Face masks, a new environmental issue in Te Tai Tokerau driven by the COVID-19 pandemic? Summary of preliminary findings.

Amount of face masks (approx. 1,0000) collected between September and November 2021 (Photo: TTTDMP)

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The global issues associated with face masks

One of the consequences of the current COVID-19 pandemic has been the widespread and surge in the production and consumption of personal protective equipment (PPE), including single-use surgical face masks (FMs) (Tesfladet and Ndeh, 2022). For example, early during the COVID-19 pandemic, the global widespread and indiscriminate use of FMs was estimated at 129 billion per month (Prata et al., 2020).

Unfortunately, the extensive use of FMs has generated global environmental issues through their improper and indiscriminate disposal, whether accidental or deliberate, and the paucity of information regarding their safe disposal. These issues include:

a) The worsening of persistent plastic pollution and other types of pollution in both terrestrial and aquatic environments. FMs are made from plastic non-woven fabrics, which are composed of plastics such as polyacrylonitrile (PAN), polycarbonate (PC), polyethylene (PE), polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET), and polyurethane (PU) (Aragaw, 2020). Their disposal results in the release of both micro- and nano-plastics, microfibers, as well as Pb, Cu, Sr, Zn, Mn, Ti, and environmentally persistent free radicals or EPFRs (e.g. Fadare and Okoffo, 2020; Saliu et al., 2021; Liu et al., 2022). This type of pollution can aggravate the risks to our ecological systems (e.g. Wang et al., 2021). According to Shen et al. (2021), a fully weathered FM could release several billions of microplastic fibers into the aquatic environment.

b) Solid waste management challenges, such as change in waste amount, composition, timing/frequency, distribution, and risk, affecting the handling and treatment practices (e.g. Fan et al., 2021).

c) The possibility of FMs to act as a medium for disease outbreak, transmission of the virus. Plastic particles and fibres can survive for several days on inanimate matter (e.g. Mol and Caldas, 2020; Abedin et al., 2022) and are known to propagate microbes such as invasive pathogens (Reid et al., 2019).

d) Potential impacts on human health via the exposure to PPE-derived pollutants through direct and indirect pathways (e.g. inhalation of microplastics). These pollutnats may cause detrimental and cytotoxic effects (e.g. De-la-Torre et al.; 2021).

e) Impacts on wildlife. Impacts include entanglement and ingestion (e.g. Fukuoka et al., 2022; Gallo Neto et al., 2021), the accumulation of microplastics across the food web (e.g. Aragaw, 2020), and the potential zoonotic transmission in marine animals (e.g. Mathavarajah et al., 2020).

Mandating face masks in Aotearoa New Zealand

Wearing a face mask was not mandated in New Zealand during the first lockdown around April 2020 but became mandatory on August 21, 2020 under Alert levels 2, 3, and 4 for anyone using public transport and ride-sharing apps. The decision was made following the recent transmission of Covid-19 on public transport (Kronast, 2020).

On August 18, 2021, while under Level 4 (lockdown), FMs became mandatory for anyone over the age of 12 when accessing essential services (e.g. supermarkets, pharmacies, dairies, and service stations) to protect essential workers and reduce the risk of transmission from the virus. This has led to the noticeable increase of FMs found in our environment or taiao compared to 2020 (COVID-19 Public Health Response (Alert Level Requirements) Order (No 9) Amendment Order 2021).

On February 3, 2022, several changes were made to mask rules in the red traffic light system to slow down the spread of the Omicron variant. Anyone should wear a FM whenever they are indoors (except when at home and in some cases when at work). Masks must be worn at food and drink businesses, close proximity businesses, events, and gatherings. Face coverings must be an actual FM (i.e. bandannas, scarves, etc., are no longer accepted). Also, workers who are mandated to be vaccinated must wear a medical FM (e.g. surgical masks). Finally, all children from Year 4 and up must also wear a mask on public transport (including school buses) and indoor settings at school (COVID-19 Public Health Response (Protection Framework and Other Matters) Amendment Order 2022). Members of the public are also encouraged to wear a mask whenever leaving the house. These changes are likely to increase the number of FMs discarded improperly.

From April 5, 2022, My Vaccine Pass is no longer required although businesses can still use the system if they choose to do so. Wearing a FM in most indoor settings remains while the country is still under a red light system. According to an official government website, wearing a FM can reduce new cases of the virus by as much as 53%. FMs are, therefore, meant to contribute to lowering case numbers, the number of people hospitalised, and the number of deaths (Unite against COVID-19, 04 April 2022).

Face masks in Te Tai Tokerau/Northland

Te Tai Tokerau moved to Alert level 3 on September 2, 2021 and to Alert level 2 on September 7 2021. It then moved back to Alert level 3 between October 8 and October 18 before changing to the new Traffic Light System with the rest of the country on December 2, 2021. The region has been under the "red traffic light" since then, except for a few days between January 20 and January 23, 2022

Following the change to Alert level 2 and being out of lockdown (Level 4), Te Tai Tokerau Debris Monitoring Project (TTTDMP) observed anecdotally that the number of FMs appeared to increase while conducting weekly surveys of parking tickets at three specific car parks in Whangārei (Laurie Hall, Carruth Street, and Town Basin). As a result, on September 19, a new project was initiated with the following main objectives:

a) Quantify FM types among surveyed areas and;
b) Identify FM densities and accumulation of surveyed areas.

FMs collected have been recorded using a specific data form created using ArcGIS Survey123 ((c) ESRI, also available from any browser). Information collated include the type, state (i.e. how many strings are still intact), and location of FMs (region and specific site, e.g. car park, gutter, etc.). Results are then shared publicly on TTTDMP webpage via an interactive dashboard (Fig. 1) created using ArcGIS dashboard ((c) ESRI). Random surveys have been conducted in the region with the help of citizen scientists, while TTTDMP lead researcher, Dr Manue Martinez, has undertaken both weekly (car parks mentioned above, covering 17,115 m^2) and monthly (city centre, covering 146,110 m^2) systematic surveys.

Preliminary results from surveys conducted by TTTDMP

By the end of September 2021 or a two-week period, over 300 FMs had already been collected from both random and systematic surveys, highlighting a new issue for the region (Vidyadahran, 2021). At the end of February 2022, the number of FMs collected had increased to 2,736 and were found in many areas around the region (including in the Waipoua Forest; Fig. 2), with Kaitaia being the northernmost area randomly covered (Figs. 2a). The majority of FMs were collected around Whangārei, where TTTDMP lead researcher and most citizen scientists are located (Fig. 2b, c).

Within the region, the majority of FMs were collected in gutters (20.9%, n = 555), followed by grass/vegetation on the roadside (18.1%, n = 480), and car parks ground (16.4%, n = 434; Fig. 3).

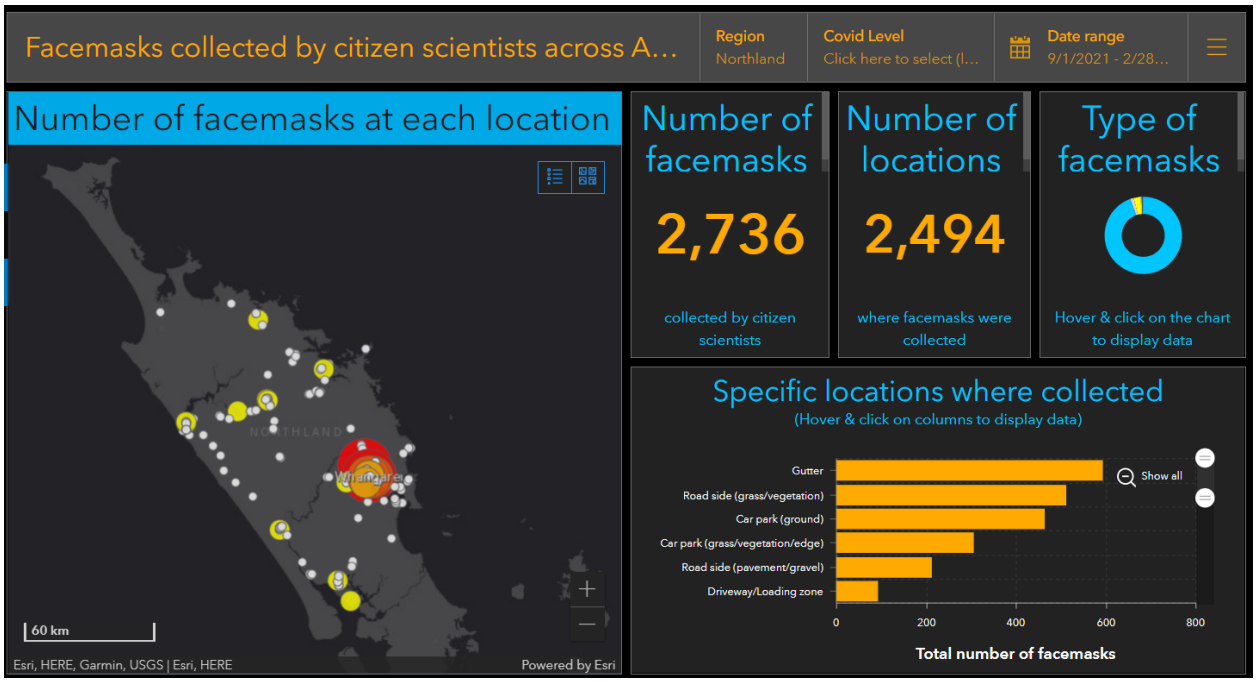

Fig. 1: TTTDMP interactive dashboard displaying the results of FMs surveys in Te Tai Tokerau/Northland from September 19 2021 onward.

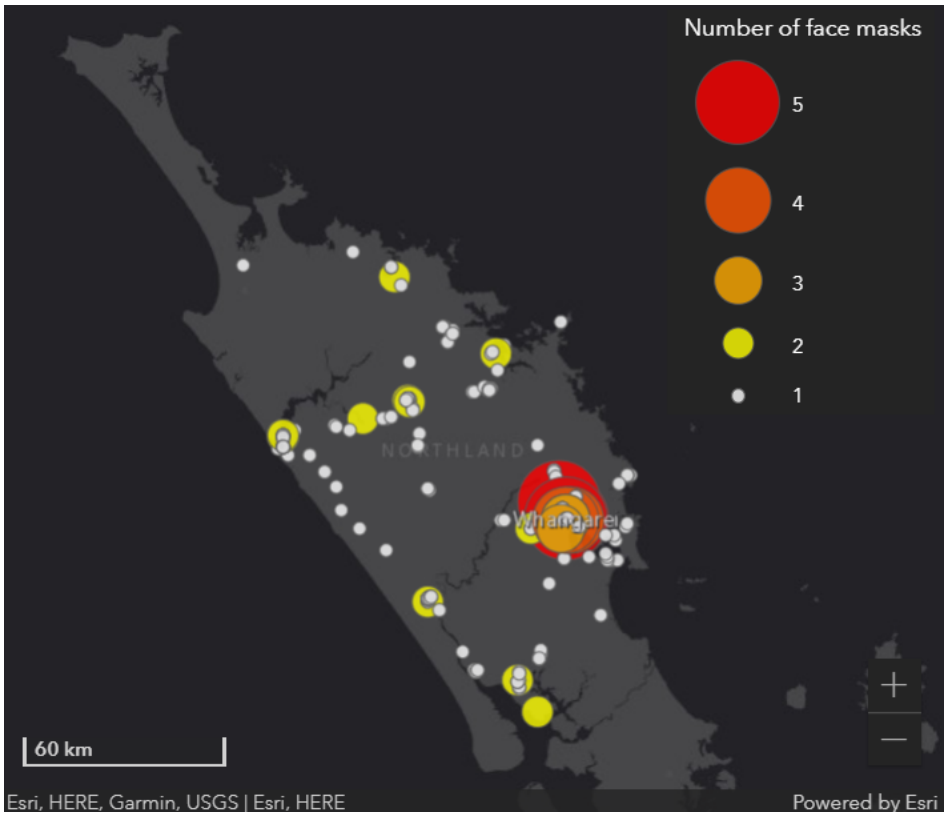

Fig. 2a: TTTDMP interactive dashboard displaying the location of FMs collected between September 19 2021 and February 28 2022 in Te Tai Tokerau/Northland.

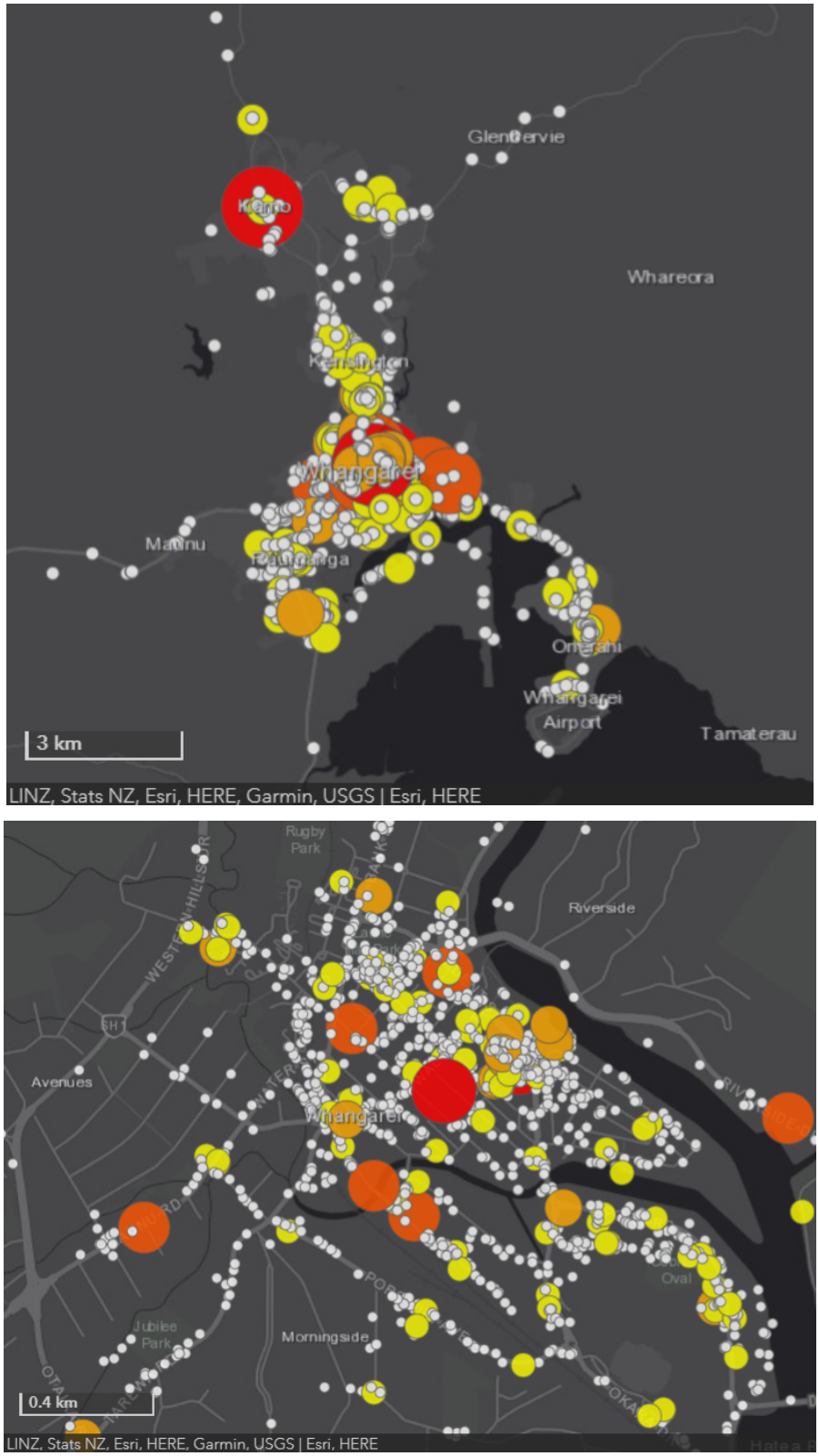

Fig. 2c: TTTDMP interactive dashboard displaying the location of FMs collected between September 19 2021 and February 28 2022 in b) Whangārei and c) Whangārei city centre, Te Tai Tokerau/Northland.

Fig. 3: Examples of specific locations where FMs were collected by TTTDMP between September 19 2021 and February 28 2022 in Te Tai Tokerau/Northland (Photos: TTTDMP).

Type of FMs

The majority of FMs collected were single-used surgical FMs (94.5%, n = 2,566), followed by cloth (2.8%, n = 77), and KN95 masks (1.5%, n = 40). This trend is consistent with the systematic surveys (surgical: 92.3%, n = 626; Cloth: 3.7%, n = 21; KN95: 1.3%, n = 9) and with studies conducted in Albury, Australia (surgical FMs: 91.8%; Spenneman, 2021a) and Metropolitan Toronto, Canada (surgical FMs: 95%; Ammendolia et al., 2021).

Cloth masks recorded (2.8-3.7%%) can be regarded to be genuinely lost (only one had a broken string), while the others are examples of passive and active littering. Given that 76.6% of surgical FMs (n = 2,027) with information recorded on the strings had still both strings intact, the inability to use this type of single-use FMs cannot be the cause of their indiscriminate disposal. In Albury, Australia, Spennemann (2021b) demonstrated that while cloth FMs were worn by 33.6% of the public, over 90% of FMs found littered in public places were of the single-use type. According to the author, this reflects the community's rubbish discard behaviour rather than the actual usage of mask type. Anecdotal observations from TTTDMP suggest that this phenomenon might also apply in Te Tai Tokerau.

Mean density of FMs in Whangārei

The highest numbers of FMs collected randomly occurred in October (n = 398) and November (n = 456) 2021 when more time could be dedicated to such surveys (Fig. 4). Results from systematic surveys (Fig. 4), however, indicate that more FMs were collected in December 2021 (n = 167) and February 2022 (n = 168), which better reflect actual trends. More people were likely in the city as we approached the end of the year holidays and in February, a new order regarding FM was put in place.

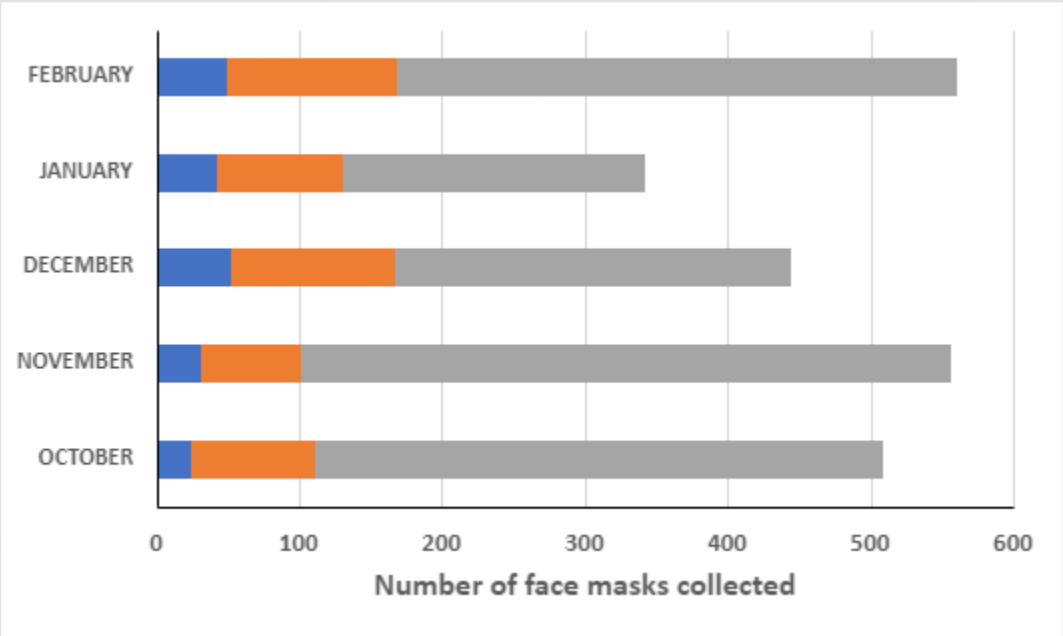

Fig. 4: Number of FMs collected randomly in Te Tai Tokerau/Northland (grey), car parks (blue) in Whangārei, and around Whangārei city centre (orange) between October 1 2021 and February 28 2022.

When comparing the results of the systematic surveys in Whangārei (Fig. 5), the mean density of FMs was higher in car parks than in the city, which would be expected. In Metropolitan Toronto, Canada, Ammedolia et al. (2021) found the highest density of PPE in the large grocery store parking lot at 0.00475 items/m2, where there is a higher foot traffic and usage.

Within the car parks (Fig. 5), the mean density of FMs has been increasing since October, with a peak in December. A peak also occurred in December in the city centre.

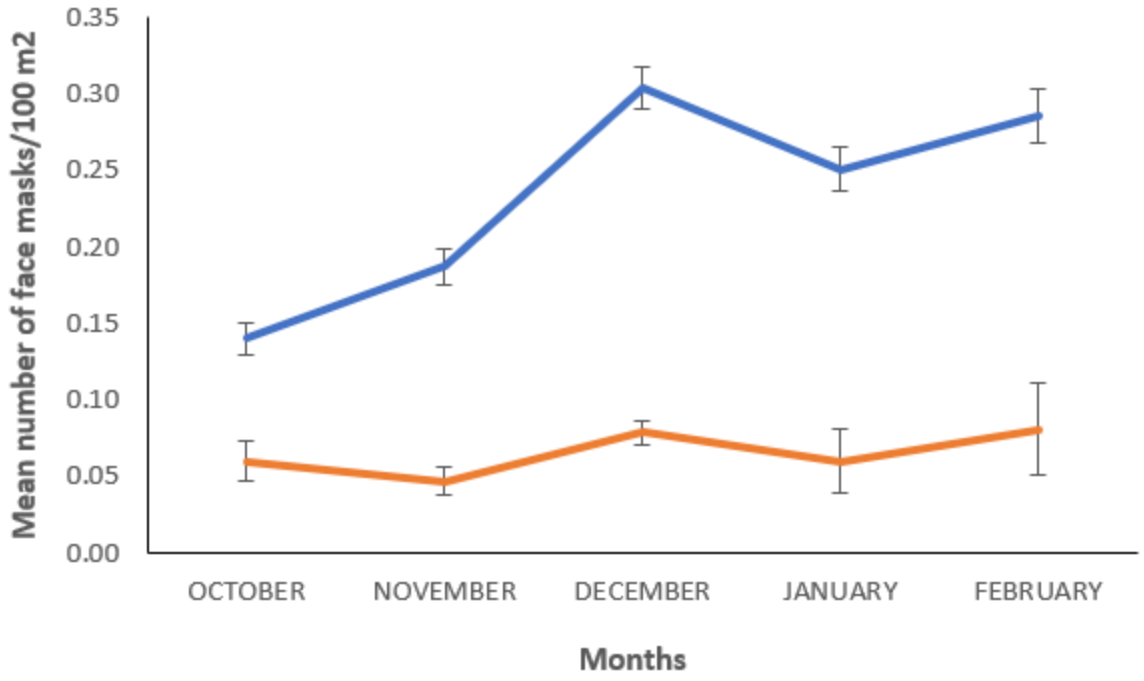

Fig. 5: Mean number of FMs collected per 100 squared metres in car parks (blue) and around Whangārei city centre (orange) between October 1 2021 and February 28 2022. Error bars represent the standard errors of the mean.

Estimated daily surgical FM use and waste generation in Te Tai Tokerau and Aotearoa New Zealand

The estimated daily surgical FM generation (DFM) was calculated for both Te Tai Tokerau and Aotearoa New Zealand based on the following equation:

$$DFM = T_p \times U_p \times A_r \times A_c$$

where T_p is the total population of a given area, U_p is the percentage of people using surgical FMs, A_r is the percentage of FM wearing compliance rate, and A_c is the estimated daily FM use per capita. T_p was based on Stats NZ population estimates for 2021. Here, we used the total population for people above 14 years old as children under 12 are not mandated to wear FMs. U_p was based on Spennemann's (2021b) study (i.e. 76% wear non-cloth FMs) as no data are currently available in New Zealand. A_r or compliance to wear a FM in public places was estimated at 93% from Kaine et al. (2022), assuming that all 7% of skeptics regarding the efficiency of wearing a mask do not wear a FM. The same scenario described in Torres and De-la-Torre (2021) and based on only surgical FMs was applied to calculate A_c. A_c was determined as 1 FM per day per person. Three additional scenarios were also included, where A_c was set as 0.2, 0.1, and 0.05 FM per day per person, to represent FMs that are 5, 10, and 20 times reusable. Calculations are shown in Table 1. Finally, the average weight of a surgical FM is approximately 3.35g.

The overall daily FM waste generation could reach 107,681 masks day^{-1} and 2,936,047 masks day^{-1} under the single-use scenario for Te Tai Tokerau and the whole country, respectively (Table 1). These amounts could translate to 361.3 kg day^{-1} and 1,967.2 kg day^{-1} of waste. The overall waste generation lowers proportionally with varying the assumption of one daily FM per capita (Table 1). Given that many people keep their FMs in the cars, often hanging from the rear mirror (EM, pers. obs), surgical FM usage and waste generation is more likely to be closer to the lower ranges. From global estimates that 10% of litter reaches the ocean (Avio et al, 2017), between 540 and 10,786 FMs in Te Tai Tokerau (197,100-3,936,890 year^{-1}) and between 14,680 and 293,605 FMs in New Zealand (5,358,200-107,165,825 year^{-1}) could eventually reach our oceans from our daily usage.

Table 1: Estimated daily FM usage and waste generated in Te Tai Tokerau and Aotearoa New Zealand.

Population (> 14 yo)	Use of surgical FMs (%)	FM compliance rate (%)	FM/day/ capita	Total daily FMs	Total waste/day (kg)
Northland					
152,604	76.0	93.0	0.05	5,393	18.1
			0.1	10,786	36.1
			0.2	21,572	72.3
			1	107,861	361.3
Aotearoa/NZ					
4,154,000	76.0	93.0	0.05	146,802	491.8
			0.1	293,605	983.6
			0.2	587,209	1,967.2
			1	2,936,047	9,835.8

Recommendations:

TTTDMP preliminary results reinforce the recommendations made by other studies on PPE litter. Waste currently created by mass use of FM in our region as well as nationally is likely unsustainable.

There is, therefore, an urgent need to limit the number of FM entering our taiao. Waste management systems, significant efforts, and changes are paramount to the quality of human health and the environment, respectively. These include the following:

a) Increased and improved public education on the need to dispose of FM properly, including the effects associated with their indiscriminate disposal. Most of the official Covid-19 posters requiring members of the public to wear FM mention the importance of kaitiakitanga (Fig 6, top). If they do, there is no mention of cutting the strings to reduce potential effects on wildlife (i.e. entanglement; Fig 6, bottom).
b) Proper collection system for FM. Dedicated bins could be made accessible to the public at various vantage points such as in heavily used businesses or institutions (e.g. supermarkets, schools), marae, government buildings, health sector, and in any large organisation with over 50 employees. More productive ways of handling this type of waste and other PPEs should be encouraged.
c) Proper disposal of FM waste. The content of the bins mentioned above could be collected with the help of Northland Waste Management, compacted, and sent away to be recycled into construction material (e.g. into fence posts by FuturePost). Another option includes the pyrolyzation of PPE to recycle medical plastics into oil (e.g. Aragaw and Mekonnen, 2021) and/or the use of FMs fibres to improve the strength of concrete (Kilmartin-Lynch et al., 2021) .
d) Promote the production of biodegradable FM (e.g. made with hemp or flax) to replace polypropylene. Natural textile FM can be made anti-microbial by applying various herbal anti-microbial extracts (Pandit et al., 2021)

Fig. 6: Examples of official Covid-19 posters promoting the use of FMs in Aotearoa New Zealand.

Further study:

TTTDMP is seeking support to:

a) Implement solutions to reduce and minimise waste generated by FM and other PPE waste at the local, regional, and national level;
b) Continue both weekly and monthly systematic surveys in Whangārei (up to 3 months following the end of mandating FMs);
c) Assess the effectiveness of management systems put in place to reduce the amount of waste created by FMs (e.g. dedicated bin disposal);
d) Expand random surveys to the whole region, including the marine environment; and
e) Encourage more citizen scientists to take part and collect data.

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