Instant air purification.

Evidence brochure

EVIDENCE BROCHURE

from the makers of
clinell®

rediair™

Removes 10x more particles than domestic H13 air filters

A single Rediair unit provides

effective ventilation for rooms up to 120m³

After introducing portable HEPA filters the

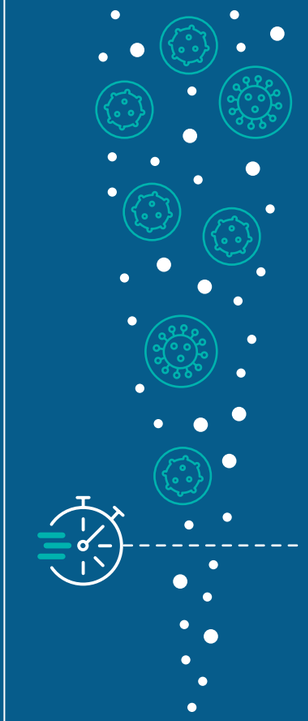
inhaled dose of respiratory pathogens was reduced by a factor of 6

Curtuis et al. Aerosol Sci Technol. 2021;55(5)[1].

Clears

90% of particles

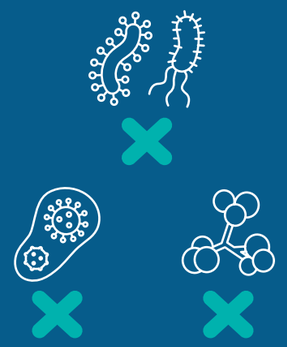
within 20 minutes



Captures

99.995% of particles

down to 0.3µm



Removes airborne bacteria, fungi and viral aerosols

CONTENTS

HOW INFECTION SPREADS

Aerosols and droplets

We constantly release bacteria, viruses and fungi into the air around us. Pathogens like *Mycobacterium tuberculosis,* influenza, respiratory syncytial virus and coronaviruses are found in droplets and aerosols expelled when their host talks, coughs or even breathes[2–5].

Droplets are particles above 5 micrometres (µm) in diameter that typically settle within 2 metres.

Aerosols are smaller particles (below 5µm) that remain airborne longer and spread over large distances.

Droplet and aerosol emission varies from person to person[6] but we know they're released by both symptomatic or asymptomatic people[7].

30 seconds of speaking produces more viable aerosols than a cough[8].

The problem of poor ventilation

Poor ventilation allows infectious microorganisms to survive in the air much longer[9–11]. This causes larger droplets to evaporate down in size to become 'droplet nuclei' – small airborne particles the size of aerosols (figure 1).
That means poor ventilation allows 'droplet' organisms such as coronaviruses, *Pseudomonas spp.*[12] or norovirus[13] to become airborne and spread over much greater distances[14–16].

The WHO advises that, in cases of poor ventilation, 'droplet' pathogens can spread via airborne routes[17].

Common 'droplet' precaution infections (>5µm)
Influenza, coronaviruses (including SARS-CoV-2), diphtheria, mumps, pertussis, *Meningococcus spp.*, measles, RSV, adenovirus.

Common 'aerosol' precaution infections (<5µm)
Mycobacterium tuberculosis, Aspergillus spp., Streptococcus pneumoniae.

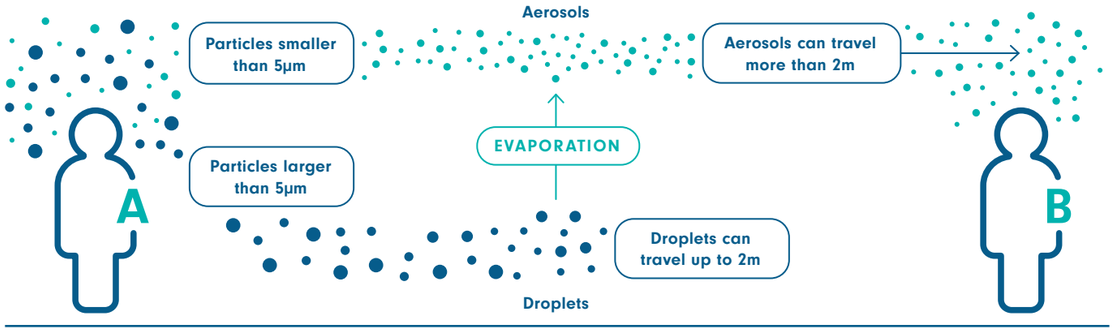


Figure 1. Adapted from Otter et al[18]. In poorly ventilated spaces, large droplets (>5µm) can partially evaporate to become smaller, airborne droplet nuclei (<5µm). Both droplets and aerosols are capable of infecting hosts directly or indirectly (by seeding inanimate surfaces)[9–11,19].

REDIAIR

An instant solution to improve ventilation and remove airborne pathogens. Our dual-intake filtration system allows Rediair to ventilate bigger spaces with a smaller form factor.

Traps 99.995% of particles

Rediair uses two advanced composite HEPA 14 & carbon filters to trap incredibly small particles – 10x more effective than domestic HEPA 13 filters.

Ultra quiet

Rediair's dual fan system means it can operate with lower fan speeds and produce less noise than single fan units.

High clean air delivery rate

Dual-intakes eliminate dead spaces and deliver up to 600m^3 of clean air every hour, ventilating rooms up to 120m^3.*

*A single Rediair unit provides up to 5 Air Changes per Hour (ACH) in a room with a volume of 120m^3.

UNDERSTANDING FILTRATION

Rediair uses HEPA and carbon filtration to remove odours, allergens and airborne pathogens.

What is HEPA filtration?

High Efficiency Particulate Air (HEPA) filters trap very fine particles from any air that passes through them. HEPA filters are classified according to the percentage of particles they trap. Each of the two H14-class HEPA filters in Rediair captures 10x more particulates than standard H13 filters.

Why is filtration important?

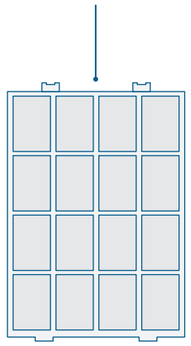
Researchers in Sweden found their mechanical ventilation system, without HEPA filters, transported viral material over 50 metres[16].

Mechanical ventilation systems can help spread pathogens over large distances if they don't feature adequate filtration.

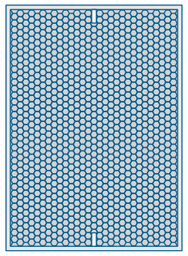
HEPA filtration systems, like Rediair, remove airborne pathogens and increase air circulation.

3 LAYERS OF FILTRATION

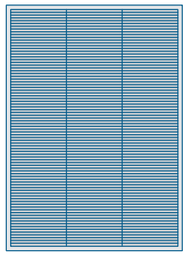
Nylon pre-filter
Removes large particles and protects the HEPA filtration layer



Carbon cloth filter
Removes odours



H14 HEPA filter
Traps bacteria, fungi, viral aerosols, pollen, dust and other allergens



HEPA 14 filters in Rediair remove 99.995% of airborne particles down to 0.3 µm (micrometres) – small enough to trap individual bacteria, fungi and viral aerosols.

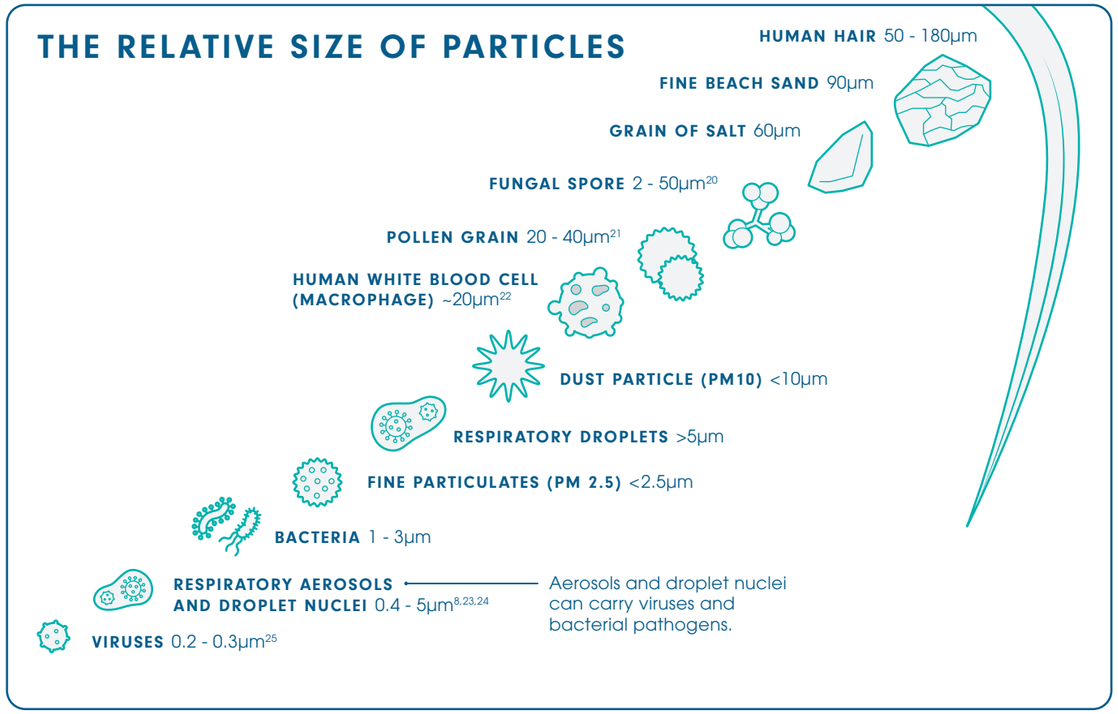


Figure 2. Typical diameters observed for common particles.

Viruses under 0.3µm

Whilst many viruses measure at least 1µm in diameter, some viruses can be smaller than 0.3µm[25]. However, viruses don't typically exist in this 'naked' state – naked viruses can quickly become inactivated on their own.

Instead, respiratory viruses typically exist in the form of droplets and aerosols released when their host talks, coughs or breathes[2–5]. These droplets and aerosols are large enough to be trapped by the HEPA 14 filters inside Rediair.

REDIAIR IN PRACTICE

Rediair uses twin side intakes and 3 layers of filtration to produce an even reduction in airborne particles throughout a given space.

Removes 90% of airborne particles within 20 minutes

Objectives

Assess the action of Rediair on a typical 4 bed hospital bay.

Methods

Investigators placed two Rediair units in a 4-bedded bay. To make sure Rediair produced a reduction throughout the whole room, particle meters were placed in all corners of the bay. Air contamination was generated in each corner using cool burn smoke matches. All windows and doors were shut for the duration of the test. 6 people remained in the room throughout the test – simulating 4 patients and 2 healthcare workers within the space.

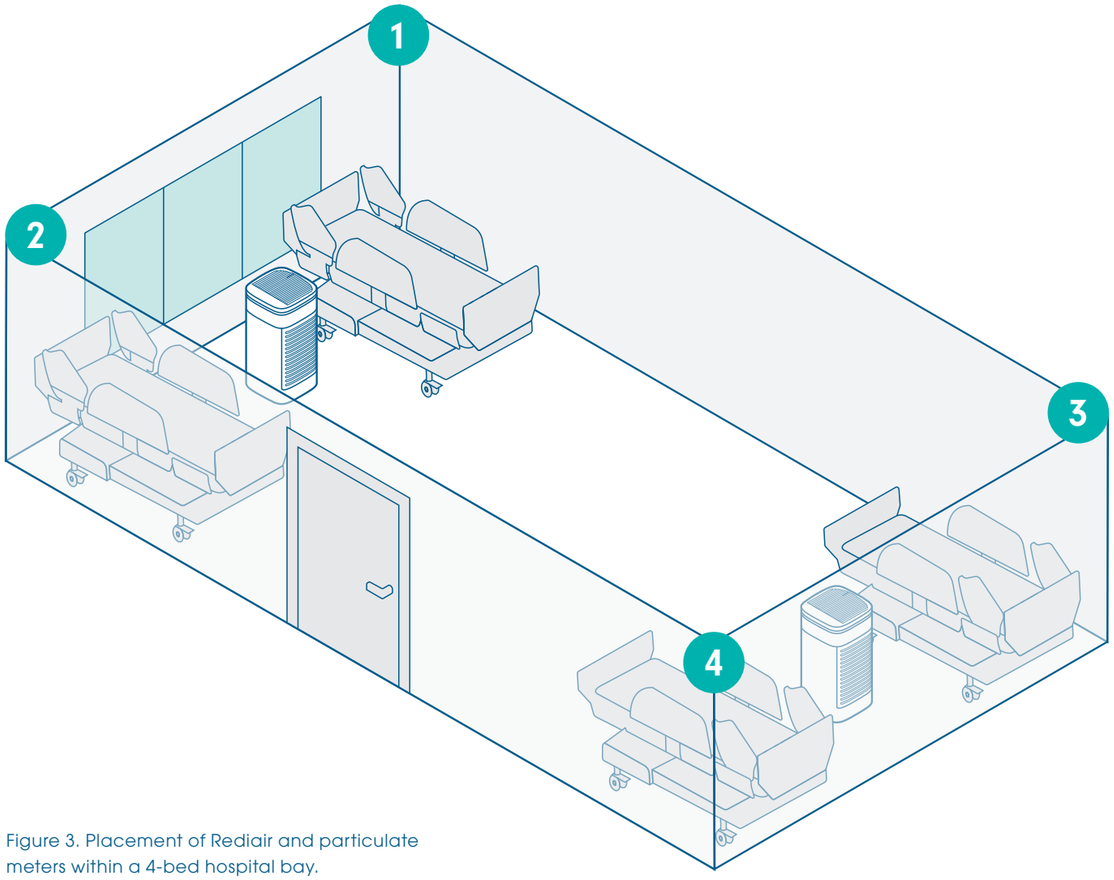


Figure 3. Placement of Rediair and particulate meters within a 4-bed hospital bay.

Results

Rediair produced a 90% reduction in particles within 20 minutes in all 4 corners of the room. As all corners saw a nearly uniform reduction curve, the investigators concluded that Rediair provided effective air filtration throughout the 4-bed bay.

	0 MIN	4 MIN	6 MIN	8 MIN	16 MIN	20 MIN	25 MIN	30 MIN
1	>9,999,999	>9,999,999	8,325,227	2,696,020	1,235,427	478,080	201,300	77,000
2	>9,999,999	>9,999,999	9,419,487	3,973,493	1,656,833	547,313	224,393	68,653
3	>9,999,999	>9,999,999	9,319,740	5,127,147	1,181,207	676,553	197,567	76,600
4	>9,999,999	>9,999,999	8,673,456	3,193,360	1,009,727	488,100	160,500	66,400

Table 1. Measurement of airborne particulate matter (0.3µm) in room corners at timed intervals (pieces/m³).

Reduction of airborne particles

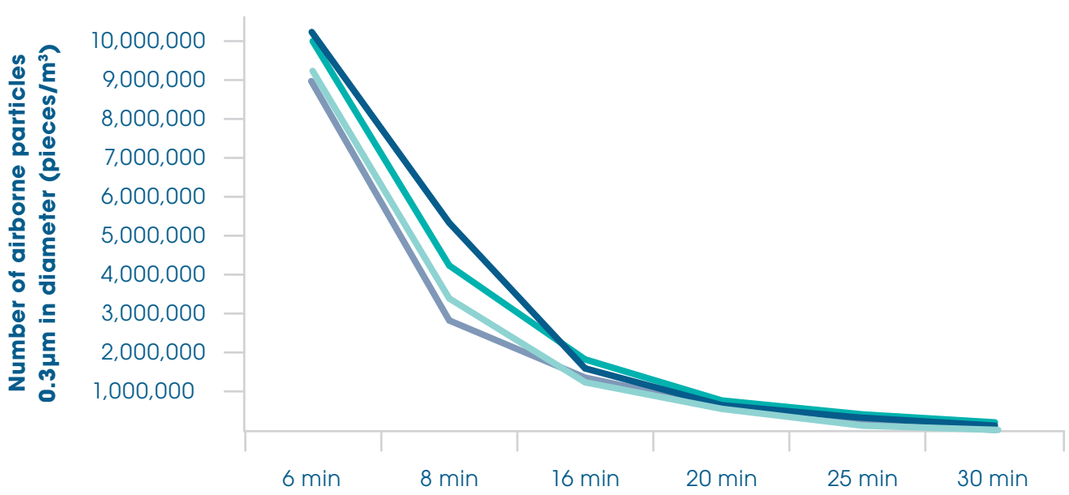


Figure 4. Reduction of particulate matter (0.3µm) in room corners at timed intervals.

UNDERSTANDING AIRFLOW

When configuring your space, there are 3 important factors to consider: clean air delivery rate, room volume and target air changes per hour.

Why is Clean Air Delivery Rate (CADR) important?

CADR provides a much more useful metric than simple air flow rate – when comparing units you should always ask the manufacturer for the CADR, not the flow rate.

CADR is calculated based on how fast air flows through the filters and how effective those filters are. The CADR of a machine impacts the size of room it can be used in.

Units with a high air flow rate, but poor filtration efficiency, will result in a low CADR. Equally, units with highly efficient filtration but low flow rate will also feature a low CADR.

Rediair has a CADR of up to 600m³ per hour.

What does Air Changes per Hour mean?

Many international bodies produce guidelines on ventilation expressed in Air Changes per Hour (ACH[26, 27]). ACH are a simple, practical way to estimate ventilation in a space. The CADR of your machine and the volume of your room determine your ACH.

Clean Air Delivery Rate (m³/h) ÷ Room volume (m³) = Air Changes per Hour (ACH)

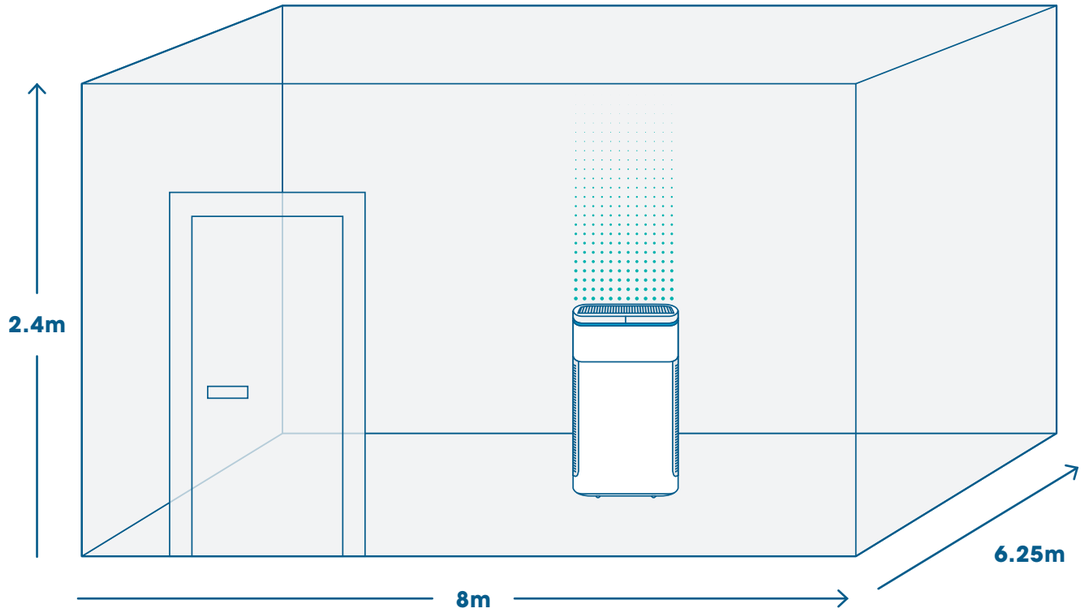
However, this doesn't mean all the air in the room is completely changed. Clean air mixes with air already in the room. At 5 ACH, assuming perfect air mixing, over 90% of the airborne contamination is removed after 30 minutes.

Air mixing applies to all ventilation systems – it's not unique to Rediair. That's why it's important to understand the recommended ACHs for your space (see page 17 for recommended ACHs by room type).

Calculating room volume

Room volume is a simple measurement. In rooms with parallel walls and flat ceilings, it's just a case of multiplying the room's width x depth x height. This will give you your room volume in metres cubed (m³).

From here, we can use the machine's Clean Air Delivery Rate to calculate the number of Air Changes per Hour in our space.



Room volume = 8m x 6.25m x 2.4m = 120m³

Rediair Clean Air Delivery Rate (CADR) = 600m³/h

Air Changes per Hour (ACH) = 600m³ ÷ 120m³ = 5 ACH

Using multiple Rediair units

For larger spaces, or for spaces requiring a very high number of air changes per hour, multiple Rediair units can be used. To find out the number of Rediair units needed for your space, use our online calculator at **www.gamahealthcare.com/rediair**

THE EVIDENCE FOR PORTABLE HEPA FILTERS

A growing base of evidence supports the efficacy and benefits of portable HEPA filters in healthcare, classrooms, workplaces and beyond.

Reduce risk in poorly ventilated spaces.

Curtius et al. *Aerosol* Sci Technol. 2021;55(5):586-599[1]

Objectives
Researchers in Germany investigated the impact of introducing 4 portable HEPA filters into a full classroom – with implications for similar spaces such as offices and other workplaces.

We know talking and breathing will generate aerosols containing viruses and other pathogens, so the researchers modelled the risk of transmission around the room based on one infectious person frequently talking.

Results
Figure 5 shows the estimated inhaled dose of someone else in the room for up to 2 hours. Without the air purifiers, the inhaled dose begins to increase exponentially after about 20 minutes. **After 2 hours, there's a 70% chance of at least one other person becoming infected.**

Introducing the portable HEPA filters dramatically reduces the inhaled dose by removing aerosols from the circulating air. **At 5.7 air changes per hour, introducing the portable HEPA filters reduces the inhaled dose of pathogens by a factor of six.**

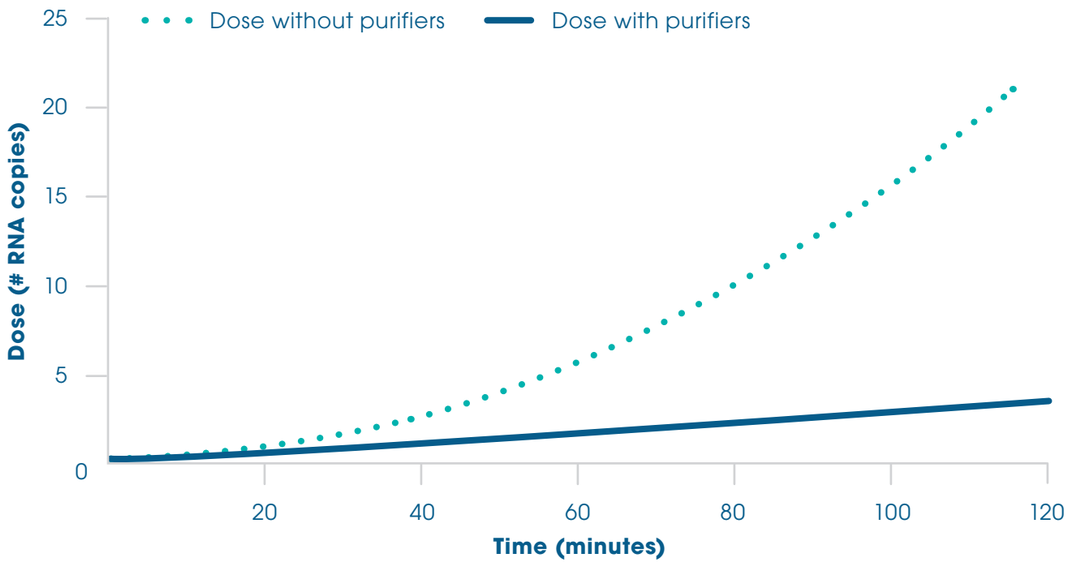


Figure 5. Inhaled dose taken in by someone in the room with an infectious person over 2 hours. Introducing portable HEPA filters causes a dramatic reduction. Adapted from Curtius et al[1].

Increase aerosol clearance, even in well ventilated spaces.

Buising et al. *Infect Control Hosp Epidemiology.* 2021;1-26[28]

Objectives
Researchers in Royal Melbourne Hospital assessed the impact of portable HEPA filters on aerosol clearance within a well-ventilated, single patient side room. They generated glycerine-based aerosols to measure how introducing portable HEPA filters would affect clearance and dispersal.

Results
Even though the existing ventilation systems in the room already produced a baseline of 12 air changes per hour, introducing portable HEPA filters removed aerosols 3 times faster than relying on the fixed HVAC system alone – clearing 99% of aerosols within 5.5 minutes.

Introducing portable HEPA filters also reduced the number of aerosolized particles that spread outside of the side room to the neighbouring ward area. The authors concluded that portable HEPA filters could dramatically increase the clearance rate of aerosols and were likely to be a cost-effective intervention in a variety of clinical settings.

Eliminate airborne virus in COVID-19 surge units.

Conway Morris et al. *Clinical Infec Dis.* 2021[29]

Objectives
Investigators in Addenbrooke's Hospital, Cambridge, examined the impact of portable HEPA filtration units on a COVID-19 surge ward and a COVID-19 ICU. They used air samplers and quantitative PCR to detect signs of the COVID-19 virus (SARS-CoV-2) and other pathogens in the air at intervals across three consecutive weeks.

15 patients were admitted to the ward and 14 to the ICU throughout the sampling period. All patients were symptomatic and tested RNA-positive for SARS-CoV-2.

Results
During the first week of sampling, whilst the filter was inactive, the authors detected airborne SARS-CoV-2 RNA on all sampling days. Introducing the portable HEPA filters completely eliminated SARS-CoV-2. It also produced significant reductions for other pathogens, including *Candida spp.*

AUTHORS	SETTING	RESULTS
Curtuis et al. 2021[1]	Classroom with 25 occupants.	At 5.7 air changes per hour, introducing the portable HEPA filters **reduced the inhaled dose of pathogens by a factor of six.**
Buising et al. 2021[28]	Well-ventilated hospital ward (baseline 12 air changes per hour).	The existing ventilation system didn't adequately remove aerosols from patient side rooms – actively dispersing them through the rest of the ward. Introducing **two portable HEPA filters into a patient side room cleared 99% of aerosols in 5.5 minutes and prevented spread throughout the rest of the ward.**
Conway Morris et al. 2021[29]	Crossover study on two COVID-19 surge units.	Introducing portable HEPA filters at 5-10 air changes per hour **completely eliminated airborne COVID-19 (SARS-CoV-2) viral RNA** and produced **significant reductions in other pathogens including *Candida spp.***
Lindsley et al. 2021[30]	Typical large meeting room or conference room.	Across a 60 minute test period, two **portable HEPA filters reduced overall aerosol exposure by two-thirds** at 5.2 air changes per hour. Portable HEPA filters together with mask-wearing reduced exposure by 90%.
Pirkle et al. 2021[31]	Hospital outpatient exam room.	**95.99% reduction in fine particles (<2.5µm) within 6 minutes**
Ren et al. 2021[32]	Dental treatment rooms.	Aerosols accumulate in rooms with natural ventilation under 15 air changes per hour – persisting for over 30 minutes. Introducing portable HEPA filters **completely removed accumulated aerosols in as little as 4 minutes.**
Lee et al. 2021[33]	Well-ventilated hospital side room (baseline of 14 air changes per hour).	**Despite the room already having good ventilation** (14 air changes per hour), introducing a portable HEPA filter **cleared aerosols 3 times faster.**
Crawford et al. 2021[19]	Negative-pressure hospital isolation room.	Again, despite the room already having permanent air filtration systems, introducing a HEPA filter can **increase removal of airborne particles by 40%** and produced a **25% reduction of particles settling onto surfaces**.
Boswell & Fox. 2006[34]	Isolation rooms of 3 hospital patients with MRSA.	With no additional filtration, 80-100% of settle plates in the room were positive for MRSA. Portable HEPA filters **reduced surface contamination by 75-93%**.
Zargar et al. 2019[35]	Aerobiology test chamber.	At 7 air changes per hour, the portable HEPA filter **reduced bacteria in the air by 99.9%** and **reduced surface settling by *S. aureus* (97% reduction) and *Acinetobacter baumannii* (87% reduction)** in 45 min.
Salam et al. 2010[36]	6 hospital wards in a large tertiary-care teaching hospital.	Portable HEPA filters produced a **51% reduction in incidence of invasive aspergillosis.**
Huang et al. 2021[37]	6 residential households.	Using **auto mode** on a portable HEPA filter was the **most effective way to reduce inhalable particulate matter** (PM2.5).
Morishita M et al. 2018[38]	Older adult care facility.	Portable HEPA filters resulted in a **significant reduction in exposure to inhalable particulate matter (PM2.5)** and was associated with reduced systolic blood pressure in older adults.

FAQS

What organisms have been shown to be transmitted through the air?

When we say 'transmission through the air', we typically mean organisms that can spread via aerosols: small, airborne particles less than 5µm in diameter. These particles are emitted when an infected or colonised host talks, coughs or breathes[2–5]. They're small enough to stay suspended in the air for hours[8] and can infect hosts via inhalation or contact with mucus membranes.

Additionally, when ventilation is poor, larger droplets (>5µm) can persist in the air much longer than normal[9–11]. Without adequate ventilation, 'droplet' organisms – such as coronaviruses – can spread through airborne routes[14–16].

As a result, 'transmission through the air' can happen with a wide variety of pathogens, including bacteria, viruses and fungi. These include organisms that commonly infect the respiratory system (such as influenza, *Mycobacterium tuberculous* and *Pseudomonas sp.*[12]) organisms that affect the gut (such as norovirus[13]) and spore-forming fungi or yeasts (such as *Aspergillus spp.*[36] and *Candida auris*[39]).

For more information on droplet and aerosol pathogens, see the section on **understanding filtration (page 3)**.

What is a HEPA 14 and how does it compare to others?

'HEPA' stands for 'High Efficiency Particulate Air'. HEPA filters are classed according to the percentage of particulates that they remove. The HEPA filters in Rediair are classed as 'H14', meaning they remove at least 99.995% of particles down to 0.3µm. That's small enough to trap allergens, individual bacteria, fungi and viruses within aerosols.

The HEPA 14 filters in Rediair trap 10x more particulates than an HEPA 13 filter – the filter class most commonly found in domestic air purifiers.

Some viruses measure under 0.3µm in diameter, is Rediair able to remove these from the air?

Many viruses measure at least 1µm in diameter, however, some viruses can be smaller than 0.3µm. Although viruses don't typically exist in this 'naked' state – naked viruses can quickly become inactivated on their own.

Instead, respiratory viruses typically exist in the form of droplets and aerosols released when their host talks, coughs or breathes[2–5]. For example, in surrogate tests, influenza was found to be transmitted by aerosols larger than 1.5µm[24]. Another study concluded that, 1 hour after emission, nearly all airborne viruses were likely lie in aerosols between 0.4µm and 4µm in diameter[8].

These droplets and aerosols are large enough to be trapped by the HEPA 14 filters inside Rediair.

What is the throughput of air through Rediair? Can you turn the units up or down?

Each Rediair unit has a Clean Air Delivery Rate (CADR) up to 600m^3 per hour.

In manual mode, you can set the CADR to a fixed rate. Turbo mode fixes Rediair into the maximum CADR of up to 600m^3/h. In auto mode, Rediair will monitor the concentration of particulates in the air and adjust the CADR in real time to maintain air quality.

How does the machine determine that air quality is poor to automatically increase flow?

Rediair uses infrared refraction to measure the concentration of particulates in the air. Within Rediair, there's an infrared light and sensor that continually monitor particulate concentration.

As particulate concentration increases, it changes the way infrared light moves through the air. The sensor picks this up and Rediair converts this data into a reading of particulates under 2.5 micrometres (PM2.5). This information is displayed on the main Rediair control panel and via the colour-change LED strip. In auto mode, Rediair will adjust fan speed in real time, aiming to keep the concentration of PM2.5 under 50µg/m^3.

Auto mode is the only mode in which Rediair will adjust fan speed automatically.

How noisy is the Rediair unit?

At 3 metres distance, Rediair produces between 22 and 66 decibels (A-weighted) depending on fan speed. These lie well below safe levels outlined by government bodies, such as the UK's Health and Safety Executive or the USA's CDC.

In areas where noise is a concern, we recommend running Rediair in auto mode. This will automatically reduce the fan speed when the airborne particulate levels are under 50µg/m^3 and, therefore, keep noise levels to a minimum. Equally, night mode reduces fan speed and turns off all system lights to allow for undisturbed sleep.

How often do you need to change the filters?

The composite HEPA and carbon cloth filters in Rediair are rated for 3000 hours of continuous filtration. We recommend changing the filters every 3000 hours of use, or every 6 months, to keep your Rediair unit filtering as effectively as possible and to avoid placing undue stress on the fan motors.

Rediair will automatically notify you when the filter is due to be changed. When the 'filter' indicator lights up continuously red on the LCD touch panel, it's time to change the filters.

For a step-by-step guide on how to change the filters in your Rediair unit, see our online resources section at:
www.gamahealthcare.com/rediair

FAQS

Where should I position Rediair to maximise air changes? What evidence do you have that you won't end up with very clean air in a small part of the room?

Every space is different but we recommend positioning Rediair away from any obstructions, or natural 'dead spots' for air circulation. In rooms with existing mechanical ventilation, avoid placing Rediair where it may disrupt established airflows.

When using multiple Rediair units, space them as evenly around the room as possible

The dual side intakes and upwards output of Rediair is designed to encourage good air mixing. Rediair has been shown to reduce airborne particulates in the far corners of a room. See the section on **understanding filtration (page 3)** for more details.

What does 'PM2.5' on top of the Rediair unit mean?

Rediair is equipped with a sensor to monitor the concentration of particulates in the air. Specifically, Rediair measures the concentration of particulates under 2.5µm (PM2.5). This information is displayed in the centre of the LCD touchscreen.

Rediair expresses PM2.5 concentration in micrograms per cubic metre of air (µg/m^3).

Please note, some particulate meters will measure 2.5 in 'pieces/m^3'. This will give a different reading than your Rediair unit, which displays PM2.5 concentration in µg/m^3.

Does Rediair have added UV? Does adding UV improve air filtration?

The antimicrobial properties of UV-C have been employed for disinfection of air, water and non-porous surfaces for some time. However, susceptibility to UV-C depends on numerous factors including lamp intensity, distance and the type of microorganisms being assessed.

Killing of pathogens by UV radiation takes several minutes of contact time. This renders it ineffective in portable HEPA filters where several litres of air can pass through the machine every minute.

At a distance of only 3cm, UV-C and UV-A irradiation together took 3 minutes of exposure to kill just 99% of bacteria[40]. The HEPA 14 filtration in Rediair, by contrast, will remove over 100x more pathogens by air filtration alone.

A report published by the CDC, reviewed in 2019, concluded that UV could not be recommended as a substitute for HEPA filtration[41]. They also concluded that use of UV and HEPA filtration together offered minimal benefits over use of a HEPA filter alone[41].

What is the warranty period?

Each Rediair unit comes with a standard 12 month warranty.

THE REDI FAMILY

Rediair is part of the Redi family of products. Redi products equip you to respond instantly to outbreaks, infections and emergencies, giving you the tools to protect your patients and staff. They are united by clever design, removing the obstacles presented by traditional solutions.

REFERENCE TABLES

Recommended Air Changes per Hour (ACH)

For more information on ACH, see the section on **understanding airflow (page 7)**.

ROOM TYPE	RECOMMENDED ACH[26]
Homes	0.35-1
Hotel rooms	1-2
Offices	2-3
Retail shops	2-3
Schools	5-6
Sports facilities	4-8
Restaurants	4-8
Hospital ward (general)[27]	6
Hospital single room[27]	6

Estimated Air Changes per Hour (ACH) by room volume

Each Rediair unit has a Clean Air Delivery Rate (CADR) of 600m^3/h. ACH can be calculated by dividing the room volume by the total CADR of units in the room. To find out the number of Rediair units needed for your space, use our online calculator at **www.gamahealthcare.com/rediair**

ROOM VOLUME	ESTIMATED ACH (WITH SINGLE REDIAIR UNIT)	ESTIMATED ACH (WITH TWO REDIAIR UNITS)
600m^3	1	2
300m^3	2	4
120m^3	5	10
100m^3	6	12
75m^3	8	16
60m^3	10	20

Product details

TECHNICAL SPECIFICATIONS	
CLEAN AIR DELIVERY RATE (CADR)	Up to 600m^3
FILTER CLASS	2x HEPA 14 filters
PARTICLES FILTERED	99.995% removed down to 0.3µm
NOISE LEVEL	22-66 dB(A) at 3 metres distance
DIMENSIONS	400 x 400 x 669 mm
WEIGHT	15.1 kg

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