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Association of Biological Sex and Gender-related Factors with Public Engagement in Protective Health Behaviours during the COVID-19 Pandemic: Lessons Learned Going Forward

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ABSTRACT

Introduction: While COVID-19 vaccination campaigns are proceeding at high-speed to advance necessary protection, recommendations regarding protective health behaviours still remain a critical part of the global response to slow the spread of the infection. Understanding what drives people to engage in or refrain from health behaviours during a pandemic is vital to planning tailored public health interventions. Given the role of sociocultural gender in shaping human behaviours, we examined whether sex and gender-related factors were associated with the public's adherence to COVID-19 recommended protective health behaviours.

Methods: Using data from the International COVID-19 Awareness and Responses Evaluation (iCARE) survey collected between March 2020 to February 2021 from 175 countries, we focused on the role of sex and gender-related factors in relation to adherence of protective health behaviors including: (i) hand washing; (ii) mask wearing; and (iii) physical distancing behaviours. Multivariable logistic regression was conducted to determine the factors associated with adherence to behaviors.

Results: Among 48,668 respondents (mean age: 43 years; 71% female), 98.3% adopted hand washing, 68.5% mask wearing, and 76.9% physical distancing. Compared with males, females were more likely to adopt hand washing (OR=1.97, 95%CI: 1.71-2.28) and maintain physical distancing (OR=1.28, 95%CI: 1.22-1.34). However, in multivariable sex-stratified models, females in countries with higher gender inequality indexes (GII) were less likely to report hand washing (aOR=0.47, 95%CI: 0.21-1.05). Females who reported being employed (aOR=0.22, 95%CI: 0.10-0.48) and in countries with low/medium GIIs (aOR=0.18, 95%CI: 0.06-0.51) were less likely to report mask wearing. Females who reported being employed were less likely to report physical distancing (aOR=0.39, 95%CI: 0.32-0.49).

Conclusion: While females showed greater adherence to COVID-19 protective health behaviours, gender-related factors, including employment status and high-country wide gender inequality were independently associated with non-adherence. These findings may inform public health and vaccination policies in current as well as future pandemic.

Keywords:

COVID-19, SARS-Cov-2, health behaviours, hand washing, mask wearing, physical distancing

Strengths and limitations of this study:

- The study had a large sample size with a global perspective, and availability of gender-related factors to examine the impact of gender.
- The online nature of the iCARE survey might have limited the participation from individuals who did not had access to computers and internet, limiting the generalization of findings.
- Our global sample was highly educated group of people whose results are likely to be 'best case scenario'.
- The global sample was also mostly women, so men are underrepresented in this study.
- Self-reported behaviour of the respondents might not have accurately represented actual behaviour, hence, the findings should be interpreted with caution.

INTRODUCTION

Public behaviour plays an important role during public health emergencies (1). Behaviours can be influenced by both the biological sex and sociocultural gender (gender identity, gender roles, gender relations, and institutionalized gender) of an individual (2). In the case of the Coronavirus Disease 2019 (COVID-19) pandemic, both men and women worldwide have shown inconsistent responses to acute infection as well as differing long-term health, economic, and social consequences (3, 4). Understanding these responses in relation to biological sex and/or gender-related attributes in the general population may be particularly valuable to inform tailored sex and gender strategies moving forward.

It has been identified that public health responses to infectious diseases require fundamental changes in individual behaviour. Hand washing, mask wearing, and physical distancing (*previously referred to as social distancing*) are the key transmission reduction public health behaviour-based prevention measures (1) that are associated with a reduction in the global incidence of COVID-19 (5, 6). Effectiveness of such responses depends not only on the generalized adherence of the public but may be specific to certain high-risk groups. Though recommended and proven to limit transmission rates, hand washing, mask wearing, and physical distancing have been inconsistently initiated and maintained. There is a dynamic relationship between the voluntary adoption of public health behaviours and infection transmission during infectious disease epidemics (7). The COVID-19 pandemic has sparked an unparalleled global discourse around the adoption of protective behaviours and other public health and social measures to slow the person-to-person spread of SARS-CoV-2 (1).

COVID-19 has highlighted the role that sex and gender play in our lives. This includes influencing an individual's exposure to COVID-19 through sex and gender-related occupations, risk-taking behaviours, and employment of precautions. Sex and gender also are known to have an impact on health through the gendered nature of the workforce and the predominant risk associated with it, increased caregiving responsibilities at home limiting the work and economic opportunities, or institutional biases and policies (2, 8). Gender affects the division of labor and care duties in families and communities. Hence, it is of utmost importance that we gather, from our recent lived experience, evidence on the potential sex and gender-related differences in perception and behavioural responses experienced during COVID-19 pandemic.

A few studies have shown sex-based differences in COVID-19 related beliefs and behaviours and have reported that compared to men, women are more likely to perceive the pandemic as a serious health problem and comply more with the preventive behaviours (9, 10). Therefore, as gender is culturally and geographically based, we hypothesized that there is a difference in preventive behaviours and pandemic related concerns based on biological sex and gender-related factors. Also, regardless of sex-based differences, our previous studies highlight the need of focusing on the gender-related factors (11, 12). Hence, the purpose of this study was to examine whether biological sex and sociocultural gender-related factors are associated with the engagement in the recommended key protective health behaviours such as hand washing, mask wearing, and physical distancing during the COVID-19 pandemic.

METHODS

Study design

Survey datasets from the ongoing iCARE (International Covid-19 Awareness and Responses Evaluation) study led by the Montreal Behavioural Medicine Centre (MBMC: www.mbmc-cmcm.ca) in collaboration with a team of 200 international collaborators from 42 countries was used for the data analyses. The iCARE study design has been previously described (13). Briefly, iCARE is an international multi-wave cross-sectional observational cohort study of public awareness, attitudes, and responses to public health policies implemented to reduce the spread of COVID-19 on people around the world (www.iCAREstudy.com). It collects data on study demographics, perceptions of government policy, health behaviours, adherence to health measures, types of concerns, and adherence motivators. The iCARE study was approved by the research ethics committee of the Comité d'éthique de recherche du CIUSSS-NIM (Centre intégré universitaire de santé et de services sociaux du Nord-de-l'île-de-Montréal), approval #: 2020-2099 / 25-03-2020. The current secondary analysis was approved by the ethics committee at the University of Alberta (Pro107407).

Survey data were collected in 4-6 week rounds using convenience snowball sampling (globally, 25-30K per wave) and parallel representative sampling (in targeted countries), generating data for multiple cohorts of participants that were added to the first round cohort launched on March 27, 2020. We analyzed data from Survey 1 – Survey 7 that was collected between March 27, 2020 to February 9, 2021. A total of 61,552 respondents participated in the survey from over 175 countries. The data was analyzed for 48,668 respondents (female=34,556, male=14,112). The questionnaire used in the survey is publicly available via the Open Science Framework (https://osf.io/nswcm/) and the survey is available in 34 languages (14).

Biological sex and gender-related factors

For each surveyed individual the following variables were collected: socio-demographic characteristics (sex at birth, age in years, level of education, work status, perceived annual household income, number of adults and children living in the household, country of residence, and likelihood of getting vaccinated *i.e.,* respondents' willingness to get a COVID-19 vaccine), the presence of a physician-diagnosed depressive and/or anxiety disorder, and adoption of protective health behaviours (hand washing, wearing a face mask, and physical distancing).

To account for institutionalized gender, the Gender Inequality Index (GII), developed by the United Nations Development Programme, was used as a measure of country specific gender inequality (15) and as a measure of institutionalized gender in this study. This index is a continuous measure for the degree of gender inequality per country on a scale between 0 and 1, with lower values representing near-perfect gender equality and higher values representing greater levels of inequality favoring males. The GII is based on several aspects of institutionalized gender: (i) reproductive health, measured by the maternal mortality ratio and adolescent birth rates; (ii) empowerment, measured by the proportion of parliamentary seats occupied by women and the proportion of adult women and men with at least some secondary education; and (iii) economic status, measured by labor force participation rate of men and women (16). GIIs in this study were divided into tertiles and later categorized into high and low/medium GII categories. We used data on GIIs from 2019. Some of the countries in the region were excluded from the analysis due to the unavailability of data.

Outcome measures

The main outcomes of the analysis were self-reported adherence to three recommended protective health behaviours including: (i) hand washing with soap and water; (ii) wearing a face mask; and (iii) a composite measure of physical distancing behaviours (specifically: staying at least 1-2 meters away from other people; staying/working at home rather than going to work or school; self-quarantining if returning from a trip; self-quarantining if one have the virus or believe they have the virus; avoid going out to bars/pubs/restaurants; avoiding large social gatherings; avoiding small social gatherings; avoiding indoor social gatherings; and avoiding any non-essential travel) (17). A composite binary variable was constructed in which, the participants who met the above mentioned criteria were coded with a value of 1; otherwise, the participants were coded with a value of 0. A set of measures in the iCARE survey intended to explore the prevention measures used by the public to prevent the spread of COVID-19 by maintaining a physical distance between two people and reducing the number of times people come into close physical contact with one another (18) were used to create a composite variable for physical distancing.

Statistical analysis

A global analysis of public engagement in three recommended protective health behaviours was performed to investigate whether the outcomes differed by sex. Descriptive sex-stratified analyses were run for: age; baseline mental health conditions (any depressive or anxiety disorders); and gender-related factors such as level of education, work status, annual household income, and GII. Continuous variables were presented as mean and standard deviation (SD). Categorical variables were presented as counts and percentages. Sex differences in outcomes (protective health behaviours) were completed and associations between sex, gender-related factors, and outcomes were tested in a multivariable model. Bivariate logistic regressions were run for crude analysis

followed by collinearity diagnostics to account for inflation in standard errors of parameter estimates caused by collinear cofactors (19). If variables were collinear, we included the variable with the least amount of missing data in the multivariable models. *A priori* age and gender-related cofactors (i.e., education level, work status, annual household income, and GII) were included in multivariable models. Two-way interaction between the sex and gender-related factors were tested by including an interaction term in bivariate models. All statistical analyses were performed using statistical software STATA version 16 (College Station, TX, USA). Tests were two sided and the significance was defined as $p<0.05$.

Ethics approval:

The study was approved by the Health Research Ethics Board-Health Panel, University of Alberta (Pro00107407).

Patient and public involvement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research. For the dissemination of results, we will submit the results of the study to relevant national and international journals with the intention of publishing the results widely. Further, we will make national and international presentations in conferences and symposiums to stakeholder groups including those involving general public, researchers, clinicians, and policymakers.

RESULTS

Descriptive characteristics of respondents

Our study population included 34,556 females (71%) and 14,112 males (29%) **(Table 1)**. The mean age of the respondents was 43 years (SD: 16). A majority (n=23,462, 48.8%) was between 26 and 50 years of age. Most respondents (79.7%) reported high levels of education, were employed (61.8%), were from Europe and North American countries (66.3%), and from regions with high levels of gender equity as measured by low/medium GIIs (66.9%). Females were more likely to report having a physician-diagnosed depressive disorder (9.5% vs 6.7%, p≤0.001) and anxiety disorder (17.7% vs 10.7%, p≤0.001) compared to males. Irrespective of sex, only 68.5% of responders disclosed wearing a facemask, while a higher percentage of females reported adherence to physical distancing behaviours compared to males (78.3% vs 73.7%, p=<0.001). Participants aged 51 and older were more likely to engage in all three-key protective behaviours as compared with younger participants: hand washing (Odds ratio [OR]= 5.60, 95% Confidence interval [CI]: 4.51-6.94); mask wearing (OR=1.11, 95% CI: 1.04-1.18); and physical distancing (OR=1.50, 95% CI: 1.41-1.61) **(Table 2)**.

Gender-related factors associated with adoption of protective health behaviours

For the univariate analysis, the proportion of people adopting the protective health-related behaviours, varied depending on the gender-related factor examined. Despite employed respondents being 84% more likely to engage in hand washing than unemployed respondents, they were 65% less likely to engage in mask wearing and 47% less likely to engage in physical distancing (p<0.001 for all comparisons). Hand washing and physical distancing was less common as the number of adults ≥18 years living in the household increased. The proportion of adoption was lowest for wearing a facemask, both for females and males (58.5% vs 57%) in low/medium GII countries **(Figure 1)**. Respondents living in the countries with high GII were 4.38 times (95% CI: 4.15-4.63) more likely to use mask than respondents living in the countries with low GIIs;

however, they were less likely to engage in hand washing and less likely to engage in physical distancing **(Table 2)**.

Sex and gender-related differences in the adoption of protective health behaviours

Sex-stratified multivariate analyses demonstrated that the factors associated with the adoption of protective health behaviours varied by sex. Among females, the factors associated with not adhering to health behaviours were: (i) for hand washing: higher country gender inequality favoring males GII (aOR=0.47, 95% CI: 0.21-1.05, p=0.07) (ii) for mask-wearing: older age (aOR females=0.35, 95% CI:0.12-1.03, p=0.05), being employed (aOR females=0.22, 95% CI:0.10-0.48, p<0.001), and living in a country with more gender equity as measured by the GII (aOR=0.18, 95% CI: 0.06-0.51, p<0.01); and (iii) for physical distancing: being employed (aOR females=0.39, 95% CI:0.32-0.49, p<0.001) **(Table 3, Appendix-Table 1a, Table 1b)**.

Factors that were associated with not adhering to protective health behaviours among males were: (i) for hand washing: higher level of education (aOR males=0.37, 95% CI: 0.14-1.01, p=0.05) and with a household size of > 2 (aOR males=0.46, 95% CI: 0.21-1.03, p=0.06); (ii) for mask wearing: being employed (aOR males=0.15, 95% CI:0.04-0.53, p<0.01) and living in a country with more gender equity as measured by the GII (aOR=0.29, 95% CI: 0.09-0.91, p<0.05); and (iii) for physical distancing: being employed (aOR males=0.38, 95% CI:0.27-0.52, p<0.001) and with household size of > 2 (aOR males=0.66, 95% CI: 0.47-0.92, p<0.05) **(Table 3, Appendix-Table 1a, Table 1b)**.

There was a significant interaction between sex and educational level of the participants. High level of education decreased the use of mask wearing among females compared to males (p=0.03).

There was a trend for living in a country with lower gender equity to be associated with poorer protective behaviors in females compared to males (p=0.056).

DISCUSSION

The present study provides a comprehensive analysis on the impact of sex and gender-related factors and the association with adherence to protective health behaviours during the COVID-19 pandemic. Overall, hand washing, mask wearing, and physical distancing behaviours were adopted globally. However, there were a number of gender-related factors associated with a lower adherence based on sex.

Lower adherence to the protective health behaviours was mainly associated with younger age, being employed, and living in a country with low/medium GII (higher gender equity) for females. While high level of education, being employed, and household size of >2 were associated with lower adoption in males. Considering these group of individuals with lower adherence to protective health behaviours, this would suggest that in the current as well as future pandemics it may be useful to target interventions based on sex and gendered factors to increase adherence and reduce disease transmission. Measures such as risk-assessment and mitigation considerations for public settings could be implemented to mitigate the risk of transmission and promote the adoption of protective health behaviours.

Overall, mask wearing was lower among both sexes compared to other protective behaviours such as hand washing and physical distancing. Many countries waited to issue mask mandates months into the pandemic (20) even though other behaviours were mandated right away. This may be one

of the reasons for lower adherence. Further, adoption of mask wearing was less likely in males compared to females, mainly among those who were employed, indicating substantial room for improvement in male's engagement to mask wearing. In our study, employed female respondents reported that they were more likely to wear a mask compared to male respondents. Similarly, a study conducted in the United States also reported that females were 1.5 times more likely to wear a mask compared to males (21). It has been suggested that females may be more likely to protect themselves and others by wearing a mask specifically because they handle the majority of caregiving within families and are overrepresented in essential work services, which generally requires mask wearing (22). Previous studies have also reported mask wearing to be significantly associated with the occupation of respondents (23, 24). A study reported that women make up almost 90 percent of nurses and nursing assistants in the United States and over two-thirds of grocery store cashiers (24). Performing the dual function of an essential worker outside and a caregiver at home, women might face a dilemma of how to keep their families healthy and safe while continuing to work in potentially risky circumstances, suggesting that these factors may make them more adherent to the protective behaviours.

Older females were the most likely participants to engage in hand washing and physical distancing, but less likely to engage in mask wearing. Older females may have a higher perceived risk of developing COVID-19 complications and mortality, and thus engaged in more protective health behaviours such as hand washing and physical distancing. Previous studies have shown that females and older adults are less likely to engage in the risky behaviours, feel more vulnerable to contracting diseases, and have a stronger sense of responsibility to protect society (25, 26). This is consistent with the findings of an American study that reported being older and female was related

to adopting more pandemic mitigating behaviours (27). Furthermore, a study conducted in China also reported that being female and older was associated with adopting protective behaviours (26). However, our study findings are in contrast with the results of a study conducted in Portugal that reported a decline in engagement in protective health behaviours with advancing age, which was reported to be related to the increased social-isolation and lack of help among older population (28). Even though the study did not report the differences by sex of the respondents, self-isolation could be the reason for lower adherence to mask wearing among females. Depending on the diverse context, public health interventions should be tailored not only to sex, but differing age groups, and importantly institutional gender related variables such as those measured by the GII.

Emerging evidence shows that gender including the institutionalized gender shapes mask wearing adherence (29). One of the interesting findings of the current study is respondents from low/medium GII countries with less gender inequity reported a significantly lower adherence to mask wearing compared to respondents from countries with high GII (high gender inequity). Even among the low/medium GII countries, adherence is reported to be poorer among males. Lower adherence among males is in line with a finding from a study conducted in the United States, in which males exhibited poorer mask wearing practices compared with their female counterparts (21). This is also supported by a review that looked at research from multiple countries and found women were 50% more likely than men to practice protective behaviour (30).

The strengths of this study include a large sample size, having a global perspective, and availability of gender-related factors to examine the impact of gender. This study also has some limitations that should be acknowledged. First, the online nature of the iCARE survey might have limited the

participation from individuals who did not had access to computers and internet, limiting the generalization of findings. However, the advantages of online surveys have been shown to outweigh the disadvantages, mainly in terms of its external validity (31); hence, the bias might be relatively low. Second, our global sample was highly educated group of people whose results are likely to be 'best case scenario'. The global sample was also mostly women, so men are underrepresented in this study. Third, self-reported behaviour doesn't always accurately represent actual behaviour, hence, the findings should be interpreted with caution. Finally, although the study established the associations between sex and gender-related factors with the adoption of protective health behaviours, no causal relationships should be assumed due to the nature of the cross-sectional design of the survey.

CONCLUSIONS

In this analysis of a multinational study population, while a majority of respondents reported wearing a facemask, this is likely reflective of country wide mask mandates as opposed to adopting it as a protective health behavior. However, our study findings, suggest that wearing a facemask appeared to be more difficult to adhere to for many compared to other key protective behaviours such as hand washing and physical distancing. Moreover, our study noted that this was even more apparent in countries with low GII (more equity between males and females) indicating substantial room for improvement in public engagement regarding protective health behaviours. Since a widespread protective behavioral response are paramount for a successful containment and control of an infectious disease contagion, the present study provides valuable information for identifying sex and gendered factors that may inform effective public health policies. Further, the Covid-19 pandemic highlights the urgent need to incorporate sex and gender analysis into all research and

innovation processes in order to target specific groups both to help contain the transmission of the virus and to formulate vaccine policies.

DECLARATIONS

Conflict of interests: The authors declare no competing interests.

Contribution to authorship:

All authors contributed to the preparation of this manuscript (RD, VR, SB, KLL, LP, CMN). CMN, LP, and VR developed the idea and design of the study. RD participated in drafting and revising the manuscript. CMN, LP, SB, KLL, and VR provided detailed comments on the draft for the revision. CMN provided substantial revisions and intellectual content to the manuscript. RD analyzed the data, and CMN and LP checked for the integrity and accuracy of the data. All authors (RD, VR, SB, KLL, LP, CMN) read and approved the final version of the manuscript.

Data availability:

Dataset available from the iCARE team upon reasonable request.

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TABLES

Table 1. Descriptive characteristics of survey respondents by biological sex (N=48668)

	N[1]	Overall n (%) or Mean [SD]	Biological sex	
			Male (N=14112) n (%) or Mean [SD]	Female (N=34556) n (%) or Mean [SD]
Socio-demographic characteristics				
Age (in years)	48524	43 [16]	42 [16]	44 [17]
Age distribution in strata	48049			
• Up to 25		8632 (18.0)	2327 (16.8)	6305 (18.5)
• 26-50		23462 (48.8)	6372 (45.8)	17090 (50.0)
• 51 and older		15955 (33.2)	5197 (37.4)	10758 (31.5)
Education level	38217			
• Low level		7758 (20.3)	2208 (20.5)	5550 (20.2)
• High level		30459 (79.7)	8564 (79.5)	21895 (79.8)
Work status	7071			
• Unemployed		2698 (38.2)	775 (40.7)	1923 (37.2)
• Employed		4373 (61.8)	1131 (59.3)	3242 (62.8)
Annual perceived household income	33814			
• Bottom third		4739 (14.0)	1249 (12.8)	3490 (14.5)
• Middle third		19107 (56.5)	4910 (50.2)	14197 (59.1)
• Top third		9968 (29.5)	3622 (37.0)	6346 (26.4)
Number of adults ≥18 years living in the household	32979			
• 1		15657 (47.5)	4419 (46.8)	11238 (47.7)
• 2		8999 (27.3)	2485 (26.3)	6514 (27.7)
• 3		4756 (14.4)	1352 (14.3)	3404 (14.5)
• 4		2231 (6.8)	700 (7.4)	1531 (6.5)
• ≥ 5		1336 (4.0)	478 (5.1)	858 (3.6)
Number of children ≤ 18 years living in the household	12357			
• 1		5951 (48.2)	1575 (45.7)	4376 (49.1)
• 2		4620 (37.4)	1271 (36.9)	3349 (37.6)
• 3		1290 (10.4)	401 (11.6)	889 (10)
• 4		323 (2.6)	117 (3.4)	206 (2.3)
• ≥ 5		171 (1.4)	82 (2.4)	91 (1)
Gender Inequality Index	45615			
• Low/Medium GII		30530 (66.9)	8188 (62.3)	22342 (68.8)
• High GII		15085 (33.1)	4951 (37.7)	10134 (31.2)
Geographic Regions	48632			
• Europe		12106 (24.9)	3558 (25.3)	8548 (24.8)
• North America		18658 (38.4)	4674 (33.2)	13984 (40.5)
• Others		17868 (36.7)	5860 (41.2)	12008 (34.8)
Likelihood of getting vaccinated	38979			
• Unlikely		4664 (11.9)	1220 (10.9)	3444 (12.4)
• Likely		34315 (88.0)	9930 (89.1)	24385 (87.6)
Psychosocial characteristics				
Depressive disorder	37616	3276 (8.7)	705 (6.7)	2571 (9.5)
Anxiety disorder	37481	5889 (15.7)	1133 (10.7)	4756 (17.7)

[1] Number of observations with complete information; GII: Gender Inequality Index

Table 2. Bivariate association between gender-related variables and adoption of three key protective health behaviours

	Hand washing (n=43318)		Mask wearing (n=42767)		Physical distancing (n=43368)	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Socio-demographic characteristics						
Biological sex						
• Male (ref)	-		-		-	
• Female	1.97 (1.71-2.28)	<0.001	0.98 (0.94-1.03)	0.41	1.28 (1.22-1.34)	<0.001
Age distribution						
• Up to 25 (ref)	-		-		-	
• 26-50	2.71 (2.31-3.17)	<0.001	0.86 (0.82-0.92)	<0.001	1.11 (1.04-1.18)	<0.001
• 51 and older	5.60 (4.51-6.94)	<0.001	1.11 (1.04-1.18)	<0.01	1.50 (1.41-1.61)	<0.001
Education level						
• Low level (ref)	-		-		-	
• High level	1.56 (1.31-1.85)	<0.001	0.99 (0.94-1.04)	0.78	1.20 (1.13-1.27)	<0.001
Work status						
• Unemployed (ref)	-		-		-	
• Employed	1.84 (1.25-2.71)	<0.01	0.35 (0.23-0.54)	<0.001	0.53 (0.47-0.60)	<0.001
Annual household income						
• Bottom third (ref)	-		-		-	
• Middle third	1.47 (1.18-1.84)	<0.01	1.18 (1.11-1.26)	<0.001	0.98 (0.91-1.06)	0.78
• Top third	1.63 (1.27-2.10)	<0.001	1.02 (0.95-1.10)	0.52	1.23 (1.12-1.33)	<0.001
Adults ≥18 years living in the household						
• 1 (ref)	-		-		-	
• 2	0.80 (0.65-0.99)	<0.05	1.27 (1.21-1.35)	<0.001	0.73 (0.69-0.78)	<0.001
• 3	0.59 (0.46-0.75)	<0.001	1.63 (1.52-1.76)	<0.001	0.64 (0.59-0.69)	<0.001
• 4	0.59 (0.43-0.82)	<0.01	2.31 (2.06-2.58)	<0.001	0.50 (0.45-0.55)	<0.001
• ≥ 5	0.35 (0.25-0.48)	<0.001	2.77 (2.39-3.22)	<0.001	0.43 (0.38-0.48)	<0.001
Children ≤18 years living in the household						
• 1 (ref)	-	-	-		-	
• 2	1.18 (0.88-1.58)	0.26	0.81 (0.74-0.87)	<0.001	1.09 (0.99-1.19)	0.06
• 3	0.91 (0.59-1.39)	0.68	0.81 (0.71-0.92)	<0.01	0.92 (0.80-1.05)	0.25
• 4	0.68 (0.34-1.36)	0.28	1.10 (0.85-1.42)	0.45	0.75 (0.58-0.96)	0.05
• ≥ 5	0.23 (0.13-0.41)	<0.001	0.95 (0.68-1.32)	0.79	0.55 (0.41-0.76)	<0.001
Gender Inequality Index						
• Low/Medium GII (ref)	-		-			
• High GII	0.52 (0.45-0.60)	<0.001	4.38 (4.15-4.63)	<0.001	0.91 (0.86-0.96)	0.01
Geographic Regions						
• Europe	1.63 (1.37-1.95)	<0.001	0.29 (0.27-0.31)	<0.001	1.21 (1.14-1.28)	<0.001
• North America	2.54 (2.13-3.04)	<0.001	0.21 (0.20-0.22)	<0.001	2.30 (2.18-2.42)	<0.001

• Others (ref)	-		-		-	
Likelihood of getting vaccinated						
• Unlikely (ref)	-		-		-	
• Likely	3.04 (2.57-3.61)	<0.001	1.15 (1.08-1.22)	<0.001	2.18 (2.04-2.32)	<0.001
Psychosocial characteristics						
Depressive disorder	0.76 (0.59-0.98)	<0.05	0.91 (0.85-0.98)	<0.05	1.15 (1.05-1.26)	<0.01
Anxiety disorder	0.91 (0.73-1.11)	0.35	0.88 (0.83-0.93)	<0.001	1.22 (1.14-1.31)	<0.001

[1]Number of observations with complete information

Table 3. Association between gender-related variables and adoption of facemask wearing, by sex

	Mask wearing							
	Female				Male			
	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value
Sociodemographic characteristics								
Age distribution								
• Up to 25 (ref)	-		-		-		-	
• 26-50	0.85 (0.79-0.91)	<0.001	0.77 (0.26-2.35)	0.65	0.91 (0.81-1.01)	0.11	0.59 (0.207-5.04)	0.63
• 51 and older	1.11 (1.02-1.18)	<0.01	0.35 (0.12-1.03)	0.05	1.12 (1.00-1.26)	<0.05	0.52 (0.206-4.47)	0.55
Education level								
• Low level (ref)	-		-		-		-	
• High level	0.95 (0.89-1.01)	0.15	0.84 (0.43-1.66)	0.61	1.08 (0.98-1.20)	0.10	0.37 (0.10-1.33)	0.12
Work status								
• Unemployed (ref)	-		-		-		-	
• Employed	0.38 (0.23-0.63)	<0.001	0.22 (0.10-0.48)	<0.001	0.31 (0.14-0.67)	<0.01	0.15 (0.04-0.53)	<0.01
Annual household income								
• Bottom third (ref)	-		-		-		-	
• Middle third	1.19 (1.10-1.29)	<0.001	0.76 (0.32-1.84)	0.54	1.12 (0.98-1.27)	0.08	1.64 (0.57-4.74)	0.36
• Top third	1.01 (0.92-1.10)	0.80	0.89 (0.35-2.28)	0.81	1.01 (0.87-1.15)	0.93	5.93 (1.64-21.48)	<0.01
Adults ≥18 years living in the household								
• ≤ 2 (ref)	-		-		-		-	
• > 2	1.79 (1.68-1.93)	<0.001	0.89 (0.46-1.71)	0.71	1.73 (1.56-1.93)	<0.001	1.79 (0.50-6.40)	0.36
Children ≤18 years living in the household								
• ≤ 2 (ref)	-				-			
• > 2	1.03 (1.81-2.49)	0.66			0.79 (0.65-0.96)	0.02		
Gender Inequality Index								
• High GII (ref)	-		-		-		-	
• Low/Medium GII	0.23 (0.21-0.24)	<0.001	0.18 (0.06-0.51)	<0.01	0.23 (0.21-0.25)	<0.001	0.29 (0.09-0.91)	<0.05
Geographic Regions								
• Europe	0.31 (0.28-0.33)	<0.001			0.26 (0.23-0.29)	<0.001		
• North America	0.21 (0.20-0.23)	<0.001			0.21 (0.18-0.23)	<0.001		
• Others (ref)	-				-			
Psychosocial characteristics								
Depressive disorder	0.91 (0.83-0.99)	<0.05	0.99 (0.33-3.07)	1.00	0.95 (0.81-1.12)	0.57	1.01 (0.20-5.01)	0.98
Anxiety disorder	0.87 (0.81-0.93)	<0.001	2.29 (0.84-6.24)	0.11	0.94 (0.82-1.07)	0.39	0.85 (0.23-3.18)	0.81

Note: In the multivariable model, geographic regions variable dropped due to collinearity with GII. Number of children in household variables dropped due to collinearity with number of adults in the household variable.

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FIGURE

Figure 1: Percentage of adherence to protective health behaviours, per group of Gender Inequality Index (GII), stratified by sex

FIGURE

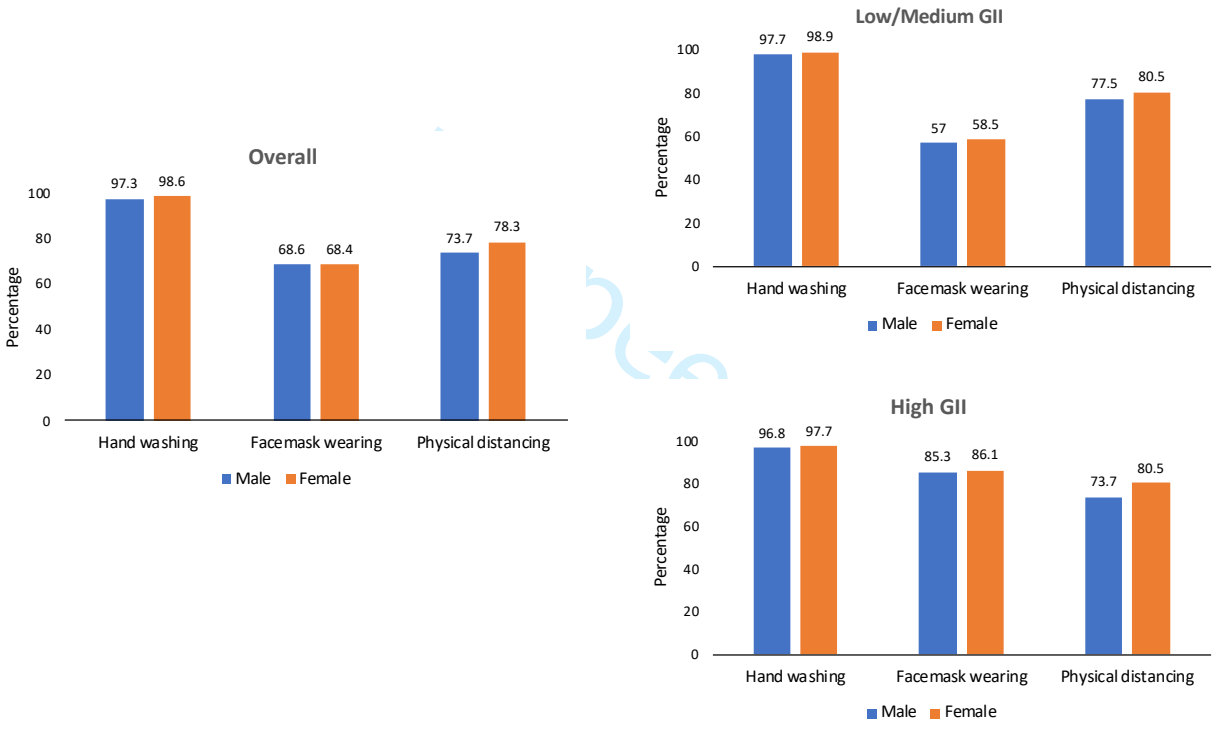

Figure 1: Percentage of adherence to protective health behaviours, per group of Gender Inequality Index (GII), stratified by sex

APPENDIX

Table 1a. Association between gender-related variables and adoption of hand washing, by sex

	Hand washing							
	Female				Male			
	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value
Sociodemographic characteristics								
Age distribution								
• Up to 25 (ref)	-		-		-		-	
• 26-50	2.91 (2.37-3.58)	<0.001	4.44 (1.68-11.76)	<0.01	2.45 (1.91-3.14)	<0.001	1.89 (0.63-5.68)	0.25
• 51 and older	7.71 (5.57-10.66)	<0.001	13.39 (2.87-62.6)	<0.01	4.56 (3.36-6.18)	<0.001	2.25 (0.81-6.27)	0.11
Education level								
• Low level (ref)	-		-		-		-	
• High level	1.63 (1.29-2.07)	<0.001	0.78 (0.32-1.91)	0.58	1.47 (1.12-1.92)	<0.01	0.38 (0.14-1.01)	0.05
Work status								
• Unemployed (ref)	-		-		-		-	
• Employed	2.41 (1.35-4.28)	<0.01	1.19 (0.50-2.83)	0.69	1.38 (0.80-2.40)	0.24	1.91 (0.89-4.13)	0.09
Annual household income								
• Bottom third (ref)	-		-		-		-	
• Middle third	1.50 (1.12-2.01)	<0.01	1.92 (0.83-4.43)	0.12	1.42 (1.00-2.01)	<0.05	1.07 (0.41-2.81)	0.88
• Top third	1.96 (1.36-2.81)	<0.001	3.20 (0.84-12.15)	0.08	1.67 (1.15-2.43)	<0.01	2.54 (0.77-8.41)	0.12
Adults ≥18 years living in the household								
• ≤ 2 (ref)	-		-		-		-	
• > 2	0.52 0.41-0.66)	<0.001	1.04 (0.44-2.43)	0.93	0.73 (0.56-0.95)	0.02	0.46 (0.21-1.03)	0.06
Children ≤18 years living in the household								
• ≤ 2 (ref)	-				-			
• > 2	0.69 (0.44-1.08)	0.12			0.84 (0.52-1.37)	0.48		
Gender Inequality Index								
• High GII (ref)	-		-		-		-	
• Low/Medium GII	2.29 (1.88-2.78)	<0.001	2.11 (0.95-4.71)	0.07	1.37 (1.09-1.72)	<0.01	0.57 (0.25-1.32)	0.18
Geographic Regions								
• Europe	1.91 (1.49-2.43)	<0.001			1.28 (0.98-1.67)	0.06		
• North America	2.93 (2.31-3.72)	<0.001			1.87 (1.42-2.46)	<0.001		
• Others (ref)	-				-			
Psychosocial characteristics								
Depressive disorder	0.73 (0.52-1.02)	0.07	0.74 (0.20-2.71)	0.65	0.63 (0.42-0.95)	<0.05	0.73 (0.18-2.98)	0.66
Anxiety disorder	0.90 (0.68-1.18)	0.45	0.98 (0.32-2.96)	0.97	0.71 (34.3-44-4)	0.05	2.51 (0.47-13.38)	0.28

Note: In the multivariable model, geographic regions variable dropped due to collinearity with GII. Number of children in household variables dropped due to collinearity with number of adults in the household variable.

Table 1b. Association between gender-related variables and adoption of physical distancing, by sex

	Physical distancing							
	Female				Male			
	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value
Sociodemographic characteristics								
Age distribution								
• Up to 25 (ref)	-		-		-			
• 26-50	1.10 (1.03-1.18)	<0.01	2.01 (1.54-2.63)	<0.001	1.11 (0.99-1.25)	0.05	2.53 (1.53-4.21)	<0.001
• 51 and older	1.60 (1.47-1.73)	<0.001	3.57 (2.72-4.68)	<0.001	1.41 (1.24-1.58)	<0.001	3.99 (2.47-6.46)	<0.001
Education level								
• Low level (ref)	-		-		-			
• High level	1.19 (1.11-1.27)	<0.001	1.39 (1.13-1.74)	<0.01	1.21 (1.09-1.34)	<0.001	0.87 (0.61-1.25)	0.45
Work status								
• Unemployed (ref)	-		-		-			
• Employed	0.55 (0.48-0.62)	<0.001	0.39 (0.32-0.49)	<0.001	0.48 (0.38-0.59)	<0.001	0.38 (0.27-0.52)	<0.001
Annual household income								
• Bottom third (ref)	-		-		-			
• Middle third	1.26 (0.99-1.60)	0.05	1.26 (0.99-1.59)	0.06	1.24 (0.89-1.73)	0.19	1.54 (1.01-2.32)	<0.05
• Top third	1.90 (1.41-2.56)	<0.001	1.53 (1.17-2.01)	<0.01	1.71 (1.19-2.45)	<0.01	2.13 (1.36-3.35)	<0.01
Adults ≥18 years living in the household								
• ≤ 2 (ref)	-		-		-		-	
• > 2	0.65 (0.60-0.69)	<0.001	0.89 (0.72-1.09)	0.27	0.61 (0.55-0.67)	<0.001	0.66 (0.47-0.92)	<0.05
Children ≤18 years living in the household								
• ≤ 2 (ref)	-				-			
• > 2	0.79 (0.69-0.92)	<0.01			0.94 (0.78-1.15)	0.56		
Gender Inequality Index								
• High GII (ref)	-		-		-			
• Low/Medium GII	0.99 (0.94-1.06)	0.95	0.72 (0.58-0.88)	<0.01	1.23 (1.13-1.34)	<0.001	0.87 (0.64-1.19)	0.39
Geographic Regions								
• Europe	1.16 (1.09-1.24)	<0.001			1.29 (1.17-1.43)	<0.001		
• North America	2.26 (2.12-2.41)	<0.001			2.26 (2.04-2.49)	<0.001		
• Others (ref)	-				-			
Psychosocial characteristics								
Depressive disorder	1.16 (1.05-1.29)	<0.01	1.07 (0.78-1.48)	0.66	1.00 (0.84-1.19)	0.96	0.86 (0.49-1.50)	0.60
Anxiety disorder	1.21 (1.12-1.31)	<0.001	1.03 (0.79-1.32)	0.84	1.00 (0.95-1.27)	0.19	1.40 (0.85-2.31)	0.18

Note: In the multivariable model, geographic regions variable dropped due to collinearity with GII. Number of children in household variables dropped due to collinearity with number of adults in the household variable.

STROBE Statement—checklist of items that should be included in reports of observational studies

Association of Biological Sex and Gender-related Factors with Public Engagement in Protective Health Behaviours during the COVID-19 Pandemic: Lessons Learned Going Forward

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3-4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	NA
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	NA
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	NA

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-12
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg. analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

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Impact of biological sex and gender-related factors on public engagement in protective health behaviours during the COVID-19 pandemic: cross-sectional analyses from a global survey

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Impact of biological sex and gender-related factors on public engagement in protective health behaviours during the COVID-19 pandemic: cross-sectional analyses from a global survey

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ABSTRACT

Objective: Given the role of sociocultural gender in shaping human behaviours, the main objective of this study was to examine whether sex and gender-related factors were associated with the public's adherence to COVID-19 recommended protective health behaviours.

Design: This was a retrospective analysis of the survey that captured data on people's awareness, attitudes, and behaviours as they relate to the COVID-19 policies.

Setting: Data from the International COVID-19 Awareness and Responses Evaluation (iCARE) survey collected between March 2020 to February 2021 from 175 countries.

Participants: Convenience sample around the world.

Main outcome measures: We examined the role of sex and gender-related factors in relation to non-adherence of protective health behaviors including: (i) hand washing; (ii) mask wearing; and (iii) physical distancing. Multivariable logistic regression was conducted to determine the factors associated with non-adherence to behaviors.

Results: Among 48,668 respondents (mean age: 43 years; 71% female), 98.3% adopted hand washing, 68.5% mask wearing, and 76.9% physical distancing. Compared with males, females were more likely to adopt hand washing (OR=1.97, 95%CI: 1.71-2.28) and maintain physical distancing (OR=1.28, 95%CI: 1.22-1.34). However, in multivariable sex-stratified models, females in countries with higher gender inequality indexes (GII) were less likely to report hand washing (aOR=0.47, 95%CI: 0.21-1.05). Females who reported being employed (aOR=0.22, 95%CI: 0.10-0.48) and in countries with low/medium GIIs (aOR=0.18, 95%CI: 0.06-0.51) were less likely to report mask wearing. Females who reported being employed were less likely to report physical distancing (aOR=0.39, 95%CI: 0.32-0.49).

Conclusion: While females showed greater adherence to COVID-19 protective health behaviours, gender-related factors, including employment status and high-country wide gender inequality were independently associated with non-adherence. These findings may inform public health and vaccination policies in current as well as future pandemic.

Keywords:

COVID-19, SARS-Cov-2, health behaviours, hand washing, mask wearing, physical distancing

Strengths and limitations of this study:

- The study had a large sample size with a global perspective, and availability of gender-related factors to examine the impact of gender.
- The online nature of the iCARE survey might have limited the participation from individuals who did not had access to computers and internet, limiting the generalization of findings.
- Our global sample was highly educated group of people whose results are likely to be 'best case scenario'.
- The global sample was also mostly females, so males are underrepresented in this study.
- Self-reported behaviour of the respondents might not have accurately represented actual behaviour, hence, the findings should be interpreted with caution.

INTRODUCTION

Public behaviour plays an important role during public health emergencies.[1] Behaviours can be influenced by both the biological sex and sociocultural gender (gender identity, gender roles, gender relations, and institutionalized gender) of an individual. [2] According to Canadian Institutes of Health and Research (CIHR), sex refers to "*a set of biological attributes and associated physical and physiological features including chromosomes, gene expression, hormone levels and function, and reproductive/sexual anatomy*" and are categorized as female or male.[3] While gender refers to "*the array of socially constructed roles and relationships, personality traits, attitudes, behaviours, values, relative power and influence that society ascribes to women and men on a differential basis*".[4,5] In the case of the Coronavirus Disease 2019 (COVID-19) pandemic, both men and women worldwide have shown inconsistent responses to acute infection as well as differing long-term health, economic, and social consequences.[6,7] Understanding these responses in relation to sex and/or gender-related attributes in the general population may be particularly valuable to inform tailored sex and gender strategies moving forward.

It has been identified that public health responses to infectious diseases require fundamental changes in individual behaviour. Hand washing, mask wearing, and physical distancing (*previously referred to as social distancing*) are the key transmission reduction public health behaviour-based prevention measures [1] that are associated with a reduction in the global incidence of COVID-19.[8,9] Effectiveness of such responses depends not only on the generalized adherence of the public but may be specific to certain high-risk groups. Though recommended and proven to limit transmission rates, hand washing, mask wearing, and physical distancing have been inconsistently initiated and maintained. There is a dynamic relationship between the voluntary

adoption of public health behaviours and infection transmission during infectious disease epidemics.[10] The COVID-19 pandemic has sparked an unparalleled global discourse around the adoption of protective behaviours and other public health and social measures to slow the person-to-person spread of SARS-CoV-2.[1]

COVID-19 has highlighted the role that sex and gender play in our lives. This includes influencing an individual's exposure to COVID-19 through sex and gender-related occupations, risk-taking behaviours, and employment of precautions. Sex and gender also are known to have an impact on health through the gendered nature of the workforce and the predominant risk associated with it, increased caregiving responsibilities at home limiting the work and economic opportunities, or institutional biases and policies.[2,11] Gender affects the division of labor and care duties in families and communities. Hence, it is of utmost importance that we gather, from our recent lived experience, evidence on the potential sex and gender-related differences in perception and behavioural responses experienced during COVID-19 pandemic.

A few studies have shown sex-based differences in COVID-19 related beliefs and behaviours and have reported that compared to men, women are more likely to perceive the pandemic as a serious health problem and comply more with the preventive behaviours.[12,13] Therefore, as gender is culturally and geographically based, we hypothesized that there is a difference in preventive behaviours and pandemic related concerns based on sex and gender-related factors. Also, regardless of sex-based differences, our previous studies highlight the need of focusing on the gender-related factors.[14,15] Hence, the purpose of this study was to examine whether sex and gender-related factors are associated with the engagement in the recommended key protective

health behaviours such as hand washing, mask wearing, and physical distancing during the COVID-19 pandemic.

METHODS

Study design

Survey datasets from the ongoing iCARE (International Covid-19 Awareness and Responses Evaluation) study led by the Montreal Behavioural Medicine Centre (MBMC: www.mbmc-cmcm.ca) in collaboration with a team of 200 international collaborators from 42 countries was used for the data analyses. The iCARE study design has been previously described.[16] Briefly, iCARE is an international multi-wave cross-sectional observational cohort study of public awareness, attitudes, and responses to public health policies implemented to reduce the spread of COVID-19 on people around the world (www.iCAREstudy.com). It collects data on study demographics, perceptions of government policy, health behaviours, adherence to health measures, types of concerns, and adherence motivators.

Survey data were collected in 4-6 week rounds using convenience snowball sampling (globally, 25-30K per wave) and parallel representative sampling (in targeted countries), generating data for multiple cohorts of participants that were added to the first round cohort launched on March 27, 2020. We analyzed data from Survey 1 – Survey 7 that was collected between March 27, 2020 to February 9, 2021. A total of 61,552 respondents participated in the survey from over 175 countries. The data was analyzed for 48,668 respondents (female=34,556, male=14,112). The questionnaire used in the survey is publicly available via the Open Science Framework (https://osf.io/nswcm/) and the survey is available in 34 languages.[17]

Biological sex and gender-related factors

For each surveyed individual the following variables were collected: socio-demographic characteristics (sex at birth, age in years, level of education, work status, perceived annual household income, number of adults and children living in the household, country of residence, and likelihood of getting vaccinated *i.e.,* respondents' willingness to get a COVID-19 vaccine), the presence of a physician-diagnosed depressive and/or anxiety disorder, and adoption of protective health behaviours (hand washing, wearing a face mask, and physical distancing).

To account for institutionalized gender, the Gender Inequality Index (GII), developed by the United Nations Development Programme, was used as a measure of country specific gender inequality[18] and as a measure of institutionalized gender in this study. This index is a continuous measure for the degree of gender inequality per country on a scale between 0 and 1, with lower values representing near-perfect gender equality and higher values representing greater levels of inequality favoring males. The GII is based on several aspects of institutionalized gender: (i) reproductive health, measured by the maternal mortality ratio and adolescent birth rates; (ii) empowerment, measured by the proportion of parliamentary seats occupied by women and the proportion of adult women and men with at least some secondary education; and (iii) economic status, measured by labor force participation rate of men and women.[19] GIIs in this study were divided into tertiles and later categorized into high and low/medium GII categories. We used data on GIIs from 2019. Some of the countries in the region were excluded from the analysis due to the unavailability of data.

Outcome measures

The main outcomes of the analysis were self-reported non-adherence to three recommended protective health behaviours including: (i) hand washing with soap and water; (ii) wearing a face mask; and (iii) a composite measure of physical distancing behaviours (specifically: staying at least 1-2 meters away from other people; staying/working at home rather than going to work or school; self-quarantining if returning from a trip; self-quarantining if one have the virus or believe they have the virus; avoid going out to bars/pubs/restaurants; avoiding large social gatherings; avoiding small social gatherings; avoiding indoor social gatherings; and avoiding any non-essential travel).[20] A composite binary variable was constructed in which, the participants who met the above-mentioned criteria were coded with a value of 1; otherwise, the participants were coded with a value of 0. A set of measures in the iCARE survey intended to explore the prevention measures used by the public to prevent the spread of COVID-19 by maintaining a physical distance between two people and reducing the number of times people come into close physical contact with one another[21] were used to create a composite variable for physical distancing.

Statistical analysis

A global analysis of public engagement in three recommended protective health behaviours was performed to investigate whether the outcomes differed by sex. Our outcome of interest in the modeling process was the non-adherence to behavioural recommended measures. Descriptive sex-stratified analyses were run for: age; baseline mental health conditions (any depressive or anxiety disorders); and gender-related factors such as level of education, work status, annual household income, and GII. Continuous variables were presented as mean and standard deviation (SD). Categorical variables were presented as counts and percentages. Sex differences in outcomes (protective health behaviours) were completed and associations between sex, gender-related

factors, and outcomes were tested in a multivariable model. Bivariate logistic regressions were run for crude analysis followed by collinearity diagnostics to account for inflation in standard errors of parameter estimates caused by collinear cofactors.[22] If variables were collinear, we included the variable with the least amount of missing data in the multivariable models. *A priori* gender-related cofactors (i.e., gender role [work status], gender identity [depressive and/or anxiety disorders], and institutionalized gender [education level, annual household income, and GII]) were included in multivariable models adjusting for the potential confounders (i.e., age and geographical regions). Two-way interaction between the sex and gender-related factors were tested by including an interaction term in bivariate models. All statistical analyses were performed using statistical software STATA version 16 (College Station, TX, USA). Tests were two sided and the significance was defined as $p<0.05$.

Patient and public involvement

It was not possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research. For the dissemination of results, we will submit the results of the study to relevant national and international journals with the intention of publishing the results widely. Further, we will make national and international presentations in conferences and symposiums to stakeholder groups including those involving general public, researchers, clinicians, and policymakers.

RESULTS

Descriptive characteristics of respondents

Our study population included 34,556 females (71%) and 14,112 males (29%) **(Table 1)**. The mean age of the respondents was 43 years (SD: 16). A majority (n=23,462, 48.8%) was between 26 and 50 years of age. Most respondents (79.7%) reported high levels of education, were employed (61.8%), were from Europe and North American countries (66.3%), and from regions with high levels of gender equity as measured by low/medium GIIs (66.9%). Females were more likely to report having a physician-diagnosed depressive disorder (9.5% vs 6.7%, p≤0.001) and anxiety disorder (17.7% vs 10.7%, p≤0.001) compared to males. Irrespective of sex, only 68.5% of responders disclosed wearing a facemask, while a higher percentage of females reported adherence to physical distancing behaviours compared to males (78.3% vs 73.7%, p=<0.001). Participants aged 51 and older were more likely to engage in all three-key protective behaviours as compared with younger participants: hand washing (Odds ratio [OR]= 5.60, 95% Confidence interval [CI]: 4.51-6.94); mask wearing (OR=1.11, 95% CI: 1.04-1.18); and physical distancing (OR=1.50, 95% CI: 1.41-1.61) **(Table 2)**.

Gender-related factors associated with adoption of protective health behaviours

For the univariate analysis, the proportion of people adopting the protective health-related behaviours, varied depending on the gender-related factor examined. Despite employed respondents being 84% more likely to engage in hand washing than unemployed respondents, they were 65% less likely to engage in mask wearing and 47% less likely to engage in physical distancing (p<0.001 for all comparisons). Hand washing and physical distancing was less common as the number of adults ≥18 years living in the household increased. The proportion of adoption was lowest for wearing a facemask, both for females and males (58.5% vs 57%) in low/medium GII countries **(Figure 1)**. Respondents living in the countries with high GII were 4.38 times (95% CI: 4.15-4.63) more likely to use mask than respondents living in the countries with low GIIs;

however, they were less likely to engage in hand washing and less likely to engage in physical distancing **(Table 2)**.

Sex and gender-related differences in the adoption of protective health behaviours

Sex-stratified multivariate analyses demonstrated that the factors associated with the adoption of protective health behaviours varied by sex. Among females, the factors associated with not adhering to health behaviours were: (i) for hand washing: higher country gender inequality favoring males GII (aOR=0.47, 95% CI: 0.21-1.05, p=0.07) (ii) for mask-wearing: older age (aOR females=0.35, 95% CI:0.12-1.03, p=0.05), being employed (aOR females=0.22, 95% CI:0.10-0.48, p<0.001), and living in a country with more gender equity as measured by the GII (aOR=0.18, 95% CI: 0.06-0.51, p<0.01); and (iii) for physical distancing: being employed (aOR females=0.39, 95% CI:0.32-0.49, p<0.001) **(Table 3, Appendix-Table 1a, Table 1b)**.

Among males, factors that were associated with not adhering to protective health behaviours were: (i) for hand washing: higher level of education (aOR males=0.37, 95% CI: 0.14-1.01, p=0.05) and with a household size of > 2 (aOR males=0.46, 95% CI: 0.21-1.03, p=0.06); (ii) for mask wearing: being employed (aOR males=0.15, 95% CI:0.04-0.53, p<0.01) and living in a country with more gender equity as measured by the GII (aOR=0.29, 95% CI: 0.09-0.91, p<0.05); and (iii) for physical distancing: being employed (aOR males=0.38, 95% CI:0.27-0.52, p<0.001) and with household size of > 2 (aOR males=0.66, 95% CI: 0.47-0.92, p<0.05) **(Table 3, Appendix-Table 1a, Table 1b)**.

There was a significant interaction between sex and educational level of the participants. High level of education decreased the use of mask wearing among females compared to males (p=0.03).

There was a trend for living in a country with lower gender equity to be associated with poorer protective behaviors in females compared to males (p=0.056).

DISCUSSION

The present study provides a comprehensive analysis on the impact of sex and gender-related factors and the association with adherence to protective health behaviours during the COVID-19 pandemic. Overall, hand washing, mask wearing, and physical distancing behaviours were adopted globally. However, there were a number of gender-related factors associated with a lower adherence based on sex.

Lower adherence to the protective health behaviours was mainly associated with younger age, being employed, and living in a country with low/medium GII (higher gender equity) for females. While high level of education, being employed, and household size of >2 were associated with lower adoption in males. Considering these group of individuals with lower adherence to protective health behaviours, this would suggest that in the current as well as future pandemics it may be useful to target interventions based on sex and gendered factors to increase adherence and reduce disease transmission. Measures such as risk-assessment and mitigation considerations for public settings could be implemented to mitigate the risk of transmission and promote the adoption of protective health behaviours.

Overall, mask wearing was lower among both sexes compared to other protective behaviours such as hand washing and physical distancing. Many countries waited to issue mask mandates months into the pandemic[23] even though other behaviours were mandated right away. This may be one of

the reasons for lower adherence. Further, adoption of mask wearing was less likely in males compared to females, mainly among those who were employed, indicating substantial room for improvement in male's engagement to mask wearing. In our study, employed female respondents reported that they were more likely to wear a mask compared to male respondents. Similarly, a study conducted in the United States also reported that females were 1.5 times more likely to wear a mask compared to males.[24] It has been suggested that females may be more likely to protect themselves and others by wearing a mask specifically because they handle the majority of caregiving within families and are overrepresented in essential work services, which generally requires mask wearing.[25] Previous studies have also reported mask wearing to be significantly associated with the occupation of respondents.[26,27] A study reported that women make up almost 90 percent of nurses and nursing assistants in the United States and over two-thirds of grocery store cashiers.[27] Performing the dual function of an essential worker outside and a caregiver at home, women might face a dilemma of how to keep their families healthy and safe while continuing to work in potentially risky circumstances, suggesting that these factors may make them more adherent to the protective behaviours.

Older females were the most likely participants to engage in hand washing and physical distancing, but less likely to engage in mask wearing. Older females may have a higher perceived risk of developing COVID-19 complications and mortality, and thus engaged in more protective health behaviours such as hand washing and physical distancing. Previous studies have shown that females and older adults are less likely to engage in the risky behaviours, feel more vulnerable to contracting diseases, and have a stronger sense of responsibility to protect society.[28,29] This is consistent with the findings of an American study that reported being older and female was related

to adopting more pandemic mitigating behaviours.[30] Furthermore, a study conducted in China also reported that being female and older was associated with adopting protective behaviours.[29] However, our study findings are in contrast with the results of a study conducted in Portugal that reported a decline in engagement in protective health behaviours with advancing age, which was reported to be related to the increased social-isolation and lack of help among older population.[31] Even though the study did not report the differences by sex of the respondents, self-isolation could be the reason for lower adherence to mask wearing among females. Depending on the diverse context, public health interventions should be tailored not only to sex, but differing age groups, and importantly institutional gender related variables such as those measured by the GII.

Emerging evidence shows that gender including the institutionalized gender shapes mask wearing adherence.[32] One of the interesting findings of the current study is respondents from low/medium GII countries with less gender inequity reported a significantly lower adherence to mask wearing compared to respondents from countries with high GII (high gender inequity). Even among the low/medium GII countries, adherence is reported to be poorer among males. Lower adherence among males is in line with a finding from a study conducted in the United States, in which males exhibited poorer mask wearing practices compared with their female counterparts.[24] This is also supported by a review that looked at research from multiple countries and found women were 50% more likely than men to practice protective behaviour.[33] The correlation between a Gini coefficient (a measure of income inequality) and GII (a measure of gender inequality) could explain the lower adherence to protective health behaviours in countries with low/medium GII where income inequality arises mainly through gender gaps in economic participation.[34]

The strengths of this study include a large sample size, having a global perspective, and availability of gender-related factors to examine the impact of gender. This study also has some limitations that should be acknowledged. First, the online nature of the iCARE survey might have limited the participation from individuals who did not had access to computers and internet, limiting the generalization of findings. However, the advantages of online surveys have been shown to outweigh the disadvantages, mainly in terms of its external validity;[35] hence, the bias might be relatively low. Second, our global sample was highly educated group of people whose results are likely to be 'best case scenario'. The global sample was also mostly women, so men are underrepresented in this study. Third, self-reported behaviour doesn't always accurately represent actual behaviour, hence, the findings should be interpreted with caution. Finally, although the study established the associations between sex and gender-related factors with the adoption of protective health behaviours, no causal relationships should be assumed due to the nature of the cross-sectional design of the survey.

CONCLUSIONS

In this analysis of a multinational study population, while a majority of respondents reported wearing a facemask, this is likely reflective of country wide mask mandates as opposed to adopting it as a protective health behavior. However, our study findings, suggest that wearing a facemask appeared to be more difficult to adhere to for many compared to other key protective behaviours such as hand washing and physical distancing. Moreover, our study noted that this was even more apparent in countries with low GII (more equity between males and females) indicating substantial room for improvement in public engagement regarding protective health behaviours. Since a widespread protective behavioral response are paramount for a successful containment and control

of an infectious disease contagion, the present study provides valuable information for identifying sex and gendered factors that may inform effective public health policies. Further, the Covid-19 pandemic highlights the urgent need to incorporate sex and gender analysis into all research and innovation processes in order to target specific groups both to help contain the transmission of the virus and to formulate vaccine policies.

DECLARATIONS

Competing interests: The authors declare no competing interests.

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Contributors:

All authors contributed to the preparation of this manuscript (RD, VR, SB, KLL, LP, CMN). CMN, LP, and VR developed the idea and design of the study. RD participated in drafting and revising the manuscript. CMN, LP, SB, KLL, and VR provided detailed comments on the draft for the revision. CMN provided substantial revisions and intellectual content to the manuscript. RD analyzed the data, and CMN and LP checked for the integrity and accuracy of the data. All authors (RD, VR, SB, KLL, LP, CMN) read and approved the final version of the manuscript.

Ethics approval:

The iCARE study was approved by the research ethics committee of the Comité d'éthique de recherche du CIUSSS-NIM (Centre intégré universitaire de santé et de services sociaux du Nord-

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Data availability statement:

Dataset are available from the iCARE team upon reasonable request.

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TABLES

Table 1. Descriptive characteristics of survey respondents by biological sex (N=48668)

	N[1]	Overall n (%) or Mean [SD]	Biological sex	
			Male (N=14112) n (%) or Mean [SD]	Female (N=34556) n (%) or Mean [SD]
Socio-demographic characteristics				
Age (in years)	48524	43 [16]	42 [16]	44 [17]
Age distribution in strata	48049			
• Up to 25		8632 (18.0)	2327 (16.8)	6305 (18.5)
• 26-50		23462 (48.8)	6372 (45.8)	17090 (50.0)
• 51 and older		15955 (33.2)	5197 (37.4)	10758 (31.5)
Education level	38217			
• Low level		7758 (20.3)	2208 (20.5)	5550 (20.2)
• High level		30459 (79.7)	8564 (79.5)	21895 (79.8)
Work status	7071			
• Unemployed		2698 (38.2)	775 (40.7)	1923 (37.2)
• Employed		4373 (61.8)	1131 (59.3)	3242 (62.8)
Annual perceived household income	33814			
• Bottom third		4739 (14.0)	1249 (12.8)	3490 (14.5)
• Middle third		19107 (56.5)	4910 (50.2)	14197 (59.1)
• Top third		9968 (29.5)	3622 (37.0)	6346 (26.4)
Number of adults ≥18 years living in the household	32979			
• 1		15657 (47.5)	4419 (46.8)	11238 (47.7)
• 2		8999 (27.3)	2485 (26.3)	6514 (27.7)
• 3		4756 (14.4)	1352 (14.3)	3404 (14.5)
• 4		2231 (6.8)	700 (7.4)	1531 (6.5)
• ≥ 5		1336 (4.0)	478 (5.1)	858 (3.6)
Number of children ≤ 18 years living in the household	12357			
• 1		5951 (48.2)	1575 (45.7)	4376 (49.1)
• 2		4620 (37.4)	1271 (36.9)	3349 (37.6)
• 3		1290 (10.4)	401 (11.6)	889 (10)
• 4		323 (2.6)	117 (3.4)	206 (2.3)
• ≥ 5		171 (1.4)	82 (2.4)	91 (1)
Gender Inequality Index	45615			
• Low/Medium GII		30530 (66.9)	8188 (62.3)	22342 (68.8)
• High GII		15085 (33.1)	4951 (37.7)	10134 (31.2)
Geographic Regions	48632			
• Europe		12106 (24.9)	3558 (25.3)	8548 (24.8)
• North America		18658 (38.4)	4674 (33.2)	13984 (40.5)
• Others		17868 (36.7)	5860 (41.2)	12008 (34.8)
Likelihood of getting vaccinated	38979			
• Unlikely		4664 (11.9)	1220 (10.9)	3444 (12.4)
• Likely		34315 (88.0)	9930 (89.1)	24385 (87.6)
Psychosocial characteristics				
Depressive disorder	37616	3276 (8.7)	705 (6.7)	2571 (9.5)
Anxiety disorder	37481	5889 (15.7)	1133 (10.7)	4756 (17.7)

[1] Number of observations with complete information; GII: Gender Inequality Index

Table 2. Bivariate association between gender-related variables and adoption of three key protective health behaviours

	Hand washing (n=43318)		Mask wearing (n=42767)		Physical distancing (n=43368)	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Socio-demographic characteristics						
Biological sex						
• Male (ref)	-		-		-	
• Female	1.97 (1.71-2.28)	<0.001	0.98 (0.94-1.03)	0.41	1.28 (1.22-1.34)	<0.001
Age distribution						
• Up to 25 (ref)	-		-		-	
• 26-50	2.71 (2.31-3.17)	<0.001	0.86 (0.82-0.92)	<0.001	1.11 (1.04-1.18)	<0.001
• 51 and older	5.60 (4.51-6.94)	<0.001	1.11 (1.04-1.18)	<0.01	1.50 (1.41-1.61)	<0.001
Education level						
• Low level (ref)	-		-		-	
• High level	1.56 (1.31-1.85)	<0.001	0.99 (0.94-1.04)	0.78	1.20 (1.13-1.27)	<0.001
Work status						
• Unemployed (ref)	-		-		-	
• Employed	1.84 (1.25-2.71)	<0.01	0.35 (0.23-0.54)	<0.001	0.53 (0.47-0.60)	<0.001
Annual household income						
• Bottom third (ref)	-		-		-	
• Middle third	1.47 (1.18-1.84)	<0.01	1.18 (1.11-1.26)	<0.001	0.98 (0.91-1.06)	0.78
• Top third	1.63 (1.27-2.10)	<0.001	1.02 (0.95-1.10)	0.52	1.23 (1.12-1.33)	<0.001
Adults ≥18 years living in the household						
• 1 (ref)	-		-		-	
• 2	0.80 (0.65-0.99)	<0.05	1.27 (1.21-1.35)	<0.001	0.73 (0.69-0.78)	<0.001
• 3	0.59 (0.46-0.75)	<0.001	1.63 (1.52-1.76)	<0.001	0.64 (0.59-0.69)	<0.001
• 4	0.59 (0.43-0.82)	<0.01	2.31 (2.06-2.58)	<0.001	0.50 (0.45-0.55)	<0.001
• ≥ 5	0.35 (0.25-0.48)	<0.001	2.77 (2.39-3.22)	<0.001	0.43 (0.38-0.48)	<0.001
Children ≤18 years living in the household						
• 1 (ref)	-	-	-		-	
• 2	1.18 (0.88-1.58)	0.26	0.81 (0.74-0.87)	<0.001	1.09 (0.99-1.19)	0.06
• 3	0.91 (0.59-1.39)	0.68	0.81 (0.71-0.92)	<0.01	0.92 (0.80-1.05)	0.25
• 4	0.68 (0.34-1.36)	0.28	1.10 (0.85-1.42)	0.45	0.75 (0.58-0.96)	0.05
• ≥ 5	0.23 (0.13-0.41)	<0.001	0.95 (0.68-1.32)	0.79	0.55 (0.41-0.76)	<0.001
Gender Inequality Index						
• Low/Medium GII (ref)	-		-			
• High GII	0.52 (0.45-0.60)	<0.001	4.38 (4.15-4.63)	<0.001	0.91 (0.86-0.96)	0.01
Geographic Regions						
• Europe	1.63 (1.37-1.95)	<0.001	0.29 (0.27-0.31)	<0.001	1.21 (1.14-1.28)	<0.001
• North America	2.54 (2.13-3.04)	<0.001	0.21 (0.20-0.22)	<0.001	2.30 (2.18-2.42)	<0.001

• Others (ref)	-		-		-	
Likelihood of getting vaccinated						
• Unlikely (ref)	-		-		-	
• Likely	3.04 (2.57-3.61)	<0.001	1.15 (1.08-1.22)	<0.001	2.18 (2.04-2.32)	<0.001
Psychosocial characteristics						
Depressive disorder	0.76 (0.59-0.98)	<0.05	0.91 (0.85-0.98)	<0.05	1.15 (1.05-1.26)	<0.01
Anxiety disorder	0.91 (0.73-1.11)	0.35	0.88 (0.83-0.93)	<0.001	1.22 (1.14-1.31)	<0.001

[1]Number of observations with complete information

Table 3. Association between gender-related variables and adoption of facemask wearing, by sex

	Mask wearing							
	Female				Male			
	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value
Sociodemographic characteristics								
Age distribution								
• Up to 25 (ref)	-		-		-		-	
• 26-50	0.85 (0.79-0.91)	<0.001	0.77 (0.26-2.35)	0.65	0.91 (0.81-1.01)	0.11	0.59 (0.207-5.04)	0.63
• 51 and older	1.11 (1.02-1.18)	<0.01	0.35 (0.12-1.03)	0.05	1.12 (1.00-1.26)	<0.05	0.52 (0.206-4.47)	0.55
Education level								
• Low level (ref)	-		-		-		-	
• High level	0.95 (0.89-1.01)	0.15	0.84 (0.43-1.66)	0.61	1.08 (0.98-1.20)	0.10	0.37 (0.10-1.33)	0.12
Work status								
• Unemployed (ref)	-		-		-		-	
• Employed	0.38 (0.23-0.63)	<0.001	0.22 (0.10-0.48)	<0.001	0.31 (0.14-0.67)	<0.01	0.15 (0.04-0.53)	<0.01
Annual household income								
• Bottom third (ref)	-		-		-		-	
• Middle third	1.19 (1.10-1.29)	<0.001	0.76 (0.32-1.84)	0.54	1.12 (0.98-1.27)	0.08	1.64 (0.57-4.74)	0.36
• Top third	1.01 (0.92-1.10)	0.80	0.89 (0.35-2.28)	0.81	1.01 (0.87-1.15)	0.93	5.93 (1.64-21.48)	<0.01
Adults ≥18 years living in the household								
• ≤ 2 (ref)	-		-		-		-	
• > 2	1.79 (1.68-1.93)	<0.001	0.89 (0.46-1.71)	0.71	1.73 (1.56-1.93)	<0.001	1.79 (0.50-6.40)	0.36
Children ≤18 years living in the household								
• ≤ 2 (ref)	-				-			
• > 2	1.03 (1.81-2.49)	0.66			0.79 (0.65-0.96)	0.02		
Gender Inequality Index								
• High GII (ref)	-		-		-		-	
• Low/Medium GII	0.23 (0.21-0.24)	<0.001	0.18 (0.06-0.51)	<0.01	0.23 (0.21-0.25)	<0.001	0.29 (0.09-0.91)	<0.05
Geographic Regions								
• Europe	0.31 (0.28-0.33)	<0.001			0.26 (0.23-0.29)	<0.001		
• North America	0.21 (0.20-0.23)	<0.001			0.21 (0.18-0.23)	<0.001		
• Others (ref)	-				-			
Psychosocial characteristics								
Depressive disorder	0.91 (0.83-0.99)	<0.05	0.99 (0.33-3.07)	1.00	0.95 (0.81-1.12)	0.57	1.01 (0.20-5.01)	0.98
Anxiety disorder	0.87 (0.81-0.93)	<0.001	2.29 (0.84-6.24)	0.11	0.94 (0.82-1.07)	0.39	0.85 (0.23-3.18)	0.81

Note: In the multivariable model, geographic regions variable dropped due to collinearity with GII. Number of children in household variables dropped due to collinearity with number of adults in the household variable.

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FIGURE

Figure 1: Percentage of adherence to protective health behaviours, per group of Gender Inequality Index (GII), stratified by sex

FIGURE

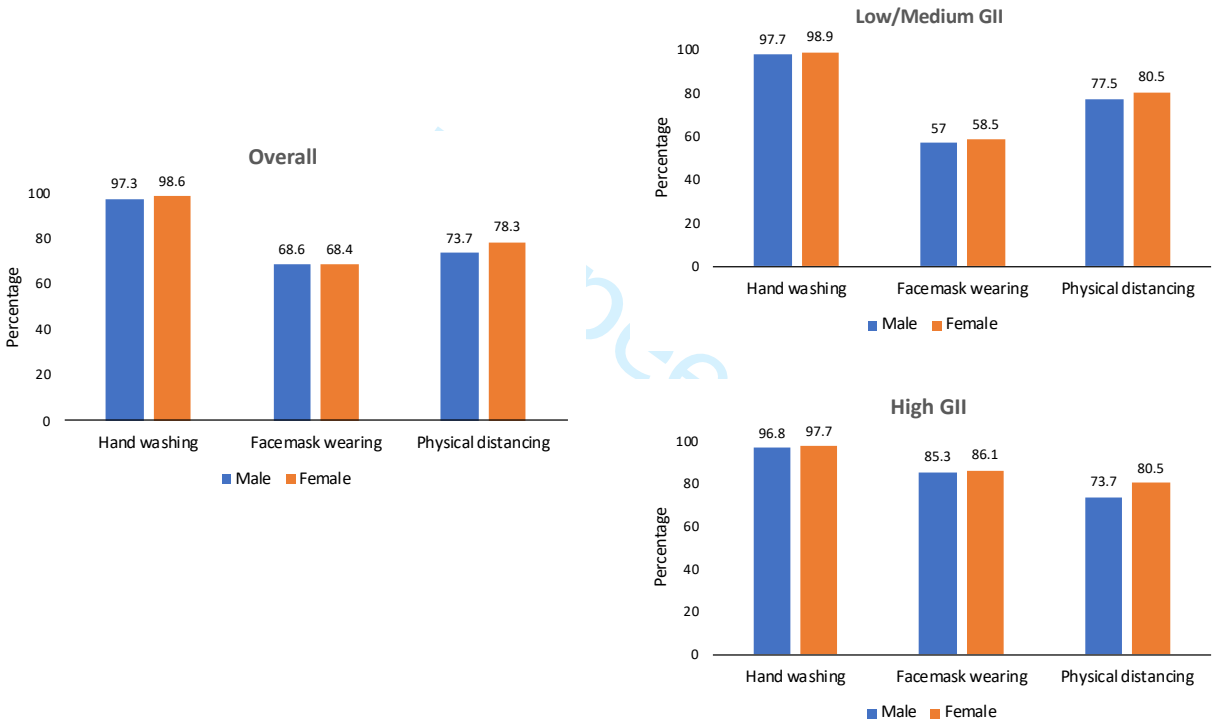

Figure 1: Percentage of adherence to protective health behaviours, per group of Gender Inequality Index (GII), stratified by sex

APPENDIX

Table 1a. Association between gender-related variables and adoption of hand washing, by sex

	Hand washing							
	Female				Male			
	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value
Sociodemographic characteristics								
Age distribution								
• Up to 25 (ref)	-		-		-		-	
• 26-50	2.91 (2.37-3.58)	<0.001	4.44 (1.68-11.76)	<0.01	2.45 (1.91-3.14)	<0.001	1.89 (0.63-5.68)	0.25
• 51 and older	7.71 (5.57-10.66)	<0.001	13.39 (2.87-62.6)	<0.01	4.56 (3.36-6.18)	<0.001	2.25 (0.81-6.27)	0.11
Education level								
• Low level (ref)	-		-		-		-	
• High level	1.63 (1.29-2.07)	<0.001	0.78 (0.32-1.91)	0.58	1.47 (1.12-1.92)	<0.01	0.38 (0.14-1.01)	0.05
Work status								
• Unemployed (ref)	-		-		-		-	
• Employed	2.41 (1.35-4.28)	<0.01	1.19 (0.50-2.83)	0.69	1.38 (0.80-2.40)	0.24	1.91 (0.89-4.13)	0.09
Annual household income								
• Bottom third (ref)	-		-		-		-	
• Middle third	1.50 (1.12-2.01)	<0.01	1.92 (0.83-4.43)	0.12	1.42 (1.00-2.01)	<0.05	1.07 (0.41-2.81)	0.88
• Top third	1.96 (1.36-2.81)	<0.001	3.20 (0.84-12.15)	0.08	1.67 (1.15-2.43)	<0.01	2.54 (0.77-8.41)	0.12
Adults ≥18 years living in the household								
• ≤ 2 (ref)	-		-		-		-	
• > 2	0.52 0.41-0.66)	<0.001	1.04 (0.44-2.43)	0.93	0.73 (0.56-0.95)	0.02	0.46 (0.21-1.03)	0.06
Children ≤18 years living in the household								
• ≤ 2 (ref)	-				-			
• > 2	0.69 (0.44-1.08)	0.12			0.84 (0.52-1.37)	0.48		
Gender Inequality Index								
• High GII (ref)	-		-		-		-	
• Low/Medium GII	2.29 (1.88-2.78)	<0.001	2.11 (0.95-4.71)	0.07	1.37 (1.09-1.72)	<0.01	0.57 (0.25-1.32)	0.18
Geographic Regions								
• Europe	1.91 (1.49-2.43)	<0.001			1.28 (0.98-1.67)	0.06		
• North America	2.93 (2.31-3.72)	<0.001			1.87 (1.42-2.46)	<0.001		
• Others (ref)	-				-			
Psychosocial characteristics								
Depressive disorder	0.73 (0.52-1.02)	0.07	0.74 (0.20-2.71)	0.65	0.63 (0.42-0.95)	<0.05	0.73 (0.18-2.98)	0.66
Anxiety disorder	0.90 (0.68-1.18)	0.45	0.98 (0.32-2.96)	0.97	0.71 (34.3-44-4)	0.05	2.51 (0.47-13.38)	0.28

Note: In the multivariable model, geographic regions variable dropped due to collinearity with GII. Number of children in household variables dropped due to collinearity with number of adults in the household variable.

Table 1b. Association between gender-related variables and adoption of physical distancing, by sex

	Physical distancing							
	Female				Male			
	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value
Sociodemographic characteristics								
Age distribution								
• Up to 25 (ref)	-		-		-		-	
• 26-50	1.10 (1.03-1.18)	<0.01	2.01 (1.54-2.63)	<0.001	1.11 (0.99-1.25)	0.05	2.53 (1.53-4.21)	<0.001
• 51 and older	1.60 (1.47-1.73)	<0.001	3.57 (2.72-4.68)	<0.001	1.41 (1.24-1.58)	<0.001	3.99 (2.47-6.46)	<0.001
Education level								
• Low level (ref)	-		-		-		-	
• High level	1.19 (1.11-1.27)	<0.001	1.39 (1.13-1.74)	<0.01	1.21 (1.09-1.34)	<0.001	0.87 (0.61-1.25)	0.45
Work status								
• Unemployed (ref)	-		-		-		-	
• Employed	0.55 (0.48-0.62)	<0.001	0.39 (0.32-0.49)	<0.001	0.48 (0.38-0.59)	<0.001	0.38 (0.27-0.52)	<0.001
Annual household income								
• Bottom third (ref)	-		-		-		-	
• Middle third	1.26 (0.99-1.60)	0.05	1.26 (0.99-1.59)	0.06	1.24 (0.89-1.73)	0.19	1.54 (1.01-2.32)	<0.05
• Top third	1.90 (1.41-2.56)	<0.001	1.53 (1.17-2.01)	<0.01	1.71 (1.19-2.45)	<0.01	2.13 (1.36-3.35)	<0.01
Adults ≥18 years living in the household								
• ≤ 2 (ref)	-		-		-		-	
• > 2	0.65 (0.60-0.69)	<0.001	0.89 (0.72-1.09)	0.27	0.61 (0.55-0.67)	<0.001	0.66 (0.47-0.92)	<0.05
Children ≤18 years living in the household								
• ≤ 2 (ref)	-				-			
• > 2	0.79 (0.69-0.92)	<0.01			0.94 (0.78-1.15)	0.56		
Gender Inequality Index								
• High GII (ref)	-		-		-		-	
• Low/Medium GII	0.99 (0.94-1.06)	0.95	0.72 (0.58-0.88)	<0.01	1.23 (1.13-1.34)	<0.001	0.87 (0.64-1.19)	0.39
Geographic Regions								
• Europe	1.16 (1.09-1.24)	<0.001			1.29 (1.17-1.43)	<0.001		
• North America	2.26 (2.12-2.41)	<0.001			2.26 (2.04-2.49)	<0.001		
• Others (ref)	-				-			
Psychosocial characteristics								
Depressive disorder	1.16 (1.05-1.29)	<0.01	1.07 (0.78-1.48)	0.66	1.00 (0.84-1.19)	0.96	0.86 (0.49-1.50)	0.60
Anxiety disorder	1.21 (1.12-1.31)	<0.001	1.03 (0.79-1.32)	0.84	1.00 (0.95-1.27)	0.19	1.40 (0.85-2.31)	0.18

Note: In the multivariable model, geographic regions variable dropped due to collinearity with GII. Number of children in household variables dropped due to collinearity with number of adults in the household variable.

STROBE Statement—checklist of items that should be included in reports of observational studies

Association of Biological Sex and Gender-related Factors with Public Engagement in Protective Health Behaviours during the COVID-19 Pandemic: Lessons Learned Going Forward

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3-4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	NA
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	NA
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	NA

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-12
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg. analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
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Impact of biological sex and gender-related factors on public engagement in protective health behaviours during the COVID-19 pandemic: cross-sectional analyses from a global survey

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ABSTRACT

Objective: Given the role of sociocultural gender in shaping human behaviours, the main objective of this study was to examine whether sex and gender-related factors were associated with the public's adherence to COVID-19 recommended protective health behaviours.

Design: This was a retrospective analysis of the survey that captured data on people's awareness, attitudes, and behaviours as they relate to the COVID-19 policies.

Setting: Data from the International COVID-19 Awareness and Responses Evaluation (iCARE) survey collected between March 2020 to February 2021 from 175 countries.

Participants: Convenience sample around the world.

Main outcome measures: We examined the role of sex and gender-related factors in relation to non-adherence of protective health behaviors including: (i) hand washing; (ii) mask wearing; and (iii) physical distancing. Multivariable logistic regression was conducted to determine the factors associated with non-adherence to behaviors.

Results: Among 48,668 respondents (mean age: 43 years; 71% female), 98.3% adopted hand washing, 68.5% mask wearing, and 76.9% physical distancing. Compared with males, females were more likely to adopt hand washing (OR=1.97, 95%CI: 1.71-2.28) and maintain physical distancing (OR=1.28, 95%CI: 1.22-1.34). However, in multivariable sex-stratified models, females in countries with higher gender inequality indexes (GII) were less likely to report hand washing (aOR=0.47, 95%CI: 0.21-1.05). Females who reported being employed (aOR=0.22, 95%CI: 0.10-0.48) and in countries with low/medium GIIs (aOR=0.18, 95%CI: 0.06-0.51) were less likely to report mask wearing. Females who reported being employed were less likely to report physical distancing (aOR=0.39, 95%CI: 0.32-0.49).

Conclusion: While females showed greater adherence to COVID-19 protective health behaviours, gender-related factors, including employment status and high-country wide gender inequality were independently associated with non-adherence. These findings may inform public health and vaccination policies in current as well as future pandemic.

Keywords:

COVID-19, SARS-Cov-2, health behaviours, hand washing, mask wearing, physical distancing

Strengths and limitations of this study:

- The study had a large sample size with a global perspective, and availability of gender-related factors to examine the impact of gender.
- The online nature of the iCARE survey might have limited the participation from individuals who did not had access to computers and internet, limiting the generalization of findings.
- Our global sample was highly educated group of people whose results are likely to be 'best case scenario'.
- The global sample was also mostly females, so males are underrepresented in this study.
- Self-reported behaviour of the respondents might not have accurately represented actual behaviour, hence, the findings should be interpreted with caution.

INTRODUCTION

Public behaviour plays an important role during public health emergencies.[1] Behaviours can be influenced by both the biological sex and sociocultural gender (gender identity, gender roles, gender relations, and institutionalized gender) of an individual. [2] According to the Canadian Institutes of Health and Research (CIHR), sex refers to "*a set of biological attributes and associated physical and physiological features including chromosomes, gene expression, hormone levels and function, and reproductive/sexual anatomy*" and are categorized as female or male.[3] While gender refers to "*the array of socially constructed roles and relationships, personality traits, attitudes, behaviours, values, relative power and influence that society ascribes to women and men on a differential basis*".[4,5] In the case of the Coronavirus Disease 2019 (COVID-19) pandemic, both men and women worldwide have shown inconsistent responses to acute infection as well as differing long-term health, economic, and social consequences.[6,7] Understanding these responses in relation to sex and/or gender-related attributes in the general population may be particularly valuable to inform tailored sex and gender strategies moving forward.

It has been identified that public health responses to infectious diseases require fundamental changes in individual behaviour. Hand washing, mask wearing, and physical distancing (*previously referred to as social distancing*) are the key transmission reduction public health behaviour-based prevention measures [1] that are associated with a reduction in the global prevalence of COVID-19.[8,9] Effectiveness of such responses depends not only on the generalized adherence of the public but may be specific to certain high-risk groups. Though recommended and proven to limit transmission rates, hand washing, mask wearing, and physical distancing have been inconsistently initiated and maintained. There is a dynamic relationship between the voluntary

adoption of public health behaviours and infection transmission during infectious disease epidemics.[10] The COVID-19 pandemic has sparked an unparalleled global discourse around the adoption of protective behaviours and other public health and social measures to slow the person-to-person spread of SARS-CoV-2.[1]

COVID-19 has highlighted the role that sex and gender play in our lives. This includes influencing an individual's exposure to COVID-19 through sex and gender-related occupations, risk-taking behaviours, and employment of precautions. Sex and gender also are known to have an impact on health through the gendered nature of the workforce and the predominant risk associated with it, increased caregiving responsibilities at home limiting the work and economic opportunities, or institutional biases and policies.[2,11] Gender affects the division of labor and care duties in families and communities. Hence, it is of utmost importance that we gather, from our recent lived experience, evidence on the potential sex and gender-related differences in perception and behavioural responses experienced during COVID-19 pandemic.

A few studies have shown sex-based differences in COVID-19 related beliefs and behaviours and have reported that compared to males, females are more likely to perceive the pandemic as a serious health problem and comply more with the preventive behaviours.[12,13] In addition, as gender is culturally and geographically based, we hypothesized that there is a difference in preventive behaviours and pandemic related concerns based on sex and gender-related factors. Also, regardless of sex-based differences, our previous studies highlight the need of focusing on the gender-related factors.[14,15] Hence, the purpose of this study was to examine whether sex and gender-related factors are associated with the engagement in the recommended key protective

health behaviours such as hand washing, mask wearing, and physical distancing during the COVID-19 pandemic.

METHODS

Study design

Survey datasets from the ongoing iCARE (International Covid-19 Awareness and Responses Evaluation) study led by the Montreal Behavioural Medicine Centre (MBMC: www.mbmc-cmcm.ca) in collaboration with a team of 200 international collaborators from 42 countries was used for the data analyses. The iCARE study design has been previously described.[16] Briefly, iCARE is an international multi-wave cross-sectional observational cohort study of public awareness, attitudes, and responses to public health policies implemented to reduce the spread of COVID-19 on people around the world (www.iCAREstudy.com). It collects data on study demographics, perceptions of government policy, health behaviours, adherence to health measures, types of concerns, and adherence motivators.

Survey data were collected in 4-6 week rounds using convenience snowball sampling (globally, 25-30K per wave) and parallel representative sampling (in targeted countries), generating data for multiple cohorts of participants that were added to the first round cohort launched on March 27, 2020. We analyzed data from Survey 1 – Survey 7 that was collected between March 27, 2020 to February 9, 2021. A total of 61,552 respondents participated in the survey from over 175 countries. The data was analyzed for 48,668 respondents (female=34,556, male=14,112). The questionnaire used in the survey is publicly available via the Open Science Framework (https://osf.io/nswcm/) and the survey is available in 34 languages.[17]

Biological sex and gender-related factors

For each surveyed individual the following variables were collected: socio-demographic characteristics (sex at birth, age in years, level of education, work status, perceived annual household income, number of adults and children living in the household, country of residence, and likelihood of getting vaccinated *i.e.,* respondents' willingness to get a COVID-19 vaccine), the presence of a physician-diagnosed depressive and/or anxiety disorder, and adoption of protective health behaviours (hand washing, wearing a face mask, and physical distancing).

To account for institutionalized gender, the Gender Inequality Index (GII), developed by the United Nations Development Programme, was used as a measure of country specific gender inequality[18] and as a measure of institutionalized gender in this study. This index is a continuous measure for the degree of gender inequality per country on a scale between 0 and 1, with lower values representing near-perfect gender equality and higher values representing greater levels of inequality favoring males. The GII is based on several aspects of institutionalized gender: (i) reproductive health, measured by the maternal mortality ratio and adolescent birth rates; (ii) empowerment, measured by the proportion of parliamentary seats occupied by women and the proportion of adult women and men with at least some secondary education; and (iii) economic status, measured by labor force participation rate of men and women.[19] GIIs in this study were divided into tertiles and later categorized into high and low/medium GII categories. We used data on GIIs from 2019. Some of the countries in the region were excluded from the analysis due to the unavailability of data.

Outcome measures

The main outcomes of the analysis were self-reported non-adherence to three recommended protective health behaviours including: (i) hand washing with soap and water; (ii) wearing a face mask; and (iii) a composite measure of physical distancing behaviours (specifically: staying at least 1-2 meters away from other people; staying/working at home rather than going to work or school; self-quarantining if returning from a trip; self-quarantining if one have the virus or believe they have the virus; avoid going out to bars/pubs/restaurants; avoiding large social gatherings; avoiding small social gatherings; avoiding indoor social gatherings; and avoiding any non-essential travel).[20] A composite binary variable was constructed in which, the participants who met the above-mentioned criteria were coded with a value of 1; otherwise, the participants were coded with a value of 0. A set of measures in the iCARE survey intended to explore the prevention measures used by the public to prevent the spread of COVID-19 by maintaining a physical distance between two people and reducing the number of times people come into close physical contact with one another[21] were used to create a composite variable for physical distancing.

Methodological steps

To consider gender-related variables in the evaluation of health behavior outcomes in retrospective cohort studies, a multistep methodology has been developed by The Gender Outcomes International Group: to Further Well-being Development (GOING-FWD) group.[22] The steps applied in this study are (i) identification of gender-related variables (ii) definition of outcomes (iii) and building of feasible final variable list. The final list of gender-related variables was included in the statistical models.

Statistical analysis

A global analysis of public engagement in three recommended protective health behaviours was performed to investigate whether the outcomes differed by sex. Our outcome of interest in the modeling process was the non-adherence to behavioural recommended measures. Descriptive sex-stratified analyses were run for: age; baseline mental health conditions (any depressive or anxiety disorders); and previously defined gender-related factors such as level of education, work status, annual household income, and GII. Continuous variables were presented as mean and standard deviation (SD). Categorical variables were presented as counts and percentages. Sex differences in outcomes (protective health behaviours) were completed and associations between sex, gender-related factors, and outcomes were tested in a multivariable model. Bivariate logistic regressions were run for crude analysis followed by collinearity diagnostics to account for inflation in standard errors of parameter estimates caused by collinear cofactors.[23] If variables were collinear, we included the variable with the least amount of missing data in the multivariable models. *A priori* gender-related cofactors (i.e., gender role [work status], gender identity [depressive and/or anxiety disorders], and institutionalized gender [education level, annual household income, and GII]) were included in multivariable models adjusting for the potential confounders (i.e., age and geographical regions). Two-way interaction between the sex and gender-related factors were tested by including an interaction term in bivariate models. All statistical analyses were performed using statistical software STATA version 16 (College Station, TX, USA). Tests were two sided and the significance was defined as $p<0.05$.

Patient and public involvement

It was not possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research. However, they were involved in the survey development. For

the dissemination of results, we will submit the results of the study to relevant national and international journals with the intention of publishing the results widely. Further, we will make national and international presentations in conferences and symposiums to stakeholder groups including those involving general public, researchers, clinicians, and policymakers.

RESULTS

Descriptive characteristics of respondents

Our study population included 34,556 females (71%) and 14,112 males (29%) **(Table 1)**. The mean age of the respondents was 43 years (SD: 16). A majority (n=23,462, 48.8%) was between 26 and 50 years of age. Most respondents (79.7%) reported high levels of education, were employed (61.8%), were from Europe and North American countries (66.3%), and from regions with high levels of gender equity as measured by low/medium GIIs (66.9%). Females were more likely to report having a physician-diagnosed depressive disorder (9.5% vs 6.7%, p≤0.001) and anxiety disorder (17.7% vs 10.7%, p≤0.001) compared to males. Irrespective of sex, only 68.5% of responders disclosed wearing a facemask, while a higher percentage of females reported adherence to physical distancing behaviours compared to males (78.3% vs 73.7%, p=<0.001). Participants aged 51 and older were more likely to engage in all three-key protective behaviours as compared with younger participants: hand washing (Odds ratio [OR]= 5.60, 95% Confidence interval [CI]: 4.51-6.94); mask wearing (OR=1.11, 95% CI: 1.04-1.18); and physical distancing (OR=1.50, 95% CI: 1.41-1.61) **(Table 2)**.

Gender-related factors associated with adoption of protective health behaviours

For the univariate analysis, the proportion of people adopting the protective health-related behaviours, varied depending on the gender-related factor examined. Despite employed

respondents being 84% more likely to engage in hand washing than unemployed respondents, they were 65% less likely to engage in mask wearing and 47% less likely to engage in physical distancing (p<0.001 for all comparisons). Hand washing and physical distancing was less common as the number of adults ≥18 years living in the household increased. The proportion of adoption was lowest for wearing a facemask, both for females and males (58.5% vs 57%) in low/medium GII countries **(Figure 1)**. Respondents living in the countries with high GII were 4.38 times (95% CI: 4.15-4.63) more likely to use mask than respondents living in the countries with low GIIs; however, they were less likely to engage in hand washing and less likely to engage in physical distancing **(Table 2)**.

Sex and gender-related differences in the adoption of protective health behaviours

Sex-stratified multivariate analyses demonstrated that the factors associated with the adoption of protective health behaviours varied by sex. *Among females,* the factors associated with not adhering to health behaviours were: (i) for hand washing- higher country gender inequality favoring males GII (aOR=0.47, 95% CI: 0.21-1.05, p=0.07) (ii) for mask-wearing- older age (aOR females=0.35, 95% CI:0.12-1.03, p=0.05), being employed (aOR females=0.22, 95% CI:0.10-0.48, p<0.001), and living in a country with more gender equity as measured by the GII (aOR=0.18, 95% CI: 0.06-0.51, p<0.01); and (iii) for physical distancing- being employed (aOR females=0.39, 95% CI:0.32-0.49, p<0.001) **(Table 3, Appendix-Table 1a, Table 1b)**.

Among males, factors that were associated with not adhering to protective health behaviours were: (i) for hand washing- higher level of education (aOR males=0.37, 95% CI: 0.14-1.01, p=0.05) and with a household size of > 2 (aOR males=0.46, 95% CI: 0.21-1.03, p=0.06); (ii) for mask wearing- being employed (aOR males=0.15, 95% CI:0.04-0.53, p<0.01) and living in a country with more

gender equity as measured by the GII (aOR=0.29, 95% CI: 0.09-0.91, p<0.05); and (iii) for physical distancing- being employed (aOR males=0.38, 95% CI:0.27-0.52, p<0.001) and with household size of > 2 (aOR males=0.66, 95% CI: 0.47-0.92, p<0.05) **(Table 3, Appendix-Table 1a, Table 1b)**.

There was a significant interaction between sex and educational level of the participants. High level of education decreased the use of mask wearing among females compared to males (p=0.03). There was a trend for living in a country with lower gender equity to be associated with poorer protective behaviors in females compared to males (p=0.056).

DISCUSSION

The present study provides a comprehensive analysis on the impact of sex and gender-related factors and the association with adherence to protective health behaviours during the COVID-19 pandemic. Overall, hand washing, mask wearing, and physical distancing behaviours were adopted globally. However, there were a number of gender-related factors associated with a lower adherence based on sex.

Lower adherence to the protective health behaviours was mainly associated with younger age, being employed, and living in a country with low/medium GII (higher gender equity) for females. While high level of education, being employed, and household size of >2 were associated with lower adoption in males. Considering these group of individuals with lower adherence to protective health behaviours, this would suggest that in the current as well as future pandemics it may be useful to target interventions based on sex and gendered factors to increase adherence and

reduce disease transmission. Measures such as risk-assessment and mitigation considerations for public settings could be implemented to mitigate the risk of transmission and promote the adoption of protective health behaviours.

Overall, mask wearing was lower among both sexes compared to other protective behaviours such as hand washing and physical distancing. Many countries waited to issue mask mandates months into the pandemic[24] even though other behaviours were mandated right away. This may be one of the reasons for lower adherence. Further, adoption of mask wearing was less likely in males compared to females, mainly among those who were employed, indicating substantial room for improvement in male's engagement to mask wearing. In our study, employed female respondents reported that they were more likely to wear a mask compared to male respondents. Similarly, a study conducted in the United States also reported that females were 1.5 times more likely to wear a mask compared to males.[25] It has been suggested that females may be more likely to protect themselves and others by wearing a mask specifically because they handle the majority of caregiving within families and are overrepresented in essential work services, which generally requires mask wearing.[26] Previous studies have also reported mask wearing to be significantly associated with the occupation of respondents.[27,28] A study reported that women make up almost 90 percent of nurses and nursing assistants in the United States and over two-thirds of grocery store cashiers.[28] Performing the dual function of an essential worker outside and a caregiver at home, women might face a dilemma of how to keep their families healthy and safe while continuing to work in potentially risky circumstances, suggesting that these factors may make them more adherent to the protective behaviours.

Older females were the most likely participants to engage in hand washing and physical distancing, but less likely to engage in mask wearing. Older females may have a higher perceived risk of developing COVID-19 complications and mortality, and thus engaged in more protective health behaviours such as hand washing and physical distancing. Previous studies have shown that females and older adults are less likely to engage in the risky behaviours, feel more vulnerable to contracting diseases, and have a stronger sense of responsibility to protect society.[29,30] This is consistent with the findings of an American study that reported being older and female was related to adopting more pandemic mitigating behaviours.[31] Furthermore, a study conducted in China also reported that being female and older was associated with adopting protective behaviours.[30] However, our study findings are in contrast with the results of a study conducted in Portugal that reported a decline in engagement in protective health behaviours with advancing age, which was reported to be related to the increased social-isolation and lack of help among older population.[32] Even though the study did not report the differences by sex of the respondents, self-isolation could be the reason for lower adherence to mask wearing among females. Depending on the diverse context, public health interventions should be tailored not only to sex, but differing age groups, and importantly institutional gender related variables such as those measured by the GII.

Emerging evidence shows that gender including the institutionalized gender shapes mask wearing adherence.[33] One of the interesting findings of the current study is respondents from low/medium GII countries with less gender inequity reported a significantly lower adherence to mask wearing compared to respondents from countries with high GII (high gender inequity). Even among the low/medium GII countries, adherence is reported to be poorer among males. Lower adherence among males is in line with a finding from a study conducted in the United States, in which males

exhibited poorer mask wearing practices compared with their female counterparts.[25] This is also supported by a review that looked at research from multiple countries and found women were 50% more likely than men to practice protective behaviour.[34] The correlation between a Gini coefficient (a measure of income inequality) and GII (a measure of gender inequality) could explain the lower adherence to protective health behaviours in countries with low/medium GII where income inequality arises mainly through gender gaps in economic participation.[35]

The strengths of this study include a large sample size, having a global perspective, and availability of gender-related factors to examine the impact of gender. This study also has some limitations that should be acknowledged. First, the online nature of the iCARE survey might have limited the participation from individuals who did not had access to computers and internet, limiting the generalization of findings. However, the advantages of online surveys have been shown to outweigh the disadvantages, mainly in terms of its external validity;[36] hence, the bias might be relatively low. Second, our global sample was highly educated group of people whose results are likely to be 'best case scenario'. The global sample was also mostly women, so men are underrepresented in this study. Third, self-reported behaviour doesn't always accurately represent actual behaviour, hence, the findings should be interpreted with caution. Finally, although the study established the associations between sex and gender-related factors with the adoption of protective health behaviours, no causal relationships should be assumed due to the nature of the cross-sectional design of the survey.

CONCLUSIONS

In this analysis of a multinational study population, while a majority of respondents reported wearing a facemask, this is likely reflective of country wide mask mandates as opposed to adopting it as a protective health behavior. However, our study findings, suggest that wearing a facemask appeared to be more difficult to adhere to for many compared to other key protective behaviours such as hand washing and physical distancing. Moreover, our study noted that this was even more apparent in countries with low GII (more equity between males and females) indicating substantial room for improvement in public engagement regarding protective health behaviours. Since widespread protective behavioural responses are paramount for a successful containment and control of an infectious disease contagion, the present study provides valuable information for identifying sex and gendered factors that may inform effective public health policies. Further, the Covid-19 pandemic highlights the urgent need to incorporate sex and gender analysis into all research and innovation processes in order to target specific groups both to help contain the transmission of the virus and to formulate vaccine policies.

DECLARATIONS

Competing interests: The authors declare no competing interests.

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Contributors:

All authors contributed to the preparation of this manuscript (RD, VR, SLB, KLL, LP, CMN). CMN, LP, and VR developed the idea and design of the study. RD participated in drafting and revising the manuscript. CMN, LP, SLB, KLL, and VR provided detailed comments on the draft

for the revision. CMN provided substantial revisions and intellectual content to the manuscript. RD analyzed the data, and CMN and LP checked for the integrity and accuracy of the data. All authors (RD, VR, SLB, KLL, LP, CMN) read and approved the final version of the manuscript.

Ethics approval:

The iCARE study was approved by the research ethics committee of the Comité d'éthique de recherche du CIUSSS-NIM (Centre intégré universitaire de santé et de services sociaux du Nord-de-l'île-de-Montréal), approval #: 2020-2099 / 25-03-2020. The current secondary analysis was approved by the ethics committee at the University of Alberta (Pro107407).

Data availability statement:

Dataset are available from the iCARE team upon reasonable request.

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TABLES

Table 1. Descriptive characteristics of survey respondents by biological sex (N=48668)

	N[1]	Overall n (%) or Mean [SD]	Biological sex	
			Male (N=14112) n (%) or Mean [SD]	Female (N=34556) n (%) or Mean [SD]
Socio-demographic characteristics				
Age (in years)	48524	43 [16]	42 [16]	44 [17]
Age distribution in strata	48049			
• Up to 25		8632 (18.0)	2327 (16.8)	6305 (18.5)
• 26-50		23462 (48.8)	6372 (45.8)	17090 (50.0)
• 51 and older		15955 (33.2)	5197 (37.4)	10758 (31.5)
Education level	38217			
• Low level		7758 (20.3)	2208 (20.5)	5550 (20.2)
• High level		30459 (79.7)	8564 (79.5)	21895 (79.8)
Work status	7071			
• Unemployed		2698 (38.2)	775 (40.7)	1923 (37.2)
• Employed		4373 (61.8)	1131 (59.3)	3242 (62.8)
Annual perceived household income	33814			
• Bottom third		4739 (14.0)	1249 (12.8)	3490 (14.5)
• Middle third		19107 (56.5)	4910 (50.2)	14197 (59.1)
• Top third		9968 (29.5)	3622 (37.0)	6346 (26.4)
Number of adults ≥18 years living in the household	32979			
• 1		15657 (47.5)	4419 (46.8)	11238 (47.7)
• 2		8999 (27.3)	2485 (26.3)	6514 (27.7)
• 3		4756 (14.4)	1352 (14.3)	3404 (14.5)
• 4		2231 (6.8)	700 (7.4)	1531 (6.5)
• ≥ 5		1336 (4.0)	478 (5.1)	858 (3.6)
Number of children ≤ 18 years living in the household	12357			
• 1		5951 (48.2)	1575 (45.7)	4376 (49.1)
• 2		4620 (37.4)	1271 (36.9)	3349 (37.6)
• 3		1290 (10.4)	401 (11.6)	889 (10)
• 4		323 (2.6)	117 (3.4)	206 (2.3)
• ≥ 5		171 (1.4)	82 (2.4)	91 (1)
Gender Inequality Index	45615			
• Low/Medium GII		30530 (66.9)	8188 (62.3)	22342 (68.8)
• High GII		15085 (33.1)	4951 (37.7)	10134 (31.2)
Geographic Regions	48632			
• Europe		12106 (24.9)	3558 (25.3)	8548 (24.8)
• North America		18658 (38.4)	4674 (33.2)	13984 (40.5)
• Others		17868 (36.7)	5860 (41.2)	12008 (34.8)
Likelihood of getting vaccinated	38979			
• Unlikely		4664 (11.9)	1220 (10.9)	3444 (12.4)
• Likely		34315 (88.0)	9930 (89.1)	24385 (87.6)
Psychosocial characteristics				
Depressive disorder	37616	3276 (8.7)	705 (6.7)	2571 (9.5)
Anxiety disorder	37481	5889 (15.7)	1133 (10.7)	4756 (17.7)

[1] Number of observations with complete information; GII: Gender Inequality Index

Table 2. Bivariate association between gender-related variables and adoption of three key protective health behaviours

	Hand washing (n=43318)		Mask wearing (n=42767)		Physical distancing (n=43368)	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Socio-demographic characteristics						
Biological sex						
• Male (ref)	-		-		-	
• Female	1.97 (1.71-2.28)	<0.001	0.98 (0.94-1.03)	0.41	1.28 (1.22-1.34)	<0.001
Age distribution						
• Up to 25 (ref)	-		-		-	
• 26-50	2.71 (2.31-3.17)	<0.001	0.86 (0.82-0.92)	<0.001	1.11 (1.04-1.18)	<0.001
• 51 and older	5.60 (4.51-6.94)	<0.001	1.11 (1.04-1.18)	<0.01	1.50 (1.41-1.61)	<0.001
Education level						
• Low level (ref)	-		-		-	
• High level	1.56 (1.31-1.85)	<0.001	0.99 (0.94-1.04)	0.78	1.20 (1.13-1.27)	<0.001
Work status						
• Unemployed (ref)	-		-		-	
• Employed	1.84 (1.25-2.71)	<0.01	0.35 (0.23-0.54)	<0.001	0.53 (0.47-0.60)	<0.001
Annual household income						
• Bottom third (ref)	-		-		-	
• Middle third	1.47 (1.18-1.84)	<0.01	1.18 (1.11-1.26)	<0.001	0.98 (0.91-1.06)	0.78
• Top third	1.63 (1.27-2.10)	<0.001	1.02 (0.95-1.10)	0.52	1.23 (1.12-1.33)	<0.001
Adults ≥18 years living in the household						
• 1 (ref)	-		-		-	
• 2	0.80 (0.65-0.99)	<0.05	1.27 (1.21-1.35)	<0.001	0.73 (0.69-0.78)	<0.001
• 3	0.59 (0.46-0.75)	<0.001	1.63 (1.52-1.76)	<0.001	0.64 (0.59-0.69)	<0.001
• 4	0.59 (0.43-0.82)	<0.01	2.31 (2.06-2.58)	<0.001	0.50 (0.45-0.55)	<0.001
• ≥ 5	0.35 (0.25-0.48)	<0.001	2.77 (2.39-3.22)	<0.001	0.43 (0.38-0.48)	<0.001
Children ≤18 years living in the household						
• 1 (ref)	-	-	-		-	
• 2	1.18 (0.88-1.58)	0.26	0.81 (0.74-0.87)	<0.001	1.09 (0.99-1.19)	0.06
• 3	0.91 (0.59-1.39)	0.68	0.81 (0.71-0.92)	<0.01	0.92 (0.80-1.05)	0.25
• 4	0.68 (0.34-1.36)	0.28	1.10 (0.85-1.42)	0.45	0.75 (0.58-0.96)	0.05
• ≥ 5	0.23 (0.13-0.41)	<0.001	0.95 (0.68-1.32)	0.79	0.55 (0.41-0.76)	<0.001
Gender Inequality Index						
• Low/Medium GII (ref)	-		-			
• High GII	0.52 (0.45-0.60)	<0.001	4.38 (4.15-4.63)	<0.001	0.91 (0.86-0.96)	0.01
Geographic Regions						
• Europe	1.63 (1.37-1.95)	<0.001	0.29 (0.27-0.31)	<0.001	1.21 (1.14-1.28)	<0.001
• North America	2.54 (2.13-3.04)	<0.001	0.21 (0.20-0.22)	<0.001	2.30 (2.18-2.42)	<0.001

• Others (ref)	-		-		-	
Likelihood of getting vaccinated						
• Unlikely (ref)	-		-		-	
• Likely	3.04 (2.57-3.61)	<0.001	1.15 (1.08-1.22)	<0.001	2.18 (2.04-2.32)	<0.001
Psychosocial characteristics						
Depressive disorder	0.76 (0.59-0.98)	<0.05	0.91 (0.85-0.98)	<0.05	1.15 (1.05-1.26)	<0.01
Anxiety disorder	0.91 (0.73-1.11)	0.35	0.88 (0.83-0.93)	<0.001	1.22 (1.14-1.31)	<0.001

[1]Number of observations with complete information

Table 3. Association between gender-related variables and adoption of facemask wearing, by sex

	Mask wearing							
	Female				Male			
	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value
Sociodemographic characteristics								
Age distribution								
• Up to 25 (ref)	-		-		-		-	
• 26-50	0.85 (0.79-0.91)	<0.001	0.77 (0.26-2.35)	0.65	0.91 (0.81-1.01)	0.11	0.59 (0.207-5.04)	0.63
• 51 and older	1.11 (1.02-1.18)	<0.01	0.35 (0.12-1.03)	0.05	1.12 (1.00-1.26)	<0.05	0.52 (0.206-4.47)	0.55
Education level								
• Low level (ref)	-		-		-		-	
• High level	0.95 (0.89-1.01)	0.15	0.84 (0.43-1.66)	0.61	1.08 (0.98-1.20)	0.10	0.37 (0.10-1.33)	0.12
Work status								
• Unemployed (ref)	-		-		-		-	
• Employed	0.38 (0.23-0.63)	<0.001	0.22 (0.10-0.48)	<0.001	0.31 (0.14-0.67)	<0.01	0.15 (0.04-0.53)	<0.01
Annual household income								
• Bottom third (ref)	-		-		-		-	
• Middle third	1.19 (1.10-1.29)	<0.001	0.76 (0.32-1.84)	0.54	1.12 (0.98-1.27)	0.08	1.64 (0.57-4.74)	0.36
• Top third	1.01 (0.92-1.10)	0.80	0.89 (0.35-2.28)	0.81	1.01 (0.87-1.15)	0.93	5.93 (1.64-21.48)	<0.01
Adults ≥18 years living in the household								
• ≤ 2 (ref)	-		-		-		-	
• > 2	1.79 (1.68-1.93)	<0.001	0.89 (0.46-1.71)	0.71	1.73 (1.56-1.93)	<0.001	1.79 (0.50-6.40)	0.36
Children ≤18 years living in the household								
• ≤ 2 (ref)	-				-			
• > 2	1.03 (1.81-2.49)	0.66			0.79 (0.65-0.96)	0.02		
Gender Inequality Index								
• High GII (ref)	-		-		-		-	
• Low/Medium GII	0.23 (0.21-0.24)	<0.001	0.18 (0.06-0.51)	<0.01	0.23 (0.21-0.25)	<0.001	0.29 (0.09-0.91)	<0.05
Geographic Regions								
• Europe	0.31 (0.28-0.33)	<0.001			0.26 (0.23-0.29)	<0.001		
• North America	0.21 (0.20-0.23)	<0.001			0.21 (0.18-0.23)	<0.001		
• Others (ref)	-				-			
Psychosocial characteristics								
Depressive disorder	0.91 (0.83-0.99)	<0.05	0.99 (0.33-3.07)	1.00	0.95 (0.81-1.12)	0.57	1.01 (0.20-5.01)	0.98
Anxiety disorder	0.87 (0.81-0.93)	<0.001	2.29 (0.84-6.24)	0.11	0.94 (0.82-1.07)	0.39	0.85 (0.23-3.18)	0.81

Note: In the multivariable model, geographic regions variable dropped due to collinearity with GII. Number of children in household variables dropped due to collinearity with number of adults in the household variable.

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FIGURE

Figure 1: Percentage of adherence to protective health behaviours, per group of Gender Inequality Index (GII), stratified by sex

FIGURE

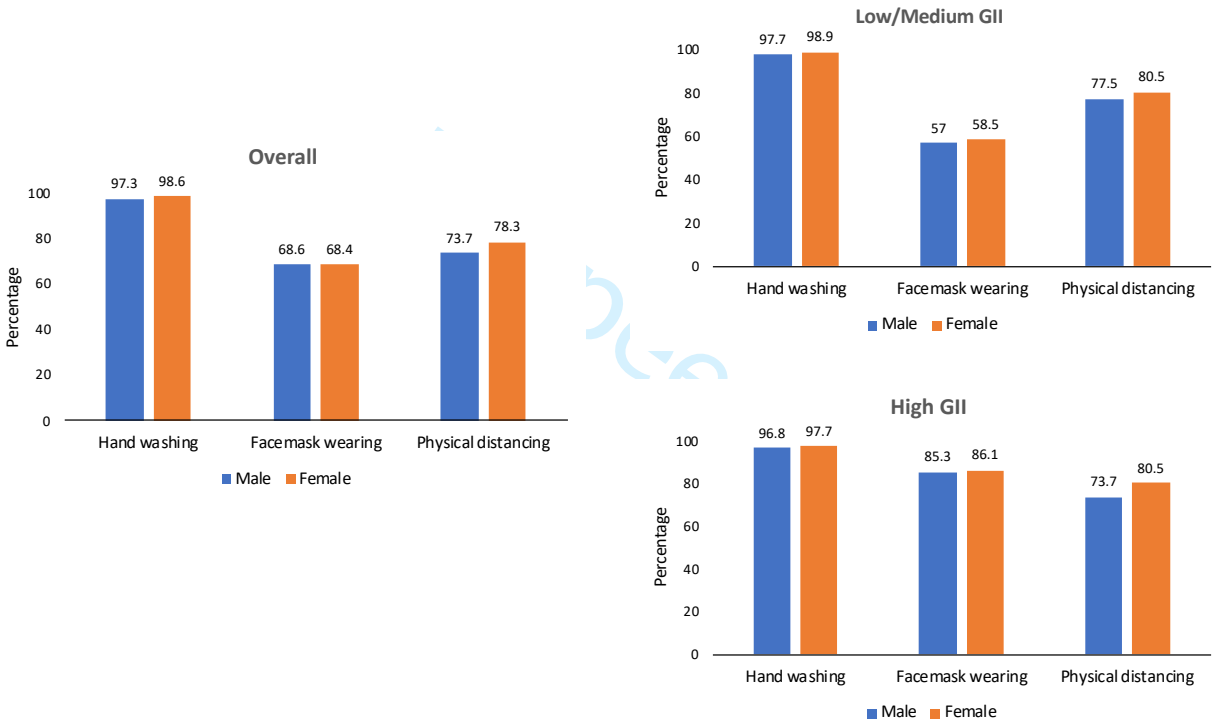

Figure 1: Percentage of adherence to protective health behaviours, per group of Gender Inequality Index (GII), stratified by sex

APPENDIX

Table 1a. Association between gender-related variables and adoption of hand washing, by sex

	Hand washing							
	Female				Male			
	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value
Sociodemographic characteristics								
Age distribution								
• Up to 25 (ref)	-		-		-		-	
• 26-50	2.91 (2.37-3.58)	<0.001	4.44 (1.68-11.76)	<0.01	2.45 (1.91-3.14)	<0.001	1.89 (0.63-5.68)	0.25
• 51 and older	7.71 (5.57-10.66)	<0.001	13.39 (2.87-62.6)	<0.01	4.56 (3.36-6.18)	<0.001	2.25 (0.81-6.27)	0.11
Education level								
• Low level (ref)	-		-		-		-	
• High level	1.63 (1.29-2.07)	<0.001	0.78 (0.32-1.91)	0.58	1.47 (1.12-1.92)	<0.01	0.38 (0.14-1.01)	0.05
Work status								
• Unemployed (ref)	-		-		-		-	
• Employed	2.41 (1.35-4.28)	<0.01	1.19 (0.50-2.83)	0.69	1.38 (0.80-2.40)	0.24	1.91 (0.89-4.13)	0.09
Annual household income								
• Bottom third (ref)	-		-		-		-	
• Middle third	1.50 (1.12-2.01)	<0.01	1.92 (0.83-4.43)	0.12	1.42 (1.00-2.01)	<0.05	1.07 (0.41-2.81)	0.88
• Top third	1.96 (1.36-2.81)	<0.001	3.20 (0.84-12.15)	0.08	1.67 (1.15-2.43)	<0.01	2.54 (0.77-8.41)	0.12
Adults ≥18 years living in the household								
• ≤ 2 (ref)	-		-		-		-	
• > 2	0.52 0.41-0.66)	<0.001	1.04 (0.44-2.43)	0.93	0.73 (0.56-0.95)	0.02	0.46 (0.21-1.03)	0.06
Children ≤18 years living in the household								
• ≤ 2 (ref)	-				-			
• > 2	0.69 (0.44-1.08)	0.12			0.84 (0.52-1.37)	0.48		
Gender Inequality Index								
• High GII (ref)	-		-		-		-	
• Low/Medium GII	2.29 (1.88-2.78)	<0.001	2.11 (0.95-4.71)	0.07	1.37 (1.09-1.72)	<0.01	0.57 (0.25-1.32)	0.18
Geographic Regions								
• Europe	1.91 (1.49-2.43)	<0.001			1.28 (0.98-1.67)	0.06		
• North America	2.93 (2.31-3.72)	<0.001			1.87 (1.42-2.46)	<0.001		
• Others (ref)	-				-			
Psychosocial characteristics								
Depressive disorder	0.73 (0.52-1.02)	0.07	0.74 (0.20-2.71)	0.65	0.63 (0.42-0.95)	<0.05	0.73 (0.18-2.98)	0.66
Anxiety disorder	0.90 (0.68-1.18)	0.45	0.98 (0.32-2.96)	0.97	0.71 (34.3-44-4)	0.05	2.51 (0.47-13.38)	0.28

Note: In the multivariable model, geographic regions variable dropped due to collinearity with GII. Number of children in household variables dropped due to collinearity with number of adults in the household variable.

Table 1b. Association between gender-related variables and adoption of physical distancing, by sex

	Physical distancing							
	Female				Male			
	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value	Bivariate OR (95% CI)	p-value	Multivariate aOR (95% CI)	p-value
Sociodemographic characteristics								
Age distribution								
• Up to 25 (ref)	-		-		-		-	
• 26-50	1.10 (1.03-1.18)	<0.01	2.01 (1.54-2.63)	<0.001	1.11 (0.99-1.25)	0.05	2.53 (1.53-4.21)	<0.001
• 51 and older	1.60 (1.47-1.73)	<0.001	3.57 (2.72-4.68)	<0.001	1.41 (1.24-1.58)	<0.001	3.99 (2.47-6.46)	<0.001
Education level								
• Low level (ref)	-		-		-		-	
• High level	1.19 (1.11-1.27)	<0.001	1.39 (1.13-1.74)	<0.01	1.21 (1.09-1.34)	<0.001	0.87 (0.61-1.25)	0.45
Work status								
• Unemployed (ref)	-		-		-		-	
• Employed	0.55 (0.48-0.62)	<0.001	0.39 (0.32-0.49)	<0.001	0.48 (0.38-0.59)	<0.001	0.38 (0.27-0.52)	<0.001
Annual household income								
• Bottom third (ref)	-		-		-		-	
• Middle third	1.26 (0.99-1.60)	0.05	1.26 (0.99-1.59)	0.06	1.24 (0.89-1.73)	0.19	1.54 (1.01-2.32)	<0.05
• Top third	1.90 (1.41-2.56)	<0.001	1.53 (1.17-2.01)	<0.01	1.71 (1.19-2.45)	<0.01	2.13 (1.36-3.35)	<0.01
Adults ≥18 years living in the household								
• ≤ 2 (ref)	-		-		-		-	
• > 2	0.65 (0.60-0.69)	<0.001	0.89 (0.72-1.09)	0.27	0.61 (0.55-0.67)	<0.001	0.66 (0.47-0.92)	<0.05
Children ≤18 years living in the household								
• ≤ 2 (ref)	-				-			
• > 2	0.79 (0.69-0.92)	<0.01			0.94 (0.78-1.15)	0.56		
Gender Inequality Index								
• High GII (ref)	-		-		-		-	
• Low/Medium GII	0.99 (0.94-1.06)	0.95	0.72 (0.58-0.88)	<0.01	1.23 (1.13-1.34)	<0.001	0.87 (0.64-1.19)	0.39
Geographic Regions								
• Europe	1.16 (1.09-1.24)	<0.001			1.29 (1.17-1.43)	<0.001		
• North America	2.26 (2.12-2.41)	<0.001			2.26 (2.04-2.49)	<0.001		
• Others (ref)	-				-			
Psychosocial characteristics								
Depressive disorder	1.16 (1.05-1.29)	<0.01	1.07 (0.78-1.48)	0.66	1.00 (0.84-1.19)	0.96	0.86 (0.49-1.50)	0.60
Anxiety disorder	1.21 (1.12-1.31)	<0.001	1.03 (0.79-1.32)	0.84	1.00 (0.95-1.27)	0.19	1.40 (0.85-2.31)	0.18

Note: In the multivariable model, geographic regions variable dropped due to collinearity with GII. Number of children in household variables dropped due to collinearity with number of adults in the household variable.

STROBE Statement—checklist of items that should be included in reports of observational studies

Association of Biological Sex and Gender-related Factors with Public Engagement in Protective Health Behaviours during the COVID-19 Pandemic: Lessons Learned Going Forward

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3-4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	NA
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	NA
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	NA

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-12
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg. analyses of subgroups and interactions, and sensitivity analyses	12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17