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1 **Factors Associated with Severe Acute Respiratory Syndrome Coronavirus-2 Infection in Hohoe**
2 **Municipality, Ghana: A Case-Control Study**
3

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14

15 # Abstract

16 Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection was a major public health
17 challenge globally and in Ghana. To prepare better for future pandemics, an evidence-based understanding
18 of the determinants of the coronavirus disease is essential to inform public health guidelines and
19 surveillance. Thus, we identified the factors for SARS-CoV-2 infection in Hohoe Municipality. We
20 conducted a facility-based, sex and age-matched (1:2) case-control study. Cases were persons with a
21 laboratory-confirmed SARS-CoV-2 infection by Reverse Transcription Polymerase Chain Reaction (RT-
22 PCR) or rapid antigen test, while controls tested negative with the same techniques. Data on
23 sociodemographic, clinical, and exposure-related factors were collected through structured interviews. We
24 employed a conditional regression model to establish the factors independently associated with SARS-
25 CoV-2 infection using Stata version 17.0. All statistical tests were two-sided, and a p-value <0.05 was

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26 considered statistically significant. A total of 234 participants were enrolled (78 cases, 156 controls). The
27 mean age of the cases and controls was 39.7±(14.6) and 39.4±(14.4) years, respectively. Moderate/high
28 levels of social interaction increased the odds of infection (aOR=3.00, 95% CI:1.05–8.56, p=0.040). Having
29 no underlying health condition (aOR=0.25, 95% CI:0.09–0.65, p=0.004) and regular physical activity or
30 exercise (aOR=0.18, 95% CI:0.04–0.70, p=0.014) reduced the risk of infection. Moderate/high level of
31 social interaction was associated with increased odds of SARS-CoV-2 infection, and having no underlying
32 condition and frequent exercise/physical activity was protective. Public health interventions should
33 therefore prioritize strengthening community awareness about the risks of close social interactions and the
34 benefits of healthy lifestyles, including regular physical activity.

35

36 **Keywords:** Factors, SARS-CoV-2 infection, Hohoe Municipality, Ghana, case-control

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37 **Introduction**

38 The novel Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) is the infectious
39 agent of the Coronavirus Disease 2019 (COVID-19) pandemic. It caused widespread infection, morbidity,
40 and mortality since late 2019 and created a global health emergency *[1]*. On January 30, 2020, the World
41 Health Organisation (WHO) declared SARS-CoV-2 a public health emergency of international concern,
42 and a pandemic on March 11, 2020 *[1,2]*. Ghana's index case was confirmed on March 12, 2020 *[3]*.

43 Due to insufficient testing capacity and a high proportion of asymptomatic infection, the pandemic
44 swiftly changed, resulting in widespread under-detection and many unaccounted cases *[4,5]*. Despite the
45 possibility of symptomatic disease, a significant proportion of the population were asymptomatic carriers,
46 and clinical presentations ranged from mild to severe or critical *[6]*. Over 80% of the cases were
47 asymptomatic or presented with mild symptoms, implying a lot of asymptomatic incubatory and healthy
48 carriers *[2]*. This made symptomatic patients a hidden potential source of transmission. Direct or indirect
49 contact with respiratory aerosols, droplets or other bodily fluids via contaminated surfaces is the known
50 predominant mode of transmission *[7,8]*.

51 The Centers for Disease Control and Prevention defined risk factors as a variety of factors that
52 could influence an individual's exposure, or response to a causative agent and increase susceptibility, or
53 predispose to a disease or infection *[9]*. Although COVID-19 is mainly transmitted through direct or
54 indirect exposure to the etiologic agent, transmission dynamics have identified demographics like advanced
55 age, clinical profiles or cardiovascular diseases, including hypertension and diabetes, and travel history to
56 predispose to the infection and may account for severe outcomes *[10,11]*. Moreover, environmental factors
57 like temperature and humidity, health system organisation and policy, politico-economic situation, large
58 gatherings, and international travel could substantially drive community transmission *[12,13,14]*

59 Even with the abundance of epidemiological data produced during the pandemic, significant
60 knowledge gaps persist regarding the specific factors associated with SARS-CoV-2 infection in rural and
61 peri-urban African communities. Thus far, no prior studies have established evidence on the determinants

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62 of SARS-CoV-2 infection within Hohoe Municipality. We identified the factors for SARS-CoV-2 infection
63 in Hohoe Municipality. We seek to provide evidence-based insights that can guide surveillance and local
64 public health interventions and contribute to the broader understanding of SARS-CoV-2 infection
65 epidemiology in the study setting and Ghana by extension. The results contribute to the larger body of
66 global health evidence on SARS-CoV-2 disease. Also, it offers implications for informing public health
67 efforts, strengthening surveillance and pandemic preparedness and response to emerging and reemerging
68 infectious illnesses.

69

70 # Methods

71 **Study Design**

72 We adopted a matched case-control design to identify the factors for SARS-CoV-2 infection. To eliminate
73 confounders, the cases were individually matched (1 case: 2 controls) to the controls, in which the enrolled
74 controls were identical to the cases in age (±*5 years*) and sex.

75

76 **Study Site**

77 Hohoe Municipality, with Hohoe as the capital, is where the study was conducted. It was carved out of the
78 Kpando District and borders the Republic of Togo on the east, on the southeast by the Afadzato district and
79 southwest by the Kpando Municipality; on the north with the Guan District, and on the northwest with the
80 Biakoye District. The municipality has a population of 114,472, representing 6.8% of the region's total
81 population *[15]*. It comprises 52.1% females and 47.9% males. About fifty-three percent of the population
82 is urban and comprises eleven major towns/settlements *[15]*. Regarding healthcare, the municipality has
83 four sub-districts, the Volta Regional Hospital, six community Health-Based Planning Services
84 Compounds, and eight health centers. The Volta Regional Hospital is the municipality's largest public
85 health and referral facility.

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86 **Study Population**

87 The study was among persons resident in Hohoe Municipality who tested for SARS-CoV-2 by Reverse
88 transcription polymerase chain reaction (RT-PCR) or rapid antigen test between March 2020 and December
89 2021. If the test result was positive, the person was classified as a case; otherwise, as a potential control.
90 Persons aged 18 years or above, and with a positive or negative laboratory-confirmed diagnosis of SARS-
91 CoV-2 by RT-PCR or antigen test between March 2020 and December 2021 were considered for inclusion.
92 The exclusion criteria were persons who tested positive for SARS-CoV-2 other than an RT-PCR or rapid
93 antigen test, tested positive later than December 2021, had previously tested positive for SARS-CoV-2 and
94 subsequently tested positive again (as potential cases of reinfection), had travelled at the time of data
95 collection, had debilitating health conditions or poor cognitive ability or incomplete or missing relevant
96 information in the SARS-CoV-2 infection-line list.

97

98 **Sample Size**

99 A priori statistical power calculation using Fleiss with Continuity Correction approach *[16]* was used to
100 determine the study's sample size, 237 (79 cases, 158 controls).

101

102 **Sampling Method**

103 We employed systematic sampling to recruit the cases using the line list of the cases as a sample frame.
104 The 79 cases were calculated proportionate to the 506 eligible cases on the line list. The sampling interval
105 (6th term) was determined by dividing the total number of cases (506) by the sample size of the cases (79).
106 Having determined this, the first case was randomly selected between the first case and the 6th term on the
107 line list. For the controls, the cases were individually matched (1 case: 2 controls) to the controls by age
108 (±5 years) and sex.

109

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Data Collection Procedure

A standard structured questionnaire was used to gather data between September 2, 2023 and October 28, 2023. A face-to-face interview was conducted, and data were captured electronically with KoboCollect. Written informed consent was obtained from the individual respondents before the questionnaire was administered.

Study Variables

Age, sex, educational level, occupation, marital status, income level, ethnicity, and residence were used to gather sociodemographic data. Clinical information, SARS-CoV-2 infection contact history, infection exposure and outcomes were also collected, including self-reported risk information on alcohol use, and smoking history/status.

Statistical Analyses

Data collated on KoboCollect was extracted in Microsoft Excel format. We then checked and resolved all discrepant data before formal analyses using Stata version 17.0 statistical software. Categorical variables were described using frequencies and percentages, and the mean (standard deviation) was computed for continuous variables. Given the individually age- and sex-matched (1:2) case–control design, associations between potential risk factors and SARS-CoV-2 infection were first explored using univariate conditional logistic regression, reporting crude odds ratios (cORs) with 95% confidence intervals (CIs). Variables with a p-value <0.20 in the univariate analyses were considered for inclusion in a multivariable conditional logistic regression model. Adjusted odds ratios (aORs) with 95% CIs were then estimated to identify factors independently associated with SARS-CoV-2 infection. All statistical tests were two-sided, and a p-value <0.05 was considered statistically significant

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135 # Results

136 ## Sociodemographic characteristics of cases and controls

137 Data was gathered from 234 respondents and the mean ages of the cases and controls were 39.7± (14.6)
138 and 39.4± (14.4) years, respectively with an overall mean age of 39.5± (14.5) years (Table 1). Urban
139 residence was higher among cases 62 (79.5%) versus controls 94 (60.3%). Less than half of the cases 21
140 (26.9%) were asymptomatic as against the controls 89 (57.0%). Of the cases, less than half 33 (42.3%) had
141 been prediagnosed with a health condition compared to the controls 108 (69.2%). The proportion of cases
142 with hypertension and diabetes was 23 (29.5%) and 18 (23.1%), respectively; versus hypertension 23
143 (14.7%) and diabetes 21 (13.5%) in the control group.

144

145 **Table 1: Sociodemographic characteristics of cases and controls**

Variable	**Case (78)** ***n*** **(%)**	**Control (156)** ***n*** **(%)**	**Total (234)** ***n*** **(%)**
Mean age ± (SD)	39.7 (14.6)	39.4 (14.4)	39.5 (14.5)
Age			
≤30	28 (35.9)	53 (34.0)	81 (34.6)
≥31	50 (64.1)	103 (66.0)	153 (65.4)
Sex			
Male	40 (51.3)	80 (51.3)	120 (51.3)
Female	38 (48.7)	76 (48.7)	114 (48.7)
Highest educational level			
None	5 (6.4)	15 (9.6)	20 (8.5)
Primary	1 (1.3)	21 (13.5)	22 (9.4)
Junior High School	11 (14.1)	33 (21.1)	44 (18.8)
Senior High School	21 (26.9)	31 (19.9)	52 (22.2)
Tertiary/post-secondary	40 (51.3)	56 (35.9)	96 (41.0)
Occupation			
Unemployed	21 (26.9)	43 (27.6)	64 (27.4)
Formal	28 (35.9)	35 (22.4)	63 (26.9)
Informal/Self-employed	29 (37.2)	78 (50.0)	107 (45.7)
Marital status			
Single	29 (37.2)	55 (35.3)	84 (35.9)
Married	47 (60.3)	83 (53.2)	130 (55.6)
Divorced/widowed	2 (2.6)	18 (11.5)	20 (8.5)
Income level			
High	7 (9.0)	18 (11.5)	25 (10.7)
Low	4 (4.1)	23 (14.7)	27 (11.5)
Middle	67 (85.9)	115 (73.7)	182 (77.8)
Residence			
Rural	16 (20.5)	62 (39.7)	78 (33.3)

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Urban	62 (79.5)	94 (60.3)	156 (66.7)
COVID-19 symptom classification			
Asymptomatic	21 (26.9)	89 (94.9%)	110 (47.0)
Symptomatic	57 (73.1)	67 (43.0)	124 (53.0)
Ever been diagnosed with a health condition			
No	45 (57.7)	48 (30.8)	93 (39.7)
Yes	33 (42.3)	108 (69.2)	141 (60.3)
Hypertension			
No	55 (70.5)	133 (85.3)	188 (80.3)
Yes	23 (29.5)	23 (14.7)	46 (19.7)
Diabetes			
No	60 (76.9)	135 (86.5)	195 (83.3)
Yes	18 (23.1)	21 (13.5)	39 (16.7)
Smoking status prior to testing			
Non-smoker	**62 (79.5)**	138 (88.5)	200 (85.5)
Smoker	**16 (20.5)**	18 (11.5)	34 (14.5)
Substance use prior to testing			
Current user	27 (34.6)	25 (16.0)	52 (22.2)
Former user	51 (65.4)	131 (84.0)	182 (77.8)

146
147
148 **Contact History and Disease Exposure of Cases and Controls**

149 Table 2 illustrates the contact history and disease exposure of the respondents. Among the cases, the
150 majority 47 (60.3%) attended a gathering of less than ten people, and a greater 54 (69.2%) proportion
151 travelled within Ghana. Most 65 (83.3%) of the cases had a moderate/high level of frequent social
152 interactions compared to 82 (52.6%) of the controls.

153

154 **Table 2: Contact History and Disease Exposure of Cases and Controls**

Variable	**Case (78)** ***n*** **(%)**	**Control (156)** ***n*** **(%)**	**Total (234)** ***n*** **(%)**
Lived in a densely populated or crowded area prior to testing			
No	55 (70.5)	123 (78.8)	178 (76.1)
Yes	23 (29.5)	33 (21.2)	56 (23.9)
Attended a mass gathering prior to testing			
No	43 (55.1)	95 (60.9)	138 (59.0)
Yes	35 (44.9)	61 (39.1)	96 (41.0)
Attended a gathering of fewer than ten people prior to testing			
No	31 (39.7)	92 (59.0)	123 (52.6)
Yes	47 (60.3)	64 (41.0)	111 (47.4)

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Travelled to a place within Ghana			
No	24 (30.8)	98 (62.8)	122 (52.1)
Yes	54 (69.2)	58 (37.2)	112 (47.9)
Travel location			
Rural	14 (25.9)	25 (43.9)	39 (35.1)
Urban	40 (74.1)	32 (56.1)	72 (64.9)
Visited a healthcare facility prior to testing			
No	34 (43.6)	103 (66.0)	137 (58.6)
Yes	44 (56.4)	53 (34.0)	97 (41.4)
Had close contact with a suspected or confirmed COVID-19 case prior to testing			
No	63 (80.8)	146 (93.6)	209 (89.3)
Yes	15 (19.2)	10 (6.4)	25 (10.7)
Had close contact with a generally ill person prior to testing			
No	58 (74.4)	146 (93.6)	204 (87.2)
Yes	20 (25.6)	10 (6.4)	30 (12.8)
Usual/most frequent means of transportation prior to testing			
Private means	18 (23.1)	53 (34.0)	71 (30.3)
Public means	60 (76.9)	103 (66.0)	163 (69.7)
Level of frequent social interactions prior to testing			
Low crowding	13 (16.7)	82 (52.6)	95 (40.6)
Moderate/high crowding	65 (83.3)	74 (47.4)	139 (59.4)
Place of most possible exposure			
Health facility			
No	59 (75.6)	146 (93.9)	205 (87.6)
Yes	19 (24.4)	10 (6.4)	29 (12.4)
Workplace			
No	59 (75.6)	111 (71.2)	170 (72.6)
Yes	19 (24.4)	45 (28.8)	64 (27.4)
Had access to PPE			
No	30 (38.5)	56 (35.9)	86 (36.7)
Yes	48 (61.5)	100 (64.1)	148 (63.3)

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157 **Univariate and Conditional Multivariate Logistic Regression Analyses of Severe Acute Respiratory**
158 **Syndrome Coronavirus-2 Infection Risk Factors.**

159 Univariate logistic regression analysis displayed in Table 4 revealed several factors statistically associated
160 with SARS-CoV-2 infection. These included household residence type (cOR=0.55, 95% CI: 0.31-0.95,
161 p=0.032), symptom classification (cOR=3.57, 95% CI: 1.92-6.63, p<0.001), number of children
162 (cOR=0.33, 95% CI: 0.11-0.96, p=0.042), physical activity (cOR=0.17, 95% CI: 0.06-0.45, p<0.004),
163 gathering of less than ten people (cOR=2.13, 95% CI: 1.22-3.71, p<0.008), and level of social interaction
164 (cOR=5.82, 95% CI: 2.80-12.11, p<0.001). Additionally, a health facility as a possible place of exposure
165 (cOR=4.85, 95% CI: 2.02-11.63, p<0.001) showed an association. NHIS status (cOR=1.93, 95% CI: 1.00-
166 3.74, p=0.050) was borderline statistically significant.

167 In the conditional multivariate model, moderate/high social interaction was associated with higher odds of
168 SARS-CoV-2 infection (aOR 3.00, 95% CI 1.05–8.56). Absence of an underlying condition (aOR 0.25,
169 95% CI 0.09–0.65) and regular physical activity (aOR 0.18, 95% CI 0.04–0.70) were associated with lower
170 odds. Associations for attending small gatherings and recent travel were elevated in crude analyses but were
171 not statistically significant after adjustment.

172 **Table 3: Univariate and multivariate logistic regression analyses of predictors for SARS-CoV-2**
173 **Infection**

Variable		cOR (95% CI)	*p-value*	aOR (95% CI)	*p-value*
Residence					
	Rural	Ref.		Ref.	
	Urban	**2.44 (1.30-4.60)**	**0.006**	1.16 (0.45-3.03)	0.758
Household residence type					
	Compound house setting	Ref.		Ref.	
	Private/self-contained	**0.55 (0.31-0.95)**	**0.032**	0.57 (0.25-1.30)	0.182
National Health Insurance Scheme (NHIS) status prior to testing					
	Inactive	Ref.		Ref.	
	Active	**1.93 (1.00-3.74)**	**0.050**	1.51 (0.52-4.37)	0.447
Symptom classification					
	Asymptomatic	Ref.		Ref.	
	Symptomatic	**3.57 (1.92-6.63)**	**<0.001**	2.21 (0.90-5.41)	0.082
Number of children had prior to testing					

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	None	Ref.		Ref.	
	≥1	**0.33 (0.11-0.96)**	**0.042**	0.21 (0.03-1.37)	0.103
Diagnosed with underlying health condition(s) prior to testing					
	No	**0.25 (0.13-0.50)**	**<0.001**	**0.25 (0.09-0.65)**	**0.004**
	Yes	Ref.		Ref.	
Engaged in physical activities or exercises regularly prior to testing					
	No	Ref.		Ref.	
	Yes	**0.17 (0.06-0.45)**	**<0.004**	**0.18 (0.04-0.70)**	**0.014**
Attended gathering with less than ten people prior to testing					
	No	Ref.		Ref.	
	Yes	**2.13 (1.22-3.71)**	**0.008**	2.13 (0.87-5.18)	0.097
Travelled to another region, town or place prior to testing					
	No	Ref.		Ref.	
	Yes	**3.42 (1.92-6.07)**	**<0.007**	2.17 (0.92-5.10)	0.076
Visited a healthcare facility prior to testing					
	No	Ref.		Ref.	
	Yes	**2.57 (1.44-4.58)**	**0.001**	1.86 (0.73-4.76)	0.195
Had close contact with a suspected or confirmed COVID-19 case prior to testing					
	No	Ref.		Ref.	
	Yes	**3.72 (1.50-9.24)**	**0.005**	0.64 (0.12-3.33)	0.598
Had close contact with a generally ill person prior to testing					
	No	Ref.		Ref.	
	Yes	**4.30 (1.95-9.46)**	**<0.001**	1.16 (0.30-4.43)	0.832
Level of frequent social interactions prior to testing					
	Low crowding	Ref.		Ref.	
	Moderate/high crowding	**5.82 (2.80-12.11)**	**<0.001**	**3.00 (1.05-8.56)**	**0.040**
Health facility					
	No	Ref.		Ref.	
	Yes	**4.85 (2.02-11.63)**	**<0.001**	1.51 (0.26-8.65)	0.645

174 *aOR – Adjusted Odds Ratio, cOR – Crude Odds Ratio, CI – Confidence Interval*

175 **Boldface type indicates a statistically significant difference at p<0.05*

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179 # Discussion

180 Numerous studies have demonstrated factors that facilitate susceptibility or predisposition to
181 COVID-19. There is a clear link between certain pre-existing health conditions and SARS-CoV-2 infection
182 and its adverse prognosis *[17]*. This study found hypertension and diabetes to be the prevalent comorbid
183 conditions, which are not different from findings reported by *[18,19,20,21]*. Our study showed a syndemic
184 relationship between SARS-CoV-2 infection and preexisting health conditions. A similar study *[21]*
185 demonstrated that comorbidity emerged statistically significant with SARS-CoV-2 infection. Additionally,
186 in support, *[22]* reported that SARS-CoV-2 infection was predominant among people who presented with
187 a comorbidity. Furthermore, the outcome of a national study in Saudi Arabia disclosed that a high
188 proportion of the COVID-19 patients had a history of at least one lifelong illness, which seemingly supports
189 this study's finding *[23]*. On account of the evidence from the above studies, whose findings corroborate
190 that of our study, it is imperative to consider and tailor actions that will safeguard the health needs of persons
191 with a preexisting diagnosis. Individuals with a longstanding illness tend to face severe or critical clinical
192 outcomes or even death. Our findings imply that further studies are vital to assess the clinical outcomes of
193 SARS-CoV-2 infection cases in the study jurisdiction.

194 Epidemiological link is crucial to understanding SARS-CoV-2 infection transmission dynamics,
195 spread and evidence-based control actions. The current study established that attendance at small gatherings
196 showed an increased risk, but was however, not statistically significant in the in the final multivariate model.
197 Inversely, this finding is on par with *[18,24]* which reported that attending a mass social gathering was
198 associated with SARS-CoV-2 infection. Small gatherings create a perceived sense of safety leading to more
199 relaxed precautions and preventive behaviors such as mask use, physical distancing and attention to
200 ventilation. This false sense of security could facilitate transmission. Moreover, such gatherings typically
201 occur in indoor settings where airflow is limited and individuals remain in proximity for extended periods.
202 In contrast, larger gatherings, which have been more strictly regulated or subject to formal preventive
203 protocols during the pandemic may have entailed greater adherence to public health guidelines.

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204 Regular physical activity has been associated with enhanced immune function, which contributes
205 to a strengthened immune system, potentially reducing the severity and duration of SARS-CoV-2 infection
206 *[25,26]*. Our study uncovered that regular exercise or physical activity decreased the risk of SARS-CoV-2
207 infection. A similar finding reported by *[21]* indicated that physical exercise or activity lessened the odds
208 of infection. In support of the above assertions, a study in the United States revealed a negative correlation
209 between physical activity and SARS-CoV-2 infection further showing a worse prognosis of death among
210 those whose physical activity was less. *[27]*. Moreover, according to *[28],* adults between the ages of 40
211 and 69, those who were physically active were less likely to be confirmed SARS-CoV-2 seropositive.
212 However, in dissonance with the findings aforementioned, *[29]* found that physical activity was not
213 associated with the risk of SARS-CoV-2 infection. Similarly, it was also conversely reported that physical
214 activity had no protective association between SARS-CoV-2 infection and its related symptoms [30].
215 Physical inactivity predisposes to longstanding diseases like hypertension and diabetes, which are
216 established comorbidities that increase SARS-CoV-2-infection susceptibility or severity and point out the
217 significance of regular physical activity and exercise in SARS-CoV-2 infection prevention *[30].* Although
218 it is widely asserted that regular physical activity is a non-pharmacological intervention against SARS-
219 CoV-2 infection and could help alleviate the symptoms and severity *[31],* there is uncertainty regarding the
220 effects on SARS-CoV-2-infected individuals, despite some evidence to the effect that physical exercise
221 improves respiratory and physical health.

222 **Strengths and Limitations**

223 This study provides localised evidence for guiding tailored public health interventions and contributes to
224 the broader understanding of SARS-CoV-2 epidemiology. A major strength of this study is the use of a
225 matched case-control design, which effectively controlled for major confounders, thereby enhancing the
226 internal validity of the identified associations. Nonetheless, certain limitations must be acknowledged. A
227 notable limitation was the potential of recall bias which may have stemmed from respondents' inability to
228 accurately recall or report their exposure history or conditions, as the study was carried out long after the

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229 pandemic (time lag between exposure (2020–2021) and data collection (2023). Second, the study might
230 have been prone to social desirability bias in the reporting of preventive behaviors. Particularly, cases may
231 have overestimated adherence to preventive behaviors and protocols which could result in weak or reverse
232 true associations. However, the use of a standard and validated closed-ended questionnaire was used to
233 improve respondents' information. Lastly, missing information such as contact address in the line list
234 records may have introduced some selection bias during sampling.

235 Conclusion

236 This study identified moderate to high levels of social interaction as the main risk factor for SARS-CoV-2
237 infection, while regular physical activity and the absence of preexisting health conditions were protective.
238 These findings reinforce the importance of maintaining safe social behaviors during outbreaks and highlight
239 the role of individual health status in susceptibility to infection. Public health interventions should therefore
240 prioritize strengthening community awareness about the risks of close social interactions and the benefits
241 of healthy lifestyles, including regular physical activity. Moreover, tailored strategies should be developed
242 to protect individuals with underlying health conditions, who remain particularly vulnerable. Lessons from
243 this study provide important insights for strengthening preparedness and response strategies against future
244 pandemics in Ghana and similar settings. Further research is needed to explore the long-term effects of
245 these risk and protective factors on SARS-CoV-2 infection outcomes.

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253 **Authors' contributions**

254 Conceptualization and writing official draft: S.I., and F.B., Data collection: S.I., Y.Y., Y.S.T., and K.A,
255 Data Curation and formal Analyses: S.I., A.F.D.S, Y.S.T and Y.Y., Editing and final review: F.B., Y.Y.,
256 K.A. All authors read and approved the current version of the manuscript.

257 **Abbreviations**

258 COVID-19: Coronavirus Disease

259 RT-PCR: Reverse transcription polymerase chain reaction

260 SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus-2

261 WHO: World Health Organization

262 **Declarations**

263 **Availability of data and materials**

264 The anonymized dataset will be deposited in an open repository.

265 **Ethical Considerations**

266 The study protocol was approved by the University of Health and Allied Sciences Research Ethics
267 Committee (approval ID: *UHAS-RECA.8[88]22-23*) and the Ghana Health Service Ethics Review
268 Committee (approval ID: *GHS-ERC:029/06/23*).

269

270 **Competing interests**

271 The authors declare that the study was carried out without any potential conflicts of interest.

272

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