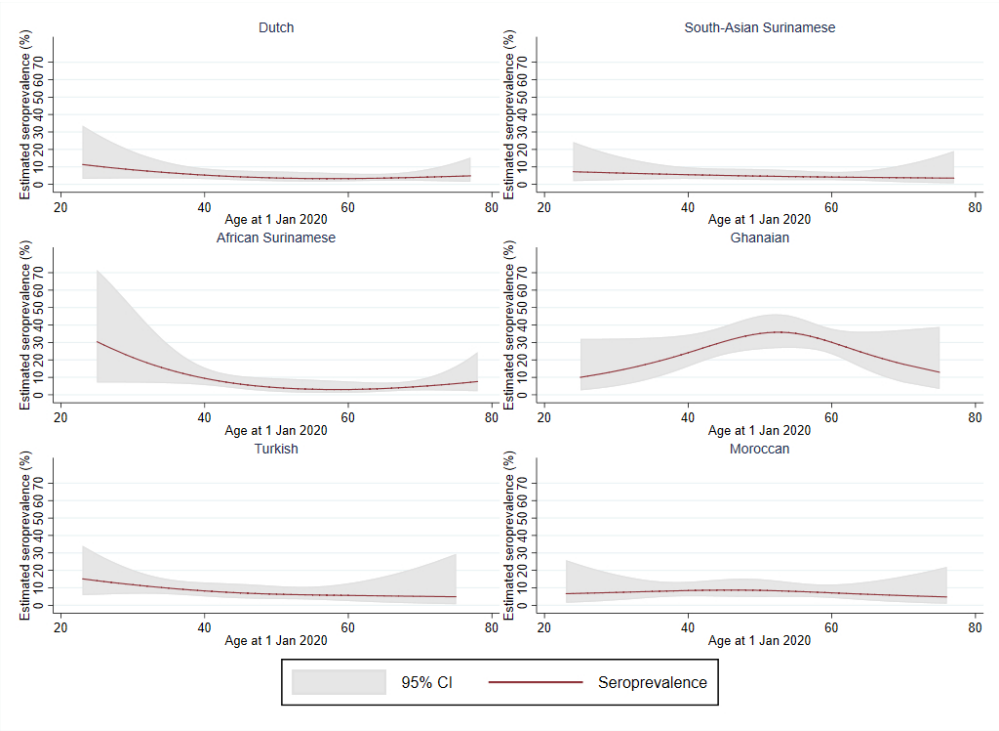

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Supplement to:

SARS-CoV-2 antibody prevalence and correlates of six ethnic groups living in Amsterdam, the Netherlands: a population-based cross-sectional study, June-October 2020

Authors

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Content **Page**

Information on seroprevalence estimation corrected for sampling, post-stratification and adjusting for differences in age, sex and calendar time between ethnic groups.

For sampling, the probability of being invited for the COVID-19 substudy (as the proportion of participants invited among those in active follow-up in the parent study) was calculated, as was the conditional probability of participating in the COVID-19 substudy (given the participant's ethnicity, age, educational level, working status and health literacy). The product of the two probabilities was taken and the inverse of this result, standardized to one, was used as a sampling weight. For post-stratification, a weight was assigned corresponding to the proportion representing the Amsterdam population of each stratum of age (20-44, 45-54, 55-59, 60-79 years), sex (male, female) and ethnicity (Surinamese, Ghanaian, Moroccan, Turkish, Dutch). Sampling and post-stratification weights were placed in a multivariable logistic regression model with covariates ethnicity, age, sex, and calendar time. Given the weighting scheme of this study, variance was calculated with the designed-based Taylor series linearization method using the 'svy' commands in STATA. Differences between ethnic groups were tested in the model using the Wald $\chi 2$ test.

Figure S1. Flowchart depicting the selection of HELIUS participants in the COVID-19 study, Amsterdam, the Netherlands, 24 June - 9 October 2020

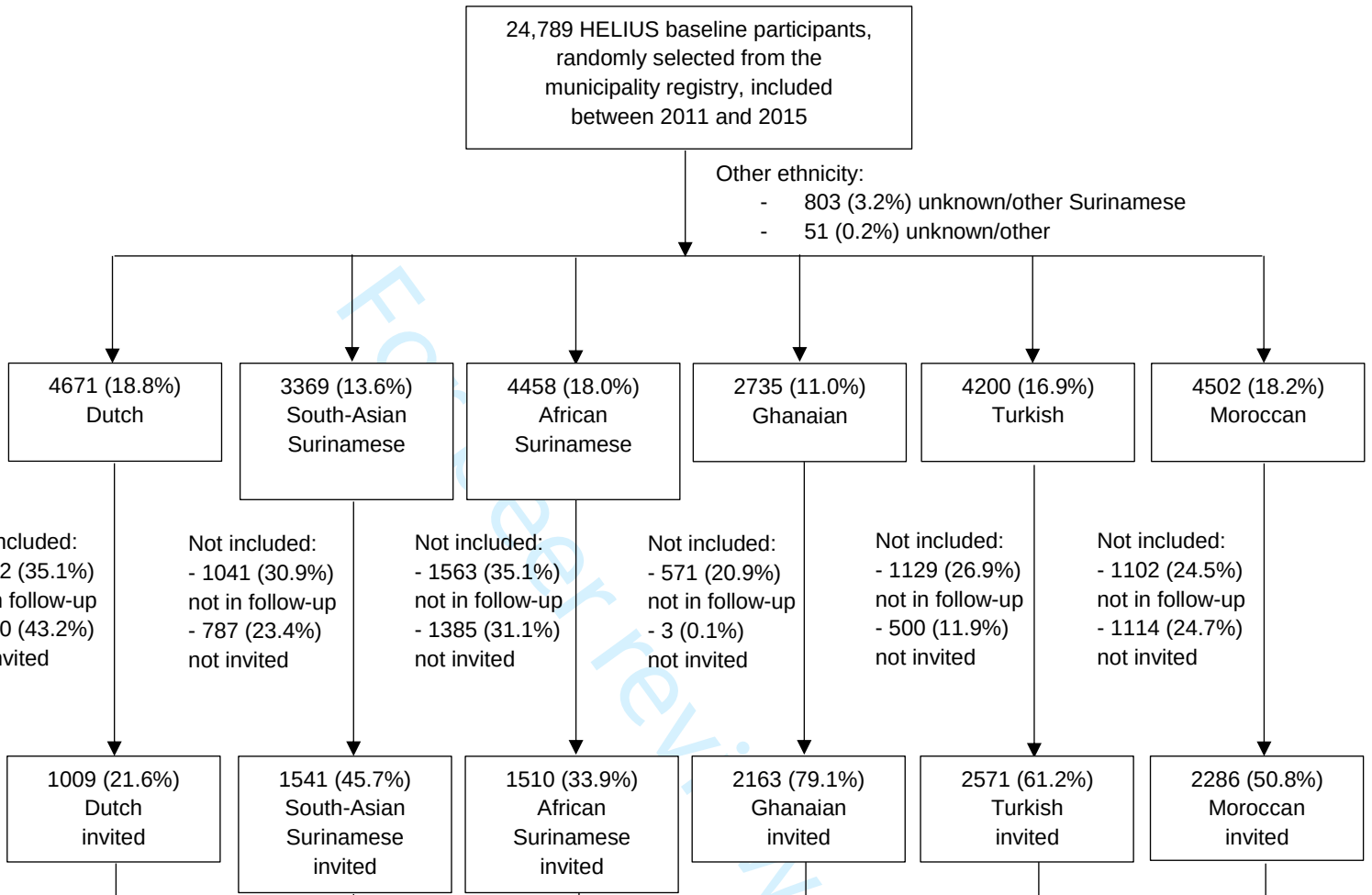


Table S1. Characteristics of three inclusion groups (invited and included in COVID-19 study invited not included not invited) within the HELIUS population (N=16889), Amsterdam, the Netherlands, 24 June - 9 October 2020

To identify potential selection bias among HELIUS participants who were still in active follow-up, demographic, socio-economic factors and access to health care indicators were compared between those who were invited versus not invited for the COVID-19 substudy. To assess the reasons for nonresponse among invited HELIUS participants, these variables were also compared between those who participated versus not participated in the COVID-19 substudy. Pearson's χ^2 or Fisher exact test were used for categorical data and Kruskal-Wallis rank test for continuous variables.

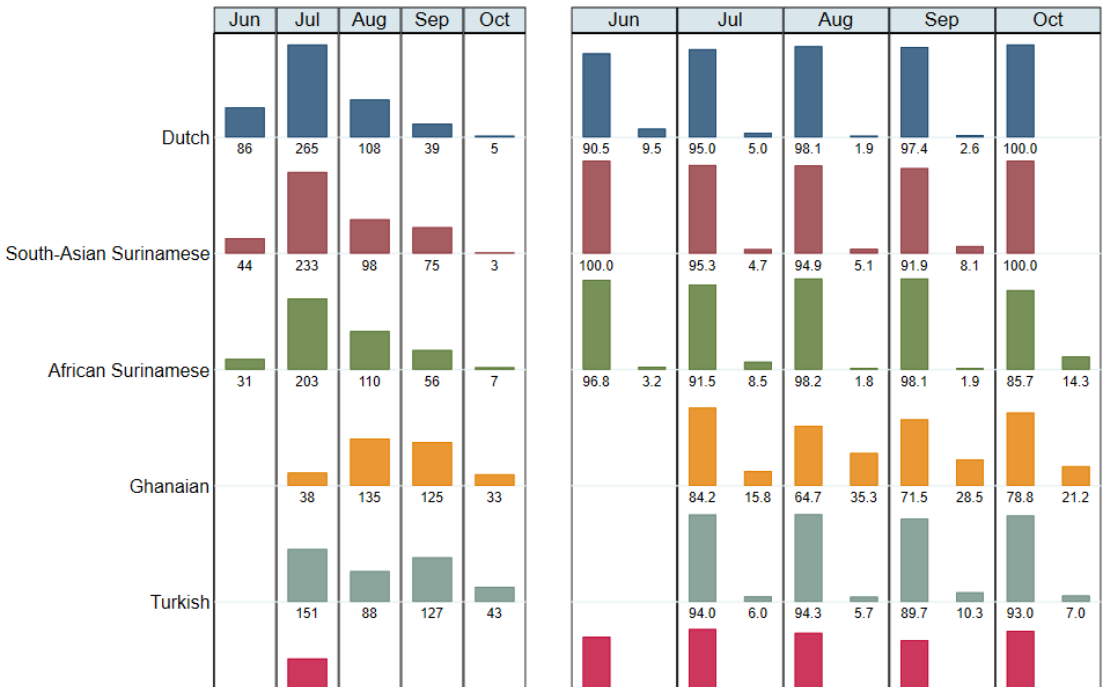
Characteristic	All HELIUS participants in follow-up* (N= 16889)	Invited included (n=2497)	Invited not included (n=8583)	Not invited (n=5809)	*Invited and included vs. invited not included*	*Invited (included and not included) vs. not invited*
	n (%)	n (%)	n (%)	n (%)	*P*-value‡	*P*-value‡
Ethnicity					<0.001	<0.001
Dutch	3029 (17.9%)	503 (20.1%)	506 (5.9%)	2020 (34.8%)		
South-Asian Surinamese	2328 (13.8%)	453 (18.1%)	1088 (12.7%)	787 (13.5%)		
African Surinamese	2895 (17.1%)	407 (16.3%)	1103 (12.9%)	1385 (23.8%)		
Ghanaian	2166 (12.8%)	331 (13.3%)	1832 (21.3%)	3 (0.1%)		
Turkish	3071 (18.2%)	409 (16.4%)	2162 (25.2%)	500 (8.6%)		
Moroccan	3400 (20.1%)	394 (15.8%)	1892 (22.0%)	1114 (19.2%)		
Sex					0.095	0.94
Male	7077 (41.9%)	1083 (43.4%)	3562 (41.5%)	2432 (41.9%)		
Female	9812 (58.1%)	1414 (56.6%)	5021 (58.5%)	3377 (58.1%)		
Age in years on 1 January 2020					<0.001	<0.001
Median [IQR]	52 [41-61]	54 [44-61]	51 [39-59]	54 [42-63]		
Migration generation					<0.001	<0.001
N.A. (Dutch group)	3029 (17.9%)	503 (20.1%)	506 (5.9%)	2020 (34.8%)		
1st	10978 (65.0%)	1656 (66.3%)	6339 (73.9%)	2983 (51.4%)		
2nd	2882 (17.1%)	338 (13.5%)	1738 (20.2%)	806 (13.9%)		
City district[b]					<0.001	<0.001
Centre	781 (4.6%)	140 (5.6%)	222 (2.6%)	419 (7.2%)		
East	2550 (15.1%)	422 (16.9%)	1,302 (15.2%)	826 (14.2%)		
West	2356 (13.9%)	294 (11.8%)	1,203 (14.0%)	859 (14.8%)		
South	1381 (8.2%)	245 (9.8%)	525 (6.1%)	611 (10.5%)		
New-West	4897 (29.0%)	606 (24.3%)	2572 (30.0%)	1719 (29.6%)		
Southeast	4794 (28.4%)	760 (30.4%)	2718 (31.7%)	1316 (22.7%)		
Other	20 (0.1%)	6 (0.2%)	8 (0.1%)	6 (0.1%)		
Missing	110 (0.7%)	24 (1.0%)	33 (0.4%)	53 (0.9%)		
Educational level†					<0.001	<0.001
No school/elementary school	3286 (19.5%)	327 (13.1%)	2175 (25.3%)	784 (13.5%)		
Lower vocational/ lower secondary school	4324 (25.6%)	612 (24.5%)	2358 (27.5%)	1354 (23.3%)		
Intermediary vocational/ intermediary secondary school	4715 (27.9%)	700 (28.0%)	2393 (27.9%)	1622 (27.9%)		

Higher vocational/university	3993 (23.6%)	792 (31.7%)	1243 (14.5%)	1958 (33.7%)		
Missing	571 (3.4%)	66 (2.6%)	414 (4.8%)	91 (1.6%)		
Labor participation†					<0.001	<0.001
Employed	9585 (56.8%)	1659 (66.4%)	4274 (49.8%)	3652 (62.9%)		
Not in workforce	2992 (17.7%)	309 (12.4%)	1645 (19.2%)	1038 (17.9%)		
Unemployed/on benefits	2372 (14.0%)	300 (12.0%)	1416 (16.5%)	656 (11.3%)		
Disabled	1309 (7.8%)	151 (6.0%)	792 (9.2%)	366 (6.3%)		
Missing	631 (3.7%)	130 (3.1%)	774 (8.7%)	154 (2.7%)		
Occupational level†					<0.001	<0.001
Elementary occupations	2454 (14.5%)	323 (12.9%)	1739 (20.3%)	392 (6.7%)		
Lower occupations	4177 (24.7%)	537 (21.5%)	2280 (26.6%)	1360 (23.4%)		
Intermediary occupations	3549 (21.0%)	599 (24.0%)	1515 (17.7%)	1435 (24.7%)		
Higher occupations	2565 (15.2%)	500 (20.0%)	783 (9.1%)	1282 (22.1%)		
Scientific occupations	928 (5.5%)	202 (8.1%)	223 (2.6%)	503 (8.7%)		
Missing	3216 (19.0%)	336 (13.5%)	2043 (23.8%)	837 (14.4%)		
Difficulty with Dutch language†					<0.001	<0.001
N.A. (Dutch group)	3029 (17.9%)	503 (20.1%)	506 (5.9%)	2020 (34.8%)		
No	7467 (44.2%)	1148 (46.0%)	3751 (43.7%)	2568 (44.2%)		
Yes	5891 (34.9%)	782 (31.3%)	3950 (46.0%)	1159 (20.0%)		
Missing	502 (3.0%)	64 (2.6%)	376 (4.4%)	62 (1.1%)		
Difficulty with Dutch language† **(excluding Dutch group)**					<0.001	<0.001
No	7467 (53.9%)	1148 (57.6%)	3751 (46.4%)	2568 (67.8%)		
Yes	5891 (42.5%)	782 (39.2%)	3950 (48.9%)	1159 (30.6%)		
Missing	502 (3.6%)	64 (3.2%)	376 (4.7%)	62 (1.6%)		
Health literacy (SBSQ)†					<0.001	<0.001
Adequate	13547 (80.2%)	2164 (86.7%)	6187 (72.1%)	5196 (89.4%)		
Low	2837 (16.8%)	274 (11.0%)	2019 (23.5%)	544 (9.4%)		
Missing	505 (3.0%)	59 (2.4%)	377 (4.4%)	69 (1.2%)		

Abbreviations: HELIUS Healthy Life in an Urban Setting; IQR interquartile range; N.A. not applicable; SBSQ Set of Brief Screening Question

* Excluding participants not belonging to one of the six ethnic groups included in the COVID-19 study † Measured at baseline (2011-2015) ‡ Pearson's χ^2 or Wilcoxon rank-sum test, as appropriate.

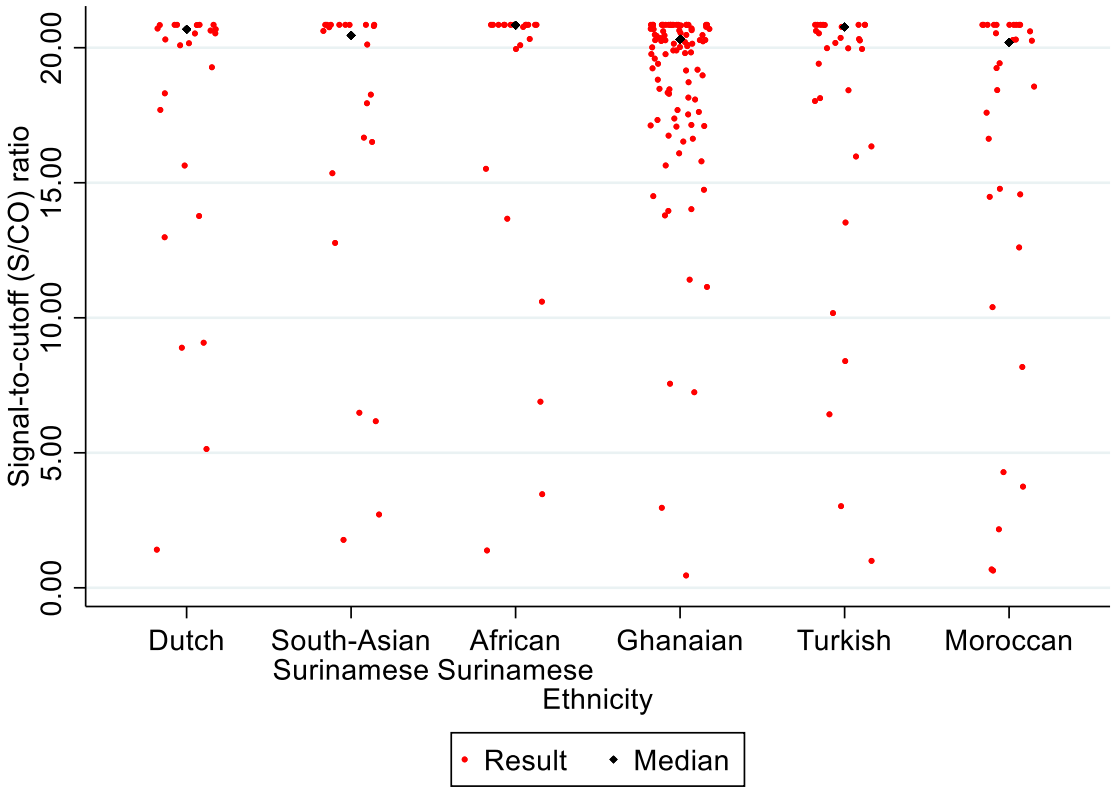
Figure S2 Inclusion numbers and test results per month by ethnicity, Amsterdam, the Netherlands, 24 June - 9 October 2020



The left side of the graph shows the number of individuals included in the substudy per month by ethnic group. The right side of the graph shows the distribution of test results per inclusion month by ethnic group, excluding people without a test result (n=14) or equivocal test result (n=8).

We tested whether the seroprevalence changed over months in survey-weighted logistic regression models per ethnic group. Odds of a positive test did not change in the Dutch (*P*=0.22), Ghanaian (*P*=0.33), Turkish (*P*=0.67) and Moroccan groups (*P*=0.15), but increased in the South-Asian Surinamese group (OR=1.87 per month increase, 95%CI=1.12-3.12, *P*=0.016) and decreased in the African Surinamese group (OR=0.56 per month increase, 95%CI=0.34-0.94, *P*=0.028).

Figure S3 Distribution of signal-to-cutoff (S/CO) ratios for positive test results (N=225) by ethnicity, Amsterdam, the Netherlands, 24 June - 9 October 2020



Kruskall Wallis test for difference between ethnic groups: *P*=0.57

Supplementary Table S2. SARS-CoV-2-related characteristics of the HELIUS participants included in the COVID-19 study, by ethnicity (N=2497), Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	Dutch (n=503)	South-Asian Surinamese (n=453)	African Surinamese (n=407)	Ghanaian (n=331)	Turkish (n=409)	Moroccan (n=392)	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	P-value*
Do you think you have been infected? (among all respondents)							
Yes, this was confirmed by a PCR test	1 (0.2%)	4 (0.9%)	5 (1.2%)	2 (0.6%)	5 (1.2%)	9 (2.3%)	<0.001
Yes, this was confirmed by a Ab test	6 (1.2%)	1 (0.2%)	1 (0.2%)	0 (0.0%)	1 (0.2%)	2 (0.5%)	
Yes, but this was not confirmed by a test	67 (13.3%)	46 (10.2%)	51 (12.5%)	16 (4.8%)	63 (15.4%)	68 (17.3%)	
No, this was confirmed by a PCR test	28 (5.6%)	22 (4.9%)	22 (5.4%)	14 (4.2%)	26 (6.4%)	17 (4.3%)	
No, this was confirmed by a Ab test	6 (1.2%)	4 (0.9%)	5 (1.2%)	2 (0.6%)	5 (1.2%)	9 (2.3%)	
No, I do not think so, but this was not confirmed by a test	178 (35.4%)	181 (40.0%)	139 (34.2%)	90 (27.2%)	112 (27.4%)	108 (27.4%)	
No, I know for certain, because I did not have any symptoms	178 (35.4%)	152 (33.6%)	144 (35.4%)	182 (55.0%)	134 (32.8%)	144 (36.5%)	
I do not know	39 (7.8%)	41 (9.1%)	40 (9.8%)	25 (7.6%)	61 (14.9%)	36 (9.1%)	
Missing	0 (0.0%)	2 (0.4%)	0 (0.0%)	0 (0.0%)	2 (0.5%)	1 (0.3%)	
Do you think you have been infected? (among SARS-CoV-2 antibody positive individuals)							<0.001
No/do not know	5 (20.8%)	9 (40.9%)	4 (18.2%)	86 (90.5%)	11 (36.7%)	13 (40.6%)	
Yes	19 (79.2%)	13 (59.1%)	18 (81.8%)	9 (9.5%)	19 (63.3%)	19 (59.4%)	
Thinks household member/steady partner was infected							<0.001
N.A.	93 (18.5%)	89 (19.6%)	104 (25.6%)	40 (12.1%)	50 (12.2%)	58 (14.7%)	
No	352 (70.0%)	321 (70.9%)	270 (66.3%)	275 (83.1%)	310 (75.8%)	281 (71.3%)	
Yes	53 (10.5%)	38 (8.4%)	33 (8.1%)	15 (4.5%)	46 (11.2%)	51 (12.9%)	
Missing	5 (1.0%)	5 (1.1%)	0 (0.0%)	1 (0.3%)	3 (0.7%)	4 (1.0%)	
Household member hospitalized for COVID-19							<0.001
N.A.	93 (18.5%)	89 (19.6%)	104 (25.6%)	40 (12.1%)	50 (12.2%)	58 (14.7%)	
No	401 (79.7%)	356 (78.6%)	302 (74.2%)	290 (87.6%)	352 (86.1%)	329 (83.5%)	
Yes	4 (0.8%)	3 (0.7%)	1 (0.2%)	0 (0.0%)	4 (1.0%)	3 (0.8%)	

Missing	5 (1.0%)	5 (1.1%)	0 (0.0%)	1 (0.3%)	3 (0.7%)	4 (1.0%)	
Number of times left home in the past week							<0.001
0-7	59 (11.7%)	144 (31.8%)	145 (35.6%)	122 (36.9%)	106 (25.9%)	101 (25.6%)	
8-11	82 (16.3%)	134 (29.6%)	99 (24.3%)	120 (36.3%)	97 (23.7%)	90 (22.8%)	
12-16	141 (28.0%)	103 (22.7%)	80 (19.7%)	58 (17.5%)	103 (25.2%)	88 (22.3%)	
17+	221 (43.9%)	70 (15.5%)	83 (20.4%)	30 (9.1%)	101 (24.7%)	113 (28.7%)	
Missing	0 (0.0%)	2 (0.4%)	0 (0.0%)	1 (0.3%)	2 (0.5%)	2 (0.5%)	
Number of unique visitors at home in the past week							
0	216 (42.9%)	218 (48.1%)	192 (47.2%)	239 (72.2%)	207 (50.6%)	209 (53.0%)	<0.001
1	89 (17.7%)	80 (17.7%)	84 (20.6%)	43 (13.0%)	48 (11.7%)	45 (11.4%)	
2-4	146 (29.0%)	120 (26.5%)	97 (23.8%)	41 (12.4%)	110 (26.9%)	102 (25.9%)	
5+	49 (9.7%)	30 (6.6%)	32 (7.9%)	6 (1.8%)	41 (10.0%)	34 (8.6%)	
Missing	3 (0.6%)	5 (1.1%)	2 (0.5%)	2 (0.6%)	3 (0.7%)	4 (1.0%)	

Abbreviations: HELIUS, Healthy Life in an Urban Setting * Pearson's χ^2 test

Supplementary Table S3. Univariable analysis of correlates of SARS-CoV-2 seropositivity per ethnic group, Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	Dutch	South-Asian Surinamese	African Surinamese	Ghanaian	Turkish	Moroccan
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sex						
Male	1	1	1	1	1	1
Female	1.50 (0.53-4.21)	1.13 (0.34-3.77)	0.76 (0.20-2.98)	1.25 (0.69-2.29)	1.23 (0.53-2.90)	2.26 (0.87-5.86)
Per year increase in age in years on 1 January 2020	0.98 (0.94-1.01)	0.98 (0.95-1.02)	0.94 (0.88-1.00)	1.02 (0.99-1.05)	0.97 (0.93-1.01)	1.00 (0.96-1.03)
Migration generation†						
1st	-	1	1	Omitted	1	1
2nd	-	1.68 (0.56-5.05)	3.97 (1.11-14.28)	Omitted	1.67 (0.71-3.89)	1.74 (0.71-4.25)
COVID-19 substudy visit after 15 August 2020*	0.58 (0.13-2.68)	2.53 (0.80-7.97)	0.28 (0.06-1.30)	1.37 (0.69-2.74)	1.18 (0.49-2.82)	2.24 (0.96-5.25)
City district† (other= omitted)						
Centre	1	Omitted	1	Omitted	1	1
East	1.13 (0.21-6.08)	1	0.91 (0.10-8.55)	1	Omitted	0.84 (0.15-4.78)
West	1.11 (0.26-4.69)	Omitted	0.25 (0.02-4.31)	1.02 (0.19-5.38)	0.89 (0.28-2.82)	1.82 (0.31-10.61)
South	1.49 (0.46-4.81)	1.05 (0.09-12.53)	2.10 (0.12-36.43)	3.75 (0.52-26.98)	0.39 (0.06-2.77)	0.32 (0.03-2.99)
New-West	0.42 (0.08-2.17)	1.44 (0.25-8.30)	0.90 (0.09-9.34)	1.49 (0.27-8.34)	0.25 (0.09-0.71)	0.34 (0.06-1.99)
Southeast	0.55 (0.07-4.62)	2.85 (0.57-14.27)	2.03 (0.22-18.94)	3.32 (1.00-11.07)	0.89 (0.28-2.82)	Omitted
Has obesity (BMI≥30.0)†						
No	1	1	1	1	1	
Yes	0.84 (0.23-3.07)	0.58 (0.10-3.42)	0.92 (0.30-2.81)	0.90 (0.45-1.81)	1.50 (0.58-3.92)	1.03 (0.37-2.90)
Educational level†						
No school/elementary school	Omitted	1	1	1	1	1
Lower vocational/ lower secondary school	Omitted	2.64 (0.53-13.21)	2.66 (0.24-28.99)	0.70 (0.33-1.50)	1.41 (0.41-4.85)	1.30 (0.34-5.00)
Intermediary vocational/ intermediary secondary school	1	1.41 (0.22-9.14)	1.54 (0.16-14.82)	0.39 (0.18-0.86)	1.17 (0.36-3.83)	1.47 (0.48-4.47)
Higher vocational/university	2.48 (0.33-18.66)	2.06 (0.28-14.89)	1.22 (0.12-12.53)	0.75 (0.23-2.47)	1.39 (0.38-5.06)	1.39 (0.41-4.72)
Missing	Omitted	Omitted	Omitted	0.58 (0.19-1.77)	Omitted	8.52 (1.92-37.78)
Labor participation†						

Employed	1	1	1	1	1	1
Not in workforce	1.57 (0.44-5.54)	0.84 (0.10-6.77)	8.09 (1.85-35.42)	0.51 (0.09-3.08)	1.68 (0.63-4.46)	1.48 (0.49-4.47)
Unemployed/on benefits	Omitted	2.66 (0.56-12.59)	0.41 (0.09-2.02)	1.34 (0.61-2.95)	1.23 (0.37-4.09)	1.03 (0.3-3.48)
Disabled	Omitted	0.55 (0.07-4.38)	1.26 (0.25-6.47)	0.80 (0.32-2.01)	0.82 (0.10-6.71)	1.01 (0.19-5.5)
Unknown/missing	Omitted	3.43 (0.37-31.95)	Omitted	1.01 (0.39-2.58)	Omitted	9.20 (2.68-31.54)
Elementary occupation[†]						
No	1	1	1	1	1	1
Yes	Omitted	1.19 (0.30-4.69)	1.83 (0.38-8.82)	1.29 (0.68-2.44)	2.08 (0.61-7.15)	1.49 (0.45-4.99)
Missing	3.11 (0.67-14.43)	0.12 (0.02-0.98)	6.64 (1.25-35.31)	0.75 (0.31-1.81)	1.41 (0.54-3.66)	4.69 (1.93-11.43)
Difficulty with Dutch language[†]						
No	-	1	1	1	1	1
Yes	-	1.45 (0.52-4.04)	0.36 (0.07-1.78)	3.21 (1.32-7.78)	1.02 (0.42-2.46)	1.53 (0.65-3.62)
Health literacy (SBSQ)[†]						
Adequate	-	1	1	1	1	1
Low	-	0.93 (0.11-7.8)	1.03 (0.10-10.43)	1.12 (0.58-2.15)	1.07 (0.43-2.66)	1.39 (0.54-3.58)
Job setting[*,§]						
No job / caretaker only	1	1	1	1	1	1
Job with no contact within 1.5 meter	0.94 (0.13-6.88)	0.27 (0.03-2.42)	0.21 (0.02-1.93)	1.66 (0.69-3.99)	1.01 (0.27-3.69)	0.82 (0.27-2.47)
Other job with contact within 1.5 meter	6.22 (1.25-30.86)	3.35 (0.99-11.32)	2.20 (0.48-10.06)	1.56 (0.71-3.43)	0.87 (0.30-2.57)	0.15 (0.03-0.63)
Child care/schools/higher education	8.23 (1.26-53.64)	1.19 (0.12-11.38)	0.31 (0.03-2.78)	1.93 (0.25-14.1)	1.02 (0.14-7.45)	2.16 (0.68-6.85)
Bar/restaurant	2.51 (0.20-32.41)	1.28 (0.12-13.30)	Omitted	1.49 (0.44-4.96)	0.99 (0.10-10.17)	0.88 (0.1-8.25)
Hospital/long-term care facility/Care worker elsewhere	8.51 (1.37-52.99)	0.46 (0.08-2.61)	3.09 (0.81-11.7)	1.11 (0.37-3.28)	1.18 (0.32-4.38)	0.13 (0.02-1.1)
Caretaker[*]						
No	1	1	1	1	1	1
Yes	0.66 (0.21-2.12)	0.27 (0.03-2.42)	0.85 (0.23-3.14)	0.80 (0.25-2.59)	2.63 (0.9-7.67)	1.59 (0.52-4.90)
Number of people in household[†]						
1 (Lives alone)	1	1	1	1	1	1
2	0.84 (0.24-2.99)	4.55 (0.53-39.15)	12.95 (2.21-76.01)	1.85 (0.63-5.50)	1.45 (0.19-11.11)	0.24 (0.03-2.26)
3	0.10 (0.01-0.90)	16.85 (1.99-142.58)	17.30 (2.45-122.24)	1.88 (0.62-5.70)	2.17 (0.37-12.65)	0.56 (0.11-2.76)
4	0.78 (0.18-3.37)	2.96 (0.30-29.11)	6.26 (1.11-35.42)	2.86 (0.96-8.48)	2.71 (0.53-13.80)	1.47 (0.39-5.51)
≥5	4.79 (0.59-38.62)	1.69 (0.10-28.05)	8.09 (1.19-55.04)	5.02 (1.59-15.86)	4.11 (0.82-20.64)	1.20 (0.34-4.17)
Lives with other people[*]	0.65 (0.19-2.25)	1.91 (0.57-6.46)	2.19 (0.43-11.24)	0.94 (0.47-1.91)	1.00 (0.26-3.77)	1.09 (0.32-3.72)
Partner	0.66 (0.22-1.99)	1.11 (0.35-3.47)	0.78 (0.23-2.66)	1.28 (0.68-2.39)	0.98 (0.40-2.38)	0.84 (0.33-2.10)

Children up to 3 years old	0.41 (0.05-3.20)	0.91 (0.11-7.49)	2.09 (0.38-11.54)	2.54 (1.00-6.46)	1.46 (0.40-5.32)	1.19 (0.41-3.44)
Children 4 through 12 years old	0.59 (0.13-2.76)	Omitted	0.12 (0.01-0.95)	1.17 (0.59-2.33)	0.67 (0.23-2.00)	1.16 (0.47-2.84)
Children 13 through 17 years old	Omitted	0.68 (0.14-3.24)	0.32 (0.07-1.58)	1.97 (1.02-3.80)	0.92 (0.32-2.66)	1.07 (0.45-2.55)
Children 18+ years old	0.25 (0.03-1.98)	0.85 (0.30-2.42)	1.22 (0.41-3.64)	1.52 (0.84-2.73)	1.29 (0.55-3.00)	0.95 (0.42-2.17)
Parents or parents-in-law	Omitted	2.03 (0.50-8.19)	1.63 (0.3-9.04)	Omitted	0.76 (0.21-2.81)	1.76 (0.36-8.71)
Other adults	2.45 (0.3-20.27)	Omitted	9.34 (1.7-51.41)	1.08 (0.51-2.30)	1.58 (0.32-7.89)	2.99 (0.74-12.07)
Household member/steady partner with suspected infection*						
N.A./No	1	1	1	1	1	1
Yes	7.53 (2.52-22.47)	7.05 (2.07-24.04)	20.08 (4.98-80.9)	1.20 (0.30-4.78)	9.15 (3.7-22.63)	5.17 (2.08-12.87)
Number of times left home in the past week*,‡						
0-7	1	1	1	1	1	1
8-11	4.22 (0.42-42.42)	2.12 (0.64-6.98)	1.52 (0.32-7.21)	0.90 (0.45-1.77)	1.69 (0.51-5.57)	0.20 (0.06-0.66)
12-16	4.51 (0.44-46.04)	0.18 (0.04-0.94)	0.40 (0.08-2.07)	1.07 (0.43-2.63)	0.92 (0.25-3.40)	0.32 (0.11-0.95)
17+	7.10 (0.89-56.58)	0.49 (0.09-2.56)	0.34 (0.05-2.27)	0.67 (0.24-1.89)	1.20 (0.33-4.37)	0.28 (0.08-1.01)
In the past week, left home to*:						
Work	2.44 (0.85-7.02)	0.62 (0.19-2.09)	2.51 (0.81-7.73)	1.91 (1.01-3.60)	1.59 (0.66-3.83)	0.47 (0.17-1.30)
Do groceries	1.47 (0.31-6.96)	1.28 (0.25-6.56)	0.22 (0.05-1.00)	1.29 (0.54-3.09)	2.21 (0.56-8.73)	0.40 (0.12-1.37)
Visit family or friends	3.18 (0.87-11.70)	1.01 (0.34-3.03)	2.53 (0.86-7.43)	0.40 (0.21-0.78)	1.14 (0.48-2.67)	0.50 (0.21-1.19)
Walk the dog or go outside with kids	0.97 (0.33-2.84)	0.55 (0.07-4.46)	0.68 (0.13-3.55)	2.27 (0.87-5.95)	0.41 (0.13-1.27)	0.96 (0.30-3.08)
Walk or exercise outside	1.81 (0.53-6.11)	1.86 (0.68-5.03)	0.08 (0.03-0.26)	0.75 (0.40-1.40)	3.53 (1.41-8.83)	1.03 (0.44-2.43)
Take care of someone	1.27 (0.44-3.67)	0.23 (0.03-1.79)	0.35 (0.07-1.74)	1.22 (0.36-4.08)	2.07 (0.66-6.46)	0.86 (0.29-2.57)
Pick up prescription medicines or visit doctor	2.98 (0.99-8.94)	1.77 (0.57-5.54)	0.90 (0.28-2.95)	0.82 (0.39-1.74)	1.38 (0.53-3.61)	1.26 (0.44-3.60)
Attend religious service	Omitted	0.73 (0.09-6.09)	1.26 (0.23-6.86)	2.76 (1.49-5.11)	0.73 (0.26-2.10)	0.59 (0.12-2.84)
Visit cultural place	1.41 (0.43-4.64)	0.89 (0.10-7.57)	0.29 (0.03-2.49)	0.51 (0.04-5.91)	3.81 (0.77-18.83)	Omitted
Visit bar or restaurant	1.37 (0.49-3.81)	0.48 (0.06-3.79)	0.17 (0.05-0.67)	0.35 (0.11-1.15)	0.76 (0.29-2.02)	0.90 (0.33-2.44)
Indoor sports	1.79 (0.46-7.02)	1.26 (0.29-5.47)	0.75 (0.15-3.72)	0.79 (0.30-2.10)	1.81 (0.58-5.67)	1.34 (0.29-6.18)
Visit recreational park	1.23 (0.43-3.54)	1.45 (0.31-6.76)	0.65 (0.12-3.47)	0.79 (0.14-4.45)	0.97 (0.35-2.68)	0.54 (0.19-1.56)
Frequency of using public transportation in the past week*						
0 days	1	1	1	1	1	1
1-2 days	0.74 (0.20-2.72)	0.81 (0.20-3.26)	0.29 (0.08-1.04)	0.73 (0.31-1.72)	2.76 (1.01-7.51)	0.40 (0.14-1.11)
3-4 days	0.97 (0.17-5.69)	Omitted	0.44 (0.10-1.98)	1.01 (0.40-2.56)	3.35 (0.64-17.39)	0.59 (0.16-2.21)
5-7 days	Omitted	1.06 (0.25-4.42)	1.88 (0.27-13.04)	0.91 (0.43-1.93)	2.72 (0.47-15.72)	0.21 (0.03-1.68)

Number of unique visitors at home in the past week[*,‡]						
0	1	1	1	1	1	1
1	1.64 (0.32-8.50)	0.37 (0.07-1.92)	0.54 (0.13-2.20)	0.47 (0.19-1.20)	0.09 (0.01-0.69)	0.13 (0.02-1.03)
2-4	0.98 (0.28-3.38)	1.07 (0.31-3.68)	4.68 (1.32-16.65)	0.57 (0.25-1.29)	0.96 (0.34-2.68)	1.09 (0.39-3.05)
5+	2.98 (0.75-11.92)	3.68 (0.53-25.58)	2.86 (0.54-15.15)	1.02 (0.17-5.93)	0.33 (0.09-1.25)	0.30 (0.07-1.38)
Travelled abroad in 2020[*]						
No	1	1	1	1	1	1
Yes	2.97 (1.03-8.60)	4.06 (1.40-11.76)	2.76 (0.77-9.89)	0.44 (0.22-0.88)	1.17 (0.49-2.78)	2.01 (0.86-4.70)

Abbreviations: CI, confidence interval; HELIUS, Healthy Life in an Urban Setting; N.A., not applicable; OR, odds ratio. Participants with an equivocal test result were excluded from this analysis. Some strata too few participants in order to be included in this model and were automatically omitted from the analysis.

* Measured at COVID-1 visit (2020) † Measured at baseline (2011-2015) ‡ Quartiles § Presumed higher exposure categories had priority, i.e. if someone was working in a school and as a careworker, they were categorized as a health worker. Caretakers were not included as a category because many had other jobs.

NB.

- In multivariable analysis for the Dutch group, the distribution of educational level and labor participation were skewed to mostly one group and hence were not included. The following variables were removed as they were no longer significant in the multivariable model: dichotomized household size, age, occupational level, number of times left home, living with child 18+ years old, job setting, and leaving home to pick up prescription medicine or visit doctor in the past weeks.
- In multivariable analysis for the South-Asian Surinamese group, the distribution of occupational level and number of times left home were skewed to mostly one group and hence were not included. The following variables were removed as they were no longer significant in the multivariable model: job setting, leaving home to care for someone, else dichotomized household size.
- In multivariable analysis for the African Surinamese group, the distribution of migration generation was skewed to mostly one group and hence were not included. The ORs for having a household member suspected of infection, walk or exercise outside, living with a child 4-12 years old, leaving home to visit bar or restaurant, and household size were extremely high with overinflated 95%CI, and hence were not included. The following variables were removed as they were no longer significant in the multivariable model: leaving home to work, traveling with public transport, leaving home to care for someone, visiting friends or family, occupational level, traveling abroad, leaving home to do groceries, labor participation, age, living with a child 13-17 years old.
- In multivariable analysis for the Ghanaian group, the following variables were removed as they were no longer significant in the multivariable model: living with a child 18+ years old, leaving home to visit bar or restaurant, travelling abroad, living with a child 13-17 years old, visiting friends or family, walk the dog or go outside with kids, difficulty with Dutch language, district.
- In multivariable analysis for the Turkish group, the following variables were removed as they were no longer significant in the multivariable model: visit cultural place, walk the dog or go outside with kids, being a caretaker, number of unique visitors past week, age, household size, district.
- In multivariable analysis for the Moroccan group, the distribution of district was skewed to mostly one group and hence were not included. The following variables were removed as they were no longer significant in the multivariable model: sex, living with other adults, number of unique visitors past week, leaving home to work, labor participation, visiting friends or family, education level, job setting, travelling abroad, groceries, number of time left house.

Supplementary Table S4. Univariable analysis of potential determinants of SARS-CoV-2 seropositivity in Ghanaian participants, Amsterdam, the Netherlands, 24 June - 9 October 2020

Characteristic	OR (95% CI)	RR (95% CI)¶
Sex		
Male	1	1
Female	1.25 (0.69-2.29)	1.18 (0.76-1.85)
Per year increase in age in years on 1 January 2020†	1.02 (0.99-1.05)	1.01 (1.00-1.03)
COVID-19 substudy visit after 15 August 2020*	1.37 (0.69-2.74)	1.27 (0.75-2.15)
City district† (other=omitted)		
Centre	Omitted	Omitted
East	1	1
West	1.02 (0.19-5.38)	1.01 (0.23-4.43)
South	3.75 (0.52-26.98)	2.85 (0.64-12.55)
New-West	1.49 (0.27-8.34)	1.41 (0.32-6.20)
Southeast	3.32 (1.00-11.07)	2.62 (0.92-7.48)
Has obesity (BMI≥30.0)†		
No	1	1
Yes	0.90 (0.45-1.81)	0.93 (0.55-1.56)
Educational level†		
No school/elementary school	1	1
Lower vocational/ lower secondary school	0.70 (0.33-1.50)	0.78 (0.46-1.32)
Intermediary vocational/ intermediary secondary school	0.39 (0.18-0.86)	0.49 (0.27-0.89)
Higher vocational/university	0.75 (0.23-2.47)	0.82 (0.35-1.90)
Missing	0.58 (0.19-1.77)	0.68 (0.30-1.55)
Labor participation†		
Employed	1	1
Not in workforce	0.51 (0.09-3.08)	0.62 (0.14-2.71)
Unemployed/on benefits	1.34 (0.61-2.95)	1.20 (0.70-2.06)
Disabled	0.80 (0.32-2.01)	0.82 (0.41-1.67)
Unknown/missing	1.01 (0.39-2.58)	1.19 (0.36-3.97)
Elementary occupation†		
No	1	1
Yes	1.29 (0.68-2.44)	1.20 (0.75-1.92)
Missing	0.75 (0.31-1.81)	0.80 (0.40-1.59)
Difficulty with Dutch language ᶜ		
No	1	1
Yes	3.21 (1.32-7.78)	2.56 (1.19-5.46)
Health literacy (SBSQ)†		
Adequate	1	1
Low	1.12 (0.58-2.15)	1.08 (0.67-1.75)
Job setting*,§		
No job / caretaker only	1	1
Job with no contact within 1.5 meter	1.66 (0.69-3.99)	1.46 (0.76-2.83)
Other job with contact within 1.5 meter	1.56 (0.71-3.43)	1.40 (0.76-2.57)
Child care/schools/higher education	1.93 (0.25-15.1)	1.62 (0.40-6.64)
Bar/restaurant	1.49 (0.44-4.96)	1.35 (0.55-3.33)
Hospital/long-term care facility/Care worker elsewhere	1.11 (0.37-3.28)	1.08 (0.46-2.55)
Caretaker*		

No	1	1
Yes	0.80 (0.25-2.59)	0.85 (0.34-2.10)
Number of people in household[†]		
1 (Lives alone)	1	1
2	1.85 (0.63-5.50)	1.67 (0.66-4.23)
3	1.88 (0.62-5.70)	1.70 (0.66-4.35)
4	2.86 (0.96-8.48)	2.32 (0.94-5.73)
≥5	5.02 (1.59-15.86)	3.35 (1.37-8.20)
Lives with other people[*]	0.94 (0.47-1.91)	0.96 (0.57-1.60)
Partner	1.28 (0.68-2.39)	1.20 (0.76-1.89)
Children up to 3 years old	2.54 (1.00-6.46)	1.87 (1.08-3.24)
Children 4 through 12 years old	1.17 (0.59-2.33)	1.12 (0.68-1.85)
Children 13 through 17 years old	1.97 (1.02-3.80)	1.61 (1.03-2.50)
Children 18+ years old	1.52 (0.84-2.73)	1.35 (0.89-2.05)
Parents or parents-in-law	Omitted	Omitted
Other adults	1.08 (0.51-2.30)	1.06 (0.61-1.83)
Household member/steady partner with suspected infection[*]		
N.A./No	1	1
Yes	1.20 (0.30-4.78)	1.14 (0.43-3.03)
Number of times left home in the past week[*,‡]		
0-7	1	1
8-11	0.90 (0.45-1.77)	0.92 (0.56-1.53)
12-16	1.07 (0.43-2.63)	1.05 (0.55-2.00)
17+	0.67 (0.24-1.89)	0.74 (0.33-1.66)
In the past week, left home to[*]**:**		
Work	1.91 (1.01-3.60)	1.63 (1.00-2.66)
Do groceries	1.29 (0.54-3.09)	1.21 (0.62-2.39)
Visit family or friends	0.40 (0.21-0.78)	0.50 (0.29-0.84)
Walk the dog or go outside with kids	2.27 (0.87-5.95)	1.74 (0.98-3.08)
Walk or exercise outside	0.75 (0.40-1.40)	0.81 (0.51-1.28)
Take care of someone	1.22 (0.36-4.08)	1.15 (0.49-2.70)
Pick up prescription medicines or visit doctor	0.82 (0.39-1.74)	0.86 (0.49-1.53)
Attend religious service	2.76 (1.49-5.11)	2.07 (1.34-3.21)
Visit cultural place	0.51 (0.04-5.91)	0.59 (0.07-4.63)
Visit bar or restaurant	0.35 (0.11-1.15)	0.42 (0.15-1.20)
Indoor sports	0.79 (0.30-2.10)	0.83 (0.39-1.78)
Visit recreational park	0.79 (0.14-4.45)	0.83 (0.22-3.21)
Frequency of using public transportation in the past week[*]		
0 days	1	1
1-2 days	0.73 (0.31-1.72)	0.79 (0.42-1.51)
3-4 days	1.01 (0.40-2.56)	1.01 (0.52-1.96)
5-7 days	0.91 (0.43-1.93)	0.94 (0.54-1.62)
Number of unique visitors at home in the past week[*,‡]		
0	1	1
1	0.47 (0.19-1.20)	0.56 (0.26-1.20)
2-4	0.57 (0.25-1.29)	0.65 (0.34-1.24)
5+	1.02 (0.17-5.93)	1.01 (0.29-3.49)
Travelled abroad in 2020[*]		
No	1	1
Yes	0.44 (0.22-0.88)	0.53 (0.30-0.92)

Abbreviations: CI, confidence interval; HELIUS, Healthy Life in an Urban Setting; OR, odds ratio; RR, relative risk ratio. Those with an equivocal test result were excluded from this analysis

* Measured at COVID-1 visit (2020) † Measured at baseline (2011-2015) ‡ Quartiles § Presumed higher exposure categories had priority, i.e. if someone was working in a school and as a careworker, they were categorized as a health worker. Caretakers were not included as a category because many had other jobs. ¶ Obtained from a log-binomial regression model.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	8-10
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7, 8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*9, 10*
Bias	9	Describe any efforts to address potential sources of bias	8,9,10
Study size	10	Explain how the study size was arrived at	8,11
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9,10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9,10
		(*b*) Describe any methods used to examine subgroups and interactions	n.a.
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	9
		(*e*) Describe any sensitivity analyses	n.a.
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12
		(b) Give reasons for non-participation at each stage	12
		(c) Consider use of a flow diagram	12
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12,
		(b) Indicate number of participants with missing data for each variable of interest	Table 1, S2
Outcome data	15*	Report numbers of outcome events or summary measures	16

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	16,18, Table 2, S3
		(*b*) Report category boundaries when continuous variables were categorized	18
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n.a.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	n.a.
Discussion			
Key results	18	Summarise key results with reference to study objectives	19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	22, 23
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	19-23
Generalisability	21	Discuss the generalisability (external validity) of the study results	22
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	24

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.