The effect of air filtration devices on transmission of infectious diseases in an educational setting: A literature review

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ABSTRACT

Background: Respiratory infectious diseases are an important cause for morbidity and mortality. The transmission of infectious diseases in schools influences the incidence of these diseases in the rest of the population. It has been hypothesized that air filtration devices might be able to reduce the transmission of infectious diseases. In healthcare settings air filtration devices seem to be effective in reducing the aerosol particle concentration and infection rate. However, there is no overview of the available evidence of these devices in a school setting. Therefore, the aim of this study was to summarize the existing evidence on the effect of air filtration devices in educational settings.

Methods: PubMed/MEDLINE and EMBASE were searched in May 2023. Intervention studies that were conducted in a school setting were eligible. Modeling and simulation studies, and observational studies were excluded. Risk of bias was assessed using a modified version of the ROBINS-I tool. The details of the classroom, device and quantitative measurement of the effect were extracted.

Results: Two studies met the inclusion criteria. The two studies were conducted in Germany after 2020. One was conducted at a primary school, the other at a secondary school. Both studies were non-randomized trials, that compared a classroom with and without air purifier. Neither of the included studies measured outcomes that were directly related to infectious disease transmission. They measured the aerosol particle concentration, particle size distribution, CO_2 levels, and relative humidity. Overall, they were both found to have moderate risk of bias. The air purifiers were found to reduce the aerosol particle concentration by 88.9% and 95%, compared to 11.8%, while not using air purifiers reduced it by 11.8% and 30% respectively.

Conclusion: None of the included studies measured outcomes related to infectious disease transmission. However, both studies concluded that using an air purifier with HEPA filter significantly reduced the aerosol particle concentration. Future research is necessary that uses outcome measures of infectious disease transmission, such as virus concentration or incidence of infection.

Plain Language Summary

Respiratory infectious diseases, such as COVID-19 and influenza, cause a lot of illness and death. These diseases are primarily spread via droplets and aerosols. Droplets are larger particles, that are mainly spread in close contact. Aerosols are smaller particles, that can stay in the air longer. Therefore, aerosols are responsible for spreading diseases over long distances, as they can travel further. There are multiple factors in classrooms that make it vulnerable to the spread of respiratory infectious diseases. These are closely spaced room with many students, in which loud speaking is a common way of spreading aerosols and droplets. Air cleaners have been found to be effective in reducing infections in healthcare settings, but there is no overview of the scientific literature of this effect in school settings. An overview of the scientific literature could help in the decision-making whether it would be effective to implement air cleaners in schools to reduce the spread of infectious diseases. Therefore, this study aimed to summarize the available literature on the effect of air cleaning devices on infectious disease spread in schools.

Two databases with scientific literature were searched, using a systematic strategy to ensure that as much relevant articles were found as possible. In total 3,170 articles were found, of which two were relevant. These studies were both conducted in Germany, of which one was done in a secondary school. The studies did not measure the virus concentration or number of infections. Instead, they measured aerosol particle concentration as the most important outcome.

Both relevant studies found that using air cleaners in the classroom caused a larger reduction in the concentration of particles in the air in the classrooms compared to not using air cleaners. With air cleaners the aerosol particle concentration was 88.9% and 95% lower, while this was 11.8% and 30% without. While air cleaners seem to be effective in filtering particles from the air, it is not studied

whether this will affect the number of infections. Therefore, studies that look at the concentration of virus particles or the number of individuals with an infectious disease are needed.

Introduction

An important cause for morbidity and mortality are respiratory infectious diseases, such as influenza and COVID-19[1-3]. Droplets and aerosolized fine particles (droplet nuclei) are a common mode of person-to-person transmission of respiratory infectious diseases, such as influenza and COVID-19[4-6]. Droplets are defined as being >5 µm and transmission mainly occurs in close contact (within 1 m)[7]. Transmission over longer distances (>1 m) are primarily caused by droplet nuclei, which are <5 µm and can remain in the air longer than droplets, allowing them to travel further, making them responsible for airborne transmission[7].

In-room air cleaners can be used to reduce the concentration of airborne pathogens and prevent transmission of airborne infectious diseases[8]. Air purifiers return cleaned air to the room, after aerosol particles are separated[9, 10]. Various types of air cleaning technologies are used as in-room air purifiers[8]. Most frequently used techniques are the high-efficiency particulate air (HEPA) filters and ultraviolet germicidal irradiation (UVGI)[8]. HEPA filters use mechanical filtration, meaning that they physically remove airborne particles from the air[8]. These filters can be placed in HVAC (heating, ventilation, air conditioning) ducts or air purifiers[8]. UVGI is a form of radiation that uses ultraviolet (UV) light to damage the deoxyribonucleic (DNA) of microorganisms, disrupting their ability to replicate and thus leaving them noninfectious[8, 11]. UVGI lamps can be placed within the ducts of the HVAC system, in the ceiling or upper wall of a room, or in air purifiers[8]. However, overexposure to UVGI lights can cause side effects, such as skin reddening (erythema) and eye inflammation (photokeratitis)[11].

A scoping review, that mapped and summarized the research that assessed the implementation of portable air cleaning technologies in healthcare settings, found that the majority of included studies demonstrated that the devices are responsible for a significant reduction of the airborne particle concentration[12]. Several non-randomized prospective studies in the review also measured the association between the rate of infections and the use of air purifiers. They concluded that the use of portable air purifiers with HEPA filter was significantly associated with a decreased infection rate[13, 14]. A rapid review from Greenhalgh et al. concluded that it was necessary to clean the indoor air using engineering controls, such as ventilation or portable air cleaners with HEPA filters, to ensure a safe return to school in the context of the COVID-19 pandemic[15]. According to the study, this should be combined with other measures, such as social distancing, vaccination, or wearing masks[15].

Currently, there is no systematic review on the available evidence of the effect air filtration devices on the transmission of infectious diseases in an educational setting. Although evidence from healthcare settings seems to be in favor of the use of air filtration devices in the healthcare settings, it might not be generalizable to non-healthcare settings, such as schools. One reasons for this is the fact that there are differences in the characteristics of the population in the healthcare and school setting. For instance, individuals in schools are generally younger and healthier than those in hospitals. In addition, students have many close contacts with each other, while in hospitals this is limited to a few close contacts. Moreover, the air cleaning technology used in healthcare settings might differ from the technology used in schools. In schools the devices are usually based on HEPA filters, whereas in healthcare settings, for example, plasma, photo-electrochemical oxidation (PECO), or photocatalytic oxidation (PCO) technologies are used, which are sometimes combined with HEPA filters[12].

In a school setting multiple factors that make it prone to the transmission of respiratory infectious diseases are combined. For instance, classes often contain many students who are in close proximity of each other. Moreover, loud speaking in rooms that often have poor circulation is not uncommon. Speaking is a crucial way people emit potentially virus-laden aerosols and droplets[16-18]. More specifically, it was found that the rate of particle emission increases with loudness[16]. Furthermore, reducing the transmission in school can also impact the transmission in the rest of the population. Research in the field of influenza has established that schools are important drivers of population spread of infectious diseases[19-22]. A study in Germany estimated that 2-20% of the transmission of

COVID-19 to the general population could be contributed to school contacts[23]. An overview of the available evidence could be useful to develop or adjust guidelines regarding air filtration in schools. Also, knowledge gaps can be identified and used to establish a research agenda. Therefore, the aim of the study was to summarize the current literature on the effect of air filtration devices on the transmission of respiratory infectious diseases in an educational setting.

Methods

Database search/Search strategy

PubMed was used to search the MEDLINE database for studies on the effect of air filtration devices on infectious disease transmission in an educational setting. Additionally, the EMBASE database was searched. An information specialist, who specialized in the (bio)medical sciences, from the Utrecht University Library was consulted. Synonyms and words related to air filtration devices and infectious disease were used to derive the search terms from. Keywords, such as “air conditioner”, “air purifier”, high efficiency particle air”, “HEPA”, “UVGI”, “heating ventilation air conditioning”, “HVAC”, “air cleaner”, “infectious disease”, and “communicable disease”, were used to conduct the search. The search strategy also used index terms (MeSH Terms and Emtree terms) and truncations. The search terms were combined using the Boolean “OR” and “AND” operators. The final search strategy can be found in Table 1. The final search was conducted on May 31st in 2023. Moreover, reference lists of papers that met the inclusion criteria were checked for publications that were missed by the search strategy. The retrieved citations were all imported into a reference manager (EndNote version 20.2), and duplicates were removed both automatically and manually.

Table 1. Search strategy for PubMed/MEDLINE and EMBASE.

	PubMed/MEDLINE	EMBASE
#1	"air conditioning"[MeSH Terms]	‘Air conditioning’/exp
#2	“air condition*”[tiab]	‘air condition*’:ti,ab,kw
#3	"air purif*"[Title/Abstract]	‘air purif*’:ti,ab,kw
#4	"air filt*"[Title/Abstract]	‘air filt*’:ti,ab,kw
#5	"high efficiency particle air"[Title/Abstract]	‘high efficiency particle air’:ti,ab,kw
#6	"HEPA"[Title/Abstract]	‘HEPA’:ti,ab,kw
#7	“ultraviolet irradiat*”[Title/Abstract]	‘ultraviolet irradiat*’:ti,ab,kw
#8	"ultraviolet germicidal irradiat*"[Title/Abstract]	‘ultra violet germinicidal irradiat*’:ti,ab,kw
#9	"uvgi"[Title/Abstract]	‘uvgi’:ti,ab,kw
#10	‘heating ventilation air condition*”[Title/Abstract]	‘heating ventilation air condition*’:ti,ab,kw
#11	"hvac"[Title/Abstract]	‘hvac’:ti,ab,kw
#12	"air clean*"[Title/Abstract]	‘air clean*’:ti,ab,kw
#13	"Communicable Diseases"[MeSH Terms]	‘Communicable disease’/exp
#14	"disease transmission, infectious"[MeSH Terms]	‘infectious disease’/exp
#15	"infectious disease*"[Title/Abstract]	‘infectious disease*’:ti,ab,kw
#16	"communicable disease*"[Title/Abstract]	‘communicable disease*’:ti,ab,kw
#17	“transmission”[Title/Abstract]	‘transmission’:ti,ab,kw
#18	“SARS”[Title/Abstract]	‘SARS’:ti,ab,kw
#19	“covid”[Title/Abstract]	‘covid’:ti,ab,kw
#20	“corona”[Title/Abstract]	‘corona’:ti,ab,kw
#21	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR # 11 OR #12	(‘article’/it OR ‘article in press’/it OR ‘preprint’/it)
#22	#13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR # 11 OR #12
#23	#21 AND #22	#13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20
#24		#21 AND #22 AND #23

Study selection

The study selection process consisted of two parts. First, the titles and abstracts of potentially relevant studies were assessed according to the in- and exclusion criteria. Second, the full text articles were examined.

Original studies with an experimental design, such as randomized controlled trials (RCTs) and intervention studies, and cohort studies with a before-after comparison were eligible for inclusion. Moreover, studies were eligible for inclusion if they were conducted in an educational setting. Furthermore, publications had to be written in English or Dutch to be included. Cross-sectional, case-control, modeling or simulation studies were excluded, as the aim was to summarize the evidence of empiric studies. Studies were also excluded if they did not include a comparative situation, one in which the air filtration device was not used, for example. Moreover, studies were excluded if they focused on the effect of masks. The rationale behind this was that masks have a different working mechanism compared to other air filtration devices and the individual can have greater influence on the effectiveness of the intervention.

Data extraction and data-analysis

General information regarding the study was extracted, such as first author, year of publication, and country of origin. Also, methodological aspects were extracted, for example, setting, population, and the different scenarios that were investigated. Furthermore, the details on the Clean Air Delivery Rate (CADR) of the air filtration device used in the study were extracted, which may be expressed as air changes per hour (ACH) or ventilation flow rates (m^3/h, m^3/min, L/min). The CADR was divided by the number of students in the room to derive a ventilation rate (m^3/h) per hour. This allowed for a more straightforward comparison of the effect of the air filtration devices. The results of relevant tests of statistical significance related to air filtration were extracted as well. The main outcome of interest was the quantitative measure of association between the air filtration device and infectious disease occurrence. Information on the infectious disease occurrence were extracted if available, such as infections and pathogen concentration. Secondary outcome measures were extracted as well. These included the aerosol particle concentration, particle size distribution, carbon dioxide (CO_2) levels, and relative humidity. These secondary outcomes were compared to a situation without air filtration device. A descriptive analysis that summarized the main outcomes of the studies was conducted based on the extracted data.

Risk of bias assessment

Assessment of the quality of the included articles was based on the ROBINS-I (Risk Of Bias In Non-randomized Studies - of Interventions) assessment tool for cohort-type studies[24]. The ROBINS-I tool consists of seven domains of bias: confounding, in the selection of study participants into the study, in the classification of interventions, due to deviations from the intended interventions, missing data, in the measurement of outcomes, and in the selection of reported result[24]. Each domain was scored with low, moderate, serious, critical risk of bias or no information, based on a series of signaling questions[24].

Results

Study selection and characteristics

The search strategy initially yielded 3,767 references. Three additional papers were identified through relevant publications and reviews. After the removal of duplicates, 3,170 publications remained. Following title and abstract screening 3,122 records were excluded. The primary reason for exclusion after title and abstract screening were that the study was explicitly not conducted in an educational setting, but in a healthcare setting or office, for example. Other important reasons for exclusion were that it was a review, or simulation/modeling study. Of the 48 articles that were included in the full-text screening, 2 studies were included in the qualitative synthesis. The primary reason for exclusion after full text review was that the publication reported a simulation or modeling study. The complete flowchart of the study selection process and reasons for exclusion are shown in Figure 1.

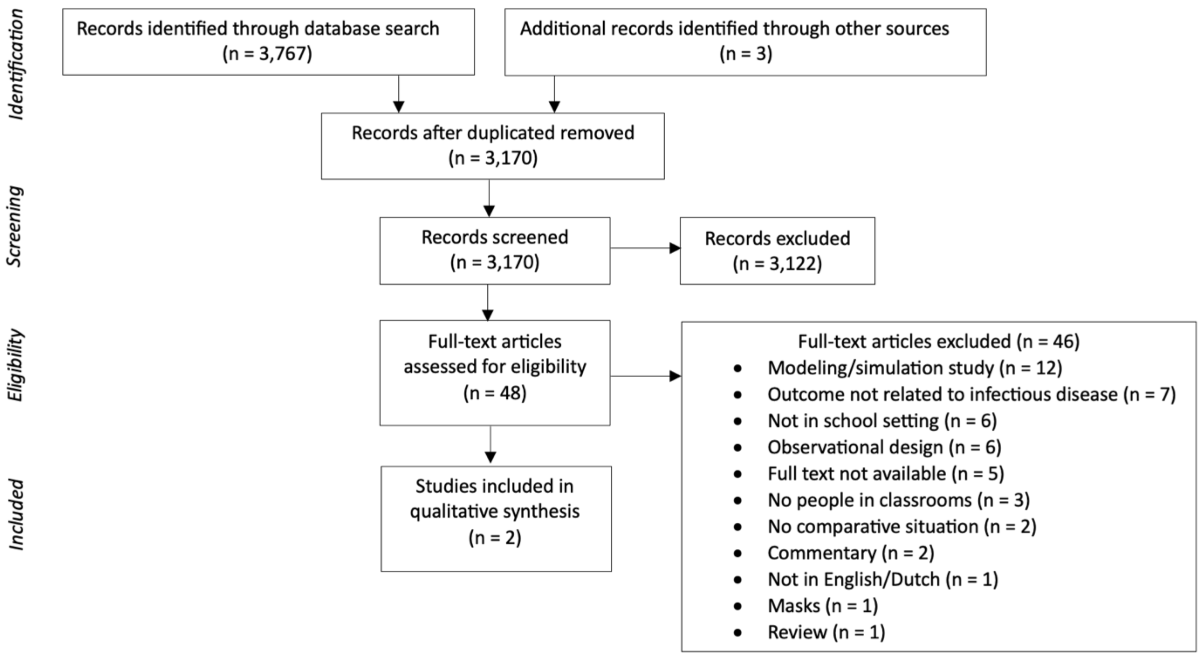

Figure 1. Flow chart of study selection process.

Table 2 shows the general characteristics of the included studies and the risk of bias assessment. Both included studies were conducted in Germany after 2020. Both studies reported that manufacturer or other stakeholders did not provide financial support for the project. One study was conducted at a secondary school, while the other one was conducted at a primary school. None of the included studies was a randomized controlled trial. The used study designs were most comparable to a non-randomized trial.

Risk of bias assessment

The overall score on the risk of bias assessment was moderate risk of bias. That is because both studies were categorized as having moderate risk of bias in the selection of the reported result, as they only reported the outcomes based on a representative day of measurements. However, the authors of the studies mention that the results were reproducible[10, 25]. Both included studies scored a low risk of bias for classification of intervention, as the intervention status was well defined and the definition of the intervention group was only based on information collected at the time of intervention, no aspects of the assignment of intervention status were determined retrospectively. Moreover, there were no deviations from the intended intervention in terms of implementation, so the studies scored a low risk of bias in this category as well. Furthermore, both studies scored a low risk of bias in the measurement of the outcomes. That is because the method of outcome assessment was similar across intervention groups, in case multiple groups/classrooms were compared. Also, the outcome measure was objective, so it was unlikely to be influenced by knowledge of the received intervention. The bias due to confounding and missing data could not be assessed, as no information was reported regarding confounding and missing data in the publications.

Clean Air Delivery Rate
The Clean Air Delivery Rate (CADR), which is used to quantify the efficacy of air purifiers, was 1026 m^3/h in one of the studies and 1060 m^3/h in the other. The study by Curtius et al. used multiple smaller air purifiers distributed over the classroom to achieve a CADR of 1026 m^3/h[25]. Based on the CADR used in the studies, a ventilation rate of the air purifier (m^3/h) per person in the room was calculated, by dividing the CADR by the number of people in the room, to create a more standardized measure. The ventilation rate per person was at least 36.6 m^3/h per person in the study from Curtius et al.[25] and at least 46.1 m^3/h per person in the study by Duill et al[10].

The primary outcome of this study, a quantitative measure of association of the effect of air purifiers on infectious disease occurrence, was not measured in any of the included papers. Both papers measured at least one secondary outcome which included: the aerosol concentration, particle size distribution, carbon dioxide concentration, or relative humidity in the classroom. The results and conclusions of the included papers are described in Table 3.

Reduction in aerosol particle concentration with and without air purifiers
Both studies concluded that the aerosol particle concentration was reduced significantly more by using an air purifier. The estimated reduction in aerosol particle concentration with air purifier was 88.9% in the study by Duill et al.[10] and 95% in the study by Curtius et al.[25], compared to 11.8% and 30%, respectively, when not using an air purifier. The reduction found in the situations without air purifier was contributed to particles diffusing to surfaces in the room, coagulation and sedimentation losses, and a fraction of aerosol particles was inhaled and deposited in the upper and lower respiratory tracts of the students and teacher in the classroom[10, 25].

Particle size distribution with and without air purifiers
Curtius et al. found that the aerosol particle concentration in the range of 0.3 to 10µm remained nearly constant in the room without air purifiers, while it decreased exponentially in the room that used air purifiers[25]. Duill et al. did not compare the reduction in aerosol particle concentration by size between the different scenarios, but found that the majority (96.4%) of the particles in the classroom is smaller than 0.5µm, which is sometimes seen as a critical particle size, as they stay airborne the longest and are able to travel the furthest[7, 10].

CO_2 levels and relative humidity with and without air purifiers
Both studies concluded that the air purifiers do not influence the CO_2 levels in the classroom and suggested ventilating regularly by opening a window[10, 25]. Duill et al. also found that using air purifiers does not have an impact on the relative humidity[10]. Curtius et al. did not report on the relative humidity.

Table 2. Characteristics of included studies and risk of bias assessment. Abbreviations: AP, air purifier; CADR, Clean Air Delivery Rate; VR, ventilation rate; HEPA, high-efficiency particulate air; HVAC, heating ventilation air conditioning; OPS, Optical Particle Sizer; s, seconds; uCPC, ultrafine Condensation Particle Counters; SMPS, Scanning Mobility Particle Sizer; NI, no information.

Author (year), country	Funding	School type and room size (m^3)	Number of students	AP specifications	CADR used (m^3/h), VR (m^3/h) per person	AP configurations	Risk of Bias Assessment							
							Confounding	Selection of study participants	Classification of interventions	Deviations from intended intervention	Missing data	Measurement of outcomes	Selection of reported results	Overall
Curtius et al. (2021)[25] Germany	No external funding	Secondary, 186.4	27 + 1 teacher	Mesh + activated charcoal + electret HEPA	186.7-365.2 Total = 1026, 36.6	3 or 4 APs were operated simultaneously. The APs were placed directly on the floor and were distributed across the room. Two at the front, one at the back and one in the middle. At the back of the room the uCPC, SMPS, and OPS were placed on a table. A second uCPC was on the teacher's desk	NI	Low	Low	Low	NI	Low	Moderate	Moderate
Duill et al. (2021)[10] Germany	State of Saxony-Anhalt (Germany)	Primary, 186.4	5-22 + 1 teacher + 1 scientist (mask)	AP1: ISO ePM10 50% pre-filter + H13 HEPA filter	1060, ≥46.1	1 AP was sufficient for the classroom size. AP: air outlet at 1.7m. 3 air ejection nozzles on the front, individually adjustable. Takes air from all sides. Placed centrally on short side of the room, opposite of blackboard. Measuring points were distributed over the room. 2 were in the corners on the side of AP2, 1 was in the middle of the room. Sampling height varied from 0.85m to 1.73m.	NI	Low	Low	Low	NI	Low	Moderate	Moderate

Table 3. Summary of the results in the included papers. Abbreviations: AP, air purifier; HEPA, high-efficiency particulate air; OPS, Optical Particle Sizer; uCPC, ultrafine Condensation Particle Counters; SMPS, Scanning Mobility Particle Sizer; CO_2, carbon dioxide; N.A., not applicable.

Author (year)	**Set-up tested scenarios**	**Primary outcome**	**Secondary outcomes comparing situation with and without AP**				**Conclusion**	**Comments**
			Overall aerosol particle concentration	**Aerosol particle concentration by size**	**CO_2 levels**	**Relative humidity**		
Curtius et al. (2021)[25]	The APs were operated at the school during the weekdays. During this time 8 single lessons (45 min each) and two double lessons (90 min each) were held at the classroom with the APs and the measurement instrumentation running, while 18 lessons were held at the reference room (without APs), respectively. On Friday, only the APs were operated for 5 lessons without the aerosol instrument to study the noise levels produced by the APs alone without influence from the measurement instrumentation.	Not measured	Without APs: The total number concentration decreased slowly over time and was reduced by 30% (from 56µg/m³ to 30-40µg/m³). With APs: The aerosol concentration decreased by more than 95% after 37 min (from 56µg/m³ to 9µg/m³). Aerosol concentration, diameter 0.01µm, using several uCPCs, SMPS, and OPS	In the room without AP the number of particles of 0.3-10µm remained almost constant, while it reduced exponentially in the room with APs.	Venting needed independent of the use of air purifiers.	N.A.	APs can reduce the aerosol load in a classroom in a fast, efficient, and homogeneous way.	The reference room without APs was perpendicular to the room with APs and was located on the side of the street. Therefore, it had higher standard aerosol concentrations.
Duill et al. (2021)[10]	A school lesson was 80 min. In measurements with scientist, window and door were opened every 20 min for 5 min. Scenario 1.1: AP, window ventilation Scenario 1.2: no AP, window ventilation Scenario 1.3: AP, no window ventilation	Not measured	Scenario 1.1: Reduction in particle number concentration of ± 88.9% between window ventilation. Scenario 1.2: Reduction in particle number concentration of ± 11.8% between window ventilation. Scenario 1.3: Reduction in particle number concentration of ±83.3%. Aerosol concentration, diameter 0.178-17.78µm, using 2 aerosol spectrometers type AQ Guard from PALAS GmbH	96.4% of detected particles are <0.5µm, 1.9% are 0.5-1µm, 1.7% >1 µm. No comparison made between the scenarios.	APs do not influence CO_2 levels. Window ventilation is needed.	APs do not influence relative humidity.	A reduction of particle number can be assumed due to the AP. Without the supply of particles through window ventilation, a low particle count in the single-digit range (particles/cm³) can be maintained.	Tested 3 types of APs, results only based on 1 type.

Discussion

Main findings

The aim of the study was to summarize the available evidence on the effect of air filtration devices on the transmission of respiratory infectious diseases in a school setting. Neither of the included studies measured outcomes directly related to infectious diseases, such as virus concentration or number of infections. The studies measured the effect of air purifiers on the aerosol concentration in the classroom and compared it to a classroom without air purifier. The included studies both showed that air purifiers are able to significantly increase the reduction in the concentration of aerosol particles in the classroom, compared to not using an air purifier.

Interpretation of the findings

The decrease in aerosol concentration was linked to a reduction of transmission risk of infectious diseases in the included papers. However, this has not been studied under empirical conditions or in real-world settings. However, multiple studies used simulations to estimate the effect of air purifiers on virus-laden particles. Banholzer et al. used epidemiological data (e.g., sex, age, COVID19 vaccination status), data on absences from school, environmental data (e.g., CO_2, aerosol number concentration), and bioaerosol samples to model the effect of using air cleaners on the SARS-CoV-2 transmission with a Bayesian semi-mechanistic hierarchical model[26]. The study found that the aerosol number and particle mass concentration were significantly lower when using an air cleaner[26]. However, according to the Bayesian transmission model, SARS-CoV-2 infections could not be prevented by using air cleaners[26]. Foster et al. investigated the effect of several mitigation strategies on SARS-CoV-2 transmission in a classroom setting, including nine students and one teacher, using computational fluid dynamics (CFD)[27]. Examples of mitigation strategies in this study were: various air purifiers, face masks, social distancing, barriers, and source control measures[27]. They concluded that the lowest transmission probability was achieved when using a combination of masks, ventilation, and various air purification strategies, based on the different air purifier models they tested[27]. These include one air purifier based on the clean air curtain model, two air purifiers of the clean air curtain model, or one conventional air purifier that has double the capacity of the clean air curtain model[27]. It was also mentioned that these measures should be combined with, for example, opening windows, but they did not investigate the effect of only air purifiers[27].

Strengths and limitations

A strength of this review is that it is among the first reviews that systematically searched for literature to summarize the available evidence regarding the effect of air filtration devices on respiratory infectious disease transmission in schools, based on empiric studies.

There are, however, also several limitations to this literature review. The included studies were conducted in German schools, which might have consequences for the generalizability of the results. The number of students in the classroom might be different across countries, for example, or the seating arrangement in the classroom can be different, meaning that in other countries more students might be close to each other. Moreover, the characteristics of the school buildings differ across countries, which might lead to differences in the use of mechanical ventilation systems. Another limitation of this study is that the study selection and risk of bias assessment were conducted by only one person. This implies that studies might have been classified differently in the study selection process or that the risk of bias assessment could have led to different results. However, the in- and exclusion criteria for the studies were defined clearly and the ROBINS-I tool was quite objective. Moreover, there were no randomized controlled trials that met the inclusion criteria retrieved from the search, which possibly compromises the risk of bias in the studies.

Implications for practice and research

Although this study found no evidence that air filtration devices are effective in reducing the transmission of infectious diseases, the results of this review seem to indicate that the aerosol particle concentration can be significantly reduced by air purifiers. These devices cannot only be used against aerosols but were also investigated by several studies as a measure to reduce particulate matter, ultrafine particles, black carbon[28, 29]. Since only two studies were eligible included in this review, more research is needed to be able to draw a conclusion regarding this relationship. Future studies that can make direct inferences on infectious disease transmission by measuring, for instance, virus concentration or incidence of infections, are necessary. Moreover, more epidemiological studies are needed to investigate this as opposed to more engineering studies, as those would consider and identify potential sources of bias in the design and analyses.

Conclusion

To conclude, there is currently no evidence that air filtration devices are effective in reducing the transmission of infectious diseases in an educational setting. However, air purifiers seem to be effective in reducing the overall aerosol particle concentration in the classroom compared to not using them. Therefore, future studies to assess this relationship directly, by measuring the virus concentration or number of cases, are needed to be able to form a conclusion as to whether air purifiers are effective.

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