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Changes in Knowledge, Attitudes and Practice of Mask Use in Australia During the COVID-19 Pandemic.

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Abstract

Objectives: Mask uptake and the timing of mask use has the potential to influence the control of the COVID-19 pandemic. This study aimed to assess the changes in knowledge, attitudes, and practices towards mask use in Sydney and Melbourne, Australia, during the 2020 COVID-19 pandemic.

Methods: An online survey was distributed to adults in Sydney and Melbourne, Australia during July-August 2020 (survey 1) and September 2020 (survey 2), coinciding with the start and decline of the second wave of the COVID-19 pandemic in Australia. Demographics, risk measures, COVID-19 severity and perception, mask attitude and uptake were recorded in the survey.

Results: A total of 700 participants completed the survey, with 402 participants in Sydney and 298 participants in Melbourne. In both Sydney and Melbourne, a consistent decrease was reported in almost all risk-mitigation behaviors between March–July 2020 and again between March–September 2020. However, mask use and personal protective equipment (PPE) use increased in both Sydney and Melbourne from March-September 2020. There was no significant difference in mask use during the pandemic between the two cities across both timepoints [1.27 (95%CI 0.74-1.35; p=0.072)]. Perceived severity and perceived susceptibility of COVID-19 infection and were significantly associated with mask uptake. Trust in information on COVID-19 from both national [1.77 (95%CI 1.29-2.44); p<0.000)] and state [1.62 (95%CI 1.18-2.22); p=0.003)] government was a predictor of mask use across both surveys.

Conclusion: Sydney and Melbourne both had high levels of reported mask wearing during July and September 2020, consistent with the second wave and mask mandates in Victoria, and cluster outbreaks in Sydney at the time. High rates of mask compliance in both cities may be explained by high trust levels in information from national and state government, mask mandates, risk perceptions, current outbreaks, and the perceived level of risk of COVID-19 infection at the time.

Strengths and limitations of this study:

- Mask uptake and the timing of mask use has the potential to influence the control of the COVID-19 pandemic.
- This study assessed the changes in knowledge, attitudes, and practices towards mask use in Sydney and Melbourne, Australia, during the 2020 COVID-19 pandemic.

- Widespread behavior modification and mask use for COVID-19 risk prevention in Australia was seen during the study periods.
- Sydney and Melbourne both had high levels of reported mask wearing during July and September 2020, consistent with the second wave and mask mandates in Victoria, and cluster outbreaks in Sydney at the time.
- A potential limitation of this study is that the survey was only administered in English, and thus there may be bias for English speakers and non-English speakers or people with limited access to the Internet may have been excluded;
- Data on participants' ethnicity and socioeconomic status were not collected. This study surveyed a simple, random sample of panel members and was not stratified to be representative of the population, so mask uptake rates in this survey may not reflect true uptake;
- Recall bias may have been introduced, as this survey provided a cross-sectional description of mask use only, which was dependent on recall for reporting behaviors early in the pandemic period.

1. Introduction

The first wave of COVID-19 in Australia occurred during January to April 2020 and a nationwide lock-down was enforced, however mask use was not mandated. The second wave, starting in June 2020, though largely localized to Melbourne (Victoria), featured much more widespread community transmission, with the highest death rate and at its peak, the state had 6767 active cases[1]. It was during this second wave that mask use was mandated by the Victorian state government on 19 July 2020, together with a state-wide lockdown[2]. At the same time, smaller epidemics occurred in Sydney with 109 cases associated with the Thai Rock Restaurant cluster and 58 cases associated with the Crossroads Hotel cluster [3,4].

During the early stages of the pandemic, amidst shortages of N95 respirators and face masks for healthcare workers (HCWs), the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC) and other health organizations actively discouraged mask use by the general public unless symptomatic[5]. However, it became evident that asymptomatic persons are potential sources of COVID-19 infection and around 40 to 45% of COVID-19 cases are asymptomatic[6–9]. In symptomatic infections, 44% of transmission occurs in the 48h prior to showing symptoms, and a further proportion on the first day of showing symptoms[10]. This, plus recognition of airborne transmission, led to a change in recommendation for mask use as a non-pharmaceutical intervention (NPIs) for COVID-19 prevention by the WHO, CDC and other agencies[11,12]. There is now evidence that universal mask use during periods of high transmission of SARS-CoV-2 may contribute to epidemic control[13–15].

Mask use by healthy people in closed community settings provides protection against respiratory infections[16] and is also a well-established method of source control[17]. Mask type varies and observational studies amongst HCWs and the general public during the SARS outbreak in China, found cotton masks to be effective at preventing infections[18]. In Victoria, Australia, use of all types of masks during the mask mandate, accounting for poor quality cloth coverings, is estimated to have been 22-33% effective and averted a much larger epidemic[13,15].

However, the role of mask uptake, perceived effectiveness, and the timing when community members use their masks during the pandemic is unknown. A Norwegian study on the people's reflections on the consequences of a potential Influenza pandemic, found that substantial proportions of the population actually considered the mortality risk during a pandemic to be lower than estimates from health authorities, and thus would implement only minimally disruptive precautions to protect themselves against the causative agent[19]. Other studies have

demonstrated that the necessity of wearing masks by the public during the COVID-19 pandemic has been under-emphasized by goverments[20]. However, despite the public demonstrating a moderate to high level of knowledge of the COVID-19 infection and adequate knowledge about its preventive aspects[21], the overall practice of face mask use was low in some settings, guidelines conflicting and changing, and was influenced by education, literacy and age in some countries[22,23]. It is therefore important to gather evidence about community understanding and practices around the use of face masks during the COVID-19 pandemic, in settings with different disease incidence and different policies. This study therefore aimed to assess changes in the knowledge, attitudes, and practices towards mask use during the COVID-19 pandemic in the Australian population at two time points of the epidemic.

2. Methods

2.1. Study design and recruitment

A cross-sectional survey was conducted in two Australian cities; Sydney, and Melbourne, at two time points. The initial survey was conducted during July-August[24], whilst the second survey was conducted in September 2020 using the same survey questions, corresponding with the peak of the Victorian second wave and the period shortly afterward. To recruit participants for the survey, a market research company, Dynata[25], was employed to randomly distribute the survey link amongst a geographically targeted sample of their panel members[26] aged 18 or older and living in either Sydney or Melbourne. Panel members that logged onto the platform had the option to open the survey link. A random sample was used for the second time point, which may not have included all those surveyed in the first time point. Once participants opened the link, they were redirected to the survey page, where data were collected using an anonymous web-based survey platform, REDCap[27,28]. It took 10-15 minutes to complete the survey. To determine a 20% difference in the rate of mask use between cities with and without mandated mask policies, the study was powered a priori with 95% confidence and 80% power. In Melbourne (with a mask mandate), a mask use prevalence of 80% was assumed and in Sydney (without a mask mandate) a mask use prevalence of 60% was assumed[29,30], together with a sampling ratio of 0.6 and 0.8 respectively, yielding a minimum required sample size of 194. The University of New South Wales Human Research Ethics Committee approved (HC #200460) the survey instrument and study protocol prior to data collection.

During the survey, participants were asked to indicate their perception of the severity of COVID-19, together with the perceived level of risk of a COVID-19 infection (Appendix, Table 1).

Participants were asked which of several risk mitigation measures were used during the pandemic, both at the start of the pandemic and at the time of the survey. To determine mask uptake during the pandemic, participants were asked to indicate if they had ever worn a mask and to specify the type of mask used, whether it had been worn correctly over both the nose and mouth and the reason for mask use, whether it was specifically due to the pandemic. A Likert scale[31] was used to assess participant attitudes towards both the national and state government during the COVID-19 pandemic.

2.2. Data analysis

Descriptive statistics were performed for variables relating to health status, mask use, attitude of participants towards mask use, and other behaviors and perceptions during the COVID-19 pandemic. Continuous variables were displayed as mean ± one standard deviation (SD), and range. Categorical variables were presented as an absolute count and percentage. A Pearson Chi Squared test was used to calculate significance levels for categorical data and a logistic regression was used to determine predictors of mask uptake during the pandemic. These relationships were expressed at a 95% confidence interval (CI). A *p*-value less than or equal to 0.05 was considered significant. The percentage change of responses to the use of risk measures in July-August and September 2020, were calculated and graphed. A comparison of the percentage change of pre-pandemic risk measures between the two surveys was performed to provide an internal validation to determine to determine how well the results among the study participants represent true findings among similar individuals across the second survey (Appendix, Table 2). Analysis was completed using Stata version 16[32].

3. Results

A total of 700 participants in Sydney (n=402) and Melbourne (n=298) completed the survey, with sampling proportionate to population size. In Sydney, 200 and 202 participants were sampled in July and September 2020, respectively. In Melbourne, 148 participants were sampled in July and 150 participants in September 2020. The mean age of participants was 45.71±16.8 with 49.7% of participants male, while 47.71% of participants indicated they had underlying co-morbidities such as such as cancer, diabetes, and pre-existing heart conditions (Appendix, Table 3).

Participants were asked to indicate infection risk measures previously and currently used for reducing the risk of COVID-19 transmission across both surveys. Figure 1 shows the frequency of COVID-19 risk-control measures used early in the pandemic during March–April 2020 and percentage changes of these measures from March-July 2020 and from March-September 2020.

Participants reported adopting a wide range of infection risk measures. In the early stages of the pandemic, the most common measures used were; avoiding crowded areas, public transport and shops (69.8% in Sydney and 84.8% in Melbourne); physical distancing (66% in Sydney and 76.4% in Melbourne); practicing hand hygiene i.e. washing hands frequently, using hand sanitizers and avoiding touching your face (57% in Sydney and 69.1% in Melbourne); restricting visitors (56.5% in Sydney and 74.3% in Melbourne); using disinfectants to clean surfaces (40% in Sydney and 51.4% in Melbourne); not attending the workplace (47.5% in Sydney and 36.5% in Melbourne); avoiding contact with sick people (35.5% in Sydney and 38.5% in Melbourne); reducing visits to medical facilities (31.5% in Sydney and 39.2% in Melbourne) and wearing masks of any type i.e. N95, P2, surgical, cloth (32% in Sydney and 41.9% in Melbourne). In both Sydney and Melbourne, a consistent decrease was reported in almost all risk-mitigation behaviors between March–July 2020 (Figure 1B). However, mask use, social distancing, reducing visits to medical facilities and avoiding contact with sick people increased in Melbourne, which was amid a second wave at the time of the survey, where mask use and lockdowns were mandated. A consistent decrease was again reported in almost all risk-mitigation behaviors between March–September 2020 (Figure 1C). However, mask use and PPE use increased in both Sydney and Melbourne. An increase in not sending children to daycare, and adults not attending the workplace was also seen in Melbourne between March–September 2020. Participants also indicated the following qualitative responses of additional risk measures which were used; “Exercise”, “only going out for shopping and medical”, “staying home more” and “keeping fit”.

Participants who used a mask during the pandemic were assessed for a variety of predictors of mask uptake during the pandemic (Table 1). Across both surveys, there was a significant association between age and mask uptake [0.67 (95%CI 0.50-0.91; *p*=0.011), with younger people more likely to wear a mask, but no association between gender [1.00 (95%CI 0.74-1.35; *p*=1.000)] or city of residence [1.27 (95%CI 0.74-1.35; *p*=0.072)] on mask uptake during the pandemic. Embarrassment when wearing a mask [0.24 (95%CI 0.10-0.54; *p*=001)] was a predictor of lower mask uptake. A small number of participants indicated issues such as people staring (5.86%), receiving negative comments (3.71%), receiving racist comments, and being perceived as an infected person (3.71%) as barriers when wearing a mask, none of which were associated with mask uptake during the pandemic. Qualitative responses included "Breathing and talking", "cannot breathe properly", "fogs up my glasses", "difficulty to breath", "discomfort especially on physical exercise", "mask too close to eyes", "itching", "uncomfortable", "hyperventilating", "people found it hard to hear me", "breathless when walking uphill", "too sweaty", "it affected my ability to look down" and "was uncomfortable to wear".

Of the factors which participants believed influenced mask uptake, 45% of participants reported significant influence on the public from a recommendation by the government or health departments in their decision to wear a mask [1.83 (95%CI 1.32-2.53; *p*<0.000)], how much infection was around at the time [1.45 (95%CI 1.00-2.09; *p*=0.049)], and experience with using masks [2.32 (95%CI 1.35-4.00; *p*=0.002)]. Information from social media platforms (9.3%), media sources such as news, TV, radio, and the internet (20.6%) had a high level of indication from participants but were not significantly associated with mask uptake.

Table 1: Predictors of mask uptake during the pandemic in Sydney and Melbourne in 2020.

	N (%)	OR (95% CI)	*p*-value
Age (<45.711 years)**	384 (54.86)	0.67 (0.50-0.91)	**0.011***
Gender_(Male)	348 (49.71)	1.00 (0.74-1.35)	1.000
City of residence (Sydney-Reference)	402 (57.43)	-	-
Melbourne	298 (42.57)	1.24 (0.99-1.22)	0.072
Barriers to wearing a mask			
Felt embarrassed to wear it	59 (8.43)	0.24 (0.10-0.54)	**0.001***
People stared at me	41 (5.86)	0.48 (0.15-1.52)	0.212
I received negative comments	26 (3.71)	0.87 (0.29-2.64)	0.804
I received racist comments	25 (3.57)	0.43 (0.05-3.98)	0.458
People thought I was infected	25 (3.57)	0.46 (0.18-1.20)	0.114
People laughed at me	13 (1.86)	0.39 (0.11-1.40)	0.148
Factors which influenced mask wearing			
A recommendation from government or health department	315 (45.0)	1.83 (1.32-2.53)	**<0.000***
How much infection is around at the time	203 (29.0)	1.45 (1.00-2.09)	**0.049***
Media information (TV, radio, internet, print)	144 (20.57)	0.83 (0.54-1.29)	0.405
A recommendation from friends or family members	124 (17.71)	1.22 (0.76-1.95)	0.405

A recommendation from my doctor	118 (16.86)	1.45 (0.92-2.29)	0.106
Experience with using these products	86 (12.29)	2.32 (1.35-4.00)	**0.002***
Social media (Facebook, Twitter, Instagram, etc.)	65 (9.29)	0.86 (0.44-1.65)	0.644
Perceived COVID-19 Severity >average**	348 (49.71)	1.96 (1.44-2.66)	**<0.000***
Perceived risk of getting COVID-19 >average**	442 (63.14)	1.98 (1.43-2.74)	**<0.000***
High trust in state government***	446 (63.71)	1.62 (1.19-2.22)	**0.003***
High trust in national government***	470 (67.14)	1.77 (1.29-2.44)	**<0.000***

**Indicates statistical significance* at $p \leq 0.05$ *(Logistic regression used for analysis).*

***Average refers to the population mean of each variable. Variables were coded as "1" if their values were larger than the population mean and coded as "0" if smaller than the population mean.*

****On a scale of 0–5, where 5 represents highest level of trust/confidence. Variables were coded as "1"(high) if their values were larger than 3 and coded as "0" if smaller than or equal to 3.*

Participants were asked how severe they believed a COVID-19 infection would be and their perceived level of risk of contracting COVID-19. On a sliding scale, the perceived severity of COVID-19 infection was 62.5±24.3 [1.96 (95%CI 1.44-2.66; p<0.000)], whilst the perceived level of risk of contracting COVID-19 was 52.7±24.2 [1.98 (95%CI 1.43-2.74; p<0.000)], both were significantly associated with mask uptake. When asked to indicate the level of trust in both state and national government regarding information on the COVID-19 pandemic, participants expressed a high level of trust in both their state (63.7%) and national (67.1%) government. Trust in information on COVID-19 from both national [1.77 (95%CI 1.29-2.44); p<0.000)] and state government [1.62 (95%CI 1.18-2.22); p=0.003)] was significantly associated with mask uptake across both surveys.

Overall, participants indicated that N95 or P2 masks were perceived to be the most effective for COVID-19 prevention (62.2±22.2), followed by surgical masks (57.3±22.3) and cloth masks (50.0±23.5) (Appendix, Table 3). However, only 18.9% of participants indicated they had worn their masks over both their nose and mouth, with 39.6% unsure and 41.6% indicating they had worn their mask under their nose and only covering their mouth.

4. Discussion

Despite established guidelines of PPE use to manage the pandemic in many countries, mask hesitancy remains a cultural issue[20]. In Western countries, many view PPE and physical barriers including wearing the mask, as contrary to freedom and individualism and a recent study on mask uptake during the COVID-19 pandemic found that negative issues experienced while wearing masks reduced the likelihood of people wearing them[24]. In this study, stigma or negativity associated with mask use was a predictor of mask uptake. Both Sydney and Melbourne participants expressed a high level of trust in information from both their state and national government during the COVID-19 pandemic. Participants also reported a significant influence on

the public from government or health departments in their decision to wear a mask together with COVID-19 risk perception.

In Sydney and Melbourne, a significant increase in mask uptake during the COVID-19 pandemic was seen in July and September 2020, whilst other mitigation methods or behaviors, like avoiding medical facilities, no longer using public transport, and practicing hand hygiene, were not reported to have changed over the period. This increase in mask use in Melbourne coincides with the resurgence of COVID-19 from June to August 2020, where a mask mandate from the Victorian government from 23 July 2020 onward (close to the peak of the second wave), along with a 6-week stage three lockdown which commenced on 9 July 2020, was issued. Demographic differences and the rate of the outbreaks' growth make it difficult to directly compare the two states' responses to the pandemic, however it is important to stress that early mask use prevents more cases than mask usage which is only implemented closer to the peak of a pandemic[13]. Whilst mask mandates have a strong effect on mask use[24], research which has shown that in countries where communities were 'socially obliged' to wear masks, the public are more likely to engage in mask wearing in response to a pandemic[33]. In this study, factors associated with mask use included an underlying co-morbidity, a requirement of work, embarrassment, perception of being COVID-19 positive, how much infection was present at the time, perceived COVID-19 severity of infection and perceived risk of infection. Gender, and city of residence were not predictors of mask uptake in Sydney and Melbourne, whilst age was associated with mask uptake. The most significant influence on mask use was a recommendation from the government or health department. State governments need to address these issues with the public when advising or mandating mask use and target campaigns breaking through the stigma of mask wearing should be considered.

A recently published study on the effect of masks during the second wave in Victoria, showed that the effect of masks increases with the increasing uptake and increased effectiveness of the masks[13]. It also demonstrated that moderately effective masks with uptake levels of 50% or greater, can have a significant effect on epidemic control[13]. N95 or P2 masks were perceived to be the most effective for COVID-19 prevention. However, the use of any mask type should be encouraged as studies have shown that even when poor quality face masks were used, wearing masks significantly reduced the spread SARS-CoV2[34,35]. Furthermore, 18.9% of participants indicated they had worn their masks over both their nose and mouth, with 39.6% unsure and 41.6% indicating they had worn their mask under their nose and only covering their mouth. It is therefore essential to educate the public on correct mask wearing for mask use to be effective.

Some of the qualitative responses from participants in survey 2, after the first wave, indicated that masks were now being worn not only to protect themselves from getting sick but also from transmitting COVID-19. This highlights the need for continued community education on mask use.

This study was not without limitations. The survey was only administered in English, and thus there may be bias for English speakers and non-English speakers or people with limited access to the Internet may have been excluded. Online panels provide a simple, cost-effective means of conducting survey research, but may be biased depending the method used by the market research company for panel member recruitment[26,36]. Data on participants' ethnicity and socioeconomic status were not collected. This study surveyed a simple, random sample of panel members and was not stratified to be representative of the population, so mask uptake rates in this survey may not reflect true uptake. Recall bias may have been introduced, as this survey provided a cross-sectional description of mask use only, which was dependent on recall for reporting behaviors early in the pandemic period.

Conclusion

There had been widespread behavior modification and mask use for COVID-19 risk prevention in Australia during the study periods. Some behaviors, like avoiding medical facilities, did not change over the period. Whilst social distancing measures were the most commonly used mitigation, mask use changed the most over the study period. Sydney and Melbourne both had high levels of reported mask wearing during September 2020, consistent with the second wave and mask mandates in Victoria and cluster outbreaks in Sydney at that time. Following the large second wave in Melbourne and smaller outbreaks in Sydney, the perceived level of risk of COVID-19 infection was high. High rates of mask compliance may be explained by high trust in both national and state governments, mask mandates at the time, risk perceptions and current outbreaks. Considering the pre-symptomatic and asymptomatic transmission of SARS-CoV2, mask use is an essential measure for COVID-19 risk mitigation. It is therefore essential to continue to encourage mask use, together with ongoing community education with an emphasis on the route of COVID-19 transmission and correct face mask use, whilst considering evidence about community understanding and practices around the use of face masks for COVID-19.

Declarations

Ethics approval and consent to participate.

The University of New South Wales Human Research Ethics Committee approved (Approval number: HC #200460) the survey instrument and study protocol prior to data collection. Completion of the survey was taken as consent.

Competing interests

The author certifies that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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Authors' contributions

AQ: Writing - original draft, project administration, conceptualization, methodology, formal analysis; MT - writing and editing; HS: writing and editing; AAC: supervision, writing and editing; CRM: conceptualization, supervision, writing and editing. All authors read and approved the final manuscript.

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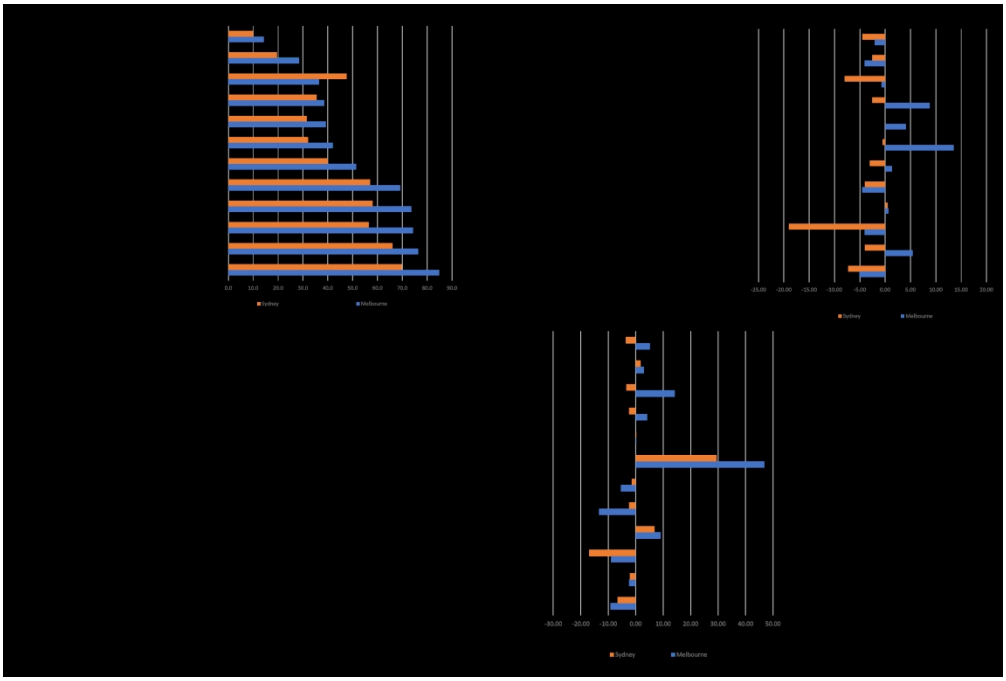

Figure 1: Frequency percentage of COVID-19 risk-control measures in March 2020 (A), and percentage changes of these measures from March-July 2020 (B) and March-September 2020 (C).

715x480mm (130 x 130 DPI)

Appendix

Table 1: Survey questionnaire – Adapted from MacIntyre *et al*., 2021[24].

Question	Type	Option	Variable coded as
Are you aged 18 or older?	Multiple choice	1 Yes 0 No	Binary
What is your city of residence?	Multiple choice	1 Sydney, Australia 2 London, UK 3 New York City, NY, USA 4 Melbourne, Australia 5 Phoenix, AZ, USA	Categorical
What is your gender?	Multiple choice	1 Female 2 Male 3 Other	Categorical
What is your age?	Open-ended		Numerical
Have you ever been told by a doctor or a nurse that you have any of the following lung conditions?	Tick box	0 None 1 Asthma 2 Emphysema 3 Chronic Bronchitis 4 Chronic Obstructive Pulmonary Disease (COPD) 5 Bronchiectasis 6 Other chronic lung disease 7 Other	Binary for each option
Please indicate whether a doctor has ever diagnosed you with any of the following (please select all that apply):	Tick box	0 None 1 Diabetes 2 Hypertension (high blood pressure) 3 Heart disease (heart attack, angina, heart failure, arrhythmia or other) 4 Cancer (current or past) 5 Stroke 6 Other neurological condition (such as epilepsy, neuropathy, Parkinson's disease, dementia) 7 Kidney disease (such as stones, nephropathy, kidney failure, dialysis) 8 Liver disease (hepatitis, liver failure, cirrhosis) 9 Allergies (hay fever, eczema) 10 Dermatitis or other skin disease 11 Immunocompromised conditions (e.g., transplantation, regular corticosteroid use) 12 Other chronic lung diseases (fibrosis) 13 Other medical condition(s)	Binary for each option

Question	Type	Option	Variable coded as
Have you ever experienced any negative issues while wearing a mask, N95 or P2?	Tick box	0 No 1 I felt embarrassed to wear it 2 I received negative comments when wearing it 3 I received racist comments when wearing it 4 People laughed at me 5 People stared at me 6 People thought I was infected 7 Other	Binary for each option
How severe do you think COVID-19 would be if you got it?	Sliding scale	Scale 1-100	Numerical
What measures have you taken for reducing your risk from COVID-19 during March and April 2020?	Tick box	0 None 1 Working from home 2 I was unable to work 3 Restricting visitors to my home 4 Avoiding crowded places or large gatherings 5 Avoiding close contact with sick people in my home 6 Avoid using public transport 7 Reduce or avoid going to hospitals or going to the doctor unless required 8 Keeping 1.5m/6 feet or more between myself and others 9 Wearing a mask or P2 or N95 10 Wearing a homemade cloth mask 11 Wearing gloves 12 Avoiding touching my eyes, nose, and mouth with unwashed hands 13 Taken herbal supplements 14 Taken vitamins 15 Wearing a face shield 16 Washing my hands frequently 17 Using hand sanitizer to clean hands when soap and water was not available for washing hands 18 Using disinfectant to clean surfaces at home or work or other places I attend frequently 19 Using homeopathic remedies 20 Reduce or avoid sending child(ren) to school or childcare 21 Shopping online for food and other necessities 22 Ensuring a balanced diet 23 Other	Binary for each option

Question	Type	Option	Variable coded as
What measures are you currently taking to reduce your risk from COVID-19?	Tick box	0 None 1 Working from home 2 I was unable to work 3 Restricting visitors to my home 4 Avoiding crowded places or large gatherings 5 Avoiding close contact with sick people in my home 6 Avoid using public transport 7 Reduce or avoid going to hospitals or going to the doctor unless required 8 Keeping 1.5m/6 feet or more between myself and others 9 Wearing a mask or P2 or N95 10 Wearing a homemade cloth mask 11 Wearing gloves 12 Avoiding touching my eyes, nose, and mouth with unwashed hands 13 Taken herbal supplements 14 Taken vitamins 15 Wearing a face shield 16 Washing my hands frequently 17 Using hand sanitizer to clean hands when soap and water was not available for washing hands 18 Using disinfectant to clean surfaces at home or work or other places I attend frequently 19 Using homeopathic remedies 20 Reduce or avoid sending child(ren) to school or childcare 21 Shopping online for food and other necessities 22 Ensuring a balanced diet 23 Other	Binary for each option
Have you ever worn a mask/N95/P2 during the COVID-19 pandemic?	Multiple choice	1 Yes 0 No	Binary
What level of trust do you have in the information about COVID-19 from your national government?	Likert scale	4 Very High 3 High 2 Intermediate 1 Low 0 Very low	Ordinal
What level of trust do you have in the information about COVID-1 from your state/ local government?	Likert scale	4 Very High 3 High 2 Intermediate 1 Low 0 Very low	Ordinal

Question	Type	Option	Variable coded as
What do you think is your level of risk of catching COVID-19 during this pandemic?	Sliding scale	Scale 1-100	Numerical
How effective did you think a surgical mask is at reducing your risk of COVID-19?	Sliding scale	Scale 1-100	Numerical
How effective did you think a N95 or P2 mask is at reducing your risk of COVID-19?	Sliding scale	Scale 1-100	Numerical
How effective did you think a cloth mask is at reducing your risk of COVID-19?	Sliding scale	Scale 1-100	Numerical

Table 2: Percentage change of participant responses providing an internal validation between survey 1 and survey 2 for each city.

	Sydney Survey 1/Survey 2	Melbourne Survey 1/Survey 2
None	-0.5	-3.4
Working from home	4.6	11.6
I was unable to work	4.9	1.9
Restricting visitors to my home	-5.5	-7.0
Avoiding crowded places or large gatherings	-2.2	-10.4
Avoiding close contact with sick people in my home	-2.3	2.8
Avoid using public transport	0.5	-7.5
Reduce or avoid going to hospitals or going to the doctor	-1.3	-4.5
Keeping 1.5m/6 feet or more between myself and others	4.3	-5.0
Wearing a mask or P2 or N95	11.1	19.6
Wearing a homemade cloth mask	12.8	15.8
Wearing gloves	1.8	-2.3

Table 3: Demographic table, perceived effectiveness of masks and wearing of masks by survey respondents (n=700).

Mean age	**Years**
	46 ± 16.8
Gender	**N (%)**
Female	351 (50.1%)
Male	348 (49.7%)
Unspecified	1 (0.1%)
Pre-existing health conditions	**N (%)**
Co-morbidities (such as diabetes, cancer, stroke etc.)	334 (47.71)
None	559 (79.9)
Pre-existing lung conditions	186 (26.6)
COVID-19 mask perception	
Perceived effectiveness of masks (1–100)	
N95/P2 masks	62.2 ± 22.2
Surgical masks	57.3 ± 22.3
Cloth masks	50.0 ± 23.5
Wearing of masks over the nose and mouth	**N (%)**
No	291 (41.6)
Unsure/did not specify	277 (39.6)
Yes	132 (18.9)

Note: (i) Percentages may not add up to 100% in some questions because participants could choose more than one option. (ii) Mean ± SD were reported for sliding scale questions of 1–100, where 1 = minimum and 100 = maximum.

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

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	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	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
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	N/A N/A 6-7
		(*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	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	6-7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	N/A
		(*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 *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A N/A **7**
		(*e*) Describe any sensitivity analyses	N/A

Continued on next page

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	N/A
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7, 24
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	7-8
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	10-12
		(*b*) Report category boundaries when continuous variables were categorized	10-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-13
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	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-14
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	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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

BMJ Open

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A Cross-Sectional Survey of Changes in Knowledge, Attitudes and Practice of Mask Use in Sydney and Melbourne During the 2020 COVID-19 Pandemic.

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Abstract

Objectives: Since mask uptake and the timing of mask use has the potential to influence the control of the COVID-19 pandemic, this study aimed to assess the changes in knowledge towards mask use in Sydney and Melbourne, Australia, during the 2020 COVID-19 pandemic.

Design:

An observational study, using a cross-sectional survey.

Setting and Participants:

Participants aged 18 or older and living in either Sydney or Melbourne.

Methods: An online survey was distributed to adults in Sydney and Melbourne, Australia during July-August 2020 (survey 1) and September 2020 (survey 2), during the COVID-19 pandemic in Australia. Demographics, risk measures, COVID-19 severity and perception, mask attitude and uptake were recorded in the survey.

Results: A total of 700 participants completed the survey. In both Sydney and Melbourne, a consistent decrease was reported in almost all risk-mitigation behaviors between March–July 2020 and again between March–September 2020. However, mask use and personal protective equipment (PPE) use increased in both Sydney and Melbourne from March-September 2020. There was no significant difference in mask use during the pandemic between the two cities across both timepoints [1.27 (95%CI 0.74-1.35; p=0.072)]. Perceived severity and perceived susceptibility of COVID-19 infection and were significantly associated with mask uptake. Trust in information on COVID-19 from both national [1.77 (95%CI 1.29-2.44); p<0.000)] and state [1.62 (95%CI 1.18-2.22); p=0.003)] government was a predictor of mask use across both surveys.

Conclusion: Sydney and Melbourne both had high levels of reported mask wearing during July and September 2020, consistent with the second wave and mask mandates in Victoria, and cluster outbreaks in Sydney at the time. High rates of mask compliance may be explained by high trust levels in information from national and state government, mask mandates, risk perceptions, current outbreaks, and the perceived level of risk of COVID-19 infection at the time.

Strengths and limitations of this study:

- This study showed that mask uptake and the timing of mask use has the potential to influence the control of the COVID-19 pandemic and widespread behavior modification and mask use for COVID-19 risk prevention in Australia was seen during the study periods

- Widespread behavior modification and mask use for COVID-19 risk prevention in Australia was seen during the study periods.
- Sydney and Melbourne both had high levels of reported mask wearing during July and September 2020.
- A potential limitation of this study is that the survey was only administered in English, and thus there may be bias for English speakers and non-English speakers or people with limited access to the Internet may have been excluded.
- Recall bias may have been introduced, as this survey provided a cross-sectional description of mask use only, which was dependent on recall for reporting behaviors early in the pandemic period.

1. Introduction

The first wave of COVID-19 in Australia occurred during January to April 2020 and a nationwide lock-down was enforced, however mask use was not mandated. The second wave, starting in June 2020, though largely localized to Melbourne (Victoria), featured much more widespread community transmission, with the highest death rate and at its peak, the state had 6767 active cases[1]. It was during this second wave that mask use was mandated by the Victorian state government on 19 July 2020, together with a state-wide lockdown[2]. At the same time, smaller epidemics occurred in Sydney with 109 cases associated with the Thai Rock Restaurant cluster and 58 cases associated with the Crossroads Hotel cluster [3,4].

During the early stages of the pandemic, amidst shortages of N95 respirators and face masks for healthcare workers (HCWs), the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC) and other health organizations actively discouraged mask use by the general public unless symptomatic[5]. However, it became evident that asymptomatic persons are potential sources of COVID-19 infection and around 40 to 45% of COVID-19 cases were asymptomatic[6–9]. In symptomatic infections, 44% of transmission occurred in the 48h prior to showing symptoms, and a further proportion on the first day of showing symptoms[10]. This, plus recognition of airborne transmission, led to a change in recommendation for mask use as a non-pharmaceutical intervention (NPIs) for COVID-19 prevention by the WHO, CDC and other agencies[11,12]. There is now evidence that universal mask use during periods of high transmission of SARS-CoV-2 may contribute to epidemic control[13–15].

Mask use by healthy people in closed community settings provides protection against respiratory infections[16] and is also a well-established method of source control[17]. Mask type varies and observational studies amongst HCWs and the general public during the SARS outbreak in China, found cotton masks to be effective at preventing infections[18]. In Victoria, Australia, use of all types of masks during the mask mandate, accounting for poor quality cloth coverings, is estimated to have been 22-33% effective and averted a much larger epidemic[13,15].

However, the role of mask uptake, perceived effectiveness, and the timing when community members use their masks during the pandemic is unknown. A Norwegian study on the people's reflections on the consequences of a potential Influenza pandemic, found that substantial proportions of the population actually considered the mortality risk during a pandemic to be lower than estimates from health authorities, and thus would implement only minimally disruptive precautions to protect themselves against the causative agent[19]. Other studies have

demonstrated that the necessity of wearing masks by the public during the COVID-19 pandemic has been under-emphasized by goverments[20]. However, despite the public demonstrating a moderate to high level of knowledge of the COVID-19 infection and adequate knowledge about its preventive aspects[21], the overall practice of face mask use was low in some settings, guidelines conflicting and changing, and was influenced by education, literacy and age in some countries[22,23]. It is therefore important to gather evidence about community understanding and practices around the use of face masks during the COVID-19 pandemic, in settings with different disease incidence and different policies. We sought to determine that widespread behavior modification and mask use for COVID-19 risk prevention in Australia, is affected by knowledge, attitude, and practice towards mask use. This study therefore aimed to assess changes in the knowledge, attitudes, and practices towards mask use during the COVID-19 pandemic in the Australian population at two time points of the epidemic.

2. Methods

2.1. Study design and recruitment

This study was part of a larger study (MacIntyre *et al*., 2021[24]), where multiple cities were included. A cross-sectional survey was conducted in two Australian cities; Sydney, and Melbourne, at two time points. The initial survey was conducted during July-August[24], whilst the second survey was conducted in September 2020 using the same survey questions, corresponding with the peak of the Victorian second wave and the period shortly afterward. To recruit participants for the survey, a market research company, Dynata[25], was employed to randomly distribute the survey link amongst a geographically targeted sample of their panel members[26] aged 18 or older and living in either Sydney or Melbourne. Panel members that logged onto the platform had the option to open the survey link. A random sample was used for the second time point, which may not have included all those surveyed in the first time point. Once participants opened the link, they were redirected to the survey page, where data were collected using an anonymous web-based survey platform, REDCap[27,28]. It took 10-15 minutes to complete the survey. To determine a 20% difference in the rate of mask use between cities with and without mandated mask policies, the study was powered a priori with 95% confidence and 80% power. In Sydney (without a mask mandate) a mask use prevalence of 60% was assumed and in Melbourne (with a mask mandate), a mask use prevalence of 80% was assumed[29,30], together with a sampling ratio of 0.6 and 0.8 respectively, yielding a minimum required sample size of 194. The University of New South Wales Human Research Ethics Committee approved (HC #200460) the survey instrument and study protocol prior to data collection.

2.2. *Patient and Public Involvement.*

No patients were involved in this study.

2.3. *Variables of interest*

A survey of 123 questions were administered to participants'. For the purposes of this paper, only Australian cities and questions pertaining to mask use, attitude and changes in behavior relating to mask use were compared for analysis. To determine changes in knowledge, attitudes and practice of mask use amongst Sydney and Melbourne participants were asked to indicate their perception of the severity of COVID-19, together with the perceived level of risk of a COVID-19 infection (Appendix, Table 1). Participants were asked which of several risk mitigation measures were used during the pandemic, both at the start of the pandemic and at the time of the survey. To determine mask uptake during the pandemic, participants were asked to indicate if they had ever worn a mask and to specify the type of mask used, whether it had been worn correctly over both the nose and mouth and the reason for mask use, whether it was specifically due to the pandemic. A Likert scale[31] was used to assess participant attitudes towards both the national and state government during the COVID-19 pandemic.

2.4. *Data analysis*

Descriptive statistics were performed for variables relating to health status, mask use, attitude of participants towards mask use, and other behaviors and perceptions during the COVID-19 pandemic. Continuous variables were displayed as mean ± one standard deviation (SD), and range. Categorical variables were presented as an absolute count and percentage. A Pearson Chi Squared test was used to calculate significance levels for categorical data and a logistic regression was used to determine predictors of mask uptake during the pandemic. These relationships were expressed at a 95% confidence interval (CI). A *p*-value less than or equal to 0.05 was considered significant. The percentage change of responses to the use of risk measures in July-August and September 2020, were calculated and graphed. A comparison of the percentage change of pre-pandemic risk measures between the two surveys was performed to provide an internal validation to determine how well the results among the study participants represent true findings among similar individuals across the second survey (Appendix, Table 2). Analysis was completed using Stata version 16[32].

3. Results

A total of 700 participants in Sydney (n=402) and Melbourne (n=298) completed the survey, with sampling proportionate to population size, with no losses. In Sydney, 200 and 202 participants were sampled in July and September 2020, respectively. In Melbourne, 148 participants were sampled in July and 150 participants in September 2020. The mean age of participants was 45.71±16.8 with 49.7% of participants male, while 47.71% of participants indicated they had underlying co-morbidities such as cancer, diabetes, and pre-existing heart conditions (Appendix, Table 3).

Participants were asked to indicate infection risk measures previously and currently used for reducing the risk of COVID-19 transmission across both surveys. Figure 1A shows the frequency of COVID-19 risk-control measures used early in the pandemic during March–April 2020 and percentage changes of these measures from March-July 2020 (Figure 1B) and from March-September 2020 (Figure 1C). Participants reported adopting a wide range of infection risk measures. In the early stages of the pandemic, the most common measures used were avoiding crowded areas, public transport and shops (69.8% in Sydney and 84.8% in Melbourne); physical distancing (66% in Sydney and 76.4% in Melbourne); practicing hand hygiene i.e. washing hands frequently, using hand sanitizers and avoiding touching your face (57% in Sydney and 69.1% in Melbourne); restricting visitors (56.5% in Sydney and 74.3% in Melbourne); using disinfectants to clean surfaces (40% in Sydney and 51.4% in Melbourne); not attending the workplace (47.5% in Sydney and 36.5% in Melbourne); avoiding contact with sick people (35.5% in Sydney and 38.5% in Melbourne); reducing visits to medical facilities (31.5% in Sydney and 39.2% in Melbourne) and wearing masks of any type i.e. N95, P2, surgical, cloth (32% in Sydney and 41.9% in Melbourne). In both Sydney and Melbourne, a consistent decrease was reported in almost all risk-mitigation behaviors between March–July 2020 (Figure 1B). However, mask use, social distancing, reducing visits to medical facilities and avoiding contact with sick people increased in Melbourne, which was amid a second wave at the time of the survey, where mask use and lockdowns were mandated. A consistent decrease was again reported in almost all risk-mitigation behaviors between March–September 2020 (Figure 1C). However, mask use and PPE use increased in both Sydney and Melbourne. An increase in not sending children to daycare, and adults not attending the workplace was also seen in Melbourne between March–September 2020. Participants also indicated the following qualitative responses of additional risk measures which were used; “Exercise”, “only going out for shopping and medical”, “staying home more” and “keeping fit”.

Participants who used a mask during the pandemic were assessed for a variety of predictors of mask uptake during the pandemic (Table 1). Across both surveys, there was a significant association between age and mask uptake [0.67 (95%CI 0.50-0.91; *p*=0.011), with younger people more likely to wear a mask, but no association between gender [1.00 (95%CI 0.74-1.35; *p*=1.000)] or city of residence [1.27 (95%CI 0.74-1.35; *p*=0.072)] on mask uptake during the pandemic. Embarrassment when wearing a mask [0.24 (95%CI 0.10-0.54; *p*=001)] was a predictor of lower mask uptake. A small number of participants indicated issues such as people staring (5.86%), receiving negative comments (3.71%), receiving racist comments, and being perceived as an infected person (3.71%) as barriers when wearing a mask, none of which were associated with mask uptake during the pandemic. Qualitative responses included "Breathing and talking", "cannot breathe properly", "fogs up my glasses", "difficulty to breath", "discomfort especially on physical exercise", "mask too close to eyes", "itching", "uncomfortable", "hyperventilating", "people found it hard to hear me", "breathless when walking uphill", "too sweaty", "it affected my ability to look down" and "was uncomfortable to wear".

Of the factors which participants believed influenced mask uptake, 45% of participants reported significant influence on the public from a recommendation by the government or health departments in their decision to wear a mask [1.83 (95%CI 1.32-2.53; *p*<0.000)], how much infection was around at the time [1.45 (95%CI 1.00-2.09; *p*=0.049)], and experience with using masks [2.32 (95%CI 1.35-4.00; *p*=0.002)]. Information from social media platforms (9.3%), media sources such as news, TV, radio, and the internet (20.6%) had a high level of indication from participants but were not significantly associated with mask uptake.

Table 1: Predictors of mask uptake during the pandemic in Sydney and Melbourne in 2020.

	N (%)	OR (95% CI)	*p*-value
Age (<45.711 years)**	384 (54.86)	0.67 (0.50-0.91)	**0.011***
Gender_(Male)	348 (49.71)	1.00 (0.74-1.35)	1.000
City of residence (Sydney-Reference)	402 (57.43)	-	-
Melbourne	298 (42.57)	1.24 (0.99-1.22)	0.072
Barriers to wearing a mask			
Felt embarrassed to wear it	59 (8.43)	0.24 (0.10-0.54)	**0.001***
People stared at me	41 (5.86)	0.48 (0.15-1.52)	0.212
I received negative comments	26 (3.71)	0.87 (0.29-2.64)	0.804
I received racist comments	25 (3.57)	0.43 (0.05-3.98)	0.458
People thought I was infected	25 (3.57)	0.46 (0.18-1.20)	0.114
People laughed at me	13 (1.86)	0.39 (0.11-1.40)	0.148
Factors which influenced mask wearing			
A recommendation from government or health department	315 (45.0)	1.83 (1.32-2.53)	**<0.000***
How much infection is around at the time	203 (29.0)	1.45 (1.00-2.09)	**0.049***
Media information (TV, radio, internet, print)	144 (20.57)	0.83 (0.54-1.29)	0.405
A recommendation from friends or family members	124 (17.71)	1.22 (0.76-1.95)	0.405

A recommendation from my doctor	118 (16.86)	1.45 (0.92-2.29)	0.106
Experience with using these products	86 (12.29)	2.32 (1.35-4.00)	**0.002***
Social media (Facebook, Twitter, Instagram, etc.)	65 (9.29)	0.86 (0.44-1.65)	0.644
Perceived COVID-19 Severity >average**	348 (49.71)	1.96 (1.44-2.66)	**<0.000***
Perceived risk of getting COVID-19 >average**	442 (63.14)	1.98 (1.43-2.74)	**<0.000***
High trust in state government***	446 (63.71)	1.62 (1.19-2.22)	**0.003***
High trust in national government***	470 (67.14)	1.77 (1.29-2.44)	**<0.000***

**Indicates statistical significance* at $p \leq 0.05$ *(Logistic regression used for analysis).*

***Average refers to the population mean of each variable. Variables were coded as "1" if their values were larger than the population mean and coded as "0" if smaller than the population mean.*

****On a scale of 0–5, where 5 represents highest level of trust/confidence. Variables were coded as "1"(high) if their values were larger than 3 and coded as "0" if smaller than or equal to 3.*

Participants were asked how severe they believed a COVID-19 infection would be and their perceived level of risk of contracting COVID-19. On a sliding scale, the perceived severity of COVID-19 infection was 62.5±24.3 [1.96 (95%CI 1.44-2.66; p<0.000)], whilst the perceived level of risk of contracting COVID-19 was 52.7±24.2 [1.98 (95%CI 1.43-2.74; p<0.000)], both were significantly associated with mask uptake. When asked to indicate the level of trust in both state and national government regarding information on the COVID-19 pandemic, participants expressed a high level of trust in both their state (63.7%) and national (67.1%) government. Trust in information on COVID-19 from both national [1.77 (95%CI 1.29-2.44); p<0.000)] and state government [1.62 (95%CI 1.18-2.22); p=0.003)] was significantly associated with mask uptake across both surveys.

Overall, participants indicated that N95 or P2 masks were perceived to be the most effective for COVID-19 prevention (62.2±22.2), followed by surgical masks (57.3±22.3) and cloth masks (50.0±23.5) (Appendix, Table 3). However, only 18.9% of participants indicated they had worn their masks over both their nose and mouth, with 39.6% unsure and 41.6% indicating they had worn their mask under their nose and only covering their mouth.

4. Discussion

Despite established guidelines of PPE use to manage the pandemic in many countries, mask hesitancy remains a cultural issue[20]. In Western countries, many view PPE and physical barriers including wearing the mask, as contrary to freedom and individualism and a recent study on mask uptake during the COVID-19 pandemic found that negative issues experienced while wearing masks reduced the likelihood of people wearing them[24]. In this study, stigma or negativity associated with mask use was a predictor of mask uptake. Both Sydney and Melbourne participants expressed a high level of trust in information from both their state and national government during the COVID-19 pandemic. Participants also reported a significant influence on

the public from government or health departments in their decision to wear a mask together with COVID-19 risk perception.

In Sydney and Melbourne, a significant increase in mask uptake during the COVID-19 pandemic was seen in July and September 2020, whilst other mitigation methods or behaviors, like avoiding medical facilities, no longer using public transport, and practicing hand hygiene, were not reported to have changed over the period. This increase in mask use in Melbourne coincides with the resurgence of COVID-19 from June to August 2020, where a mask mandate from the Victorian government from 23 July 2020 onward (close to the peak of the second wave), along with a 6-week stage three lockdown which commenced on 9 July 2020, was issued. Demographic differences and the rate of the outbreaks' growth make it difficult to directly compare the two states' responses to the pandemic, however it is important to stress that early mask use prevents more cases than mask usage which is only implemented closer to the peak of a pandemic[13]. Whilst mask mandates have a strong effect on mask use[24], research which has shown that in countries where communities were 'socially obliged' to wear masks, the public are more likely to engage in mask wearing in response to a pandemic[33]. In this study, factors associated with mask use included an underlying co-morbidity, a requirement of work, embarrassment, perception of being COVID-19 positive, how much infection was present at the time, perceived COVID-19 severity of infection and perceived risk of infection. Gender, and city of residence were not predictors of mask uptake in Sydney and Melbourne, whilst age was associated with mask uptake. The most significant influence on mask use was a recommendation from the government or health department. State governments need to address these issues with the public when advising or mandating mask use and target campaigns breaking through the stigma of mask wearing should be considered.

A recently published study on the effect of masks during the second wave in Victoria, showed that the effect of masks increases with the increasing uptake and increased effectiveness of the masks[13]. It also demonstrated that moderately effective masks with uptake levels of 50% or greater, can have a significant effect on epidemic control[13]. N95 or P2 masks were perceived to be the most effective for COVID-19 prevention. However, the use of any mask type should be encouraged as studies have shown that even when poor quality face masks were used, wearing masks significantly reduced the spread SARS-CoV2[34,35]. Furthermore, 18.9% of participants indicated they had worn their masks over both their nose and mouth, with 39.6% unsure and 41.6% indicating they had worn their mask under their nose and only covering their mouth. It is therefore essential to educate the public on correct mask wearing for mask use to be effective.

Some of the qualitative responses from participants in survey 2, after the first wave, indicated that masks were now being worn not only to protect themselves from getting sick but also from transmitting COVID-19. This highlights the need for continued community education on mask use.

This study was not without limitations. The survey was powered to detect a difference between Sydney and Melbourne with 95% confidence and 80% power but may not have had enough statistical power to compare each time point by city. The survey was only administered in English, and thus there may be bias for English speakers and non-English speakers or people with limited access to the Internet may have been excluded. Online panels provide a simple, cost-effective means of conducting survey research, but may be biased depending the method used by the market research company for panel member recruitment[26,36]. Data on participants' ethnicity and socioeconomic status were not collected. This study surveyed a simple, random sample of panel members and was not stratified to be representative of the population, so mask uptake rates in this survey may not reflect true uptake. Recall bias may have been introduced, as this survey provided a cross-sectional description of mask use only, which was dependent on recall for reporting behaviors early in the pandemic period. This study highlighted the fact that mask uptake and the timing of mask use has the potential to influence the control of the COVID-19 pandemic. By assessing the changes in knowledge, attitudes, and practices towards mask use in Sydney and Melbourne, Australia, during the 2020 COVID-19 pandemic, widespread behavior modification and mask use for COVID-19 risk prevention in Australia was seen with high levels of reported mask wearing during the study periods.

Despite a now highly vaccinated Australian population, there is still the need to maintain the correct use of masks to prevent the spread of the virus. Future research and estimates pertaining to new variants of concern (VOCs) is necessary and community understanding and practices around the use of face masks for COVID-19, particularly in light of the emergence of the highly transmissible Delta and Omicron strains is essential. With the emergence of these VOCs, mask wearing must become the "new normal" and should remain mandated in public spaces and large gatherings in future.

Conclusion

There had been widespread behavior modification and mask use for COVID-19 risk prevention in Australia during the study periods. Some behaviors, like avoiding medical facilities, did not change over the period. Whilst social distancing measures were the most commonly used mitigation, mask use changed the most over the study period. Sydney and Melbourne both had high levels

of reported mask wearing during September 2020, consistent with the second wave and mask mandates in Victoria and cluster outbreaks in Sydney at that time. Following the large second wave in Melbourne and smaller outbreaks in Sydney, the perceived level of risk of COVID-19 infection was high. High rates of mask compliance may be explained by high trust in both national and state governments, mask mandates at the time, risk perceptions and current outbreaks. Considering the pre-symptomatic and asymptomatic transmission of SARS-CoV2, mask use is an essential measure for COVID-19 risk mitigation. It is therefore essential to continue to encourage mask use, together with ongoing community education with an emphasis on the route of COVID-19 transmission and correct face mask use, whilst considering evidence about community understanding and practices around the use of face masks for COVID-19, particularly in light of the emergence of the of highly transmissible Delta and Omicron strains.

Declarations

Ethics approval and consent to participate.

The University of New South Wales Human Research Ethics Committee approved (Approval number: HC #200460) the survey instrument and study protocol prior to data collection. Completion of the survey was taken as consent.

Competing interests

The author certifies that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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Authors' contributions

AQ: Writing - original draft, project administration, conceptualization, methodology, formal analysis; MT - writing and editing; HS: writing and editing; AAC: supervision, writing and editing; CRM: conceptualization, supervision, writing and editing. All authors read and approved the final manuscript.

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Not applicable.

Data Statement:

No additional data available.

Figure Caption

Figure 1: Frequency percentage of COVID-19 risk-control measures in March 2020 (A), and percentage changes of these measures from March-July 2020 (B) and March-September 2020 (C).

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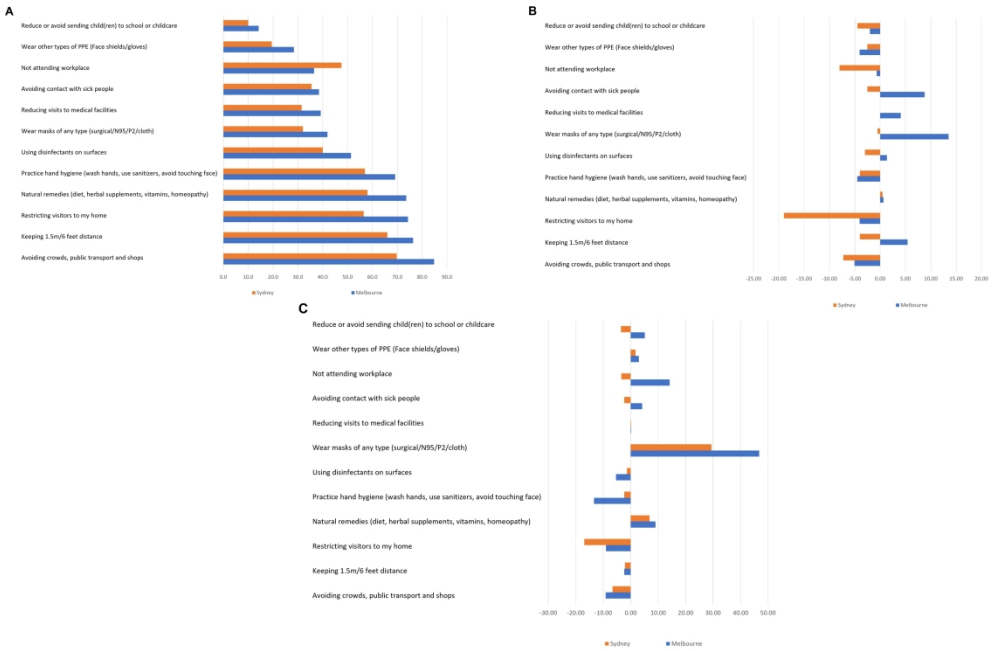

Figure 1: Frequency percentage of COVID-19 risk-control measures in March 2020 (A), and percentage changes of these measures from March-July 2020 (B) and March-September 2020 (C).

645x434mm (144 x 144 DPI)

Appendix

Table 1: Survey questionnaire – Adapted from MacIntyre *et al*., 2021[24].

Question	Type	Option	Variable coded as
Are you aged 18 or older?	Multiple choice	1 Yes 0 No	Binary
What is your city of residence?	Multiple choice	1 Sydney, Australia 2 London, UK 3 New York City, NY, USA 4 Melbourne, Australia 5 Phoenix, AZ, USA	Categorical
What is your gender?	Multiple choice	1 Female 2 Male 3 Other	Categorical
What is your age?	Open-ended		Numerical
Have you ever been told by a doctor or a nurse that you have any of the following lung conditions?	Tick box	0 None 1 Asthma 2 Emphysema 3 Chronic Bronchitis 4 Chronic Obstructive Pulmonary Disease (COPD) 5 Bronchiectasis 6 Other chronic lung disease 7 Other	Binary for each option
Please indicate whether a doctor has ever diagnosed you with any of the following (please select all that apply):	Tick box	0 None 1 Diabetes 2 Hypertension (high blood pressure) 3 Heart disease (heart attack, angina, heart failure, arrhythmia or other) 4 Cancer (current or past) 5 Stroke 6 Other neurological condition (such as epilepsy, neuropathy, Parkinson's disease, dementia) 7 Kidney disease (such as stones, nephropathy, kidney failure, dialysis) 8 Liver disease (hepatitis, liver failure, cirrhosis) 9 Allergies (hay fever, eczema) 10 Dermatitis or other skin disease 11 Immunocompromised conditions (e.g., transplantation, regular corticosteroid use) 12 Other chronic lung diseases (fibrosis) 13 Other medical condition(s)	Binary for each option

Question	Type	Option	Variable coded as
Have you ever experienced any negative issues while wearing a mask, N95 or P2?	Tick box	0 No 1 I felt embarrassed to wear it 2 I received negative comments when wearing it 3 I received racist comments when wearing it 4 People laughed at me 5 People stared at me 6 People thought I was infected 7 Other	Binary for each option
How severe do you think COVID-19 would be if you got it?	Sliding scale	Scale 1-100	Numerical
What measures have you taken for reducing your risk from COVID-19 during March and April 2020?	Tick box	0 None 1 Working from home 2 I was unable to work 3 Restricting visitors to my home 4 Avoiding crowded places or large gatherings 5 Avoiding close contact with sick people in my home 6 Avoid using public transport 7 Reduce or avoid going to hospitals or going to the doctor unless required 8 Keeping 1.5m/6 feet or more between myself and others 9 Wearing a mask or P2 or N95 10 Wearing a homemade cloth mask 11 Wearing gloves 12 Avoiding touching my eyes, nose, and mouth with unwashed hands 13 Taken herbal supplements 14 Taken vitamins 15 Wearing a face shield 16 Washing my hands frequently 17 Using hand sanitizer to clean hands when soap and water was not available for washing hands 18 Using disinfectant to clean surfaces at home or work or other places I attend frequently 19 Using homeopathic remedies 20 Reduce or avoid sending child(ren) to school or childcare 21 Shopping online for food and other necessities 22 Ensuring a balanced diet 23 Other	Binary for each option

Question	Type	Option	Variable coded as
What measures are you currently taking to reduce your risk from COVID-19?	Tick box	0 None 1 Working from home 2 I was unable to work 3 Restricting visitors to my home 4 Avoiding crowded places or large gatherings 5 Avoiding close contact with sick people in my home 6 Avoid using public transport 7 Reduce or avoid going to hospitals or going to the doctor unless required 8 Keeping 1.5m/6 feet or more between myself and others 9 Wearing a mask or P2 or N95 10 Wearing a homemade cloth mask 11 Wearing gloves 12 Avoiding touching my eyes, nose, and mouth with unwashed hands 13 Taken herbal supplements 14 Taken vitamins 15 Wearing a face shield 16 Washing my hands frequently 17 Using hand sanitizer to clean hands when soap and water was not available for washing hands 18 Using disinfectant to clean surfaces at home or work or other places I attend frequently 19 Using homeopathic remedies 20 Reduce or avoid sending child(ren) to school or childcare 21 Shopping online for food and other necessities 22 Ensuring a balanced diet 23 Other	Binary for each option
Have you ever worn a mask/N95/P2 during the COVID-19 pandemic?	Multiple choice	1 Yes 0 No	Binary
What level of trust do you have in the information about COVID-19 from your national government?	Likert scale	4 Very High 3 High 2 Intermediate 1 Low 0 Very low	Ordinal
What level of trust do you have in the information about COVID-1 from your state/ local government?	Likert scale	4 Very High 3 High 2 Intermediate 1 Low 0 Very low	Ordinal

Question	Type	Option	Variable coded as
What do you think is your level of risk of catching COVID-19 during this pandemic?	Sliding scale	Scale 1-100	Numerical
How effective did you think a surgical mask is at reducing your risk of COVID-19?	Sliding scale	Scale 1-100	Numerical
How effective did you think a N95 or P2 mask is at reducing your risk of COVID-19?	Sliding scale	Scale 1-100	Numerical
How effective did you think a cloth mask is at reducing your risk of COVID-19?	Sliding scale	Scale 1-100	Numerical

Table 2: Percentage change of participant responses providing an internal validation between survey 1 and survey 2 for each city.

	Sydney Survey 1/Survey 2	Melbourne Survey 1/Survey 2
None	-0.5	-3.4
Working from home	4.6	11.6
I was unable to work	4.9	1.9
Restricting visitors to my home	-5.5	-7.0
Avoiding crowded places or large gatherings	-2.2	-10.4
Avoiding close contact with sick people in my home	-2.3	2.8
Avoid using public transport	0.5	-7.5
Reduce or avoid going to hospitals or going to the doctor	-1.3	-4.5
Keeping 1.5m/6 feet or more between myself and others	4.3	-5.0
Wearing a mask or P2 or N95	11.1	19.6
Wearing a homemade cloth mask	12.8	15.8
Wearing gloves	1.8	-2.3

Table 3: Demographic table, perceived effectiveness of masks and wearing of masks by survey respondents (n=700).

Mean age	**Years**
	46 ± 16.8
Gender	**N (%)**
Female	351 (50.1%)
Male	348 (49.7%)
Unspecified	1 (0.1%)
Pre-existing health conditions	**N (%)**
Co-morbidities (such as diabetes, cancer, stroke etc.)	334 (47.71)
None	559 (79.9)
Pre-existing lung conditions	186 (26.6)
COVID-19 mask perception	
Perceived effectiveness of masks (1–100)	
N95/P2 masks	62.2 ± 22.2
Surgical masks	57.3 ± 22.3
Cloth masks	50.0 ± 23.5
Wearing of masks over the nose and mouth	**N (%)**
No	291 (41.6)
Unsure/did not specify	277 (39.6)
Yes	132 (18.9)

Note: (i) Percentages may not add up to 100% in some questions because participants could choose more than one option. (ii) Mean ± SD were reported for sliding scale questions of 1–100, where 1 = minimum and 100 = maximum.

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

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	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	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
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	N/A N/A 6-7
		(*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	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	6-7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	N/A
		(*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 *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A N/A **7**
		(*e*) Describe any sensitivity analyses	N/A

Continued on next page

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	N/A
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7, 24
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	7-8
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	10-12
		(*b*) Report category boundaries when continuous variables were categorized	10-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-13
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	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-14
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	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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

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A Cross-Sectional Survey of Changes in Knowledge, Attitudes and Practice of Mask Use in Sydney and Melbourne During the 2020 COVID-19 Pandemic.

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A Cross-Sectional Survey of Changes in Knowledge, Attitudes and Practice of Mask Use in Sydney and Melbourne During the 2020 COVID-19 Pandemic.

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Abstract

Objectives: Since mask uptake and the timing of mask use has the potential to influence the control of the COVID-19 pandemic, this study aimed to assess the changes in knowledge towards mask use in Sydney and Melbourne, Australia, during the 2020 COVID-19 pandemic.

Design:

An observational study, using a cross-sectional survey was distributed to adults in Sydney and Melbourne, Australia during July-August 2020 (survey 1) and September 2020 (survey 2), during the COVID-19 pandemic in Australia.

Setting and Participants:

Participants aged 18 or older and living in either Sydney or Melbourne.

Primary and secondary outcome measures: Demographics, risk measures, COVID-19 severity and perception, mask attitude and uptake were determined in this study.

Results: A total of 700 participants completed the survey. In both Sydney and Melbourne, a consistent decrease was reported in almost all risk-mitigation behaviors between March–July 2020 and again between March–September 2020. However, mask use and personal protective equipment (PPE) use increased in both Sydney and Melbourne from March-September 2020. There was no significant difference in mask use during the pandemic between the two cities across both timepoints [1.27 (95%CI 0.74-1.35; p=0.072)]. Perceived severity and perceived susceptibility of COVID-19 infection and were significantly associated with mask uptake. Trust in information on COVID-19 from both national [1.77 (95%CI 1.29-2.44); p<0.000)] and state [1.62 (95%CI 1.18-2.22); p=0.003)] government was a predictor of mask use across both surveys.

Conclusion: Sydney and Melbourne both had high levels of reported mask wearing during July and September 2020, consistent with the second wave and mask mandates in Victoria, and cluster outbreaks in Sydney at the time. High rates of mask compliance may be explained by high trust levels in information from national and state government, mask mandates, risk perceptions, current outbreaks, and the perceived level of risk of COVID-19 infection at the time.

Strengths and limitations of this study:

- Mask uptake and the timing of mask use has the potential to influence the control of the COVID-19 pandemic.

- Widespread behavior modification and mask use for COVID-19 risk prevention in Australia was seen during the study periods.
- Sydney and Melbourne both had high levels of reported mask wearing during July and September 2020.
- A potential limitation of this study is that the survey was only administered in English, and thus there may be bias for English speakers and non-English speakers or people with limited access to the Internet may have been excluded.
- Recall bias may have been introduced, as this survey provided a cross-sectional description of mask use only, which was dependent on recall for reporting behaviors early in the pandemic period.

1. Introduction

The first wave of COVID-19 in Australia occurred during January to April 2020 and a nationwide lock-down was enforced, however mask use was not mandated. The second wave, starting in June 2020, though largely localized to Melbourne (Victoria), featured much more widespread community transmission, with the highest death rate and at its peak, the state had 6767 active cases[1]. It was during this second wave that mask use was mandated by the Victorian state government on 19 July 2020, together with a state-wide lockdown[2]. At the same time, smaller epidemics occurred in Sydney with 109 cases associated with the Thai Rock Restaurant cluster and 58 cases associated with the Crossroads Hotel cluster [3,4].

During the early stages of the pandemic, amidst shortages of N95 respirators and face masks for healthcare workers (HCWs), the World Health Organization (WHO), Centers for Disease Control and Prevention (CDC) and other health organizations actively discouraged mask use by the general public unless symptomatic[5]. However, it became evident that asymptomatic persons are potential sources of COVID-19 infection and around 40 to 45% of COVID-19 cases were asymptomatic[6–9]. In symptomatic infections, 44% of transmission occurred in the 48h prior to showing symptoms, and a further proportion on the first day of showing symptoms[10]. This, plus recognition of airborne transmission, led to a change in recommendation for mask use as a non-pharmaceutical intervention (NPIs) for COVID-19 prevention by the WHO, CDC and other agencies[11,12]. There is now evidence that universal mask use during periods of high transmission of SARS-CoV-2 may contribute to epidemic control[13–15].

Mask use by healthy people in closed community settings provides protection against respiratory infections[16] and is also a well-established method of source control[17]. Mask type varies and observational studies amongst HCWs and the general public during the SARS outbreak in China, found cotton masks to be effective at preventing infections[18]. In Victoria, Australia, use of all types of masks during the mask mandate, accounting for poor quality cloth coverings, is estimated to have been 22-33% effective and averted a much larger epidemic[13,15].

However, the role of mask uptake, perceived effectiveness, and the timing when community members use their masks during the pandemic is unknown. A Norwegian study on the people's reflections on the consequences of a potential Influenza pandemic, found that substantial proportions of the population actually considered the mortality risk during a pandemic to be lower than estimates from health authorities, and thus would implement only minimally disruptive precautions to protect themselves against the causative agent[19]. Other studies have

demonstrated that the necessity of wearing masks by the public during the COVID-19 pandemic has been under-emphasized by goverments[20]. However, despite the public demonstrating a moderate to high level of knowledge of the COVID-19 infection and adequate knowledge about its preventive aspects[21], the overall practice of face mask use was low in some settings, guidelines conflicting and changing, and was influenced by education, literacy and age in some countries[22,23]. It is therefore important to gather evidence about community understanding and practices around the use of face masks during the COVID-19 pandemic, in settings with different disease incidence and different policies. We sought to determine that widespread behavior modification and mask use for COVID-19 risk prevention in Australia, is affected by knowledge, attitude, and practice towards mask use. This study therefore aimed to assess changes in the knowledge, attitudes, and practices towards mask use during the COVID-19 pandemic in the Australian population at two time points of the epidemic.

2. Methods

2.1. Study design and recruitment

This study was part of a larger study (MacIntyre *et al*., 2021[24]), where multiple cities were included. A cross-sectional survey was conducted in two Australian cities; Sydney, and Melbourne, at two time points. The initial survey was conducted during July-August[24], whilst the second survey was conducted in September 2020 using the same survey questions, corresponding with the peak of the Victorian second wave and the period shortly afterward. To recruit participants for the survey, a market research company, Dynata[25], was employed to randomly distribute the survey link amongst a geographically targeted sample of their panel members[26] aged 18 or older and living in either Sydney or Melbourne. Panel members that logged onto the platform had the option to open the survey link. A random sample was used for the second time point, which may not have included all those surveyed in the first time point. Once participants opened the link, they were redirected to the survey page, where data were collected using an anonymous web-based survey platform, REDCap[27,28]. It took 10-15 minutes to complete the survey. To determine a 20% difference in the rate of mask use between cities with and without mandated mask policies, the study was powered a priori with 95% confidence and 80% power. In Sydney (without a mask mandate) a mask use prevalence of 60% was assumed and in Melbourne (with a mask mandate), a mask use prevalence of 80% was assumed[29,30], together with a sampling ratio of 0.8 and 0.6 respectively, yielding a minimum required sample size of 194. The University of New South Wales Human Research Ethics Committee approved (HC #200460) the survey instrument and study protocol prior to data collection.

2.2. *Patient and Public Involvement.*

No patients were involved in this study.

2.3. *Variables of interest*

A survey of 123 questions were administered to participants'. For the purposes of this paper, only Australian cities and questions pertaining to mask use, attitude and changes in behavior relating to mask use were compared for analysis. To determine changes in knowledge, attitudes and practice of mask use amongst Sydney and Melbourne participants were asked to indicate their perception of the severity of COVID-19, together with the perceived level of risk of a COVID-19 infection (Appendix, Frame 1). Participants were asked which of several risk mitigation measures were used during the pandemic, both at the start of the pandemic and at the time of the survey. To determine mask uptake during the pandemic, participants were asked to indicate if they had ever worn a mask and to specify the type of mask used, whether it had been worn correctly over both the nose and mouth and the reason for mask use, whether it was specifically due to the pandemic. A Likert scale[31] was used to assess participant attitudes towards both the national and state government during the COVID-19 pandemic.

2.4. *Data analysis*

Descriptive statistics were performed for variables relating to health status, mask use, attitude of participants towards mask use, and other behaviors and perceptions during the COVID-19 pandemic. Continuous variables were displayed as mean ± one standard deviation (SD), and range. Categorical variables were presented as an absolute count and percentage. A Pearson Chi Squared test was used to calculate significance levels for categorical data and a logistic regression was used to determine predictors of mask uptake during the pandemic. These relationships were expressed at a 95% confidence interval (CI). A *p*-value less than or equal to 0.05 was considered significant. The percentage change of responses to the use of risk measures in July-August and September 2020, were calculated and graphed. A comparison of the percentage change of pre-pandemic risk measures between the two surveys was performed to provide an internal validation to determine how well the results among the study participants represent true findings among similar individuals across the second survey (Appendix, Table 1). Analysis was completed using Stata version 16[32].

3. Results

A total of 700 participants in Sydney (n=402) and Melbourne (n=298) completed the survey, with sampling proportionate to population size, with no losses. In Sydney, 200 and 202 participants were sampled in July and September 2020, respectively. In Melbourne, 148 participants were sampled in July and 150 participants in September 2020. The mean age of all participants was 45.71±16.8 with 49.7% of participants male, while 47.71% of participants indicated they had underlying co-morbidities such as cancer, diabetes, and pre-existing heart conditions (Appendix, Table 2).

Participants were asked to indicate infection risk measures previously and currently used for reducing the risk of COVID-19 transmission across both surveys. Figure 1 shows the frequency of COVID-19 risk-control measures used early in the pandemic during March–April 2020 and percentage changes of these measures from March-July 2020 (Figure 2) and from March-September 2020 (Figure 3), where March 2020 was the baseline value for comparative purposes. Participants reported adopting a wide range of infection risk measures. In the early stages of the pandemic, the most common measures used were avoiding crowded areas, public transport and shops (69.8% in Sydney and 84.8% in Melbourne); physical distancing (66% in Sydney and 76.4% in Melbourne); practicing hand hygiene i.e. washing hands frequently, using hand sanitizers and avoiding touching your face (57% in Sydney and 69.1% in Melbourne); restricting visitors (56.5% in Sydney and 74.3% in Melbourne); using disinfectants to clean surfaces (40% in Sydney and 51.4% in Melbourne); not attending the workplace (47.5% in Sydney and 36.5% in Melbourne); avoiding contact with sick people (35.5% in Sydney and 38.5% in Melbourne); reducing visits to medical facilities (31.5% in Sydney and 39.2% in Melbourne) and wearing masks of any type i.e. N95, P2, surgical, cloth (32% in Sydney and 41.9% in Melbourne). In both Sydney and Melbourne, a consistent decrease was reported in almost all risk-mitigation behaviors between March–July 2020 (Figure 2). However, mask use, social distancing, reducing visits to medical facilities and avoiding contact with sick people increased in Melbourne, which was amid a second wave at the time of the survey, where mask use and lockdowns were mandated. A consistent decrease was again reported in almost all risk-mitigation behaviors between March–September 2020 (Figure 3). However, mask use and PPE use increased in both Sydney and Melbourne. An increase in not sending children to daycare, and adults not attending the workplace was also seen in Melbourne between March–September 2020. Participants also indicated the following qualitative responses of additional risk measures which were used; “Exercise”, “only going out for shopping and medical”, “staying home more” and “keeping fit”.

Participants who used a mask during the pandemic were assessed for a variety of predictors of mask uptake during the pandemic. The unadjusted odds ratio's (OR) are shown in Table 1. Across both surveys, there was a significant association between age (<45.711) and mask uptake [0.67 (95%CI 0.50-0.91; *p*=0.011), with younger people more likely to wear a mask, but no association between gender [1.00 (95%CI 0.74-1.35; *p*=1.000)] or city of residence [1.27 (95%CI 0.74-1.35; *p*=0.072)] on mask uptake during the pandemic. Embarrassment when wearing a mask [0.24 (95%CI 0.10-0.54; *p*=001)] was a predictor of lower mask uptake. A small number of participants indicated issues such as people staring (5.86%), receiving negative comments (3.71%), receiving racist comments, and being perceived as an infected person (3.71%) as barriers when wearing a mask, none of which were associated with mask uptake during the pandemic. Qualitative responses included "Breathing and talking", "cannot breathe properly", "fogs up my glasses", "difficulty to breath", "discomfort especially on physical exercise", "mask too close to eyes", "itching", "uncomfortable", "hyperventilating", "people found it hard to hear me", "breathless when walking uphill", "too sweaty", "it affected my ability to look down" and "was uncomfortable to wear".

Of the factors which participants believed influenced mask uptake, 45% of participants reported significant influence on the public from a recommendation by the government or health departments in their decision to wear a mask [1.83 (95%CI 1.32-2.53; *p*<0.000)], how much infection was around at the time [1.45 (95%CI 1.00-2.09; *p*=0.049)], and experience with using masks [2.32 (95%CI 1.35-4.00; *p*=0.002)]. Information from social media platforms (9.3%), media sources such as news, TV, radio, and the internet (20.6%) had a high level of indication from participants but were not significantly associated with mask uptake.

Table 1: Predictors of mask uptake during the pandemic in Sydney and Melbourne in 2020.

	N (%)	OR (95% CI)	*p*-value
Age (<45.711 years)**	384 (54.86)	0.67 (0.50-0.91)	**0.011***
Gender_(Male)	348 (49.71)	1.00 (0.74-1.35)	1.000
City of residence (Sydney-Reference)	402 (57.43)	-	-
Melbourne	298 (42.57)	1.24 (0.99-1.22)	0.072
Barriers to wearing a mask			
Felt embarrassed to wear it	59 (8.43)	0.24 (0.10-0.54)	**0.001***
People stared at me	41 (5.86)	0.48 (0.15-1.52)	0.212
I received negative comments	26 (3.71)	0.87 (0.29-2.64)	0.804
I received racist comments	25 (3.57)	0.43 (0.05-3.98)	0.458
People thought I was infected	25 (3.57)	0.46 (0.18-1.20)	0.114
People laughed at me	13 (1.86)	0.39 (0.11-1.40)	0.148
Factors which influenced mask wearing			
A recommendation from government or health department	315 (45.0)	1.83 (1.32-2.53)	**<0.000***
How much infection is around at the time	203 (29.0)	1.45 (1.00-2.09)	**0.049***
Media information (TV, radio, internet, print)	144 (20.57)	0.83 (0.54-1.29)	0.405
A recommendation from friends or family members	124 (17.71)	1.22 (0.76-1.95)	0.405

A recommendation from my doctor	118 (16.86)	1.45 (0.92-2.29)	0.106
Experience with using these products	86 (12.29)	2.32 (1.35-4.00)	**0.002***
Social media (Facebook, Twitter, Instagram, etc.)	65 (9.29)	0.86 (0.44-1.65)	0.644
Perceived COVID-19 Severity >average**	348 (49.71)	1.96 (1.44-2.66)	**<0.000***
Perceived risk of getting COVID-19 >average**	442 (63.14)	1.98 (1.43-2.74)	**<0.000***
High trust in state government***	446 (63.71)	1.62 (1.19-2.22)	**0.003***
High trust in national government***	470 (67.14)	1.77 (1.29-2.44)	**<0.000***

Indicates statistical significance at $p \leq 0.05$ *(Logistic regression used for analysis).*

***Average refers to the population mean of each variable. Variables were coded as "1" if their values were larger than the population mean and coded as "0" if smaller than the population mean.*

****On a scale of 0–5, where 5 represents highest level of trust/confidence. Variables were coded as "1"(high) if their values were larger than 3 and coded as "0" if smaller than or equal to 3.*

Participants were asked how severe they believed a COVID-19 infection would be and their perceived level of risk of contracting COVID-19 (Table 1). On a sliding scale, the perceived severity of COVID-19 infection was 62.5±24.3 [1.96 (95%CI 1.44-2.66; p<0.000)], whilst the perceived level of risk of contracting COVID-19 was 52.7±24.2 [1.98 (95%CI 1.43-2.74; p<0.000)], both were significantly associated with mask uptake. When asked to indicate the level of trust in both state and national government regarding information on the COVID-19 pandemic, participants expressed a high level of trust in both their state (63.7%) and national (67.1%) government. Trust in information on COVID-19 from both national [1.77 (95%CI 1.29-2.44); p<0.000)] and state government [1.62 (95%CI 1.18-2.22); p=0.003)] was significantly associated with mask uptake across both surveys.

Overall, participants indicated that N95 or P2 masks were perceived to be the most effective for COVID-19 prevention (62.2±22.2), followed by surgical masks (57.3±22.3) and cloth masks (50.0±23.5) (Appendix, Table 2). However, only 18.9% of participants indicated they had worn their masks over both their nose and mouth, with 39.6% unsure and 41.6% indicating they had worn their mask under their nose and only covering their mouth.

4. Discussion

Despite established guidelines of PPE use to manage the pandemic in many countries, mask hesitancy remains a cultural issue[20]. In Western countries, many view PPE and physical barriers including wearing the mask, as contrary to freedom and individualism and a recent study on mask uptake during the COVID-19 pandemic found that negative issues experienced while wearing masks reduced the likelihood of people wearing them[24]. In this study, stigma or negativity associated with mask use was a predictor of mask uptake. Both Sydney and Melbourne participants expressed a high level of trust in information from both their state and national government during the COVID-19 pandemic. Participants also reported a significant influence on

the public from government or health departments in their decision to wear a mask together with COVID-19 risk perception.

In Sydney and Melbourne, a significant increase in mask uptake during the COVID-19 pandemic was seen in July and September 2020, whilst other mitigation methods or behaviors, like avoiding medical facilities, no longer using public transport, and practicing hand hygiene, were not reported to have changed over the period. This increase in mask use in Melbourne coincides with the resurgence of COVID-19 from June to August 2020, where a mask mandate from the Victorian government from 23 July 2020 onward (close to the peak of the second wave), along with a 6-week stage three lockdown which commenced on 9 July 2020, was issued. Demographic differences and the rate of the outbreaks' growth make it difficult to directly compare the two states' responses to the pandemic, however it is important to stress that early mask use prevents more cases than mask usage which is only implemented closer to the peak of a pandemic[13]. Whilst mask mandates have a strong effect on mask use[24], research which has shown that in countries where communities were 'socially obliged' to wear masks, the public are more likely to engage in mask wearing in response to a pandemic[33]. In this study, factors associated with mask use included an underlying co-morbidity, a requirement of work, embarrassment, perception of being COVID-19 positive, how much infection was present at the time, perceived COVID-19 severity of infection and perceived risk of infection. Gender, and city of residence were not predictors of mask uptake in Sydney and Melbourne, whilst age was associated with mask uptake. The most significant influence on mask use was a recommendation from the government or health department. State governments need to address these issues with the public when advising or mandating mask use and target campaigns breaking through the stigma of mask wearing should be considered.

A recently published study on the effect of masks during the second wave in Victoria, showed that the effect of masks increases with the increasing uptake and increased effectiveness of the masks[13]. It also demonstrated that moderately effective masks with uptake levels of 50% or greater, can have a significant effect on epidemic control[13]. N95 or P2 masks were perceived to be the most effective for COVID-19 prevention. However, the use of any mask type should be encouraged as studies have shown that even when poor quality face masks were used, wearing masks significantly reduced the spread SARS-CoV2[34,35]. Furthermore, 18.9% of participants indicated they had worn their masks over both their nose and mouth, with 39.6% unsure and 41.6% indicating they had worn their mask under their nose and only covering their mouth. It is therefore essential to educate the public on correct mask wearing for mask use to be effective.

Some of the qualitative responses from participants in survey 2, after the first wave, indicated that masks were now being worn not only to protect themselves from getting sick but also from transmitting COVID-19. This highlights the need for continued community education on mask use.

This study was not without limitations. The survey was powered to detect a difference between Sydney and Melbourne with 95% confidence and 80% power but may not have had enough statistical power to compare each time point by city. The survey was only administered in English, and thus there may be bias for English speakers and non-English speakers or people with limited access to the Internet may have been excluded. Online panels provide a simple, cost-effective means of conducting survey research, but may be biased depending the method used by the market research company for panel member recruitment[26,36]. Data on participants' ethnicity and socioeconomic status were not collected. This study surveyed a simple, random sample of panel members and was not stratified to be representative of the population, so mask uptake rates in this survey may not reflect true uptake. Recall bias may have been introduced, as this survey provided a cross-sectional description of mask use only, which was dependent on recall for reporting behaviors early in the pandemic period. This study highlighted the fact that mask uptake and the timing of mask use has the potential to influence the control of the COVID-19 pandemic. By assessing the changes in knowledge, attitudes, and practices towards mask use in Sydney and Melbourne, Australia, during the 2020 COVID-19 pandemic, widespread behavior modification and mask use for COVID-19 risk prevention in Australia was seen with high levels of reported mask wearing during the study periods.

Despite a now highly vaccinated Australian population, there is still the need to maintain the correct use of masks to prevent the spread of the virus. Future research and estimates pertaining to new variants of concern (VOCs) is necessary and community understanding and practices around the use of face masks for COVID-19, particularly in light of the emergence of the highly transmissible Delta and Omicron strains is essential. With the emergence of these VOCs, mask wearing must become the "new normal" and should remain mandated in public spaces and large gatherings in future.

Conclusion

There had been widespread behavior modification and mask use for COVID-19 risk prevention in Australia during the study periods. Some behaviors, like avoiding medical facilities, did not change over the period. Whilst social distancing measures were the most commonly used mitigation, mask use changed the most over the study period. Sydney and Melbourne both had high levels

of reported mask wearing during September 2020, consistent with the second wave and mask mandates in Victoria and cluster outbreaks in Sydney at that time. Following the large second wave in Melbourne and smaller outbreaks in Sydney, the perceived level of risk of COVID-19 infection was high. High rates of mask compliance may be explained by high trust in both national and state governments, mask mandates at the time, risk perceptions and current outbreaks. Considering the pre-symptomatic and asymptomatic transmission of SARS-CoV2, mask use is an essential measure for COVID-19 risk mitigation. It is therefore essential to continue to encourage mask use, together with ongoing community education with an emphasis on the route of COVID-19 transmission and correct face mask use, whilst considering evidence about community understanding and practices around the use of face masks for COVID-19, particularly in light of the emergence of the of highly transmissible Delta and Omicron strains.

Declarations

Ethics approval and consent to participate.

The University of New South Wales Human Research Ethics Committee approved (Approval number: HC #200460) the survey instrument and study protocol prior to data collection. Completion of the survey was taken as consent.

Competing interests

The author certifies that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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Authors' contributions

AQ: Writing - original draft, project administration, conceptualization, methodology, formal analysis; MT - writing and editing; HS: writing and editing; AAC: supervision, writing and editing; CRM: conceptualization, supervision, writing and editing. All authors read and approved the final manuscript.

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Not applicable.

Data Statement:

No additional data available.

Figure Caption

Figure 1: Frequency percentage of COVID-19 risk-control measures in March 2020.

Figure 2: Percentage changes of the COVID-19 risk-control measures from March-July 2020.

Figure 3: Percentage changes of the COVID-19 risk-control measures.

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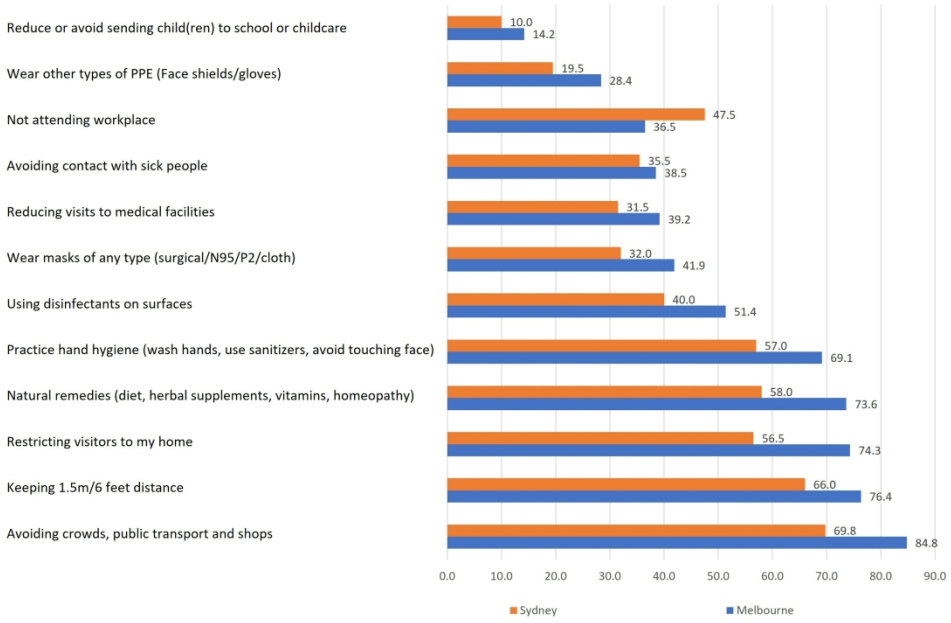

Figure 1: Frequency percentage of COVID-19 risk-control measures in March 2020.

250x177mm (300 x 300 DPI)

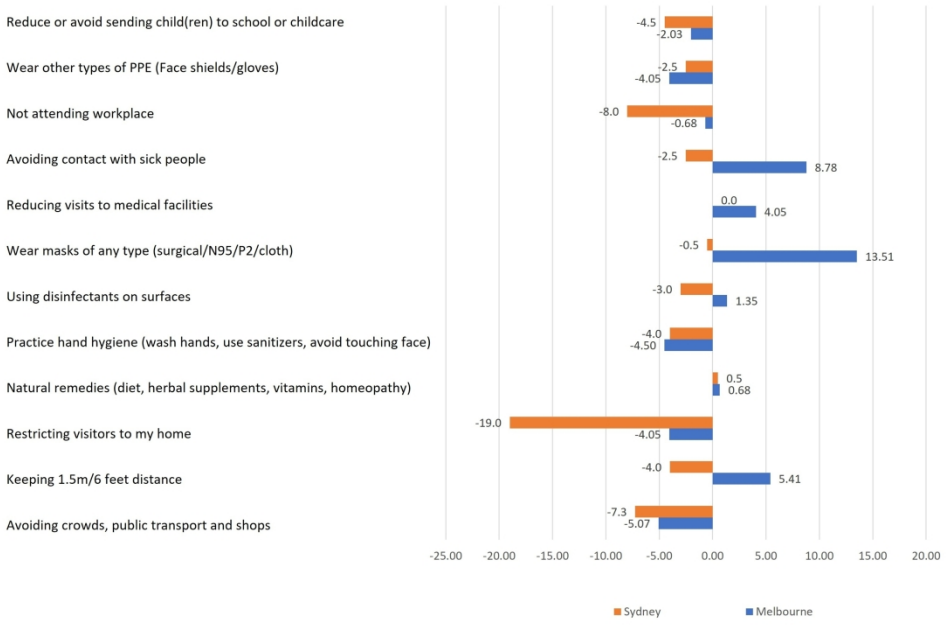

Figure 2: Percentage changes of the COVID-19 risk-control measures from March-July 2020.

251x177mm (300 x 300 DPI)

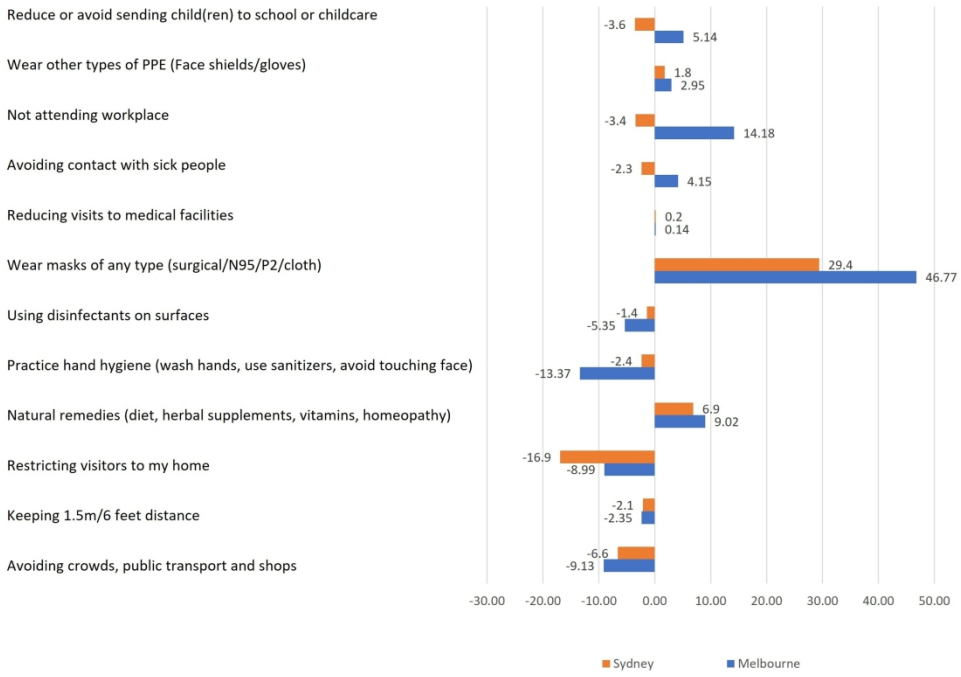

Figure 3: Percentage changes of the COVID-19 risk-control measures.

229x171mm (300 x 300 DPI)

Appendix

Frame 1: Survey questionnaire – Adapted from MacIntyre *et al*., 2021[24].

Question	Type	Option	Variable coded as
Are you aged 18 or older?	Multiple choice	1 Yes 0 No	Binary
What is your city of residence?	Multiple choice	1 Sydney, Australia 2 London, UK 3 New York City, NY, USA 4 Melbourne, Australia 5 Phoenix, AZ, USA	Categorical
What is your gender?	Multiple choice	1 Female 2 Male 3 Other	Categorical
What is your age?	Open-ended		Numerical
Have you ever been told by a doctor or a nurse that you have any of the following lung conditions?	Tick box	0 None 1 Asthma 2 Emphysema 3 Chronic Bronchitis 4 Chronic Obstructive Pulmonary Disease (COPD) 5 Bronchiectasis 6 Other chronic lung disease 7 Other	Binary for each option
Please indicate whether a doctor has ever diagnosed you with any of the following (please select all that apply):	Tick box	0 None 1 Diabetes 2 Hypertension (high blood pressure) 3 Heart disease (heart attack, angina, heart failure, arrhythmia or other) 4 Cancer (current or past) 5 Stroke 6 Other neurological condition (such as epilepsy, neuropathy, Parkinson's disease, dementia) 7 Kidney disease (such as stones, nephropathy, kidney failure, dialysis) 8 Liver disease (hepatitis, liver failure, cirrhosis) 9 Allergies (hay fever, eczema) 10 Dermatitis or other skin disease 11 Immunocompromised conditions (e.g., transplantation, regular corticosteroid use) 12 Other chronic lung diseases (fibrosis) 13 Other medical condition(s)	Binary for each option

Question	Type	Option	Variable coded as
Have you ever experienced any negative issues while wearing a mask, N95 or P2?	Tick box	0 No 1 I felt embarrassed to wear it 2 I received negative comments when wearing it 3 I received racist comments when wearing it 4 People laughed at me 5 People stared at me 6 People thought I was infected 7 Other	Binary for each option
How severe do you think COVID-19 would be if you got it?	Sliding scale	Scale 1-100	Numerical
What measures have you taken for reducing your risk from COVID-19 during March and April 2020?	Tick box	0 None 1 Working from home 2 I was unable to work 3 Restricting visitors to my home 4 Avoiding crowded places or large gatherings 5 Avoiding close contact with sick people in my home 6 Avoid using public transport 7 Reduce or avoid going to hospitals or going to the doctor unless required 8 Keeping 1.5m/6 feet or more between myself and others 9 Wearing a mask or P2 or N95 10 Wearing a homemade cloth mask 11 Wearing gloves 12 Avoiding touching my eyes, nose, and mouth with unwashed hands 13 Taken herbal supplements 14 Taken vitamins 15 Wearing a face shield 16 Washing my hands frequently 17 Using hand sanitizer to clean hands when soap and water was not available for washing hands 18 Using disinfectant to clean surfaces at home or work or other places I attend frequently 19 Using homeopathic remedies 20 Reduce or avoid sending child(ren) to school or childcare 21 Shopping online for food and other necessities 22 Ensuring a balanced diet 23 Other	Binary for each option

Question	Type	Option	Variable coded as
What measures are you currently taking to reduce your risk from COVID-19?	Tick box	0 None 1 Working from home 2 I was unable to work 3 Restricting visitors to my home 4 Avoiding crowded places or large gatherings 5 Avoiding close contact with sick people in my home 6 Avoid using public transport 7 Reduce or avoid going to hospitals or going to the doctor unless required 8 Keeping 1.5m/6 feet or more between myself and others 9 Wearing a mask or P2 or N95 10 Wearing a homemade cloth mask 11 Wearing gloves 12 Avoiding touching my eyes, nose, and mouth with unwashed hands 13 Taken herbal supplements 14 Taken vitamins 15 Wearing a face shield 16 Washing my hands frequently 17 Using hand sanitizer to clean hands when soap and water was not available for washing hands 18 Using disinfectant to clean surfaces at home or work or other places I attend frequently 19 Using homeopathic remedies 20 Reduce or avoid sending child(ren) to school or childcare 21 Shopping online for food and other necessities 22 Ensuring a balanced diet 23 Other	Binary for each option
Have you ever worn a mask/N95/P2 during the COVID-19 pandemic?	Multiple choice	1 Yes 0 No	Binary
What level of trust do you have in the information about COVID-19 from your national government?	Likert scale	4 Very High 3 High 2 Intermediate 1 Low 0 Very low	Ordinal
What level of trust do you have in the information about COVID-1 from your state/ local government?	Likert scale	4 Very High 3 High 2 Intermediate 1 Low 0 Very low	Ordinal

Question	Type	Option	Variable coded as
What do you think is your level of risk of catching COVID-19 during this pandemic?	Sliding scale	Scale 1-100	Numerical
How effective did you think a surgical mask is at reducing your risk of COVID-19?	Sliding scale	Scale 1-100	Numerical
How effective did you think a N95 or P2 mask is at reducing your risk of COVID-19?	Sliding scale	Scale 1-100	Numerical
How effective did you think a cloth mask is at reducing your risk of COVID-19?	Sliding scale	Scale 1-100	Numerical

Table 1: Percentage change of participant responses providing an internal validation between survey 1 and survey 2 for each city.

	Sydney Survey 1/Survey 2	Melbourne Survey 1/Survey 2
None	-0.5	-3.4
Working from home	4.6	11.6
I was unable to work	4.9	1.9
Restricting visitors to my home	-5.5	-7.0
Avoiding crowded places or large gatherings	-2.2	-10.4
Avoiding close contact with sick people in my home	-2.3	2.8
Avoid using public transport	0.5	-7.5
Reduce or avoid going to hospitals or going to the doctor	-1.3	-4.5
Keeping 1.5m/6 feet or more between myself and others	4.3	-5.0
Wearing a mask or P2 or N95	11.1	19.6
Wearing a homemade cloth mask	12.8	15.8
Wearing gloves	1.8	-2.3

Table 2: Demographic table, perceived effectiveness of masks and wearing of masks by survey respondents (n=700).

Mean age	**Years**
	46 ± 16.8
Gender	**N (%)**
Female	351 (50.1%)
Male	348 (49.7%)
Unspecified	1 (0.1%)
Pre-existing health conditions	**N (%)**
Co-morbidities (such as diabetes, cancer, stroke etc.)	334 (47.71)
None	559 (79.9)
Pre-existing lung conditions	186 (26.6)
COVID-19 mask perception	
Perceived effectiveness of masks (1–100)	
N95/P2 masks	62.2 ± 22.2
Surgical masks	57.3 ± 22.3
Cloth masks	50.0 ± 23.5
Wearing of masks over the nose and mouth	**N (%)**
No	291 (41.6)
Unsure/did not specify	277 (39.6)
Yes	132 (18.9)

Note: (i) Percentages may not add up to 100% in some questions because participants could choose more than one option. (ii) Mean ± SD were reported for sliding scale questions of 1–100, where 1 = minimum and 100 = maximum.

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

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	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	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
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	N/A N/A 6-7
		(*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	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	6-7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	N/A
		(*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 *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A N/A **7**
		(*e*) Describe any sensitivity analyses	N/A

Continued on next page

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	N/A
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7, 24
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	7-8
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	10-12
		(*b*) Report category boundaries when continuous variables were categorized	10-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-13
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	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-14
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	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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