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Koi Tū Rapid
Evidence
Brief

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IMPROVING MASK USE TO REDUCE COVID-19 TRANSMISSION

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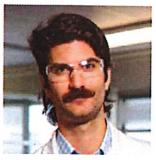

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IMPROVING MASK USE TO REDUCE COVID-19 TRANSMISSION

Key points:

The importance of mask wearing has been heightened by the emergence of the highly transmissible Delta variant of the virus that causes COVID-19. Mask wearing is a core part of blocking transmission of the virus between people and stopping its incursion into New Zealand, but there are multiple types of masks, and their effectiveness depends on how they are used. This rapid evidence brief reviews the scientific literature and evidence. It concludes that the following guidelines would offer higher protection:

FOR THE GENERAL PUBLIC

At all COVID-19 Alert Levels:

- A public educational campaign is suggested with emphasis on tight-fitting medical or three-layer cloth masks. It is essential that these fit snugly and seal well around facial contours, particularly across the nose and around the cheeks and chin. Instructions for modifying medical masks to improve the seal should be provided. It is preferable that medical masks are not reused. They should be replaced after being worn for a maximum of six hours.
- Cloth masks should be made of at least three layers of cotton or similar fabric and shaped to provide a snug seal against the face. Cloth masks with fewer layers, and loose face coverings such as bandannas and scarves, do not provide sufficient protection and should not be used. Cloth masks should be washed frequently (preferably daily) with soap and hot water, and dried thoroughly before being worn again.
- N95 and similar respirator masks should be prioritised for essential and border workers.

At COVID-19 Alert Level 2 and above:

- Universal masking is recommended for all indoor shared spaces outside the household.
- Masking practices should be strictly observed in places where people congregate, for example in airport security queues and on public transport.

FOR ESSENTIAL AND BORDER WORKERS

At all COVID-19 Alert Levels:

- All workers **at the border** are strongly recommended to wear certified N95 or similar respirator masks at all COVID-19 Alert Levels. This includes all managed isolation and quarantine facility staff, airport staff, and all other essential personnel.
- All individuals quarantining in managed isolation facilities are strongly recommended to wear certified N95 or similar respirator masks whenever they are outside their own rooms.
- Ideally no other types of masks should be used in these high-risk situations.
- All N95 respirator mask users should receive training on the optimal individual fit and use of these masks.

At COVID-19 Alert Level 2 and above:

- All essential workers **inside the border** should wear certified N95 or similar respirator masks. This includes healthcare workers and employees of essential businesses such as supermarkets.

OUR EVOLVING UNDERSTANDING OF COVID-19 TRANSMISSION

Early in the pandemic, the coronavirus responsible for COVID-19, SARS-CoV-2, was thought to spread mainly via droplets. Droplets are relatively large particles produced through actions such as talking, coughing, or sneezing. They travel only short distances (one to two metres) before falling from the air. However, there is now compelling evidence that COVID-19 can also be spread via airborne transmission.[1] This is a key concern in dealing with the more transmissible Delta variant. In one instance, transmission of this variant occurred in a New Zealand quarantine facility when two doors across a hallway were open simultaneously for just three to five seconds.[2]

Airborne transmission is also known as aerosol transmission. Aerosols are particles that are much smaller and lighter than droplets. They are extremely effective at spreading viruses because they are produced even during ordinary breathing. Aerosol particles linger and drift in the air, and people can become infected by inhaling particles containing the virus. The exact size range defining an 'aerosol' is under debate. However, particles less than 100 micrometres in diameter (about the width of a human hair) can travel farther than two metres under normal conditions. As the particle size decreases, the distance it can travel increases.[3] Aerosol particles smaller than five micrometres in diameter are believed to hold greater concentrations of virus, and the smaller the size, the deeper a particle can penetrate the airways.[4] Aerosols can remain airborne for hours, particularly when the air is still. It is therefore critical to ventilate enclosed spaces such as indoor areas or public transport.[5]

The evidence for airborne transmission of COVID-19 has been accepted by the World Health Organization[6] and the New Zealand Ministry of Health.[7] In May 2021, the Ministry of Health acknowledged that airborne transmission requires emphasis on more advanced personal protective equipment.[8] Face masks are an important item of personal protective equipment. The discovery of aerosol transmission, the arrival of the more transmissible Delta variant, and the potential for concerning new variants to emerge means that it is time to carefully consider how best to use masks to reduce transmission.

Face masks and airborne transmission of COVID-19

Face masks have two potential roles in the management of COVID-19: (1) **source control**, to reduce the risk of spreading the virus when worn by people who are (or could be) infected (noting this can be in the asymptomatic phase), and (2) **user protection**, to reduce the risk of catching the virus when worn by healthy people. Mask use in managed isolation facilities deserves particular consideration because of the facilities' inherent riskiness. In July 2021, the Ministry of Health said that the risk of airborne COVID-19 transmission in these facilities is mitigated by masking returnees and using specific air filters (HEPA filters) in high-risk shared spaces.[9] Images in the news media and observations from those previously in managed isolation and quarantine facilities note that returnees in managed isolation facilities, as well as medical and New Zealand Defence Force staff working in and around these facilities, are supplied with standard medical masks (see Figure 1)[i].

Medical masks are designed to protect against fluid splashes and other forms of droplet transmission, not the much smaller aerosols.[10] They are not subject to the same level of testing that N95 and similar

i There are three broad categories of face mask used in the COVID-19 pandemic: (1) medical masks, (2) cloth masks, and (3) N95 and similar respirator masks. See Glossary for further detail.

approved respirator masks are.[11] Ministry of Health guidelines on mask use for managed isolation and quarantine facility staff were updated in November 2020 and significantly strengthened in August 2021 after the emergence of the Delta variant.[12] That update significantly extended the use of N95 respirators in MIQ although they did not make their use universal at the border.

Overseas, mask mandates have changed rapidly in response to rises and falls of case numbers. Several countries tightened mask requirements in response to the emergence of the Delta variant. Berlin currently requires N95 respirator masks in certain situations such as on public transport, and it requires either an N95 or medical mask in a range of indoor shared spaces.[13] Austria made N95 respirators mandatory in indoor public spaces (although cloth masks can now also be worn), and France recommended masks that performed to N95 standards. Some commentators in the United Kingdom have suggested implementing stricter mask requirements.[14] Major airlines in the northern hemisphere are also tightening their requirements towards properly worn medical masks or universal use of N95 masks.

This rapid evidence brief reviews what is known about the effectiveness of the three main types of face mask and suggests guidelines for upgraded mask use in light of the potential for future COVID-19 outbreaks.

EFFECTIVENESS OF MEDICAL MASKS

Figure 1: Medical mask

Summary:

- Laboratory tests suggest medical masks worn normally are 50-75 percent effective at filtering particles.
- Their effectiveness can be increased to 60-90 percent when they are modified to create a tighter seal against the face.
- They are intended to be used only once and for a limited time.

Formal studies of the value of medical masks in the fight against COVID-19 are limited because of its recent emergence. Thus, most studies of their effectiveness were conducted prior to the COVID-19 pandemic using other viruses such as influenza (the flu virus).

A review conducted in 2020 after the start of the COVID-19 pandemic (but prior to the Delta variant emerging) canvassed studies evaluating mask use for SARS-CoV-2, the specific coronavirus which causes COVID-19, as well as other types of coronavirus. The designs of these studies meant that the findings were limited to observing associations between mask use and infection rates, and could not directly attribute any change in infection risk to mask use. Overall, medical mask use was associated with a lower infection risk compared with no mask, and N95 respirators were slightly more protective than either medical or cloth masks.[15]

There are some experimental studies. One compared people during natural breathing who wore either no mask or a medical mask, and who were infected with coronavirus (not SARS-CoV-2), rhinovirus, or influenza virus. For coronavirus, viral concentrations were reduced in droplet and aerosol particles by wearing a medical mask; for influenza, viral concentrations were reduced in droplets but not aerosols; and for rhinovirus, masks made no difference to either droplet or aerosol viral concentrations.[16] Another study, published as a preprint in August 2021, was conducted during the COVID-19 pandemic and compared rates of SARS-CoV-2 infection in villages in Bangladesh. In the study's 'intervention' villages, around 42 percent of people wore medical masks, and in 'control' villages around 13 percent wore medical masks. The medical masks used were manufactured specifically for the study. Wearing masks reduced the rate of COVID-19 infection by 11 percent overall and by 35 percent in people older than 60 years of age.[17]

One experimental study compared the effectiveness of medical masks with N95 respirators when these are worn by patients diagnosed with COVID-19. The study showed that medical masks are less effective

than N95 respirators at preventing people emitting airborne virus particles. Seven patients were asked to cough while each wore no mask, a medical mask, or an N95 respirator. When patients wore no mask or a medical mask, SARS-CoV-2 was detected in petri dishes placed in front of patients in three out of seven cases. When patients wore an N95 respirator, no virus was detected. This study was small, but it suggests that medical masks are less effective than N95 respirators.[18]

Various laboratory tests, mostly using manikins and breathing machines, suggest that medical masks typically filter 50-75 percent of various test particles.[19-26] In one study that used the SARS-CoV-2 virus, medical masks blocked around 50 percent of virus release.[27] Gaps around the face allow leakage of air, which significantly reduces mask effectiveness.[21, 28]

The effectiveness of medical masks can be greatly improved when they are modified to improve the seal against the face. They can filter 60-90 percent of particles when modified using various methods, including knotting the ear loops and tucking in the side pleats, placing three connected rubber bands on top of the mask and behind the ears, wearing a cloth mask on top of the medical mask, and adding a nylon hosiery layer.[19, 23, 25] Two of these modifications are shown in Figure 2.

Figure 2: Modifications to improve the fit and performance of medical masks. (Left) Knotting the ear loops and tucking in the side pleats; (Right) placing three connected rubber bands, elastic cords or similar on top of the mask and behind the ears. Image credit: Jason Chua

Medical masks are designed to be worn for a limited time (up to around six hours) and disposed of after each use.[29] Due to supply shortages during the COVID-19 pandemic and the costs of masks, some strategies for the potential reuse of disposable masks have been investigated, but the majority focus on N95 or similar respirators rather than medical masks.[29-31] Evidence reviews have identified only one study that evaluated possible decontamination methods for medical masks, which showed that dry heat produced the smallest reduction in filtration efficiency, while a range of other methods tended to damage the mask materials.[31] Based on this finding, there is currently no evidence indicating a safe and effective method to decontaminate medical masks, and reuse is not recommended.[29, 31]

EFFECTIVENESS OF CLOTH MASKS

Figure 3: Cloth masks

Summary:

- The effectiveness of cloth masks is highly variable and depends on the style and materials used.
- A three-layer design that fits snugly against the contours of the face can be 70-90 percent effective, similar to a well-fitting medical mask.
- Cloth masks can be washed and reused, unlike medical masks which are designed for single use.

Cloth masks come in a wide range of styles and fabric types. Accordingly, studies of their filtration effectiveness report highly variable results ranging from 10-91 percent.[19-26, 32-35] In one study specific to aerosol transmission, the use of three-layer cotton masks on 'speaker' and 'audience' manikins reduced aerosol concentration in the room by 72 percent.[35] In another study, a cloth mask on a manikin 'exhaling' SARS-CoV-2 virus blocked more than 50 percent of virus. Likewise, a cloth mask on a manikin 'inhaling' a mist of suspended virus led to a 20-40 percent reduction in virus uptake.[27]

Studies generally conclude that cloth masks provide the best results when they are well-fitting and made of three or more layers of fabric. The best fabric appears to be cotton with an inner filtering layer of silk, chiffon, or flannel.[32, 36, 37] These types of masks can be over 90 percent effective in filtering small droplet-sized particles and 70-80 percent effective in filtering even smaller aerosol particles that N95 respirators are better designed to protect against.[24, 25, 33] As with medical masks, gaps around the face allow leakage of air and significantly reduce effectiveness.

Single- and double-layer cloth masks should not be used. One often-cited study showed a higher rate of infection for cloth masks compared to medical masks, but this poorly controlled study involved two-layer masks being worn by healthcare workers in a clinical environment.[38] It should not be considered strong evidence against well-fitting three-layer cloth masks used by the general public.

Cloth masks can be reused, which is an advantage in terms of affordability, access and environmental impact. Frequent washing with hot water and soap is recommended, preferably after each use, and masks should be dried thoroughly before reuse.[19, 37, 39]

EFFECTIVENESS OF N95 AND SIMILAR RESPIRATORS

Figure 4: N95 and P2 respirators

Summary:

- Certified N95 and similar respirators are designed to filter airborne particles.
- They are the most effective of the three mask types, but in order to be maximally effective they must be individually fitted and tested.
- Poor fit reduces effectiveness to levels below that of tight-fitting medical and cloth masks.

Certified respirator masks are specifically designed to filter out airborne particles. International standards vary slightly, but respirators typically need to filter out at least 95 percent of aerosol particles 0.3 micrometres in size to pass certification requirements.[11] The filtering capability of N95 masks is usually higher at larger particle sizes. This high level of effectiveness relies heavily on a proper fit, and in New Zealand it is a requirement that people using a respirator mask in a work environment (previously primarily industrial use) be individually fit-tested to ensure the respirator works as expected.[40]

The results of laboratory testing of N95 respirators highlight the critical importance of fit. Respirators placed on manikins are only 40-60 percent effective and leak substantially.[20, 21, 26] However, when specialised fit-testing machines are used or respirators are tightly fitted to a manikin or person, certified respirator masks successfully filter between 80 and almost 100 percent of aerosol particles.[22, 25-27]

KN95 masks are a specific subset of respirator masks that are not recommended for professional use in New Zealand due to variations in production quality. They perform worse than certified models and have a measured filtration effectiveness of around 40 percent.[19, 27]

N95 respirators are also designed to be single-use. Due to critical shortages during the COVID-19 pandemic, strategies for the safe reuse of respirators have been investigated. There is emerging evidence that reuse of certified respirators may be viable if they can be decontaminated and checked for integrity and fit between uses. A study of healthcare workers found that over 95 percent of respirators remained effective for up to 23 uses when checked before each use for damage, seal integrity, and fit.[41] A systematic review of potential decontamination methods found that ultraviolet germicidal radiation and vaporised hydrogen peroxide are promising in terms of virus inactivation, but they may have destructive effects on respirators after multiple treatments.[42] Dry heat treatment may also be a viable decontamination option.[43]

Some respirators have valves that make it easier to exhale and to reduce moisture build-up inside the respirator. These provide the same level of protection to the wearer as a non-valved respirator, but they do not protect others from droplets or particles exhaled by the wearer, so valved respirators should not be used in any measures against COVID-19 transmission.

SUGGESTED MASK GUIDELINES FOR MANAGING THE RISK OF COVID-19 INFECTION AND SPREAD

Essential and border workers

Laboratory testing shows that properly fitted N95 and similar certified respirators consistently perform the best at blocking transmission of aerosol particles. It has been demonstrated that the fit of medical masks during normal wear is not adequate to block transmission of aerosol particles. In light of community cases of the Delta variant of COVID-19 capable of airborne transmission and the ongoing risk of new variants arriving at New Zealand's border, current mask guidelines for essential workers, particularly those at high potential risk of COVID-19 aerosol exposure such as managed isolation and quarantine facility staff, are likely insufficient to maximally reduce the risk of transmission.

All COVID-19 Alert Levels: *The available evidence supports the use of certified N95 or similar respirator masks for all workers* ***at the border*** *at all COVID-19 Alert Levels. This includes all managed isolation and quarantine facility staff, airport staff, and other essential personnel. It is additionally suggested that all individuals in managed isolation and quarantine facilities wear certified N95 or similar respirator masks whenever they are not inside their own rooms, for source control.*

COVID-19 Alert Level 2 and above: *Certified N95 or similar respirator masks are recommended for all essential workers* ***inside the border****. This includes healthcare workers and employees of essential businesses operating at these Alert Levels such as supermarkets.*

It is acknowledged that this would require dedicated staff for the fitting of respirator masks and training in proper use reinforced by video instruction. The costs involved should be weighed against the costs of further lockdowns plus the care and medical treatment of people who acquire COVID-19.

General public

N95 and similar respirators must be prioritised for essential and border workers. These workers are at high exposure risk, and it is possible for them be individually fitted with these masks and trained in their use. Unless procurement of sufficient supplies for all essential workers can be assured over the long term, use of these masks by the general public risks exhausting supply. In addition, it would not add significant benefit due to their reduced effectiveness when worn without proper technique.

Modelling of earlier COVID-19 variants demonstrates that universal masking in general populations with mask effectiveness of around 50-75 percent can decrease the rate of COVID-19 spread.[44, 45] Medical masks can be made much more effective by modifying them to create a tight seal or by wearing a cloth mask layered on top. Cloth masks are most effective when they are three-layered and fit snugly around facial contours. Masks with an exhalation valve should not be used.

All COVID-19 Alert Levels: *A public education campaign is suggested that emphasises the proper use of snug-fitting medical or three-layer cloth masks. Instructions for modifications to medical masks to improve the seal across the nose and around the cheeks and chin should be provided. Two methods*

are suggested which require no or minimal extra equipment: (1) knotting the ear loops and tucking in the pleats, and (2) using three connected rubber bands, elastic cords, or similar across the front of the mask and around the ears (Figure 2). An instructional video for the knotting and tucking modification is available from the US Centers for Disease Control and Prevention: https://www.youtube.com/watch?v=GzTAZDsNBe0

Acknowledging the cost implications, medical masks should not be reused or used for more than six hours without replacement.

Cloth masks should be made of at least three layers of cotton or similar fabric and should be shaped to provide a snug seal against the face. Cloth masks with fewer layers, and loose face coverings such as bandannas and scarves, do not provide sufficient protection. Cloth masks should be washed frequently (preferably daily) with soap and hot water, and dried before reuse.

COVID-19 Alert Level 2 and above: *Universal masking appears logical for all indoor shared spaces. It is not sufficient to rely solely on social distancing indoors; this does not protect against airborne transmission because aerosols can linger in the air, drift across large distances, and accumulate in enclosed spaces. Thus, masking practices should be more strictly observed in places where people congregate such as in airline security queues and on public transport. Improved ventilation, filtering, and air flow strategies can be implemented alongside mask use to reduce transmission potential.*

Such guidelines would be prudent at the border while New Zealand continues to try and exclude the virus from entering the community, a strategy that is clearly required until vaccination rates are much higher. They also seem appropriate for essential workers inside the border and for the wider community while there is any substantive risk of community spread – that is, while a region remains at COVID-19 Alert Level 2 or above.

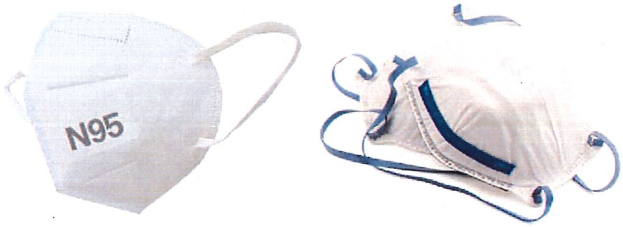
GLOSSARY

Medical masks

These are also known as surgical masks or procedure masks. They are typically made from non-woven materials and may have ear loops or ties. They were originally designed to protect against large droplets and fluid splashes during medical procedures, and they can help prevent transmission of infectious agents by blocking respiratory droplets from entering or leaving the wearer's mouth and nose.

Cloth masks

These masks are made from fabrics such as cotton. They are available in a variety of styles, materials, and number of layers.



N95 and similar respirators

These are shaped masks that are specifically designed to protect the wearer from inhaling aerosols (small airborne particles). Approved N95 respirators meet United States safety standards. Similar respirators include P2 and FFP2, depending on which international standard the respirator has been manufactured to meet. The preferred respirator for work environments in New Zealand is P2 as it specifically adheres to the Australian and New Zealand Standard. An example of a P2-type respirator is pictured on the right.

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