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COVID Face Masks: Policy Shift Results in Increased Littering

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Abstract: The introduction of the mandatory use of fitted face masks in indoor spaces to limit the transmission of COVID-19 resulted in increased municipal waste of discarded single-use surgical face masks and other personal protective equipment (PPE) such as latex gloves. In parallel, the occurrence of intentionally or accidentally discarded masks has created a major environmental problem. This paper presents the data of a longitudinal study of the occurrence of discarded face masks in an urban environment of a community in regional Australia. It demonstrates that the shift from voluntary to mandatory use of fitted face masks resulted in an immediate increase of publicly discarded masks and other items of PPE. The overserved spatial and temporal patterns allow us to draw inferences on human behavior.

Keywords: COVID-19; personal protective equipment; face masks; littering; human discarding behavior

1. Introduction

Between January and March 2020, COVID-19, the disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1], rapidly developed into a truly global pandemic, affecting every continent. As the year 2020 merged with 2021, several countries have experienced a second and even a third wave of infections [2]. Governments at each national level engaged in measures to curb or at least slow the progress of COVID-19. Given that SARS-CoV-2 is primarily transmitted via aerosols emitted from infected persons [3,4] many governments have recommended or mandated the wearing of fitted face masks as part of their public health initiatives [5–8]. The public had, in essence, two choices: single-use, disposable surgical masks and multi-use, washable cloth masks [9]. Since then, an increasing body of literature has highlighted the threat that discarded single-use face masks pose to the environment. The magnitude is readily illustrated by a search of GoogleScholar (on 16 August 2021), which found 2730 results for the keyword combination “COVID + face mask + pollution.” Of particular concern was entanglement [10] as well as ingestion by wildlife [11] and the long-term impact of microplastics [12,13] in particular due to physical wear and UV degradation [14,15]. The numbers are truly staggering with an excess of three billion masks discarded globally each day [12]. While the majority of the masks ends up in landfill or is incinerated, a single disposable mask decaying in the environment can release 1.5 million microplastics [14].

This paper will be concerned with the situation with a community in New South Wales (NSW), Australia’s most populous state. As the health system in Australia is state-based, public health regulations differ across the country. The wearing of fitted face coverings (masks) was recommended by NSW health authorities on 6 August 2020 in situations where social distancing (staying apart 1.5 m or having less than 4 m²/person in enclosed spaces) was not feasible [16]. It cannot be assessed to what extent this was followed as there are no data on the mask-wearing behavior of the Australian population. The NSW government mandated the wearing of masks for all persons over 12 years of age in the Greater Sydney area from 2 January to 26 March 2021 [17,18].

After the Delta-strain of COVID-19 seeded in Sydney (NSW) on 5 May 2021 and began to spread through the community, the NSW government strengthened the conditions for...
the wearing masks in the Greater Sydney area from the 6 May [19,20] and extended this across the entire state on 26 June [21]. The carrying of masks when outside the private home became mandatory for all people ages 12 years and older on 15 August 2021, at the same time as a state-wide lockdown was declared [22].

As part of a broader project on the assessment and documentation of cultural heritage aspects of the COVID-19 pandemic [23], the author had been examining the material culture and ephemeral structures associated with COVID-19 [24,25]. As an extension of that work, the occurrence and type of discarded or lost items of PPE on the streets of Albury (NSW) was systematically documented since mid-November 2020. Drawing on the longitudinal nature of the observations, this paper will examine whether the public policy shift from voluntary to mandatory use of fitted face masks in enclosed public spaces resulted in an increase of publicly discarded face masks in the urban and natural environment.

2. Materials and Methods

This paper employs a mixed methods methodology, encompassing physical survey and lived experience with participant observation.

2.1. Survey Location and Timing

All data were collected in Albury, a rural service center located in regional Southern New South Wales (NSW), Australia, with an estimated population of 54,353 people (census 2016: 51,076), [26,27]. The survey area is comprised of central Albury, and covers the CBD, peripheral main streets to the north, south and west, and established suburban residential streets to the west.

The physical survey had to be terminated on 15 August 2021, after a state-wide lockdown was declared [22], curtailing the author’s movements.

2.2. Survey Method

The physical survey, carried out by the author, recorded observations of discarded/lost face masks and latex/nitrile gloves on the streets and footpaths of the city between mid-November 2020 (week 46) and August 2021 (week 32). The survey process itself comprised of a walk-through of parts of Albury’s street grid, with the author (a trained archaeologist) scanning for evidence of discarded PPE. Given the nature of the background (pavement, nature strips, lawns) and size of the masks, object recognition was high [28]. All facemasks and latex/nitrile gloves encountered were photographed in their setting and as a close-up image, which allowed the author to classify the type of location and the type of mask/glove encountered (see Table 1).

| Table 1. Distribution by type of location of masks and gloves (Albury, December 2020–August 2021). |
| --- |
| **Pedestrian** |
| Disposable | KN95 |
| Cloth | Blue | Black | Plain | Valve | Gloves | Subtotal | Total |
| footpath, main street | 1 | 27 | 1 | 1 | | 29 |
| footpath, other | 1 | | | | | 1 |
| footpath, residential street | 2 | 13 | | 1 | | 16 |
| footpath, shopping street | 14 | | 1 | | 1 | 17 |
| footpath, university campus | | 1 | | | | 1 |
| all pedestrian | | | | | | 64 |
| **Parking** |
| carpark, cinema | | | | | | 6 |
| carpark, club | | | | | | 15 |
| carpark, general | | | | | | 3 |
Table 1. Cont.

| Location                                  | Disposable |      | KN95 |      |
|-------------------------------------------|------------|------|-----|------|
|                                           | Cloth      | Blue | Black| Plain| Valve| Gloves| Subtotal| Total |
| carpark, medical centre                   | 7          |      |      |      |      |        |         | 7     |
| carpark, offices                          | 3          |      |      |      |      |        |         | 3     |
| carpark, school                           | 3          |      |      |      |      |        |         | 3     |
| carpark, shopping                         | 2          | 41   | 1    |      | 1    |        |         | 45    |
| carpark, shopping specialist              | 48         |      |      |      |      |        |         | 48    |
| car park, sports complex,                 | 1          | 7    |      |      |      |        |         | 8     |
| parking, main street (in gutter)          | 1          | 27   | 1    |      |      |        |         | 29    |
| parking, main street (in vegetation)      | 4          |      |      |      |      |        |         | 4     |
| parking, private business                 | 2          |      |      |      |      |        |         | 2     |
| parking, residential street (in gutter)   | 9          |      |      |      |      |        |         | 9     |
| parking, residential street (in vegetation)| 1         |      |      |      |      |        |         | 1     |
| parking, shopping street (in gutter)      | 1          | 22   |      | 3    |      |        |         | 26    |
| parking, sports complex (in gutter)       | 3          |      | 1    |      |      |        |         | 4     |
| all parking                               |            |      |      |      |      |        |         | 213   |
| On the street                             |            |      |      |      |      |        |         | 11    |
| street, main                              | 2          |      |      |      |      |        |         | 2     |
| street, residential                       | 2          | 1    | 1    | 1    | 1    |        |         | 5     |
| street, shopping                          | 4          |      |      |      |      |        |         | 4     |
| all on the street                         |            |      |      |      |      |        |         | 11    |
| Greenspaces                               |            |      |      |      |      |        |         | 28    |
| greenspace, in waterway                   | 1          |      |      |      |      |        |         | 1     |
| greenspace, park                          | 2          |      |      |      |      |        |         | 2     |
| greenspace, residential                   | 4          |      |      |      |      |        |         | 4     |
| greenspace, roadside verge                | 3          | 1    |      |      |      |        |         | 4     |
| greenspace, sports complex                | 2          | 15   |      |      |      |        |         | 17    |
| all greenspace                            |            |      |      |      |      |        |         | 28    |
| Other                                     |            |      |      |      |      |        |         | 1     |
| public toilets                            | 1          |      |      |      |      |        |         | 1     |
| all other                                 |            |      |      |      |      |        |         | 1     |
| Total                                     | 13         | 288  | 2    | 4    | 1    | 9      | 317     | 317   |

Even though the survey sampling framework is unsystematic, inasmuch as the data were not collected in a randomized or stratified (e.g., specific street types) fashion, the data collection is internally consistent. Methodologically, the survey is comprised of continuous loop walk-overs and point-visits. It is based on and reflects the author’s lived experience movement pattern over the 43-week period, which was defined by commutes to work (by car), shopping and recreational activities. While there was some week-to-week variation (e.g., trips to specialty shops such as hardware stores), the overall pattern is comprised of intermittent shopping during the work week (with site fidelity), mid-week visits to a sports stadium, a major grocery shop on the weekend (usually the same sub-localities) and extended recreational walks (with a dog) through the streets of the CBD and adjacent parkland on the weekend (with the exception of the work commute all primarily within a 2.8 km² area).
2.3. Limitations

While this methodology, primarily the subjectivity of the survey design, has its limitations, the streets and areas covered by walks throughs and point visits in the weeks prior to and after the introduction of mandated face coverings are the same and, thus, the observations are internally consistent.

A further potential limitation is the street waste removal carried out by the municipal government. As the street cleaning trucks operate on a weekly schedule, however, the data collection, which follows a regimented weekly pattern, remains internally consistent.

2.4. Statistics

The significance assessment of observed differences in proportions used the Chi-squared test with n-1 correction of the MEDCALC comparison of proportions calculator [29–31].

3. Results

The data set is comprised of 319 observations, nine of which were gloves. The weekly frequency of discarded and dropped masks and gloves observed in Albury is plotted in Figure 1. Also marked are the dates of the mask mandates and the commencement of lockdown. The dip in week 28 was caused by the author being in mandatory self-isolation waiting for the delayed results of a COVID-19 test [32,33] which effectively terminated the author’s movements for 96 h, 60 of which were the weekend of week 28. The histogram shows the increase in discarded masks soon after the mandatory ruling came into place, followed by a dramatic spiking in weeks 31 and 32.

![Figure 1](image)

**Figure 1.** Frequency of discarded and dropped masks and gloves observed in Albury, November 2020–August 2021.

The vast majority of the observations of masks (92.2%) occurred during the period when mask-wearing was mandatory (from week 26), resulting in an average daily observation of 5.78 masks/day, compared to an average of 0.14 masks/day in the pre-mandatory period. The overwhelming majority of masks encountered were white and blue single-use surgical masks (93.5%) followed by re-usable cloth masks (4.2%) (Figure 2i). Single-use type KN95 masks (with or without exhale valve), commonly used in industrial and construction workplace settings (paint, dust) (Figure 2j–l) were less common (1.6%), as were black single-use masks (Figure 2h) (Table 1).
Figure 2. Types of masks and discard patterns observed during the study.
The majority of masks were in carparks and in street gutters next to parking bays (67.2%), followed by masks encountered on or next to footpaths (20.1%) and on greenspaces (9.1%) (Table 1). Only a small number of masks were seen on the road surface of streets (3.2%). The proportion of masks in carparks and street parking locations was significantly greater than that for masks on footpaths and greenspaces (both \( p < 0.0001 \)). The proportion of masks encountered in carparks is statistically significantly greater than that seen in street gutters next to parking bays \( (p < 0.0001) \).

A number of disposable facemasks were observed with torn loops, with 12.8% in carparks and 9.1% in street parking situations, as well as 9.8% on footpaths. While there was no statistically significant difference in the proportions of masks with torn loops between carparks and footpaths, carparks had significantly more torn loops than street parking \( (p = 0.4565) \). The highest proportion of torn loops (25%) was observed on greenspaces, which is significantly greater than carparks \( (p = 0.1498) \), street parking \( (p = 0.0693) \) and footpaths \( (p = 0.0928) \).

4. Discussion

Single-use surgical face masks have been alluded to as ‘the new cigarette butts’ in their capacity to become a ubiquitous urban refuse item [34]. Unlike in the case of cigarette butts, which are always symbols of an intentional discarding by people broadly apathetic to environmental concerns [35,36], there is another principal plausible reason for the presence of fitted face coverings found on the ground in outdoor settings: accidental loss. In the following, we will discuss the data in terms of the mechanics of discarding and what the patterns can tell us about the underlying behavior. The masks that were encountered may have been (i) dropped unobserved (genuine loss); (ii) accidentally dropped but not retrieved due to apathy (passive littering); or iii) intentionally discarded (active littering).

Active littering applies to the masks that were encountered with torn loops (Figure 2b) or were scrunched up (Figure 2i). Such masks were particularly frequent outside the Lauren Jackson sporting complex (located peripheral to the CBD), where the wearing of masks was mandatory for spectators for the duration of being inside the stadium, and for players (over 12 years of age) and coaches while entering and exiting the sports complex (Table 1). Observations during July and August showed that almost all visitors removed their masks almost immediately upon exiting, often while juggling other paraphernalia such as items of clothing, balls and drink bottles.

Past studies have shown that the presence of litter and/or the absence of trash receptacles increased a person’s propensity to actively litter or not to remove their accidentally dropped litter items [37,38]. In the setting of the sport center, permanent trash receptacles are placed at the entrance/exit. As a consequence of the COVID-9 pandemic, the visitor flow had to be unidirectional. However, all spectators and players were directed to exit through emergency exists where no trash receptacles were provided. Observations at other locations, where such unidirectional flow was not mandated, showed that while a few patrons continued wearing masks until they reached their car, most removed their masks immediately on exiting major premises, and either discarded them in trash receptacles (Figure 3) or took them to their vehicle.
The literature suggests that active littering is less common than passive littering, with the incidence of the latter determined by the length of latency between the item being placed in the environment and the person leaving the location [39]. The broad-scale spatial patterns evident in Table 1 show the bulk of masks was encountered at carparks and in street gutters next to parking spaces. This suggests a loss or discarding of masks when getting in or out of vehicles, which is not surprising, given that most of the local transport is by private car. A commonly observed behavior was that people partially removed their mask, letting it dangle from one ear (Figure 4). This was noted when people were loading purchased goods into their cars and while communicating with others. Given the lightweight nature of the disposable masks, it is not surprising that some would have fallen off. Examples for single-use masks dropped accidentally are those that were used and neatly folded (Figure 2g) and presumably slipped out a pocket when other items, such as car keys, were retrieved. In multi-space carparks, the majority of masks were observed near the lines delineating parking spaces rather than in the center of the parking spot, suggesting they were dropped while getting in or out of the vehicle. This is not surprising given that many drivers appear to keep their spare masks in the side pockets of their car doors. This is corroborated by a number of masks that appeared to be a pristine condition without evidence of having been worn (Figure 2a), and where without evidence that they had been retrospectively flattened out by car tyres (see Figure 2c for such an example).
Figure 4. Human behavior while communicating (10 August 2021).

While the high concentration of single-use masks encountered in the carparks of supermarkets is in keeping with the higher rate of active and passive littering (in particular shopping dockets) observed there, the same cannot be said for masks observed in gutters of street parking bays.

The proportion of accidental loss compared with passive and active littering can be inferred from the nature and the condition of the masks. As noted, 95.8% of the masks encountered on the ground were single-use type masks (blue and white surgical and KN95 masks). Yet, data from a rapid walk-through survey of various shopping locations of Albury showed that 32.4% of the people were wearing cloth masks [40]. The lower proportion of cloth masks in the sample encountered on the ground (4.2%) compared to the proportion noted during the rapid walk-through survey is significant at $p < 0.0001$. Given the expenditure involved ($4–25 per piece, all prices in Aus$), and since they are washable, it can be expected that an accidentally dropped and soiled cloth mask would be retrieved to be cleaned and reused at a later date, whereas an accidentally dropped and soiled single-use mask has no further purpose. Thus it can be surmised that any cloth mask encountered on the ground would have been lost rather than discarded.

The costs of single-use surgical masks, on the other hand, is quite low. Depending on vendors, they ranged from $1–2 for single masks and $4–10 for packs of ten. Subject to availability, boxes of 100 masks could be obtained for $25–30. The prices of KN95 masks ranged from $40 charged by a hardware chain (or $4 for packs of 10) to $2.95 charged by a stationary chain (all prices pers. obs. July and August 2021). In addition, some venues chose to provide free single-use surgical face masks to retain customers who forgot to bring a mask.

Extrapolating from the ratios of cloth masks encountered on the ground worn vs. those worn, suggests that only about 9.1% of all masks encountered in the ground are genuine losses. If we add on another 10% as cases of active littering, then about 80% of the single-use surgical masks encountered on the ground represent passive littering.

On a broader level, the data discussed in this paper also reflect cultural and cross-cultural differences in mask-wearing behavior and attitudes towards littering. Overall, the level of littering in Albury is low, a fact which is influenced by the generally conservative nature of the population of a rural service center with very low incidence of anti-social behavior (e.g., graffiti, vandalism), and by the existence of an effective municipal garbage removal system. By and large, masks were worn as mandated. For example, when the wearing of masks in indoor venues became mandatory [21], people who don masks prior entering the premises, but not when driving or walking on the street (pers. obs.). Once
the wearing of masks became mandatory while being outdoors (unless exercising) [22], people who do not wear masks when exiting their cars, but not while driving (pers. obs.). Setting aside public anti-mask protests, which were mainly confined to the metropolitan cities [41], mask-wearing was perceived as a personal chore/necessity rather than being embraced as community effort as in some other countries where masks tend to be worn as soon as the person leaves the house [42,43].

In the absence of qualitative data, it is unclear to what extent people perceive single-use masks as litter that is non-harmful to the environment. While micro-plastics have been repeatedly in the news in the early part of 2021, there appears to be a disconnect between awareness of the existence of microplastics (and their environmental consequences) [44,45] and the discarding of single-use masks and the resulting microplastics. Indeed, recent media items certainly comment on the polluting effects of discarded single-use masks, but only allude to them as a macro-litter [46].

5. Conclusions and Future Directions

The NSW state-wide introduction of the mandatory use of fitted face masks in indoor spaces on 26 June [21] resulted in increased occurrence of intentionally or accidentally discarded masks (and gloves) in the urban environment of Albury. The effects of the change in policy were only detectable because baseline data existed to extend for a considerable period.

There is a need to develop further baseline datasets, in particular for situations where the discarded PPE may not only constitute an environmental, but also a public health hazard. Considerations for future surveys of this nature, at other locations, should draw on systematic linear transects (streets and non-vehicular paths) and small-scale area surveys (parking lots) using in socio-economically stratification for site selection, augmented by usage data (vehicle counts, pedestrian counts). Such a survey frame can be developed using census and planning data.

As the analysis has shown, 80% of the single-use masks seems to have been accidentally dropped but left on the ground as an act of passive littering. This high degree of environmental apathy is of concern. There is space for qualitative research into PPE-related litter behavior once the lockdown periods have come to an end and social research is again possible. Given that SARS-CoV-2 will not be the last and that it is predictable from an epidemiological point of view that another zoonotic coronavirus will manifest itself in the foreseeable future as an epidemic [47], such research will have practical implications in the foreseeable future.

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