Unaffordability of COVID-19 tests: assessing age-related inequalities in 83 countries

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Abstract

Background: Diagnostic testing for SARS-CoV-2 is critical to manage the pandemic and its different waves. The requirement to pay out-of-pocket (OOP) for testing potentially represents both a financial barrier to access and, for those who manage to make the payment, a source of financial hardship, as they may be forced to reduce spending on other necessities. This study aims to assess age-related inequality in affordability of COVID-19 tests.

Methods: Daily data from the *Global COVID-19 Trends and Impact Survey among adult respondents* across 83 countries from July 2020 to April 2021 was used to monitor age-related inequalities across three indicators: the experiences of, first, reducing spending on necessities because of paying OOP for testing, second, facing financial barriers to get tested (from January to April 2021), and third, having anxiety related to household finance in the future. Logistic regressions were used to assess the association of age with each of these.

Results: Among the population ever tested, the adjusted odds of reducing spending on necessities due to the cost of the test decreased non-linearly with age from 2.3 [CI95%: 2.1–2.5] among ages 18–24 to 1.6 [CI95%: 1.5–1.8] among ages 45–54. Among the population never tested, odds of facing any type of barrier to testing were highest among the youngest age group 2.5 [CI95%:2.4–2.5] and decreased with age. Finally, among those reporting reducing spending on necessities, the odds of reporting anxiety about their future finances decreased non-linearly with age, with the two younger groups being 2.4–2.5 times more anxious than the oldest age group. Among those reporting financial barriers due to COVID-19 test cost, there was an inverse U-shape relationship.

Conclusions: COVID-19 testing was associated with a reduction in spending on necessities at varying levels by age. Younger people were more likely to face financial barrier to get tested. Both negative outcomes generated anxiety across all age-groups but more frequently among the younger ones. To reduce age-related inequalities in the affordability of COVID-19 test, these findings support calls for exempting everyone from paying OOP for testing and, removing other type of barriers than financial ones.

Keywords: Covid-19 testing, Financial protection, Accessibility, Catastrophic health expenditure, Age-related inequalities

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Background

Diagnostic testing for SARS-CoV-2, the virus that causes COVID-19, is critical to prevent and control the spread of the disease and its different variants. At the onset of the pandemic, the World Health Organization (WHO) recommended to remove out-of-pocket payment not just for testing but also for treatment, in order to "enable the timely diagnosis and treatment of COVID-19 for all who need them" [1]. While an exhaustive assessment of the

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numbers of countries with policies aiming at reducing or eliminating user fees is yet to be made, the *2021 Global Monitoring Report on Financial Protection* [2] indicated that across all regions, some countries implemented fee-reduction policies in public facilities, where co-payments for diagnostic tests were not charged *whenever* the eligibility criteria for tests were met (which depended on the testing policy in place) [2–5]. However, tests carried out by the private sector were not always free of charge [3]. The limited coverage of fully subsidized tests is of concern as the need for individuals to pay out-of-pocket potentially represents both a source of financial hardship and a barrier to access. To date there is very little evidence on these issues, let alone on age-related inequalities. This paper aims to fill such gaps.

People paying out-of-pocket for testing might struggle to meet other basic needs. Information on both the actual cost paid out-of-pocket to get tested and an individual's capacity to pay is needed to track this issue, however, there is little data for either of these outcomes, alone or jointly. Based on data from testing at international airports, which are not valid for the general population, one can observe there was a huge variability in the cost of both Polymerase chain reaction (PCR) and Antigen Rapid Diagnostic tests. For instance, in April 2021, the costs of PCR tests varied from about USD 10 in India to about USD 300 in Sweden and Finland, with an average of USD 100 [6]: these costs were not marginal for individuals and represented on average 3.1 times the daily household consumption per capita [7]. Moreover, results from the *Global Monitoring Report on Financial Protection 2021* [2] have shown that among those tested within the last fourteen days, the proportion self-reporting reducing spending on other necessities because of the cost of the test increased between 2020 and 2021 [2]. These results are further discussed and disaggregated by age in this paper.

A comparable assessment of the extent to which there are barriers to get tested for COVID-19 and their evolution over time is also missing to date. But there is information on countries' testing policies and capacities, which are important preconditions to facilitate access. At the onset of the outbreak in March 2020, the main type of tests available and validated were PCR tests [8, 9]. The WHO recommended testing all individuals with symptoms and where resources were constrained, to prioritize individuals at risk of developing a severe form of the disease, health workers, and individuals in closed settings at first symptomatic case [8, 10]. However, the demand for such tests exceeded the supply and countries' capacity to test were in general limited, especially in low- and middle-income countries [8, 11, 12], therefore initially testing policies were mainly restrictive, i.e., limited to those

with symptoms and meeting a specific criterion [10, 13]. The policies and the prioritization of specific categories of people differed depending on incidence as well as on testing capacities [10].

Nevertheless, testing policies and countries' capacity evolved quickly in 2020, as did the types of tests available [14]. According to WHO, by the second quarter of 2020, most countries and territories had the capacity to test for the SARS-CoV-2 virus [14]. The percentage of low-income countries (LIC) and high-income countries (HIC) with an open testing policy reached 60 and 75% in December 2021 respectively, up from 1% vs 4% in March 2020 [13]. Countries' capacity also improved quickly, at all income levels, but with large differences: in LICs, the testing volume doubled between 2020 and 2021, from 0.04 to 0.08 tests performed daily per thousand people; in HICs, it started at a significantly higher level, and it increased even more, from 1.70 to 4.55 [15].

There is also a lack of data on the extent to which individuals did experience barriers to get tested, such as unavailability of test or not knowing where to go, let alone financial ones. The extent to which paying out-of-pocket for the test and the reduction in spending on necessities because of such payments varied by the age profile of the individuals still needs to be determined, as there are reasons to believe that there are age-related inequalities. Indeed, COVID-19 is often more severe among the elderly, observing higher need for hospitalizations and higher mortality rates [14, 16, 17]. Older individuals are therefore likely to be part of the population prioritized for testing [18]. At the same time, older people tend to spend less time outside the house (due to retirement and social distancing encouragement measures) [19], and, overall, most COVID-19 cases and tests are in younger adults [14, 16, 20]. In addition, in places where they are not exempted from paying out-of-pocket for the test, older people may be better able to cope with the direct payments made for a fewer number of them than younger individuals (e.g., by relying on savings). However, people living in older households (with members aged 60 years or more) also had higher rates of catastrophic health spending prior to the pandemic, therefore, the proportion of older people forced to reduce spending on necessities due to testing may not be marginal, even if it is lower than in other age groups [2, 21].

To date, there is very little evidence on the prevalence of unaffordability of COVID-19 test. This paper uses the only global (social media) survey with individual's self-reported information on reducing spending on necessities due to out-of-pocket payments for testing, financial barriers to get tested and anxiety about household's future economic security to monitor age-related inequalities in the unaffordability of COVID-19 test.
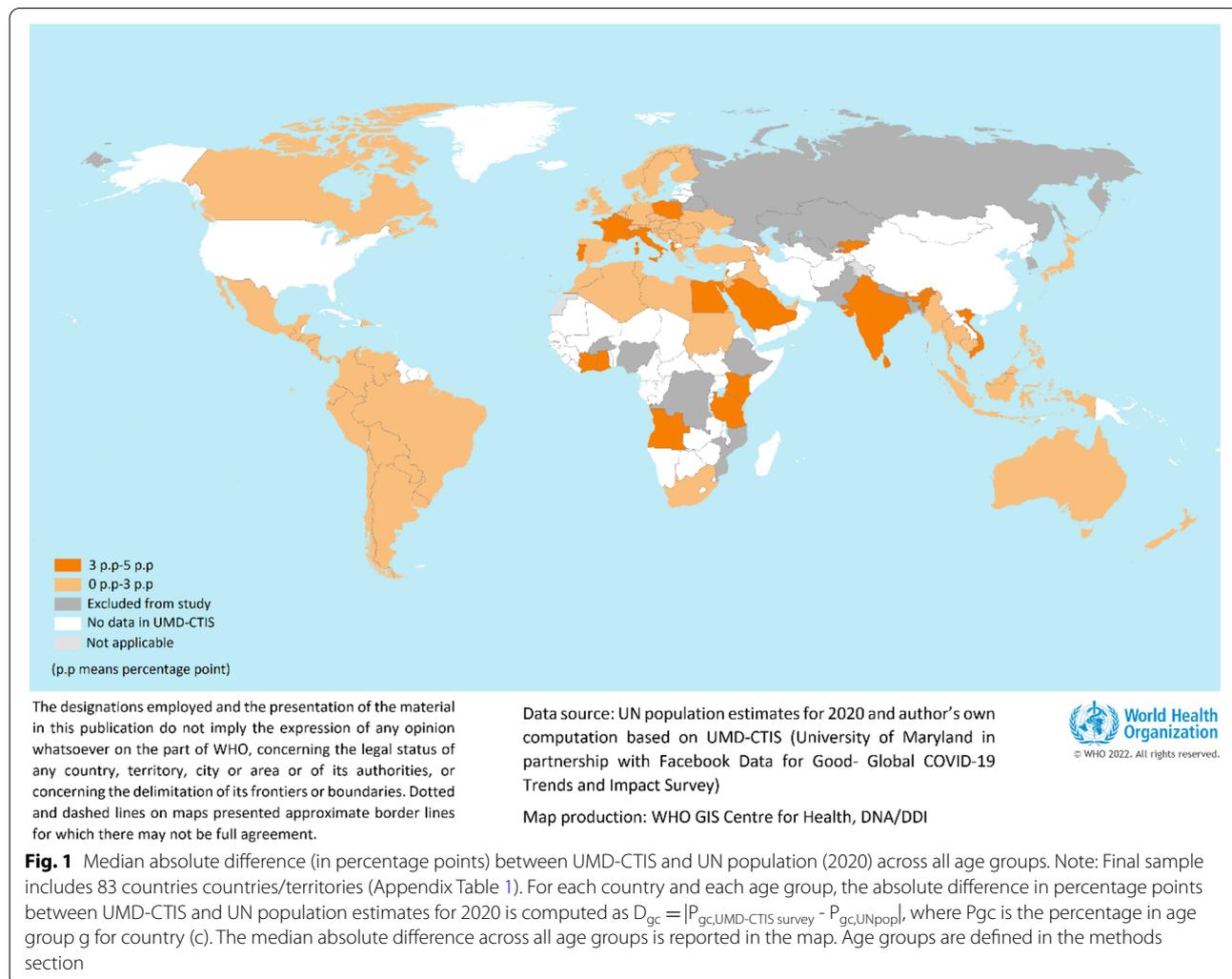
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Methods

Main data source

The main data used for the analysis comes from the "*Global COVID-19 Trends and Impact Survey*", which was launched in April 2020 by the *University of Maryland* in partnership with Facebook Data for Good [22] and is referred to throughout this paper as UMD-CTIS. A cross-sectional random and representative sample of Facebook active users aged at least 18 years old across more than 200 countries or territories are invited daily to report on topics related to COVID-19 such as symptoms, social distancing behavior, vaccine acceptance, mental health issues, and financial constraints. The survey is available in 56 languages and more details about the survey methodology is found in Astley et al. (2021) [23] and Fan et al. (2020) [24]. The survey has been found to be reliable to explore the impacts of COVID-19 [23] with a focus on trends and comparisons across groups [24]. For the latter, careful benchmarking to other data sources is necessary to avoid producing biased results. Sample weights are used to adjust for sample bias and try to minimize errors of representation, including coverage, random sampling, and non-response errors [25]. This study uses daily responses from 83 of the 109 countries or territories included in the UMD-CTIS study, all of which are members of the World Health Organization (see Fig. 1 and Appendix Table 1), which account for 54% of the world population aged at least 18 years old. Twenty-five countries were excluded due to small sample sizes within age groups or discrepancies in the age structure of the population compared to the United Nations population estimates [26] which were not corrected when applying UMD-CTIS sample weights (see details in Supplementary File 1). One country was excluded due to the lack of information about testing policies.

The data supporting the quantitative analyses was collected between July 2020 and April 2021 (see details

3 p.p-5 p.p
0 p.p-3 p.p
Excluded from study
No data in UMD-CTIS
Not applicable

(p.p means percentage point)

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Data source: UN population estimates for 2020 and author's own computation based on UMD-CTIS (University of Maryland in partnership with Facebook Data for Good- Global COVID-19 Trends and Impact Survey)

Map production: WHO GIS Centre for Health, DNA/DDI

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Fig. 1 Median absolute difference (in percentage points) between UMD-CTIS and UN population (2020) across all age groups. Note: Final sample includes 83 countries countries/territories (Appendix Table 1). For each country and each age group, the absolute difference in percentage points between UMD-CTIS and UN population estimates for 2020 is computed as $D_{gc} = |P_{gc,\text{UMD-CTIS survey}} - P_{gc,\text{UNpop}}|$, where Pgc is the percentage in age group g for country (c). The median absolute difference across all age groups is reported in the map. Age groups are defined in the methods section

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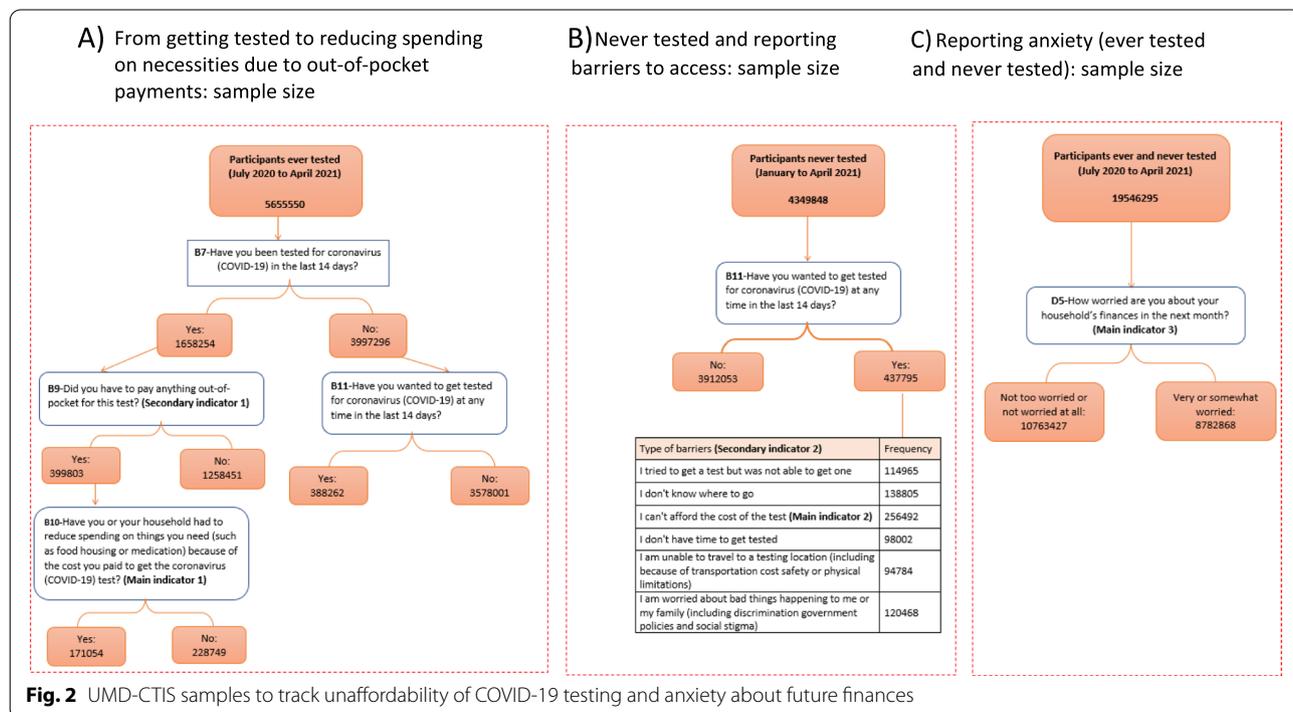
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in Supplementary file 2). While a total of 35 million individuals responded to the survey, 2.4 million did not report information on COVID-19-test, leaving 33.2 million individuals which was then split into two groups: ever tested group (9.4 million) and never tested group (23.8 million). Of the 9.4 million ever tested individuals, only those that reported information on age, gender, education level, employment status, crowd density, and area residence, was used in the analysis. This comprises 5.6 million individuals which was used in the analysis for the first main indicator which assessed what proportion of individuals reported a reduction in spending on necessities due to out-of-pocket payments for testing. For the second main indicator described in next section, a subset of the never tested data was used in the analysis. Because the questionnaire evolved over time, the question on financial barriers was only available for the never tested individuals between January to April 2021 (see details in Supplementary file 2). Of the 14.3 million respondents during the period, only 13.3 million have information on COVID-19 test. Of this, 8.0 million reported not being tested and of this, 4.3 million reported information on age, gender, and other characteristics that were used in the regression. Over this period and in these countries, around 100 million confirmed cases and 2 million of deaths from COVID-19 infection were reported, corresponding to about 75 new cases and 1.6 deaths both per million each day on average [15].

Main outcomes of interest

Three main indicators and two secondary indicators were used. The first main indicator assessed what proportion of individuals reported a reduction in spending on necessities due to out-of-pocket payments for testing. Using data from 5.6 million ever tested from July 2020 and April 2021, a variable "reducing spending on necessities" was constructed to identify those who replied "yes" to the question "Have you been tested for coronavirus (COVID-19) in the last 14 days?" ($n = 1.65$ million), then "yes" to "Did you have to pay anything out of pocket for this test?" ($n = 399,803$). and lastly "yes" to "Have you or your household had to reduce spending on things you need (such as food, housing, or medication) because of the cost you paid to get the coronavirus (COVID-19) test?". A total of 171,054 individuals reporting "reducing spending on necessities" (see Fig. 2 and Appendix Table 2).

The second main indicator of unaffordability of COVID-19 tests was the proportion of individuals who reported the cost of the test as the reason for not getting tested, hereafter referred to as financial barriers to get tested. A variable "financial barrier" was constructed to identify those who responded "no" to "Have you been tested for coronavirus (COVID-19) in the last 14 days?" ($n = 4.3$ million) between January to April 2021,

Fig. 2 UMD-CTIS samples to track unaffordability of COVID-19 testing and anxiety about future finances

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then "yes" to "have you wanted to get tested for coronavirus (COVID-19) at any time in the last 14 days?" ($n = 437,795$) and lastly replied "I can't afford the cost of the test" ($n = 256,492$, see Fig. 2 and Appendix Table 2).

Because barriers are only experienced by people who were unable to get tested and the reduction in necessities by those who managed to pay for the test out-of-pocket, two secondary outcome variables are used to understand better what is driving the unaffordability of tests, namely: "had to pay for OOP" ($n = 399,803$, see Fig. 2 and Appendix Table 2) and "any type of barrier". A variable "any type of barrier" was constructed for those who had any response to the question "Do any of the following reasons describe why you haven't been tested for coronavirus (COVID-19)?" For this question, participants could report multiple reasons, which were classified into three dimensions using the Tanahashi framework [27], i.e. availability ("I don't know where to go", "I tried to get a test but was not able to get one"), accessibility ("I am unable to travel to a testing location, including because of transportation cost, safety, or physical limitations") and acceptability ("I am worried about bad things happening to me or my family, including discrimination, government policies, and social stigma", "I don't have time to get tested", "I can't afford the cost of the test") (see Fig. 2).

Lastly, the third main outcome indicator is anxiety related to household finance in the next month. Individuals were asked to indicate if they were concerned about their household's future finance and whether it was due to losing income or impending health costs. We used this information to construct a variable of experiencing anxiety about household's finance in the next month, hereafter referred to as anxiety about future economic security.

Details on how each variable was constructed is presented in Appendix Table 3. Table 1 shows the summary statistics, including regional location of individuals and other demographic variables.

Control variables

Individual characteristics available in the UMD-CTIS and used in this analysis include age, gender, the number of years of completed education and employment status (see Appendix Table 3 for more details). Five age groups were categorized from the originally available seven predefined subgroups: 18–24, 25–34, 35–44, 45–54, at least 55 years old (which combines the 55–64, 65–74 and the 75 years and older subgroups). The last three subgroups were regrouped to increase sample sizes and better align with the population structure of each country in older age groups. To control for differences in living conditions and to better reflect different socio-economic profiles and to some extent risk exposure to the COVID-19 disease, we constructed a variable to capture crowd density

in the household by dividing the number of people sleeping in the place respondents stayed the night before by the total number of rooms available to sleep. We also controlled for the location of the individual (country, area of residence) and the month of data collection.

Additional datasets were used to add relevant control variables. The Oxford COVID-19 Government Response Tracker (OxCGRT) is a global panel dataset which provides continuously updated, readily usable and comparable information on policy measures governments are taking to tackle COVID-19 [13, 28]. The policies of interest for this study concern those identifying who can get tested for the current infection and are split into two categories: a "restricted testing policy" category and an "open testing policy". Data from Our World in Data (OWID), Statistics and Research on COVID-19 [15] was merged by day and by country with Global COVID-19 Trends and Impact Survey datasets to control for the epidemiological context during the period of interest as part of the robustness checks included in the appendix Table 6. Specifically, the number of new deaths attributed to COVID-19 (7-day smoothed) per 1,000,000 people in each country were used to control for the COVID-19 context in space and time.

Statistical analyses

All computations were done in the pooled sample for the 83 countries or territories using SAS 9.4. Figures were created using STATA MP version 16 unless otherwise specified. Individual specific sample weights for each country were applied to all analyses.

First, to understand to what extent people were getting tested or not, we estimated the prevalence of the population ever and never tested by age group over each relevant period of analysis.

Second, we computed the prevalence of the three main indicators across the five age groups. We assessed age-related inequalities by comparing age-disaggregated estimates by different time periods (see Supplementary File 4).

Third, to quantify age-related inequalities, we ran a series of multivariate logistic regressions, controlling for age (18–24 years, 25–34 years, 35–44 years, 45–54 years), with the 55 years and more being the reference group, and individual's characteristics such as age gender, education, employment status, area of residence, crowd density, and the testing policy in the respondent country/territory of residence on the day of the survey. Months and countries were used as fixed effects. More details are provided in Supplementary File 3. The dependent variables were defined as follows. First, we analyzed the association between age and the probability of paying out-of-pocket for the test, second, conditional on paying out-of-pocket for the test, the association between age

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Table 1 Summary statistics among those "Ever tested" and "Never tested" (UMD-CTIS) *

Factor	Ever tested (July 2020 to April 2021)						Never tested (January 2021 to April 2021)					
	All age groups	18–24 years	25–34 years	35–44 years	45–54 years	55 years old and more	All age groups	18–24 years	25–34 years	35–44 years	45–54 years	55 years old and more
Main outcomes of interest												
Paying out-of-pocket for COVID-19 test**	8.0	8.3	8.6	8.4	7.8	6.8	–	–	–	–	–	–
Reducing spending on necessities**	3.6	4.5	4.5	4.0	3.2	1.9	–	–	–	–	–	–
Having any barriers to get COVID-19 test***	–	–	–	–	–	–	8.2	12.4	9.7	8.6	6.7	4.7
Financial barriers***	–	–	–	–	–	–	5.9	9.0	7.2	6.4	4.8	3.0
Anxiety for future household finance	44.9	53.7	52.2	48.6	42.0	28.0	47.1	57.5	57.0	53.1	44.9	27.1
Individual's characteristics												
Female	46.0	46.2	47.8	43.4	46.9	45.3$^{\varphi}$	48.8	51.4	52.8	46.0	48.2	45.2$^{\varphi}$
Education level												
0–6 years	16.1	20.4	18.5	15.4	14.1	13.1	13.0	15.8	16.1	12.8	10.9	9.8
7–12 years	22.6	25.6	21.5	22.3	21.8	23.5	25.6	27.8	25.5	26.4	24.5	24.6
12 years and more	61.3	54.1	60.1	62.4	64.2	63.5	61.4	56.4	58.5	60.8	64.6	65.6
Unemployed in the last 7 days	49.8	60.8	45.8	42.2	42.5	63.8	54.4	67.4	49.2	43.5	43.0	67.8
Crowd density												
0–0.49	9.5	11.1	13.2	12.6	6.4	3.1$^{\varphi}$	11.6	14.2	16.9	16.7	8.3	3.1$^{\varphi}$
0.5–0.99	40.7	39.7	41.6	46.4	43.4	31.3	38.7	40.3	40.6	44.1	41.4	29.3
1.0–1.49	29.7	27.8	27.3	25.9	31.0	37.0	28.2	23.9	24.9	24.2	29.5	36.1
1.5 and more	20.1	21.3	17.8	15.1	19.1	28.6	21.5	21.5	17.4	14.9	20.7	31.4
Area Residence: Rural	19.1	24.4	20.5	17.7	16.9	17.7	20.9	24.6	23.4	20.1	18.2	18.7
Testing policy												
Open testing policy	34.5	32.8	34.4	32.4	36.1	36.6	42.0	44.3	47.8	39.4	41.8	36.4
Time period (Month)												
2020-07	4.9	5.4	5.3	5.0	4.7	4.2	–	–	–	–	–	–

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Table 1 (continued)

Factor	Ever tested (July 2020 to April 2021)						Never tested (January 2021 to April 2021)					
	All age groups	18–24 years	25–34 years	35–44 years	45–54 years	55 years old and more	All age groups	18–24 years	25–34 years	35–44 years	45–54 years	55 years old and more
2020–08	5.9	6.3	6.5	6.1	5.7	5.2	–	–	–	–	–	–
2020–09	7.5	7.8	8.0	7.6	7.1	6.5	–	–	–	–	–	–
2020–10	9.0	9.7	9.6	9.2	8.5	8.2	–	–	–	–	–	–
2020–11	9.0	9.3	9.3	9.2	8.6	8.2	–	–	–	–	–	–
2020–12	10.0	10.0	10.1	10.3	10.0	9.8	–	–	–	–	–	–
2021–01	11.8	11.6	11.5	12.0	12.0	11.9	25.5	25.3	25.7	26.2	25.3	24.9
2021–02	12.6	12.2	12.1	12.3	13.0	13.2	24.9	25.1	24.9	24.9	25.0	24.6
2021–03	14.1	13.4	13.4	13.7	14.7	15.6	25.6	25.6	25.4	25.3	25.5	26.3
2021–04	15.3	14.4	14.3	14.7	15.9	17.3	24.0	24.0	24.1	23.6	24.1	24.2
WHO Region												
African	5.0	5.2	5.8	5.9	4.6φ	2.9	5.5	6.5	7.4	6.9	4.6φ	2.6
Region of the Americas	19.4	18.1	17.7	21.9	19.7	20.0	18.9	20.6	17.2	20.5	18.5	18.4
Eastern Mediterranean	6.5φ	6.6	7.7	7.8	6.1	3.9	6.5φ	8.9	7.8	7.6	5.8	3.3
European Region	33.3	26.6	24.3	32.3	37.3	47.4	19.5	12.2	12.4	18.4	21.2	31.3
South-East Asian	29.4	37.5	38.4	26.0	26.4	18.8	34.9	40.3	43.4	31.8	34.2	25.4
Western Pacific	6.4	6.1	6.3	6.3	6.0	7.1	14.7	11.5	11.9	14.8	15.7	19.0

Notes: *: The entries in each cell are the percentage of population by each factor across age groups

: Paying Out-Of-Pocket and Reducing spending on necessities were not asked to people never tested (shown as "–"). *: Having any barriers and financial barriers to get COVID-19 test were not asked to people who got the test (shown as "–")

Definition of variables are presented in Appendix Table 3. All percentage are population-weighted estimates based on 5,655,550 observations from 83 countries for ever tested population from July 2020 to April 2021 and 4,349,848 observations from 83 countries for never tested population from January 2021 to April 2021. All differences between population "ever tested" and "never tested" overall and in age groups were significant at the 5% level except cases with "φ"

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and reducing spending on necessities. These analyses are based on two independent multivariate logistic regressions applied to the sample of individual ever tested only. This allows us to understand if the age gradient in the unconditional prevalence of reducing spending on necessities due to the cost of the COVID-19 test is driven by differences in the likelihood of paying out-of-pocket for the test and/or by differences in the consequences such payments have on individuals.

Similarly, to understand if the age gradient in the unconditional prevalence of financial barriers to get tested is driven by differences in the likelihood of experiencing any type of barrier to get tested and/or financial ones specifically, two multivariate regressions were used. The two independent variables are the probability of reporting any type of barrier and then, conditional on that, the probability of reporting a financial barrier. As a robustness check, we also controlled for the prevalence of deaths due to COVID-19 in the regressions for both outcomes. These analyses are performed only on the sample of individuals never tested.

To understand if the extent to which unaffordability of COVID-19 test raises concerns beyond its immediate impact and how this association varies by age, we tested if people reporting a reduction in necessary spending due to the cost of the COVID-19 test or facing financial barriers to get tested were more likely to report anxiety about their economic security. For this specific model, the information from all individuals (those ever and never tested) was pooled and in addition to age and all other individual's characteristic used for previous logistic regressions, we also controlled for testing status. To measure inequalities within the oldest age group and between the oldest and other age groups, we added interactions terms: age groups and reduced spending, and age group and financial barriers (see Appendix Table 2 and method details in Supplementary File 3).

Results

Descriptive statistics

Among the 83 countries represented in this study, 33 are from the European region, 19 from the Americas, 11 from the Eastern Mediterranean region, eight from the West and Pacific, seven from sub-Saharan Africa, and five from Southeast Asia (see Appendix Table 1). One country is classified as low-income (Sudan), while 22 countries are lower-middle income, 27 are upper middle income, and 31 are high-income countries.

Between July 2020 and April 2021, on average one in four people in the studied population across the 83 countries had ever been tested. Figure 3 shows the percentage of people ever and never tested across the five age groups - which are then treated as two different studied populations in the analyses that follow. Panel A shows that, over the period July 2020 to April 2021, the prevalence of testing increased with age, following an inverted U-shaped pattern with a minimum among the youngest adults aged 18–24 years (21.1%) and a maximum in the second oldest
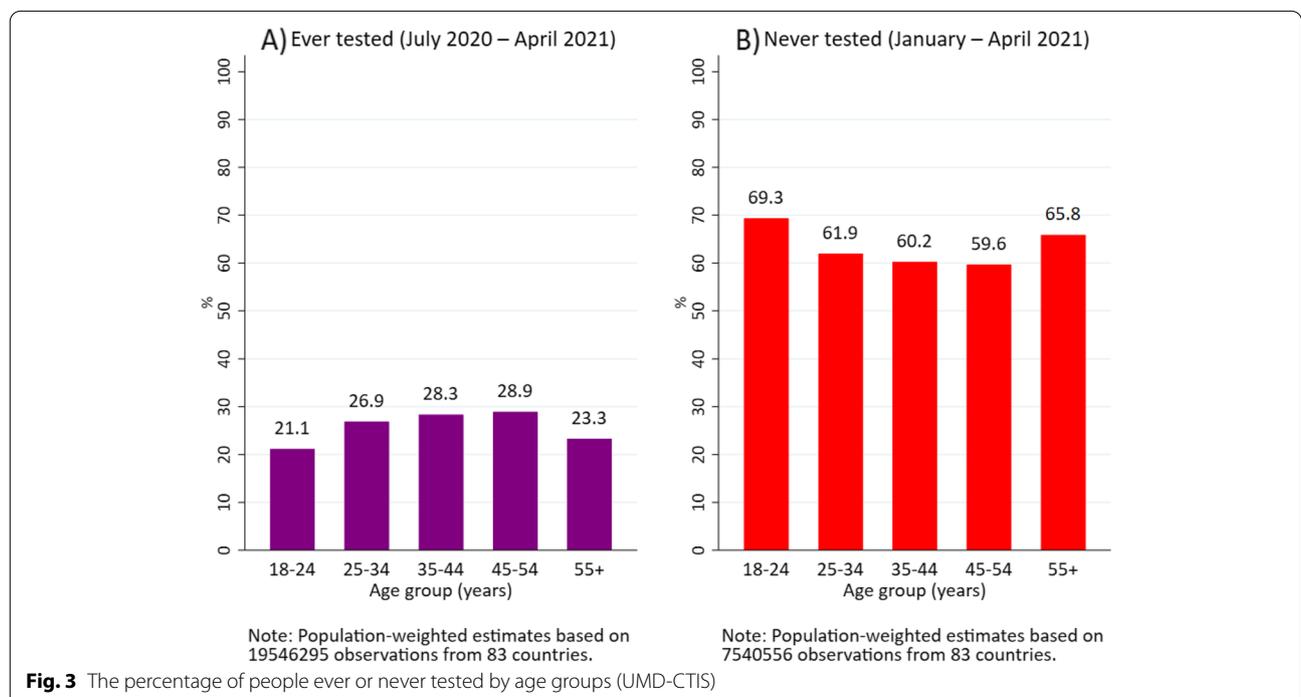
Fig. 3 The percentage of people ever or never tested by age groups (UMD-CTIS)

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age group (28.9% among 45–54 years). Similarly, panel B shows that, within the first four months of 2021, the prevalence of no test decreased with age and followed a U-shaped pattern with the highest proportions of those never tested among the youngest adults (69.3%) and the oldest (65.8%), and the lowest among the middle-aged people (59.6–61.9%). In the rest of this section, unless otherwise specified, results related to those never tested concern this shorter and more recent period but those related to the population ever tested cover the whole period (July 2020 to April 2021).

Table 1 shows first that, over the period July 2020–April 2021, 8.0% of the ever-tested population reported paying out-of-pocket for the test over the past 14 days, and 3.6% were forced to reduce spending on necessities. Second, between January to April 2021, 8.2% of the never tested population reported any type of barrier to get tested, while 5.9% of the never tested population reported financial barrier to testing. (Supplementary file 4 shows averages per month, averages for the period between July to December 2020 and January to April 2021, and for the whole period of July 2020 to April 2021 for the 3 main indicators, which suggests a slightly decreasing trend for all indicators among all age groups).

Table 1 also presents pooled means for all individual's characteristics used in the multivariate logistic regressions for the overall studied population and by age groups. It shows that, in both never tested and ever tested populations across the 83 countries, 61% of people had at least 12 years of completed education, half of people were sleeping in crowded places, only one in five lived in rural areas, and those living in Africa, the Americas and the Eastern Mediterranean jointly accounted only

for one third of the studied population. In both ever and never tested groups, the older individuals were less likely to sleep in overcrowded places (32.4–34.4%) compared to younger groups (49.7–60.8%); they were also more likely to come from the European region, and less likely from the South-East Asian, African, and Eastern Mediterranean regions (altogether 25.6–31.3% vs 50.6–57.1% among the 18–34 years old). In the supplementary file 1, we discuss the differences between the population "ever" and "never" tested and find that they differ in terms of unemployment, gender, and regional location, among others, in addition to the differences by age as discussed above. Therefore, in the rest of the paper we refrain from comparing these two groups directly.

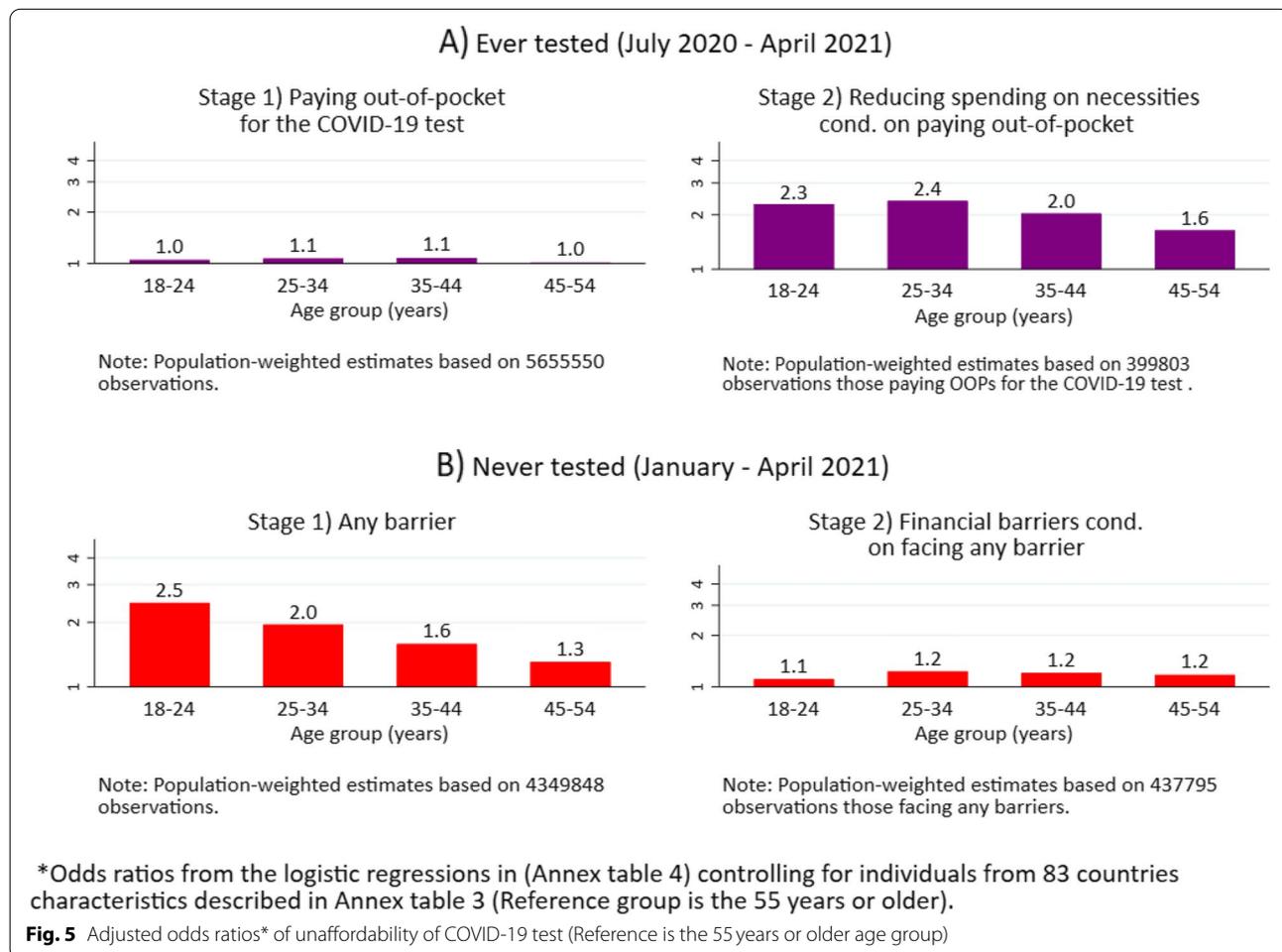### Age-related inequalities in unaffordability of tests

Figure 4 shows age-related inequalities in the unaffordability of COVID-19 over time. Panel A shows that between July and August 2020, 2.5% of the older population reported reducing spending on necessities due to out-of-pocket payments for testing; this rate then decreased, although with some fluctuations, until it reached 1.7% in April 2021. Younger populations from all age groups showed systematically larger rates. Between July and August 2020, the hardship experienced as a result of the costs of COVID-19 test was the highest among the 18–24 and 25-34 years' age groups (5.3–5.5%), but over time, this decreased and converged with the 35–45 years age group, with the three groups reaching 4.2–4.4% in April 2021; the absolute difference between the oldest age group and the three younger groups remained in a range from 2 to 3 percentage points over the period. While some people had to reduce spending

Fig. 4 The prevalence of the two indicators of unaffordability of COVID-19 test by age groups (UMD-CTIS)

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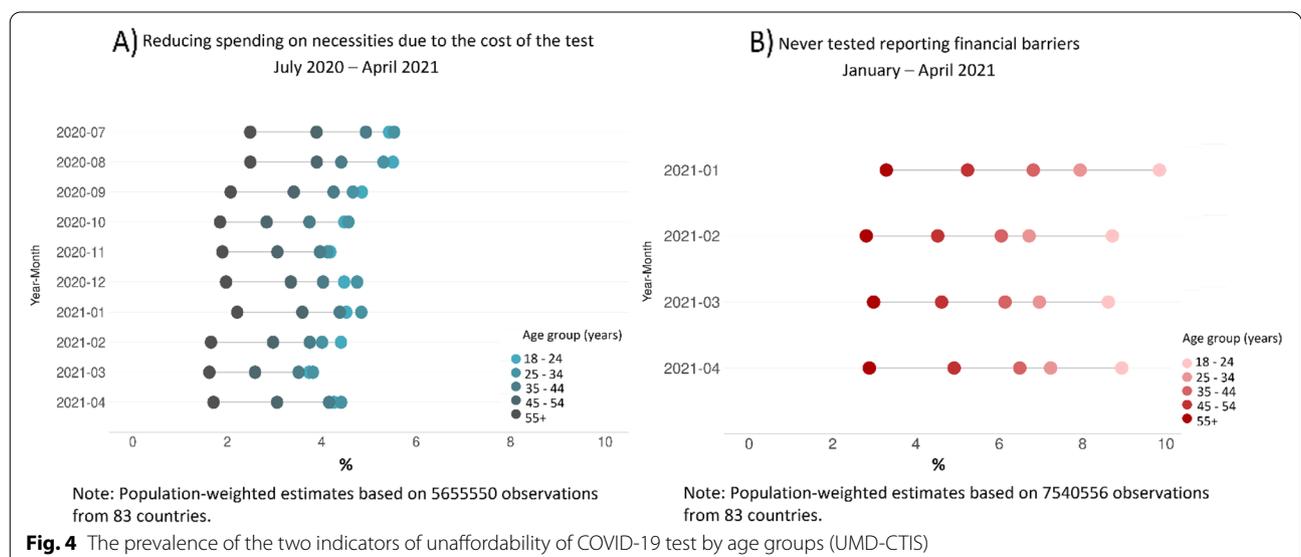
on necessities due to the cost of the test, others could simply not get tested at all. Panel B shows that in January 2021, about 3.3% of the older population reported facing financial barriers to get a test, which decreased to 2.9% in April 2021. Again, these proportions were systematically higher for younger groups, with, on average over the four-month period, respectively 8.9, 7.2, 6.5 and 4.9% for the 18–24-, 25–34-, 35–44-, and 45–54-year-old groups. Absolute inequality between age subgroups remained similar over time – with for instance the youngest age group being systematically around 6 percentage points above the oldest age group (5.6 to 6.5 p.p.), suggestive of little variability in inequalities in incurring financial barriers.

Figure 5 shows the odds ratios of age-related inequalities in the unaffordability of COVID-19 tests, adjusted for possible confounders (see Appendix Table 4 for regression results). Panel A displays the adjusted odds ratios of each age group compared to the older population (55 years or older) related to the probability of 1) having to pay out-of-pocket for testing, and 2) having

to reduce spending on necessities, conditional on paying out-of-pocket for the test. It clearly shows that there was little to no age-related inequality in the odds of paying out-of-pocket for testing but important age-related inequalities in the consequences of paying out-of-pocket for the test. For the latter, the estimated adjusted odds ratios decreased non-linearly with age from 2.3 [CI95%: 2.1–2.5] among ages 18–24 to 1.6 [CI95%: 1.5–1.8] among ages 45–54. Similar results were obtained when controlling for the prevalence of deaths due to COVID-19: age-related coefficients were similar, as such the interpretation of the results did not change (see Appendix Table 6). Taken together, these results indicate that younger age groups did experience more pressure to reduce their spending on necessities due to testing costs than people aged 55 years or older for similar odds of paying out-of-pocket for the test. It also indicates that the age-related gradient towards reducing spending on necessities because of the cost of the test was likely driven by the gradient in reducing spending on necessities, rather than on having to pay the test out-of-pocket.

Fig. 5 Adjusted odds ratios* of unaffordability of COVID-19 test (Reference is the 55 years or older age group)

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Panel B displays the adjusted odds ratios of each age group compared to the older population (55 years or older) related to the probability of 1) facing any barriers to accessing COVID-19 test, and 2) facing financial barriers to get access to COVID-19 test conditional on any barrier. For the former, the odds ratios were systematically above 1 and ranged between 2.5 [CI95%:2.4–2.5] for the 18–24 years old group and 1.3 [CI95%:1.3–1.4] for the 45–54 years group, confirming that the younger faced more barriers than the 55 years or older group. On the other hand, conditional on reporting any type of barrier, the odds of reporting a financial barrier in accessing testing did not differ markedly across age group (1.1–1.2 with confidence intervals between 1.0 and 1.3). These results are robust to controlling for the prevalence of deaths due to COVID-19 (see Appendix Table 6). Taken together, these two panels indicate that younger age groups did experience more barriers in general to access a COVID-19 test than people aged 55 years or older, rather than financial ones specifically.

Age-related inequalities in anxiety about future economic security

Within the older population, anxiety is greater for those facing unaffordability issues. Specifically, for those facing financial barriers to the test, people aged 55 and above have 3.5 times higher odds of anxiety than people aged 55+ without financial barriers (see Appendix Table 5, exponential of the coefficient of financial barrier, exp. (1.24)). For those with reduced spending on

necessities due to costs of tests, people age 55 and above have 4 (see Appendix Table 5, exponential of the coefficient of reduced spending, exp. (1.41)) times higher odds of anxiety than people aged 55+ who did not reduce spending. Figure 6 shows adjusted odd ratios of financial anxiety among those experiencing two dimensions of unaffordability for each age group compared to the older population. Panel A shows that between July 2020 and April 2021, the odds of anxiety decreased with age among those reporting reducing spending on necessities, with the two younger groups being 2.4 to 2.5 times more anxious and the 45–54 years old group being 1.7 times more anxious than the oldest age group. Panel B shows that between January and April 2021, there were significant age-related inequalities in being anxious about household's future finance among those reporting financial barriers due to COVID-19 test cost. Odds ratios draw a reverted U-shaped pattern, indicating that the two middle age groups were the most anxious compared to the oldest age group when experiencing financial barriers (with adjusted OR around 2.1 and 2.3), while the 45–54 years old and the youngest groups had similar odds (adjusted OR = 1.8) but still significantly different from the oldest age group.

Discussion
Summary of findings
Diagnostic testing for SARS-CoV-2, the virus that causes COVID-19, is part of a comprehensive strategy to reduce transmission to manage the pandemic and its different

Among those reducing spending on necessities (July 2020 - April 2021)
(bars) 18-24: 2.4; 25-34: 2.5; 35-44: 2.0; 45-54: 1.7
Age group (years)
Note: Population-weighted estimates based on 19546295 observations.

Among those with financial barriers (January - April 2021)
(bars) 18-24: 1.8; 25-34: 2.3; 35-44: 2.1; 45-54: 1.8
Age group (years)
Note: Population-weighted estimates based on 7540556 observations.

*Odds ratios are computed as exponentiated logistic regression coefficient of reducing necessities or financial barrier (Annex table 5) which are controlled for individuals from 83 countries characteristics described in Annex table 3 (Reference group is the 55 years or older).

Fig. 6 Adjusted odds ratios* of anxiety about household's finances in future by two indicators of unaffordability

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waves. The requirement to pay out-of-pocket for testing potentially represents both a financial barrier to access and, for those who manage to make the payment, a source of financial hardship, as they may be forced to reduce spending on other necessities. This study aimed first to assess the prevalence of both issues with a focus on age-related inequalities, controlling for individuals's and countries' characteristics to unpack its main drivers. Then it aimed to assess how unaffordability of COVID-19 tests is associated with anxiety about future economic security still focusing on age-related inequalities.

The survey data indicated that, over the period of analysis (9 months), on average one in four people in the studied population across the 83 countries got tested at some point. The unaffordability of COVID-19 tests issue was identified through two distinct indicators: reducing spending on necessities due to testing (over July 2020–April 2021) and avoiding testing because of a financial barrier (over January–April 2021). Findings suggest that the older population (55 years old and older) was the least affected by unaffordability of tests.

The reduction in spending on necessities due to the COVID-19 test cost decreased from 2.1 to 1.8% among the older population between 2020 and 2021 respectively, while it ranged from 3.9 and 4.7% for the younger and middle age individuals (18–34 years old). The adjusted odds ratios show that even when controlling for differences in individual's and countries' characteristics, the younger groups were more likely to be forced to reduce their spending on necessities when paying out-of-pocket for the test than the older population for similar probabilities of paying out-of-pocket for the test because younger population tend to be less wealthy than other population groups. This finding points to major inequalities in the consequences of such payments across age groups rather than on the exposure to such payments.

Among the people who were never tested, reporting financial barriers to get a test concerned about 3.0% of the older population over January–April 2021; this percentage was greater at younger ages, reaching a maximum (9.0%) within the youngest group (18–24 years old). The adjusted odds ratios confirmed this age gradient and suggested that it was driven by the likelihood of facing any barrier rather than financial ones specifically.

Unaffordability of COVID-19 tests is not just of concern because of the implication it has on individuals' day to day consumption of other necessities and potential risk to their own health as well as that of others. This paper shows that it may also exacerbate anxiety about a household's future finance. Older people having to reduce spending on necessities due to the cost of the tests or facing financial barriers to access the test were respectively 4 and 3.5 times more likely to report anxiety about their finances than older people without unaffordability issues. This paper also shows that anxiety among those reducing spending on necessities due to the cost of test decreases with age. For those experiencing a reduction in spending on necessities, anxiety was most pronounced among the youngest age groups, and for those experiencing financial barriers to get tested, anxiety was highest among the middle age groups.

Implications of findings in the context of existing research

Even when COVID-19 tests are provided widespread and for free, there can be motivation and capability barriers, especially for people with lower health literacy. In the literature, the main barriers include uncertainty about eligibility and how to access tests; difficulty interpreting symptoms; the lack of accessible testing locations and uncertainty regarding where to go for testing; costs and logistical issues including transport to and from test sites; fear of pain/discomfort of sample extraction; long wait times for testing results; and concerns about the consequences of a positive result, including discrimination [29–32]. Among these barriers, monetary costs are considered as an important barrier to get tested, be it with fees, travel costs and/or indirect costs [33]. A study in the USA in May 2020 found that many immigrants had faced financial barriers to testing because they did not have any health insurance coverage at that time (also due to job loss following the restrictions) [34]. In our study, the financial barrier to getting tested appeared to be the most often reported compared to availability, discrimination and stigma worries, time, and travel issues.

Older people are the most at risk of developing a severe infection and as such it is important to quickly diagnose them. Older people may test less often than younger people, as they are more likely to stay more at home and therefore be less at risk of catching the virus [16, 20]. On the other hand, younger people, are more socially active, and then are more at risk of being infected and of spreading the virus: testing younger people when having symptoms is important on a public health perspective, to slow down the pandemic [19]. However, this study suggests that while financial barriers are the most often reported, they do not drive age related inequalities in access to COVID-19 testing: controlling for individual's characteristics, younger people are more likely to report facing any barriers to get a test, rather than financial ones specifically. This tends to reduce the effectiveness of "the testing strategy": if the idea is to contain the spread, populations who are more at risk of carrying the virus should find easy way to get tested.

For several years, protection of households from financial hardship has been widely accepted as a desirable objective to move toward Universal Health Coverage

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[35]. Many countries introduced a variety of policies to ensure that financial barriers were not a binding constraint to receiving COVID-19 tests and treatment. Testing is part of a comprehensive strategy to reduce transmission and making it free of charge for everyone makes it more accessible. Moreover, in 2020 and in many countries in the Region of the Americas, diagnostic tests did not require any co-payment, at least in public facilities [2]. In the WHO European Region, countries also quickly mobilized significant additional public funds to respond to the COVID-19 pandemic [36] and most countries provided tests free of charge to all people [3, 4]. In South Eastern Asia also, all countries expanded service coverage and provided free COVID-19 testing for suspect cases in the public sector and, in some cases, the private sector [5]. Cost-sharing policies evolved over the course of the pandemic. For example, in Sri Lanka tests were initially only free in public facilities for those with observable symptoms or a direct contact, but by March 2021 these restrictions were lifted. In Bangladesh, a user fee was introduced for COVID-19 tests as a way to dissuade over-use, but was quickly removed as it led to a significant reduction in the number of tests performed every day [2, 5]. Although there is some evidence that COVID-19 test costs were covered in most countries, at least in public facilities, there were disparities in terms of the beneficiaries of such subsidies (e.g. uninsured people, undocumented migrants, etc.) partly depending on the criteria of testing policies [3–5, 35, 37, 38]. The evidence emerging from this study suggests if tests were made free of charge, it might not constitute a barrier to anyone (younger populations included), nor lead to sacrificing consumption of other necessities. This study also suggests that while there are no age-related inequalities in the probability of paying out of pocket for the test, there are regarding the consequences of such payments on the capacity to sustain spending on necessities: the younger population are more likely to reduce such spending because of the test which points to an additional source of impoverishment for multigenerational households. Indeed, the *Global Monitoring Report on Financial Protection* 2021 [35] reported that, in all income groups and UN regions, multigenerational households (including both younger and older individuals as well as children) were more likely to be pushed or further pushed into poverty by out-of-pocket health spending [35].

Limitations

The UMD-CTIS used in this analysis is a very large global database with daily repeated cross-sectional data which provides a valuable source of information related to COVID-19. However, it also has several potential sources of bias. First, individuals invited to respond are Facebook App users which exclude completely the representation of some countries (e.g. China and Iran (Islamic Republic of)) and for those included in the study, the users may have different characteristics than the general population (e.g. in terms of socio-economic conditions but also access to the digital network) [23, 24] given that there are age biases in recruitment. In addition, many survey respondents do not complete the entire survey and questions that appear later in the survey (like age, gender or education) can be missing for 10–20% of survey responses [24]. To limit some of these biases, countries for which the population age structure computed through the dataset differ largely to the one reported by the UN population estimates were removed from the analysis. Our final dataset covering 83 countries included a larger share of those living in European and Asian countries, a larger share of people with high education and a smaller share of people living in low- and middle-income countries, rural places, and in overcrowded places. Therefore, our results may have been influenced by such composition. Lastly, the information available about individual characteristics was limited, which restricted our analysis.

Our main findings were based on the only global survey with comparable evidence on both indicators of unaffordability adapted to the COVID-19 pandemic context. While we were able to benchmark the age distribution of such survey to other reliable internationally comparable sources of information, we were unable to do so for the main outcomes of interest in this paper. As already mentioned, information on out-of-pocket health spending for COVID-19 diagnostic or treatment as well as on barriers to access was largely unavailable from other sources for two reasons. On the one hand, the typical way to collect such data is through face-to-face household surveys that have been largely interrupted due to the social distancing measures in place [39]. On the other hand, most rapid data collection surveys implemented since the beginning of the pandemic have largely omitted to capture direct payments for health for COVID-19 or non-COVID-19 services, and few have attempted to unpack barriers to access [40, 41].

While we controlled for the type of testing policy in place in the country when individuals reported on financial barriers to get tested and reducing spending on necessities, a full assessment of the impact of such policies on unaffordability is beyond the scope of this current paper. Indeed, more granular information than what is currently available in the OxCGRT database would be needed, which would require a detailed review of the relevant documents in each one of the 83 countries.

Our analysis covered both 2020 and early 2021 but misses the period with more rapid and cheaper tests available in many countries as well as greater availability

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of vaccines, due to our indicators of interest not collected in the survey post-April 2021. Some countries later shifted a greater share of the cost of COVID-19 tests to unvaccinated individuals as an incentive to get vaccinated [14, 42]. We were unable to assess to what extent those changes impacted unaffordability.

Lastly, our analysis provides evidence on age-related inequalities in barriers to get tested and the consequences of paying out-of-pocket for the test for individual's consumption of necessities. We were unable to compare these rates to those experienced for diagnostics during other types of health shocks, which again emphasizes the need to strengthen this type of monitoring to ensure that countries are better prepared to reduce these types of inequalities during future health crises.

Conclusions

Over the period July 2020 to April 2021, 8.0% of the ever-tested population reported paying out-of-pocket for COVID-19 testing over the past 14 days, and 3.6% were forced to reduce spending on necessities due to this. In early 2021, 8.2% of the population never tested reported barriers to getting tested, with 5.9% reporting financial barriers specifically. Beyond those average values there are marked age-related inequalities in both the probability of reducing spending on necessities conditional on paying out-of-pocket for the test and in the likelihood to experience any type of barrier rather than financial ones. People facing unaffordability issues in this period were also much more likely to report anxiety about their future finances – and such association was even more frequent among younger groups. Therefore, this study suggests that although COVID-19 tests costs were covered in many countries at least for some people, there were age-related disparities in benefitting from such type of financial protection. Findings suggest that governments should consider age-related inequalities regarding financial access to tests when revising the designs of testing and financial protection policies, as ensuring that everyone is able to be diagnosed is critical to monitor the pandemic and early prevention is needed to slow down the pandemic [19].

This study also points to the need to actively track the impact of cost-sharing and exemption policies, as to date there has been no systematic attempt to monitor the extent to which people are paying out-of-pocket for testing, let alone for COVID-19 treatment. That said, it also has to be noted that affordability is not only about the cost of tests themselves, it also includes transport costs, time off work, and self-isolation when positive [29]. All of this should be considered when designing testing policies.

Abbreviations

COVID-19: Coronavirus disease 2019; HIC: High Income Country; LIC: Low Income Country; OR: Odds ratio; OWID: Our World in Data; OxCGRT: Oxford COVID-19 Government Response Tracker; PCR: Polymerase chain reaction; SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2; UMD-CTIS: University of Maryland - Global COVID-19 Trends and Impact Survey; UN: United Nations; WHO: World Health Organization..

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12939-022-01784-4.

Additional file 1: Supplementary file 1. Methodological details on the sample selection.

Additional file 2: Supplementary file 2. Availability of the information on unaffordability in the UMD-CTIS.

Additional file 3: Supplementary file 3. Methodological details on the logistic regressions.

Additional file 4: Supplementary file 4. Unaffordability of COVID-19 test and anxiety for future household finance, disaggregated by age.

Additional file 5: Appendix Table 1. List of countries/territories retained for this study and regional classification from UMD-CTIS. **Appendix Table 2.** UMD-CTIS sample. **Appendix Table 3.** Definition of UMD-CTIS, OxCGRT and Our World in Data (OWID) variables. **Appendix Table 4.** Factors associated with unaffordability of COVID-19 tests (UMD-CTIS). **Appendix Table 5.** Anxiety about household's finances in the next month (UMD-CTIS). **Appendix Table 6.** Factors associated with unaffordability of COVID-19 tests (UMD-CTIS).

Authors' contributions

GF contributed to develop the questions on financial barriers and reducing spending on necessities when the UMD-CTIS was being designed; GF, CK, AA and RL developed the analytical plan; RL, CK and AA prepared and curated the databases; CK conducted the literature review, AA was the main data analyst; GF, CK, AA wrote the first draft of this manuscript. All authors contributed to writing the final manuscript and have read and approved the final manuscript.

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Availability of data and materials

1. The University of Maryland Social Data Science Centre Global COVID-19 Trends and Impact Survey (UMD-CTIS): UMD-CTIS data is available from Facebook Data for Good upon signing of Data Use Agreements: https://dataforgood.faceb ook.com/dfg/docs/covid-19-trends-and-impact-survey-request-for-data-access. The UMD-CTIS Open Data API, Microdata Repository, and contingency tables are available via https://covidmap.umd.edu.

2. Data from Our World in Data (OWID): The updated confirmed cases and deaths attributed to COVID-19 are provided via: https://github.com/owid/covid-19-data/tree/master/public/data

3. The Oxford COVID-19 Government Response Tracker (OxCGRT): OxCGRT as a global panel dataset provides continuously updated, readily usable and comparable information on policy measures governments have taken to tackle COVID-19. OxCGRT data are freely available, on the website of the Oxford COVID-19 Government Response Tracker: https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker.

4. All SAS and STATA codes to reproduce tables and figures are available upon request.

Declarations

Ethics approval and consent to participate

This study is based on secondary data analysis. Ethical clearance was not sought. The main data source (UMD Global CTIS study) received ethical clearance from the University of Maryland Institutional review board (1587016–10). All respondents gave informed consent before participating in the survey. Informed consent was documented in the digital platform by the respondent (no witness required). This study did not include minors. Access to the microdata was granted to WHO in accordance with the user agreement signed between WHO and UMD. The policy data does not include individual's specific data. The last data set comes from WHO (WHO COVID-19 Detailed Surveillance Data Dashboard) and is used to contextualize the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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