Two metres or one: what is the evidence for physical distancing in covid-19?

Rigid safe distancing rules are an oversimplification based on outdated science and experiences of past viruses, argue Nicholas R Jones and colleagues

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Physical distancing is an important part of measures to control covid-19, but exactly how far away and for how long contact is safe in different contexts is unclear. Rules that stipulate a single specific physical distance (1 or 2 metres) between individuals to reduce transmission of SARS-CoV-2, the virus causing covid-19, are based on an outdated, dichotomous notion of respiratory droplet size. This overlooks the physics of respiratory emissions, where droplets of all sizes are trapped and moved by the exhaled moist and hot turbulent gas cloud that keeps them concentrated as it carries them over metres in a few seconds. After the cloud slows sufficiently, ventilation, specific patterns of airflow, and type of activity become important. Viral load of the emitter, duration of exposure, and susceptibility of an individual to infection are also important.

Instead of single, fixed physical distance rules, we propose graded recommendations that better reflect the multiple factors that combine to determine risk. This would provide greater protection in the highest risk settings but also greater freedom in lower risk settings, potentially enabling a return towards normality in some aspects of social and economic life.

Origins of 2 metre rule

The study of how droplets are emitted during speech or more forcefully when coughing or sneezing began in the 19th century, with scientists typically collecting samples on glass or agar plates. In 1897, for example, Flugge proposed a 1-2 m safe distance based on the distance over which sampled visible droplets contained pathogens. In the 1940s, visual documentation of these emissions became possible with close-up still imaging of sneezing, coughing, or talking (fig 1). A study in 1948 of haemolytic streptococci spread found 65% of the 48 participants produced large droplets only, fewer than 10% of which travelled as far as 5½ feet (1.7 m). However, in 10% of participants, haemolytic streptococci were collected 9½ feet (2.9 m) away. Despite limitations in the accuracy of these early study designs, especially for longer ranges, the observation of large droplets falling close to a host reinforced and further entrenched the assumed scientific basis of the 1-2 m distancing rule.

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Yet eight of the 10 studies in a recent systematic review showed horizontal projection of respiratory droplets beyond 2 m for particles up to 60 μm. In one study, droplet spread was detected over 6-8 m (fig 2). These results suggest that SARS-CoV-2 could spread beyond 1-2 m in a concentrated packet through coughs or sneezes. In recent related viral outbreaks, such as SARS-CoV-1, MERS-CoV, and Avian flu, multiple studies reported suspected spread beyond 2 m.
**Droplet size, droplet spread**

The 1-2 m rule is based on a longstanding framework which dichotomises respiratory droplets into two sizes, large and small. The size of a droplet is thought to determine how far it will travel from the infected person. According to studies by Wells, emitted large droplets fall through the air more quickly than they evaporate and land within a 1-2 metre range. Small droplets (later called aerosols or airborne droplets), typically invisible to the naked eye, evaporate more quickly than they fall. Without airflow, they cannot move far, remaining in the exhaler’s vicinity. With airflow they can spread along greater distances.

While conceptually useful up to a point, this dichotomy framework overlooks contemporary science about respiratory exhalations. Droplets exist across a continuum of sizes. Contextual factors such as exhaled air and ambient airflow are extremely important in determining how far droplets of all sizes travel. Without exhaled airflow, the largest droplets would travel furthest (1-2 m), while the small ones would encounter high resistance (drag) and stay close to the source. When accounting for the exhaled airflow, clouds of small droplets can travel beyond 2 m in the air, and even large droplets have enhanced range.

**Airborne particle spread of SARS-CoV-2**

Diseases that can be transmitted by airborne particles, such as measles and varicella, can travel much further, and in concentrated clouds, than those transmitted by large droplets, which drop from clouds more quickly. They can therefore expose others rapidly and at greater distance and may need different public health measures, including extended physical distancing. Laboratory studies also suggest SARS-CoV-1, SARS-CoV-2, and MERS-CoV viral particles are stable in airborne samples, with SARS-CoV-2 persistent for longest (up to 16 hours).

In a literature search for studies using air sampling techniques to detect viral particles surrounding covid-19 patients, we found nine studies in hospital and two in community settings. Seven of the hospital studies reported at least one airborne sample tested positive for SARS-CoV-2, though the proportion of positive samples across studies ranged between 2% and 64%. Only two reported positive results in relation to distance from an infected patient (one at 2 m and another at 4 m in the corridor). Of the two hospital studies that did not find SARS-CoV-2 particles in air samples, one collected positive swab samples from ventilation units in the patient’s room, which is consistent with airborne droplet spread.

Neither community study reported positive air samples, although one collected specimens up to 17 days after covid-19 carriers had left the room and the other did not report time of sampling since.
cleaning or sampling distance from the infected person. These negative studies thus fail substantially short of proving that airborne spread does not occur.

Only two of the airborne sampling studies directly measured whether SARS-CoV-2 in the samples remained infectious, rather than just analysing for the presence of viral RNA. No viable virus was found in either, though one found signs of viral ability to replicate. Of note, no study found viable virus on surface swabs.

These studies were small, observational, and heterogeneous in terms of setting, participants, sample collection, and handling methods. They were prone to recall bias (few people can accurately recall how close they came to others when asked to remember some time later). Overall, these studies seem to support the possibility of airborne spread of SARS-CoV-2, but they do not confirm that there is a risk of disease transmission.

Force of emission, ventilation, exposure time

Breathing out, singing, coughing, and sneezing generate warm, moist, high momentum gas clouds of exhaled air containing respiratory droplets. This moves the droplets faster than typical background air ventilation flows, keeps them concentrated, and can extend their range up to 7-8 m within a few seconds. These findings from fluid dynamic studies help explain why at one event, participants, sample collection, and handling methods. They were prone to recall bias (few people can accurately recall how close they came to others when asked to remember some time later). Overall, these studies seem to support the possibility of airborne spread of SARS-CoV-2, but they do not confirm that there is a risk of disease transmission.

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Fig 3 | Risk of SARS-CoV-2 transmission from asymptomatic people in different settings and for different occupation times, venting, and crowding levels (ignoring variation in susceptibility and viral shedding rates). Face covering refers to those for the general population and not high grade respirators. The grades are indicative of qualitative relative risk and do not represent a quantitative measure. Other factors not presented in these tables may also need to be taken into account when considering transmission risk, including viral load of an infected person and people's susceptibility to infection. Coughing or sneezing, even if these are due to irritation or allergies while asymptomatic, would exacerbate risk of exposure across an indoor space, regardless of ventilation.

The levels of risk in fig 3 are relative not absolute, especially in relation to thresholds of time and occupancy, and they do not include additional factors such as individuals' susceptibility to infection, shedding level from an infected person, indoor airflow patterns, and where someone is placed in relation to the infected person. Humidity may also be important, but this is yet to be rigorously established.

Further work is needed to extend our guide to develop specific solutions to classes of indoor environments occupied at various usage levels. Urgent research is needed to examine three areas of uncertainty: the cut-off duration of exposures in relation to the indoor condition, occupancy, and level of viral shedding (5-15 minute current ad-hoc rules), which does not seem to be supported by evidence; the detailed study of airflow patterns with respect to the infected source and its competition with average venting; and the patterns and properties of respiratory emissions and droplet infectivity within them during various physical activities.

Physical distancing should be seen as only one part of a wider public health approach to containing the covid-19 pandemic. It needs to be implemented alongside combined strategies of people-air-surface-space management, including hand hygiene, cleaning, occupancy and indoor space and air managements, and appropriate protective equipment, such as masks, for the setting.

### Key messages

Current rules on safe physical distancing are based on outdated science. Distribution of viral particles is affected by numerous factors, including airflow. Evidence suggests SARS-CoV-2 may travel more than 2 m through activities such as coughing and shouting. Rules on distancing should reflect the multiple factors that affect risk, including ventilation, occupancy, and exposure time.

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**Table: Risk of transmission**

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<thead>
<tr>
<th>Type and level of group activity</th>
<th>Low occupancy</th>
<th>High occupancy</th>
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<tbody>
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<td>Outdoors and well ventilated</td>
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<td>Wearing face coverings, contact for short time</td>
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<td>Speaking</td>
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<tr>
<td>Shouting, singing</td>
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<td>Wearing face coverings, contact for prolonged time</td>
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<td>Shouting, singing</td>
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<td>No face coverings, contact for short time</td>
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* Borderline case that is highly dependent on quantitative definitions of distancing, number of individuals, and time of exposure.
Patient and public involvement: Three members of the public provided feedback on the article. They strongly supported the need for an in-depth analysis of physical distancing and thought our summary figure was helpful in presenting factors that influence categories of risk. Specific feedback led to addition of discussion points addressing transmission risk in complex settings such as the meat packing industry and with exercise.

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