



## Cross-sectional Study

# Social contributors for the rise of COVID-19 infections in South Asia: A large cross-sectional survey



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## ABSTRACT

**Background:** The ongoing global coronavirus disease 2019 (COVID-19) pandemic, caused by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) was first reported in South Asia on 30<sup>th</sup> January 2020 in India. Ever since, certain countries have witnessed multiple waves of COVID-19, requiring attention by public health experts and strategists in the region. The objectives of this study are to assess social contributors to the recurrent waves of COVID-19 in South Asia including first demographic traits, second household characteristics and social measures, third workplace trends and personal protective equipment use, and fourth satisfaction and attitudes concerning public health measures and vaccination status. The study also aims to plan for control strategies focusing on India, Pakistan, Bangladesh, Sri Lanka, and Nepal, countries with the highest burden of COVID-19 in South Asia.

**Methods:** A population-based large cross-sectional study was conducted from 1st July to August 10th, 2021 using online mediums. The survey consisted of 31 questions divided into sociodemographic and COVID-19 status information, household characteristics and social measures, workplace trends and personal protective measures, satisfaction and attitudes towards public health measures, and vaccination status. Bivariate, receiver operating characteristic (ROC) analysis, and the Kruskal Wallis test was conducted for factors associated to COVID-19 infection and positive vaccination status.

**Findings:** We enrolled 1046 participants with 57.1% females and 41.8% males, comprising 48.9% healthcare workers. Statistically significant associations were found using ANOVA based on the Kruskal-Wallis test for differences between thoughts towards public health authorities implementing standard operating procedures (SOPs) and HCW status were statistically significant ( $P = 0.002$ ). The most important social predictors for positive vaccination status based on the ROC analysis were gender ( $P < 0.001$ ), job role ( $P < 0.001$ ), income group ( $P < 0.001$ ), healthcare worker status ( $P < 0.001$ ), household member tested positive ( $P = 0.007$ ), personal vehicle ownership ( $P < 0.001$ ), job requiring close contacts ( $P < 0.001$ ) and co-worker masking habits ( $P = 0.02$ ).

**Conclusions:** Public health experts and strategists are required to focus control strategies on political and religious gatherings, reopening offices, noncompliance of SOPs by the masses, and crowded commuting to limit the reemergence of COVID-19 infections in countries with the highest burden in the region.

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## 1. Introduction

The ongoing global coronavirus disease 2019 (COVID-19) pandemic, is caused by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) [1]. One month after the notification from Wuhan, China, on 30th January 2020, the first COVID-19 case of South Asia was reported in India [2]. South Asia, a sub-region of Asia, consists of the Indo-Gangetic Plain and peninsular India, includes the countries of Bangladesh, Bhutan, India, Pakistan, Nepal, Sri Lanka, Afghanistan, and the Maldives [3]. Certain countries in South Asia witnessed multiple waves of COVID-19, now consuming the attention of several governments in the region [4]. In the last few months, COVID-19 cases spiked in the South Asian countries along with the further extension to countries in mainland Asia [5]. The surge in South Asia has also been driven by the Delta SARS-CoV-2 amid other variants and sociocultural factors, prompting considerations of lockdowns, and attempts to rapidly scale up vaccination production and distribution across the region [6].

Studies conducted in South Asia have shown adequate knowledge and good perception with a positive attitude towards the COVID-19 pandemic [7,8]. Measures including use of personal protection equipment (PPE), social distancing, education for COVID-19, and mass vaccination have great potential to control the further spread of COVID-19 [9,10]. This is, however, challenging for South Asia that consist of low- and middle-income countries (LMICs) with under-resourced healthcare systems, economic closures, and widespread misconceptions towards SARS-CoV-2 infections and vaccinations [11, 12]. Groups at risk of higher morbidity and mortality due to community transmission of COVID-19 are people on low income, self-employed, in institutions, and homeless individuals; vulnerable groups are those who have lower income and constitute a high proportion of the population in South Asia, with the direct effect of income and health having been established already [13,14].

The aims and objectives of this study are to assess social contributors to the recurrent waves of COVID-19 in South Asia including first demographic traits, second household characteristics and social measures, third workplace trends and personal protective equipment use, and fourth satisfaction and attitudes concerning public health measures and vaccination status. The objectives of the study are also to plan for control strategies focusing on India, Pakistan, Bangladesh, Sri Lanka, and Nepal, countries with the highest burden of COVID-19 in South Asia.

## 2. Methods

A population-based cross-sectional study was conducted across South Asian populations comprising of general populations and healthcare workers from 1st May to August 10th 2021 to assess the social contributors to the ongoing COVID-19 waves. The study was conducted in accordance with the Declaration of Helsinki (Recommendations guiding physicians in biomedical research involving human subjects). The STROCCS 2021 checklist is appended in the supplementary materials [15]. Due to the risk of transmission of COVID-19 in conducting face-to-face interactions, a web-based application named Google Forms was utilized to collect the responses. This survey was registered with Research Registry “researchregistry7877” [16].

A self-administered questionnaire was designed post piloting it among 10 general medical practitioners and also going through previously validated questionnaires from similar published studies [17,18] (Supplementary Material). The results of the piloting were not included in the final results. The target group was the adult population, anyone aged 18 years old or over and resident of South Asian countries including Bangladesh, Bhutan, India, Pakistan, Nepal, Sri Lanka, and Afghanistan. The survey instrument was created to address the objectives of the study. The following components were listed: i) Sociodemographic and COVID-19 status information (9 questions), ii) Household characteristics and social measures (10 questions), iii) Workplace trends and personal protective measures (7 questions), iv) Satisfaction and attitudes towards

public health measures (4 questions), and v) Vaccination status (1 question). Participants were required to enter responses for all required questions. Implicit consent was obtained using forms by every participant before beginning the survey. Those who did not wish to participate were excluded from the study.

Sample size was calculated with OpenEpi software (Version 3.01; Open Source Epidemiologic Statistics for Public Health) to be 384 using the estimate of population size to be 1,000,000 X due to lack of exact number of X. The sample size was calculated using the following formula:  $[(DEFF * Np(1-p))] / [(d^2 / Z^2 * \alpha / 2 * (N-1) + p * (1-p))]$ . The predicted hypothesis of outcome factor was estimated as 50% as there are no clear studies in the subject. The confidence interval was 95%, and accepted margin of error was 5%. This was further increased to 1046 participants to ensure maximum representation of the South Asian population. Descriptive statistics were calculated using Statistical Package for the Social Sciences (SPSS, v.24 Chicago, IL: IBM® SPSS® Statistics). The results were presented as means, standard deviations for quantitative variables and as frequencies/proportions for qualitative variables. A bivariate analysis was conducted to compare the differences among infected and non-infected respondents. A comparison of infection status and other factors among the two groups was made using the Chi-square test, which was tabulated. P-values were considered to be statistically significant if  $< 0.05$ .

To understand the social contributors to the rise of COVID-19 across infected and non-infected individuals, and vaccinated and non-vaccinated individuals a receiver operating characteristic (ROC) analysis was performed, which was reported as area under curve (AUC) values with 95% confidence intervals (CI). The results helped in understanding the strongest predictors of COVID-19 positive and positive vaccinated status individuals among the respondents. To ensure that the most important predictors were listed, we shortlisted the significant predictors based on the model. A Kruskal-Wallis test was conducted to see if healthcare workers as opposed to general population members thought that adequate measures are being taken by public health authorities to maintain standard operating procedures (SOPs). An additional risk estimation analysis was conducted to measure the magnitude of positive vaccination status with relation to gender and healthcare worker status. Cronbach’s alpha was used to assess internal consistency for the household characteristics scale and for the satisfaction and attitude scale.

## 3. Results

A total of 1046 participants completed the online questionnaire out of the total 1903 that were distributed, yielding a response rate of 55%. As represented in Table 1, the mean age of all participants was 31.74 years, ranging from 18 to 85 ( $P = 0.026$ ). The female gender was represented slightly more than males with 597 (57.1%) responses. A majority of the respondents were from India ( $n = 373$ , 35.7%), and Pakistan ( $n = 377$ , 36%), followed by Nepal ( $n = 147$ , 14.1%), and Bangladesh ( $n = 82$ , 7.8%) ( $P < 0.001$ ). In our sample set, 635 (60.7%) respondents had a graduate degree, whereas 289 (27.6%) were educated to an undergraduate level. In total, 378 (36.1%) respondents were employed in the private sector, with 305 (29.2%) individuals currently enrolled as students; 100 (9.6%) were unemployed ( $P = 0.006$ ). A majority of the participants had a monthly income of less than 199\$ ( $n = 465$ , 44.5%), followed by 271 (25.9%) respondents belonging to the \$200–499 group ( $P < 0.001$ ). Around half of the respondents were healthcare workers ( $n = 511$ , 48.9%) ( $P = 0.01$ ) (Table 1).

The household characteristics and social habits practiced by the respondents are presented in Table 2. A large number of respondents resided in a one-family house/villa ( $n = 622$ , 59.5%), followed by residing in an apartment building ( $n = 229$ , 21.9%). The majority reported number of rooms as 4–6 ( $n = 502$ , 48%), followed by 1–3 ( $n = 394$ , 37.7%). The number of people in the household not including the respondent was reported as 4–6 by 475 (45.4%) participants followed by

**Table 1**  
Characteristics of the study population.

	Total Sample N = 1046	Tested COVID-19 positive N = 299	Tested COVID-19 negative N = 747	Chi Square	P-value
<b>Age in Years</b> (Mean ± SD; Range)	31.74 ± 12.32 [18–85]	32 ± 12.24; [18–82]	31.64 ± 12.35; [18–85]	79.569	0.026*
<b>Gender</b>				1.431	0.232
Female	597 (57.1)	162 (54.2)	435 (58.2)		
Male	437 (41.8)	135 (45.2)	302 (40.4)		
Prefer not to say	12 (1.1)	2 (0.7)	10 (1.3)		
<b>Country of Residence</b>				28.256	< 0.001*
Afghanistan	24 (2.3)	7 (2.3)	17 (2.3)		
Bangladesh	82 (7.8)	16 (5.4)	66 (8.8)		
Bhutan	4 (0.4)	0 (0)	4 (0.5)		
India	373 (35.7)	136 (45.5)	237 (31.7)		
Nepal	147 (14.1)	50 (16.7)	97 (13)		
Pakistan	377 (36)	81 (27.1)	296 (39.6)		
Sri Lanka	39 (3.7)	9 (3)	30 (4)		
<b>Highest Level of Education</b>				3.471	0.482
Less than high school	18 (1.7)	8 (2.7)	10 (1.3)		
High school or equivalent	42 (4)	15 (5)	27 (3.6)		
Some college education	62 (5.9)	18 (6)	44 (5.9)		
Undergraduate degree	289 (27.6)	81 (27.1)	208 (27.8)		
Graduate degree	635 (60.7)	177 (59.2)	458 (61.3)		
<b>Job Occupation</b>				16.266	0.006*
Private Sector	378 (36.1)	90 (30.1)	288 (38.6)		
Public Sector	158 (15.1)	60 (20.1)	98 (13.1)		
Retired	7 (0.7)	2 (0.7)	5 (0.7)		
Self-employed	98 (9.4)	29 (9.7)	69 (9.2)		
Student	305 (29.2)	80 (26.8)	225 (30.1)		
Unemployed	100 (9.6)	38 (12.7)	62 (8.3)		
<b>Monthly Income (USD)*</b>				24.154	< 0.001*
<\$199	465 (44.5)	104 (34.8)	361 (48.3)		
\$200-499	271 (25.9)	102 (34.1)	169 (22.6)		
\$500-999	163 (15.6)	57 (19.1)	106 (14.2)		
>\$1000	147 (14.1)	36 (12)	111 (14.9)		
<b>Healthcare worker status</b>				6.620	0.01*
No	534 (51.1)	134 (44.8)	400 (53.5)		
Yes	511 (48.9)	165 (55.2)	346 (46.3)		

\*The income in the local currency was converted to USD using the standard conversion rates on August 12, 2021.

430 (41.1%) reporting 0–3 (P < 0.001). The number of people in the household aged 18–65 was found to be 4–6, reported by 475 (45.5%) respondents (P = 0.013). Notably, 958 (91.6%) respondents stated that 0–3 household members not including themselves were working outside of home for at least 10 h per week (P < 0.001). In total, 957 (91.5%) respondents stated that 0–3 household members were suspected to have COVID-19, followed by 70 (6.7%) who stated that 4–6 household members were suspected (P < 0.001). In total, 376 (35.9%) respondents stated that household members were tested positive for COVID-19, not including themselves (P < 0.001), with 934 (89.3%) stating that the household member was not tested positive in the last 14 days. Overall,

**Table 2**  
Household characteristics and social measures.

	Total Sample N = 1046	Tested COVID-19 positive N = 299	Tested COVID-19 negative N = 747	Chi Square	P-value
<b>Type of Residence</b>				11.478	0.075
Apartment building	229 (21.9)	83 (27.8)	146 (19.5)		
Assisted-living facility/nursing facility	5 (0.5)	1 (0.3)	5 (0.7)		
Dormitory	30 (2.9)	5 (1.7)	25 (3.3)		
Hostel	9 (0.9)	2 (0.6)	7 (0.9)		
Multi-family house/villa	141 (13.5)	40 (13.4)	101 (13.5)		
One-family house/villa	622 (59.5)	167 (55.9)	455 (60.9)		
Rented house	10 (0.9)	1 (0.3)	9 (1.2)		
<b>Number of rooms (not including bathrooms, laundry rooms, hallways etc.)</b>				1.66	0.646
1–3	394 (37.7)	117 (39.1)	277 (37.1)		
4–6	502 (48)	135 (45.2)	367 (49.1)		
7–9	102 (9.7)	33 (11)	69 (9.2)		
10+	48 (4.6)	14 (4.7)	34 (4.6)		
<b>Number of people in the household (not including respondent)</b>				36.148	< 0.001*
0–3	430 (41.1)	163 (54.5)	267 (35.7)		
4–6	475 (45.4)	115 (38.5)	360 (48.2)		
7–9	92 (8.8)	12 (4)	80 (10.7)		
10+	49 (4.7)	9 (3)	40 (5.4)		
<b>Number of people in the household aged 18–65 years</b>				10.727	0.013*
0–3	502 (48)	163 (54.5)	339 (45.4)		
4–6	433 (41.4)	116 (38.8)	317 (42.4)		
7–9	73 (7)	12 (4)	61 (8.2)		
10+	38 (3.6)	8 (2.7)	30 (4)		
<b>Number of household members, not including respondent, working outside of home for at least 10 h per week</b>				25.594	< 0.001*
0–3	958 (91.6)	268 (89.6)	690 (92.4)		
4–6	69 (6.6)	16 (5.4)	53 (7.1)		
7–9	9 (0.9)	8 (2.7)	1 (0.1)		
10+	10 (0.9)	7 (2.3)	3 (0.4)		
<b>Household members suspected to have COVID-19</b>				55.075	< 0.001*
0–3	957 (91.5)	244 (81.6)	713 (95.5)		
4–6	70 (6.7)	46 (15.4)	24 (3.2)		
7–9	8 (0.8)	4 (1.3)	4 (0.5)		
10+	11 (1)	5 (1.7)	6 (0.8)		
<b>Household members tested positive for COVID-19</b>				148.791	< 0.001*
I don't know	28 (2.7)	4 (1.3)	24 (3.2)		
No	642 (61.4)	102 (34.1)	540 (72.3)		
Yes	376 (35.9)	193 (64.5)	183 (24.5)		
<b>Household member tested positive in the last 14 days</b>				5.796	0.122
I don't know	11 (1.1)	3 (1)	8 (1.1)		
No	934 (89.3)	275 (92)	659 (88.2)		
Not applicable	73 (7)	12 (4)	61 (8.2)		
Yes	28 (2.7)	9 (3)	19 (2.5)		
<b>Practicing physical distancing, meaning 6 feet distance, when the household member was suspected or confirmed to be sick</b>				64.35	< 0.001*
No	94 (9)	29 (9.7)	65 (8.7)		
Not applicable	364 (34.8)	49 (16.4)	315 (42.2)		
Yes		221 (73.9)	367 (49.1)		

(continued on next page)

Table 2 (continued)

	Total Sample N = 1046	Tested COVID-19 positive N = 299	Tested COVID-19 negative N = 747	Chi Square	P-value
588 (56.2)					
<b>Guests the household received per week in the last 2 weeks</b>				7.894	0.048*
1 per week	234 (22.4)	66 (22.1)	168 (22.5)		
2-4 per week	265 (25.3)	60 (20.1)	205 (27.4)		
5 or more per week	81 (7.7)	29 (9.7)	52 (7)		
None	466 (44.6)	144 (48.2)	322 (43.1)		

588 (56.2%) respondents stated that they practiced physical distancing when the household member was suspected or confirmed to be sick, with 94 (9%) participants not practicing physical distancing (P < 0.001). Whole 466 (44.6%) respondents stated that they did not receive guests in the last 2 weeks, 265 (25.3%) participants stated that they received 2–4 guests per week in the past 2 weeks (P = 0.048) (Table 2).

The workplace trends and PPE use trends are listed in Table 3. Of all, 843 (80.6%) individuals had a personal vehicle (P < 0.001). In the last 2 weeks, 408 (39%) and 317 (30.3%) respondents left their home 5 or more times and 1–2 times per week respectively (P = 0.041). While 746 (71.3%) respondents used a personal vehicle for commuting, 104 (10%) individuals used a cab/auto ricksha, followed by 65 (6.2) participants who preferred walking (P = 0.021). Many of the respondents stated that they always wore personal protective equipment when leaving the house in the last two weeks (n = 875, 83.7%), whereas 113 (10.8%) wore PPE often. On inquiring whether the job requires close contact with the public or co-workers, 537 (51.3%) said yes, whereas 305 (29.2%) selected no (P = 0.013). Out of all, 347 (33.2%) respondents stated that their customers/co-workers wear face masks, whereas, 294 (28.1%) selected often. On noting PPE provision, 261 (25%) stated that their employer/boss always provided personal protective equipment, whereas, 176 (16.8%) stated almost every time, followed by 120 (11.5) stated occasionally or sometimes (Table 3).

The satisfaction and attitudes among respondents concerning public health measures and vaccination status are listed in Table 4. In total 492 (47%) respondents were extremely concerned that the standard operating protocols were not being implemented properly, whereas 342 (32.7%) were moderately concerned. A huge proportion of respondents (n = 493, 47.1%) stated that they were following SOPs strictly, with 389 (37.2%) expressing that they were probably following SOPs strictly. On inquiring about the rise of COVID-19 was causing burnout among the public regarding SOP implementation, 547 (52.3%) agreed, and 353 (33.7%) strongly agreed. On the other hand, when respondents were asked their thoughts about adequate measures being taken by public health authorities to maintain SOPs across their respective countries, 295 (28.2%) stated probably, 247 (23.6%) said possibly, and 200 (19.1%) selected probably not. In total, 238 (22.8%) had not acquired any vaccine dose so far, whereas, 217 (20.7%) had only one dose, and 591 (56.5%) had obtained both doses of the COVID-19 vaccine (P < 0.001) (Table 4). The analysis of variance (ANOVA) based on the Kruskal-Wallis test found that the differences between thoughts towards public health authorities implementing SOPs implementation and HCW status were statistically significant (P = 0.002). The Cronbach's alpha coefficient for the household characteristics scale was 0.659, and 0.743 for the satisfaction and attitude scale.

A summary of the factors used as the predictors and associators, AUC with 95% CI and P values is enlisted in Table 5.

The ROC curve analysis for revealed significance for the following factors as predictors for positive COVID-19 infection across all

Table 3

Workplace trends and PPE use.

	Total Sample N = 1046	Tested COVID-19 positive N = 299	Tested COVID-19 negative N = 747	Chi Square	P-value
<b>Do you have a personal vehicle (bike, care, van etc.)?</b>				12.01	0.001*
No	203 (19.4)	38 (12.7)	165 (22.1)		
Yes	843 (80.6)	261 (87.3)	582 (77.9)		
<b>In the last 2 weeks, how many times did you leave home per week (e.g., work, social gatherings, errands etc.)?</b>				7.678	0.041*
1-2 times per week	317 (30.3)	73 (24.4)	244 (32.7)		
3-4 times per week	203 (19.4)	62 (20.7)	141 (18.9)		
5 or more times per week	408 (39)	131 (43.8)	277 (37.1)		
None	118 (11.3)	33 (11)	85 (11.4)		
<b>In the last 2 weeks, how did you commute when leaving the house?</b>				14.951	0.021*
Bicycle	22 (2.1)	6 (2)	16 (2.1)		
Bus	48 (4.6)	7 (2.3)	41 (5.5)		
Cab/Auto Ricksha	104 (10)	19 (6.4)	85 (11.4)		
Carpool	20 (1.9)	5 (1.7)	15 (2)		
Personal vehicle	746 (71.3)	235 (78.6)	511 (68.4)		
Walking	65 (6.2)	15 (5)	50 (6.7)		
Not Applicable	41 (3.9)	12 (4)	29 (3.9)		
<b>How frequently have you worn personal protective equipment (e.g., face mask) when leaving the house in the last 2 weeks?</b>				2.3	0.681
Always	875 (83.7)	255 (85.3)	620 (83)		
Never	14 (1.3)	5 (1.7)	9 (1.2)		
Often	113 (10.8)	29 (9.7)	84 (11.2)		
Rarely	17 (1.6)	5 (1.7)	12 (1.6)		
Sometimes	27 (2.6)	5 (1.7)	22 (2.9)		
<b>Does your job require close contact with the public or co-workers?</b>				8.683	0.013*
No	305 (29.2)	75 (25.1)	230 (30.8)		
Not applicable	204 (19.5)	49 (16.4)	155 (20.7)		
Yes	537 (51.3)	175 (58.5)	362 (48.5)		
<b>How often do these customers/co-workers wear face masks?</b>				5.782	0.328
Always	347 (33.2)	101 (33.8)	246 (32.9)		
Never	3 (0.3)	1 (0.3)	2 (0.3)		
Not applicable	227 (21.7)	65 (21.7)	162 (21.7)		
Often	294 (28.1)	94 (31.4)	200 (26.8)		
Rarely	42 (4)	9 (3)	33 (4.4)		
Sometimes	133 (12.7)	29 (9.7)	104 (13.9)		
<b>How frequently does your employer/boss provide personal protective equipment (e.g., face masks)?</b>				9.167	0.103
Almost every time	176 (16.8)	51 (17.1)	125 (16.7)		
Almost never	60 (5.7)	23 (7.7)	37 (5)		
Every time	261 (25)	81 (27.1)	180 (24.1)		
Never	120 (11.5)	24 (8)	96 (12.9)		
Not applicable	309 (29.5)	91 (30.4)	218 (29.2)		
Occasionally/sometimes	120 (11.5)	29 (9.7)	91 (12.2)		

**Table 4**  
Satisfaction and attitudes concerning public health measures and vaccination status.

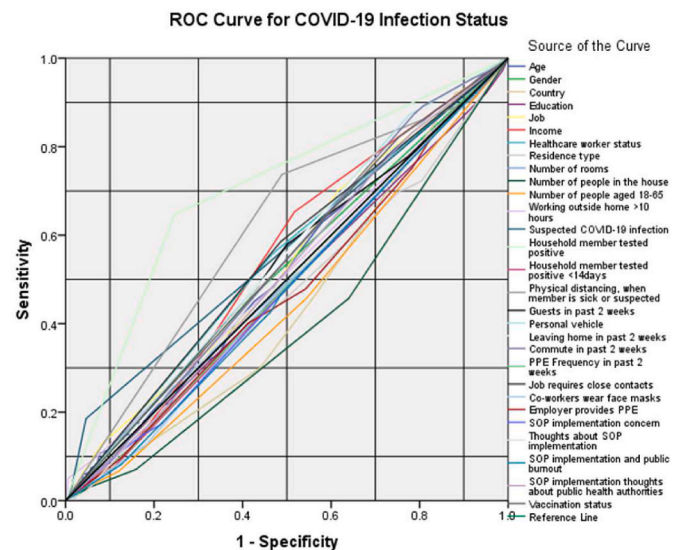
	Total Sample N = 1046	Tested COVID-19 positive N = 299	Tested COVID-19 negative N = 747	Chi Square	P-value
<b>How concerned are you that Standard operating procedures (SOPs) are not being implemented properly?</b>				3.801	0.434
Extremely concerned	492 (47)	144 (48.2)	348 (46.6)		
Moderately concerned	342 (32.7)	104 (34.8)	238 (31.9)		
Not at all concerned	34 (3.3)	6 (2)	28 (3.7)		
Slightly concerned	44 (4.2)	10 (3.3)	34 (4.6)		
Somewhat concerned	134 (12.8)	35 (11.7)	99 (13.3)		
<b>Do you think you are following SOPs strictly?</b>				7.116	0.130
Definitely	493 (47.1)	143 (47.8)	350 (46.9)		
Definitely Not	16 (1.5)	3 (1)	13 (1.7)		
Possibly	111 (10.6)	27 (9)	84 (11.2)		
Probably	389 (37.2)	121 (40.5)	268 (35.9)		
Probably Not	37 (3.5)	5 (1.7)	32 (4.3)		
<b>Do you feel the rise of COVID-19 has led to burnout among the public regarding SOP implementation?</b>				5.657	0.096
Agree	547 (52.3)	162 (54.2)	385 (51.5)		
Disagree	25 (2.4)	10 (3.3)	15 (2)		
Strongly Agree	353 (33.7)	102 (34.1)	251 (33.6)		
Strongly Disagree	4 (0.4)	1 (0.3)	3 (0.4)		
Undecided	117 (11.2)	24 (8)	93 (12.4)		
<b>Do you think that adequate measures are being taken by public health authorities to maintain SOPs?</b>				4.71	0.318
Definitely	219 (21)	52 (17.4)	167 (22.4)		
Definitely Not	85 (8.1)	25 (8.4)	60 (8)		
Possibly	247 (23.6)	77 (25.8)	170 (22.8)		
Probably	295 (28.2)	92 (30.8)	203 (27.2)		
Probably Not	200 (19.1)	53 (17.7)	147 (19.7)		
<b>Vaccination Status</b>				15.472	<0.001*
No	238 (22.8)	54 (18.1)	184 (24.6)		
Yes, both doses	591 (56.5)	161 (53.8)	430 (57.6)		
Yes, only one dose so far	217 (20.7)	84 (28.1)	133 (17.8)		

respondents (N = 1046) (Fig. 1). They include country of origin (AUC = 0.447, 95% CI = 0.41–0.485, P = 0.008), income group (AUC = 0.547, 95% CI = 0.51–0.585, P = 0.018), healthcare worker status (AUC = 0.545, 95% CI = 0.507–0.585, P = 0.022), number of people in the house (AUC = 0.395, 95% CI = 0.358–0.433, P < 0.001), number of people aged 18–65 (AUC = 0.447, 95% CI = 0.409–0.486, P = 0.008), suspected COVID-19 patient at home (AUC = 0.569, 95% CI = 0.529–0.609, P < 0.001), household member tested positive (AUC = 0.701, 95% CI = 0.664–0.737, P < 0.001), practicing physical distancing when a household member is suspected or confirmed COVID-19 positive (AUC = 0.611, 95% CI = 0.572–0.649, P < 0.001), owning a personal vehicle (AUC = 0.548, 95% CI = 0.51–0.585, P = 0.017), and requiring close contacts during job (AUC = 0.549, 95% CI = 0.51–0.587, P = 0.014) (Fig. 1).

The ROC curve analysis for revealed significance for the following factors as predictors for positive vaccination status across all

**Table 5**  
Summary trends of ROC curve analysis.

Associated Factors	AUC	95% CI	P value
<b>Predictors of positive COVID-19 infection status</b>			
Country of origin	0.447	0.41–0.485	0.008
Income group	0.547	0.51–0.585	0.018
Healthcare worker status	0.545	0.507–0.585	0.022
Number of people in the house	0.395	0.358–0.433	<0.001
Number of people aged 18–65	0.447	0.409–0.486	0.008
Suspected COVID-19 patient at home	0.569	0.529–0.609	<0.001
Household member tested positive	0.701	0.664–0.737	<0.001
Practicing physical distancing when a household member is suspected or confirmed COVID-19 positive	0.611	0.572–0.649	<0.001
Owning a personal vehicle	0.548	0.51–0.585	0.017
Requiring close contacts during job	0.549	0.51–0.587	0.014
<b>Predictors of positive vaccination status</b>			
Gender	0.589	0.548–0.629	<0.001
Highest educational level	0.446	0.404–0.488	0.012
Income	0.648	0.611–0.685	<0.001
Healthcare worker status	0.593	0.552–0.633	<0.001
Number of people working outside the house for 10 or more hours	0.412	0.377–0.465	<0.001
Household members tested positive for COVID-19	0.558	0.517–0.599	0.007
Owning a personal vehicle	0.578	0.544–0.631	<0.001
Job requires close contact with co-workers	0.623	0.582–0.664	<0.001
Co-workers wear face masks	0.55	0.506–0.593	0.02



**Fig. 1.** The ROC curve schematic representation for positive COVID-19 infection.

respondents (N = 1046) (Fig. 2). These include gender (AUC = 0.589, 95% CI = 0.548–0.629, P < 0.001), highest educational level (AUC = 0.446, 95% CI = 0.404–0.488, P = 0.012), job (AUC = 0.631, 95% CI = 0.59–0.672, P < 0.001), income (AUC = 0.648, 95% CI = 0.611–0.685, P < 0.001), healthcare worker status (AUC = 0.593, 95% CI = 0.552–0.633, P < 0.001), number of people working outside the house for 10 or more hours (AUC = 0.412, 95% CI = 0.377–0.465, P < 0.001), household members tested positive for COVID-19 (AUC = 0.558, 95% CI = 0.517–0.599, P = 0.007), owning a personal vehicle (AUC = 0.578, 95% CI = 0.544–0.631, P < 0.001), job requires close contact with co-workers (AUC = 0.623, 95% CI = 0.582–0.664, P < 0.001), co-workers wearing face masks (AUC = 0.55, 95% CI = 0.506–0.593, P = 0.02) (Fig. 2).

An additional risk estimate was yielded for positive vaccination status with the female gender presenting higher odds of acquiring one or two doses of the vaccine (OR = 2.12, 95% CI = 1.553–2.894). Finally,



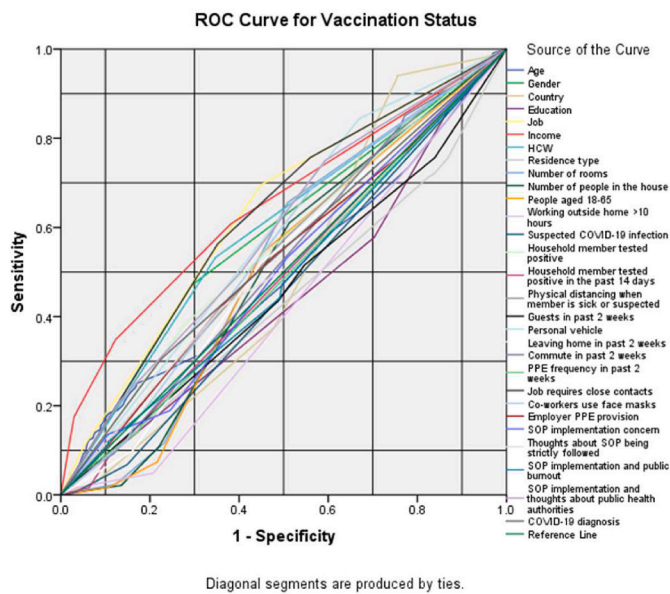


Fig. 2. The ROC curve schematic representation for positive vaccination status.

the healthcare workers were more likely to acquire the vaccine as compared to general population members in the entire sample (OR = 1.82, 95% CI = 1.435–2.31).

#### 4. Discussion

We aimed to elucidate various social contributors of the subsequent waves of COVID-19 in South Asian countries with high burden of disease. We also made an effort to correlate the social activities with a history of COVID-19 infection to ascertain their predictive value.

To our understanding, this is the first survey-based questionnaire study addressing the social contributors to COVID-19 infections in South Asia. We find that certain countries ( $P = 0.008$ ) and people belonging to differing income groups ( $P = 0.018$ ) may be more prone to COVID-19 infection. Moreover, being a healthcare worker may lead to an overrepresentation of protective social actions. However, our results are in half represented by general population leading to a wholesome picture of the included participants. Moreover, various workplace trends such as requiring close contact ( $P = 0.014$ ), owning personal vehicles ( $P = 0.017$ ), and practicing physical distancing when a household member is suspected or confirmed COVID-19 positive ( $P < 0.001$ ) are characteristic social contributors to the rising COVID-19 cases.

Overall, our findings are relevant, in light of the detection of the Delta variant in India in April 2021. The SARS-CoV-2 Delta variant, also known as B.1.617.2, was identified in December 2020 and surged in South Asia in March 2021, due to a higher transmission risk and the evasive nature [19]. The Delta variant is about 60% higher transmission than the Alpha variant (B.1.1.7), which is significantly higher than that found in Wuhan, China in December 2019 [20]. The cultural, political, and religious gatherings in South Asian countries with a high burden of COVID-19 have emerged as a major challenge for the region [21]. The detection of the SARS-CoV-2 Delta variant, lack of adherence to social distancing measures, sub-optimal rates of vaccination, and a large number of public events have resulted in a “perfect storm” for South Asia’s burden of COVID-19.

Herd immunity is the goal of mass vaccination programs globally. However, herd or “collective” immunity and its spread is also associated with varying levels of social activity [22]. Importantly, the social activities across communities has changed throughout various periods of the COVID-19 pandemic [23]. The subsequent waves witnessed across South Asia are the result of ongoing changes in the level of social

behaviors and activity of the people. In the first wave of the COVID-19 pandemic, majority of the countries in South Asia had implemented a nation-wide lockdown with stay-at-home orders and mask mandates [24]. However, as the lockdown measures eased down following a reduction in the daily incidence of COVID-19 cases, there were subsequent waves across South Asian countries. There has been great attention paid to herd immunity and its potential to end local transmission of COVID-19 [25]. However, there was a lack of consideration of curbing social activities of the local community dependent upon lockdowns or other mitigation strategies [26]. The easing of public health restrictions and the spread of novel variants have fueled the various waves of the COVID-19 pandemic in South Asia, particularly countries including India, Nepal, Bangladesh, and India [5]. With the public health surveillance data, it is essential to make the necessary shifts in social policies to mitigate new variants from spreading and for leaders to implement immediate actions.

It is necessary to take into consideration the increased transmissibility of COVID-19 infection following the detection of different variants alongside increased social activity following the ease of lockdown measures in South Asia [27]. Based on the area under curve analysis, and the levels of significance, we determined that the most important predictors for positive vaccination status comprised of the following: 1) gender, 2) job role, 3) income, 4) healthcare worker status, 5) household member tested positive for COVID-19 anytime in the past, 6) personal vehicle ownership, 7) job requiring close contacts with co-workers and 8) co-worker face masking habits. These seven factors out of the 30 tested determined excellent results as predictors for positive vaccination status in South Asia, which accounts for the presence of vaccine acceptance among some groups more so than the others [24,25]. Therefore, a practical approach to overcome the current and upcoming COVID-19 waves is to act practically and eliminate misinformation in real-time, promote continued usage of PPE, encourage vaccination, and avoid large religious and social gatherings until true herd immunity is achieved from vaccination campaigns in South Asia [28–31].

While our study findings help to understand the social contributors to the rise of COVID-19 infections in South Asia, there are certain limitations. At first, the survey was distributed among popular social media platforms including WhatsApp, Instagram, and Facebook, hence the respondents may have belonged to a younger and higher education group. This may have led to overestimation of certain social trends. Second, the data generated with this study are specific to the South Asian population; while the findings may be applicable to other developing countries across the world, it is essential to further test the contributors across those population. Third, we were unable to distribute paper surveys suggesting that there may be an underrepresentation of individuals who belong to the lower socio-economic and education class. Notably, around half of the respondents were healthcare workers, which could influence the attitudes and perceptions towards the contributors of COVID-19. Finally, we did not address vaccine hesitancy as a direct outcome of the study’s objectives among the participants as it was deemed out of scope.

#### 5. Conclusion

Our study finds that gender differences, educational levels, workplace requirements, income groups, healthcare worker status, household traits, and commuting habits have contributed to positive vaccination status and COVID-19 infection in the South Asian region. Public health experts and strategists ought to focus their control strategies on political/religious/social gatherings, reopening of offices, noncompliance of PPE and social distancing, and finally crowded transportation to limit reemergence of COVID-19 waves in countries with the highest burden in South Asia.

## Ethical approval

An exempt status was predetermined due to the non-identifiable nature of this survey. The protocol was registered with Research Registry.

## Sources of funding

No funding was obtained to conduct this research.

## Author contribution

All authors contributed equally. ICO was the supervisor of the study. All authors have reviewed and approved the final manuscript.

## Registration of research studies

Name of the registry: Research Registry.

Unique Identifying number or registration ID: researchregistry7877.

Hyperlink to your specific registration (must be publicly accessible and will be checked): <https://www.researchregistry.com/browse-the-registry#/home/registrationdetails/6274011b85094b001e5f74bf/>

## Guarantor

Ivan Cherrez-Ojeda, Zouina Sarfraz.

## Consent

Individuals consented to partaking in this study. All of them were volunteers and did not reveal any identifying information when partaking in the survey. All responses were anonymous to the researchers. The survey was conducted in accordance with the Declaration of Helsinki.

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The authors do not have any financial sources to disclose.

## Authorship contributions

All authors contributed equally. ICO was the supervisor of the study. All authors have reviewed and approved the final manuscript.

## Provenance and peer review

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## Declaration of competing interest

All authors declare no conflict of interest.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2022.104212>.

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