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Indoor air quality in hospital environments, aircraft, cruise ships and the risk of airborne transmission by Coronavirus

Calidad del aire interior en hospitales, aviones, cruceros y el riesgo de transmisión aérea por Coronavirus

Qualidade do ar interior em hospitais, aeronaves, navios de cruzeiros e o risco de transmissão aérea pelo Coronavírus

ABSTRACT
Viruses represent a common cause of infectious disease acquired indoors, as they are easily transmitted, especially in crowded and poorly ventilated environments. Recently, the world has been experiencing the pandemic of the Severe Acute Respiratory Syndrome of Coronavirus 2 (SARS-CoV-2). This study aimed to verify in the international literature the risk of transmission of the virus by aerosols in acclimatized environments, such as hospitals, aircraft and cruise ships. It was an integrative literature review. The guiding question of this review was: Can the coronavirus spread through the indoor air of acclimatized environments such as hospitals, aircraft and ships and pose a risk of transmission to users of these environments? The researched literature revealed that viral aerosols can compromise indoor air quality and facilitate the transmission of SARS-CoV-2. Therefore, more research must be carried out to corroborate these findings and urgent measures are also needed to improve the cleanliness and hygiene of these environments, in addition to checking the renewal and filtering of indoor air in isolation rooms in hospitals, aircraft and cruise ships.
DESCRIPTORES: Severe Acute Respiratory Syndrome; Aerosols; Coronavirus; Indoor Air.

RESUMEN
Los virus representan una causa común de enfermedades infecciosas adquiridas en interiores, ya que se transmiten fácilmente, especialmente en entornos abarrotados y con poca ventilación. Recientemente, el mundo ha estado experimentando la pandemia del Síndrome Respiratorio Agudo Severo Del Coronavirus 2 (SARS-CoV-2). Este estudio tuvo como objetivo verificar en la literatura internacional el riesgo de transmisión del virus por aerosoles en entornos aclimatados, como hospitales, aviones y cruceros. Fue una revisión bibliográfica integradora. La pregunta guía de esta revisión fue: ¿Puede el coronavirus propagarse a través del aire interior de entornos aclimatados como hospitales, aviones y barcos y presentar un riesgo de transmisión a los usuarios de estos entornos? La literatura investigada reveló que los aerosoles virales pueden comprometer la calidad del aire interior y facilitar la transmisión del SARS-CoV-2. Por lo tanto, se debe realizar más investigación para corroborar estos hallazgos y también se necesitan medidas urgentes para mejorar la limpieza e higiene de estos entornos, además de verificar la renovación y el filtrado del aire interior en salas de aislamiento en hospitales, aviones y cruceros.
DESCRITORES: Síndrome Respiratorio Agudo Grave; Aerosoles; Coronavirus; Aire em Interiores.

RESUMO
Os vírus representam causa comum de doença infecciosa adquirida em ambientes interiores, pois são facilmente transmitidos, especialmente em ambientes lotados e mal ventilados. Recentemente, o mundo vem passando pela pandemia da Síndrome Respiratória Aguda Grave do Coronavírus 2 (SARS-CoV-2). Esse estudo objetivou verificar na literatura internacional o risco de transmissão do vírus por aerossóis em ambientes climatizados, como hospitais, aeronaves e navios de cruzeiro. Tratou-se de revisão integrativa da literatura. A questão norteadora desta revisão foi: O Coronavírus pode se propagar pelo ar interior de ambientes climatizados como hospitais, aeronaves e navios e representar risco de transmissão para os usuários desses ambientes? A literatura pesquisada revelou que os aerossóis virais podem comprometer a qualidade do ar de ambientes interiores e facilitar a transmissão da SARS-CoV-2. Portanto, mais pesquisas devem ser realizadas no sentido de corroborar esses achados e também são necessárias medidas urgentes para melhorar a limpeza e higienização desses ambientes, além da verificação da renovação e filtragem do ar interior em salas de isolamento em hospitais, aeronaves e navios de cruzeiro.
DESCRIPTORS: Síndrome Respiratória Aguda Grave; Aerossóis; Coronavírus; Ar Interior.

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INTRODUCTION

The importance that air quality has for the health of populations is recognized. Studies have revealed that air pollution inside environments is often much higher than levels outside[1].

Both public and private indoor environments, including homes, offices, schools, workplaces and transportation systems, contain numerous pollutants that are potentially harmful to health. Recently, exposure to biological agents, mainly bacteria and fungi, has aroused growing interest, but studies on the presence of viral aerosols in indoor air are scarce[2].

During and after the disease, viruses are eliminated in large numbers in bodily secretions, including blood, feces, urine, saliva and nasal fluid[3], which can contaminate surfaces and air. When an infected person coughs, sneezes or speaks, droplets are spread and can be inhaled or reach the mucous membranes of the mouth, nose or eyes of people who are close[2].

Aerosols, which are airborne suspensions of solid or liquid particles, travel short distances (1-2 meters) before laying on surfaces where viruses can remain viable for hours or days. Droplet transmission should not be confused with aerial transmission. Droplets do not remain suspended in the air. On the other hand, airborne transmission depends on evaporated droplet nuclei (small particles ≤ 5 μm), containing viruses, which can remain suspended in the air for long periods[4].

Coronaviruses are RNA viruses, of the Coronaviridae family, known to cause respiratory and enteric diseases [7].

Once released indoors, the movement and fate of viruses in the air is a complex process, involving many factors: the mechanism and speed with which droplets are ejected from the infected person, the concentration of viruses in respiratory secretions, the presence of material particulate/organic matter, environmental factors that affect the ineffectiveness and viability of the virus (eg temperature and humidity), ventilation, heating and air conditioning system[5,6].

Coronaviruses are RNA viruses, of the Coronaviridae family, known to cause respiratory and enteric diseases [7]. A new human Coronavirus called Se-

vere Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), previously called HCoV-19, appeared in Wuhan, China in late 2019 and is now causing a pandemic[8].

Although the origin of HCoV-19 is still being investigated, current evidence suggests that the spread to humans occurred through transmission of wild animals sold illegally in the wholesale seafood market in Huanan, China[9].

Hospitals are environments where viral aerosols can be particularly dangerous, as patients tend to be especially prone to infections due to preexisting diseases. The main routes of viral transmission in hospitals are by air, droplets and direct contact[2].

In other environments, such as schools and universities, the main means of transmitting biological agents, such as viruses, are: direct contact, proximity between student benches, lack of renewal of indoor air, lack of hygiene in air conditioning units and inadequate cleaning of classroom furniture and floors[10,11].

There is also evidence of airborne Coronavirus transmission on aircraft and cruise ships, as SARS patients on these means of transport have contaminated healthy people while traveling[12,13].

Viruses have prolonged survival in cold and dry environments, precisely those provided by air-conditioned environments(14,15), in addition, a research[8] revealed that SARS-CoV-2 remained more stable in plastic and stainless steel than in copper and cardboard, being detected up to 72 hours after application on these surfaces. The same study showed that Coronaviruses have the ability to survive for a long time on aerosols and surfaces.

Given the greater viability of SARS-CoV-2 in a cold, air-conditioned environment, in addition to a few studies on the transmission of this virus through aerosols and the growing pandemic, the present study aimed to verify in the international literature whether the environmental contamination of indoor air could explain the risk of transmission of the virus in hospital environments, aircraft and cruise ships.

METHODOLOGY

This is an integrative literature review. This method has the purpose of gathering and synthesizing research results on a given topic or issue, in a systematic and orderly manner, contributing to the deepening of the knowledge of the investigated topic[16].

The bibliographic review was carried out in March 2020 and included international publications, from January 2003 to March 2020. The choice of the initial year of the time frame is due to the increase in discussions and the publication regarding the Severe Acute Respiratory Syndrome (SARS) by Coronavirus.

The integrated search was carried out using the following descriptors in English and the corresponding ones in Spanish: [coronavirus, COVID-19, hospital]; [coronavirus, COVID-19, aircraft]; [coronavirus, COVID-19, cruise ship], uniting them with the "AND" connective. Latin American and Caribbean Literature in Health Sciences (LILACS) and PubMed search sources were verified.

The guiding question of this integrative review was: Can the Coronavirus spread through the indoor air of acclimatized environments such as hospitals, aircraft and ships and pose a risk of transmission to users of these environments?

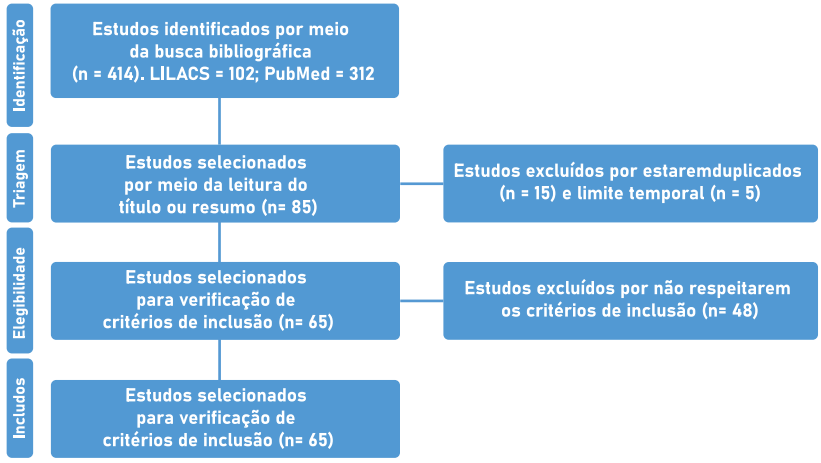
The inclusion criteria were: articles and editorials written in English or Spanish; be available electronically in full; present in the title and/or abstract at least three of the descriptors. Dissertations and theses on that subject and articles that were not available free of charge and electronically in the studied databases were excluded.

After confirming that the article would be included in the study, it was read to fill in the data collection script, which sought to investigate the year of publication, type of study, description of the sample and the studied environment (hospital, aircraft, cruise ship) and main findings.

Results and Discussion

Four hundred and fourteen papers were found referring to the researched theme. However, after excluding duplicates and meeting the inclusion criteria, 17 studies were used (Figure 1), which are listed in Chart 1.

Figure 1. Flowchart of this integrative review. Três Lagoas, MS, Brazil, 2020



Adaptado de Moher D et al. The PRISMA Group. Preferred reporting items for systematic reviews. Plos Med. 2009; 6(7): e1000097[17].

In order to facilitate the understanding of the results and discussion, they were summarized in the following topics: transmission of Coronavirus in aircraft, transmission of Coronavirus in cruise ships, SARS and hospital environments.

Chart 1. Works included in the integrative review regarding indoor air quality and the risk of transmission of Coronavirus in hospitals, aircraft and cruise ships. Três Lagoas, MS, Brazil, Jan/2003 - Mar/2020.

ANO	AUTOR	TIPO DO ESTUDO	AMOSTRA	PRINCIPAIS ACHADOS
2003	Lee et al.[27]	Estudo de coorte	138 pacientes foram admitidos no Prince of Wales Hospital, em Hong Kong, de 11 a 25 de março de 2003, com suspeita de SARS.	A maioria (n= 66,48%) era profissionais de saúde. Dentre os 138 pacientes, os sintomas mais comuns incluíram febre, calafrios, mialgia, tosse e dor de cabeça. Um total de 32 pacientes (23,2%) foi admitido na unidade de terapia intensiva e 5 pacientes morreram.
2003	Booth et al., 2003[7]	Estudo de coorte	144 pacientes adultos admitidos em 10 hospitais na área da grande Toronto, Ontário, entre 7 de março e 10 de abril de 2003, com suspeita ou diagnóstico de SARS.	A maioria dos casos de SARS (51%) foi adquirida em hospitais por profissionais de saúde. Os sintomas mais relatados pelos pacientes foram febre, tosse, mialgia e dispneia. Vinte e nove pacientes (20%) foram admitidos na UTI com ou sem ventilação mecânica e 8 morreram.
2003	Olsen et al.[12]	Estudo epidemiológico	Foram investigados 3 voos, entre Hong Kong a Tapei e Hong Kong a Pequim. No primeiro voo viajou um homem pré-sintomático e após 4 dias confirmou a SARS. Nenhum dos entrevistados relatou sintomas da doença. No segundo voo, um dos passageiros era sintomático para SARS e 22 pessoas relataram que estavam com a doença, após a viagem. No terceiro voo, havia 4 passageiros sintomáticos (todos também estavam no voo 2). Das 166 pessoas entrevistadas, uma relatou febre e sintomas respiratórios, mas, não realizou exame para SARS.	A transmissão da SARS pode ocorrer por aerossóis ou contato direto entre os passageiros, quando pessoas infectadas voam durante a fase sintomática da doença.
2003	Desenclos et al.[18]	Estudo de caso	Paciente com SARS que trabalhava em hospital francês no Vietnã foi a fonte de transmissão para outros três casos confirmados; incluindo duas pessoas expostas ao paciente durante o voo Hanói-Paris.	Os autores recomendam que pessoas com SARS por Coronavírus sejam impedidas de viajar em aeronaves. Ainda, enfatizam a necessidade do isolamento de casos prováveis e a manutenção de quarentena na prevenção da disseminação da SARS.
2004	Breugelmans et al. [19]	Estudo epidemiológico	Um homem, empresário, de 48 anos, positivo para SARS-CoV, viajou de Hong Kong para Frankfurt, Alemanha e, depois em sete voos por toda a Europa. Os entrevistados preencheram questionários e tiveram amostras de sangue colhidas, as quais foram negativas para SARS-CoV.	Nenhuma transmissão de SARS foi mostrada entre os passageiros sentados nas proximidades do paciente infectado. Como a inefetividade é maior na segunda semana da doença e o paciente viajou na primeira semana isso pode ter contribuído para a não transmissão da doença.

2005	Li et al.[28]	Estudo retrospectivo	Análise ambiental da enfermaria de um hospital, em Hong Kong, que sofreu surto de SARS, em 2003.	Inspeções no local, medições da ventilação e sistema de distribuição de ar foram verificadas, além de simulações computacionais de dinâmica de fluidos para analisar a dispersão de bioaerossóis na enfermaria do hospital. A concentração de bioaerossóis na enfermaria parece ter sido fator causal para o surto de SARS.
2005	Booth et al.[7]	Estudo ambiental com coletadas de amostras de ar interior e de superfícies	Amostras ambientais foram coletadas de 19 salas para tratamento de SARS de 4 centros de saúde de Toronto. Amostras foram testadas quanto à presença de SARS-CoV pelo uso da reação em cadeia da polimerase (PCR) e análise de cultura.	Duas amostras de ar foram positivas do quarto ocupado por um paciente com SARS, indicando a presença do vírus no ar da sala. Além disso, superfícies apresentaram positividade para Coronavírus em salas ocupadas por pacientes com SARS (uma mesa de cabeceira e um controle remoto de televisão) e no posto de enfermagem (na porta da geladeira para medicamentos).
2006	Vogt et al.[20]	Estudo epidemiológico	Os cinco pacientes incluídos nessa pesquisa adoeceram em fevereiro ou março de 2003 após viajarem para uma região afetada pela SARS. Quatro pacientes-índices foram confirmados laboratorialmente por infecção de SARS-CoV. O quinto paciente foi caso-índice de um surto em Toronto e morreu antes da realização do exame. Nenhum dos 312 passageiros pesquisados que viajaram com os pacientes-índices apresentaram positividade para SARS-CoV.	Embora o tamanho amostral tenha sido limitado, o trabalho sugere que o risco de transmissão de SARS-CoV não é alto a bordo de aeronaves, mesmo entre passageiros sentados perto do paciente-índice em voos longos. É mais provável que a probabilidade de transmissão seja determinada pela infecciosidade do paciente-índice e não pelo ambiente físico (por exemplo, aeronave, sala de aula ou hospital).
2013	La Rosa et al.[2]	Revisão Bibliográfica	A grande maioria dos estudos enfocou hospitais e outros serviços de saúde.	Os vírus são causa bem conhecida de infecções ocupacionais e nosocomiais nesses ambientes. A falta de regulamentações, valores limítrofes e métodos padronizados de detecção de vírus em ambientes internos dificultam a interpretação dos resultados em ambientes hospitalares.
2020	Van Doremalen et al.[8]	Experimental	Experimentos envolvendo dois vírus (SARS-CoV-2 e SARS-CoV-1) em cinco condições ambientais (aerossóis, plástico, aço inoxidável, cobre e papelão). Foi utilizado um nebulizador para criar os aerossóis (<5 µm) e modelo de regressão bayesiana para estimar as taxas de decaimento dos vírus nos aerossóis e superfícies.	O SARS-COv-2 foi detectado em aerossóis por até 3 horas, até quatro horas em cobre, até 24 horas em papelão e de 2 a 3 dias em plástico e aço inoxidável. A estabilidade do SARS-CoV-2 foi semelhante à do SARS-CoV-1 nas circunstâncias experimentais testadas.
2020	Ong et al.[3]	Estudo microbiológico de amostras de superfícies	26 amostras de superfícies foram coletadas durante 2 semanas de sala de isolamento, banheiro e antecâmara de 01 paciente (C) com SARS-CoV-2 antes da limpeza de rotina e de 2 pacientes (A e B) com a doença após a limpeza de rotina.	Amostras da sala do paciente C se mostraram positivas para SARS-CoV-2, incluindo ventiladores de saída de ar da sala; vaso sanitário, pia e maçaneta da porta do banheiro. O paciente C teve comprometimento do trato respiratório superior, sem pneumonia e, apresentou 2 amostras de fezes positivas para SARS-CoV-2.
2020	Arashiro et al. [21]	Estudo de caso	Amostras de SARS-CoV-2 foram testadas para dois tripulantes (uma garçonete e um limpador de cozinha) de um navio de cruzeiro.	A mulher, de 35 anos, do sul da Ásia, foi informada que tinha resultado positivo para SARS-CoV-2 no 6º dia e transferida para o hospital. O homem, de 27 anos, também do sul da Ásia, testou positivo para SARS-CoV-2 no 5º dia e foi internado.

2020	Kakimoto et al.[25]	Desenvolvimento de método matemático para estimar o número de novos casos diários no navio.	Navio com mais de 3.700 passageiros a bordo com primeiro caso sintomático de SARS-CoV-2 que embarcou em 25 de janeiro de 2020 e, em 9 de fevereiro, foram detectados 20 novos casos da doença. As pessoas foram mantidas em quarentena por 14 dias no navio e após esse período foram detectados mais de 700 casos da doença.	As pessoas que desenvolverem sintomas de SARS-CoV-2 enquanto estiverem a bordo de um navio devem ser isoladas para limitar a transmissão a outros passageiros e tripulantes.
2020	Mizumoto, Chowell[13]	Estudo de modelo matemático e dados de incidência de séries temporais que descreveram a trajetória do surto entre passageiros e membros da tripulação em navio com surto de SARS-CoV-2.	3.711 pessoas a bordo do navio Diamond Princess. Dois dias após o término da quarentena programada de duas semanas, um total de 621 pessoas sintomáticas e assintomáticas apresentou positividade para SARS-CoV-2.	A transmissão de passageiro a passageiro dominou a dinâmica de transmissão no navio. Os pesquisadores estimaram diminuição substancialmente dos casos de SARS-CoV-2, após o governo japonês implementar um controle aprimorado de quarentena, com a permanência dos passageiros em suas cabines.
2020	Mizumoto, Kagaya, Zarebski, Chowell[23]	Estudo epidemiológico para estimar o número de assintomáticos entre pacientes positivos para SARS-CoV-2.	634 casos foram confirmados entre 3.063 testados, sendo 306 sintomáticos e 328 assintomáticos. A faixa etária mais acometida foi de 70-79 anos.	Atualmente, não há evidências claras de que pessoas assintomáticas com SARS-CoV-2 possam transmitir a doença, mas há evidências indicando que uma parcela substancial de indivíduos infectados com SARS-CoV-2 é assintomática. Os autores estimaram 17,9% de assintomáticos entre indivíduos com resultado positivo para SARS-CoV-2.
2020	Wilson et al. [22]	Estudo epidemiológico para estimar o risco de mortalidade por SARS-CoV-2.	Os autores utilizaram dados da Organização Mundial da Saúde (OMS) para calcular estimativas do risco de mortalidade pela SARS-CoV-2, em 5 de março de 2020, para 4 populações: China; China, excluindo a província de Hubei; um grupo de 82 países, territórios e áreas; e passageiros e tripulação de um navio de cruzeiro.	Os riscos de mortalidade foram de 3,5% na China; 0,8% na China, excluindo a província de Hubei; 4,2% no grupo de 82 países, territórios e áreas e 0,6% para o navio de cruzeiro. De todos os resultados, o menos generalizável ó caso da China, que pode ser elevado devido a casos leves não diagnosticados, escassez inicial de kits de teste e risco elevado de morte devido às altas demandas iniciais do sistema de saúde em Wuhan. No entanto, dadas às incertezas residuais, os autores sugerem que as estimativas de risco de mortalidade por SARS-CoV-2 podem variar de 0,25% a 3,0%.
2020	Zhang et al. [26]	Estudo epidemiológico para projeção de novos casos de SARS-CoV-2 em um navio de cruzeiro para um período de 10 dias.	Até 16 de fevereiro de 2020, foram confirmados 355 casos com infecção por SARS-CoV-2 no navio Diamond Princess, em Yokohama, na China.	O número provável de novos casos chegaria a 1514 no décimo dia. No entanto, com a retirada dos pacientes doentes do navio e o sistema de quarentena adequado, o número total estimado de casos cumulativos seria reduzido. Nesse estudo foi considerada a transmissão de aerossóis com o SARS-CoV-2 pelo sistema central de ar condicionado entre os passageiros.

Coronavirus transmission in aircraft

In 2003, the first study was published that pointed to a probable transmission of Coronavirus in an aircraft, from an infected person to passengers located in seven rows ahead[12].

The same study showed that the highest concentration of people who were infected was in armchairs in front of the patient with Coronavirus than in the back and pointed to the role of cough in transmission, causing a combination of aerosol and spread of small droplets.

Large splashing droplets can be propagated up to 15 centimeters, while aerosols (< 5 μm) range from 1 to 2 meters. In the case of the SARS patient who contaminated passengers in the front rows, the spread may have occurred through aerosols or even fomites (contaminated clothing and surfaces), contact resulting from the movement of the closest passengers during the flight and contact in the areas or rows waiting, immediately before boarding or after disembarking[12]. Other research[18] also confirmed the transmission of SARS by Coronavirus during aircraft travel in France.

However, the literature is controversial regarding the transmission of Coronavirus during commercial flights. In 2004, a study was carried out to check whether a SARS patient who traveled from Hong Kong to Germany and seven other European countries contaminated passengers during flights. The survey did not detect passengers with SARS and stated that the degree of ineffectiveness of the disease in the first week is lower than in the second, which coincided with the patient's travel period[19].

Still, another study carried out in the United States with 5 index passengers, meaning that they had SARS-CoV during flights and surveyed 339 passengers, of which 312 completed questionnaires and 127 collected laboratory samples for SARS-CoV, detected that the serology was negative in all cases, demonstrating that there was no infection by Coronavirus[20].

The same work emphasized that the probability of transmission was determined by the infectivity of the index patient and not by the physical environment (for example, aircraft, classroom or hospital).

Coronavirus transmission on cruise ships

In the study of Arashiro(21) two cruise ship crew members with SARS-CoV-2 outbreak participated, a woman, 35, waitress and a man, 27, who worked as a kitchen cleaner on the ship. The waitress and her roommate shared the bathroom with 2 other people who had similar symptoms previously. The woman was detected with SARS-CoV-2 on the 6th day of the disease and the man on the 5th day, both were transferred to the hospital for treatment, but did not progress to pneumonia, which may represent the clinical course in young and healthy people .

The risk of mortality from SARS-CoV-2 is higher at older ages, when the patient already has a pre-existing disease or in places where the health system is deficient. The risk of mortality from SARS-CoV-2 can vary from 0.25% to 3.0%[22].

As the virus spreads, mild or asymptomatic cases of SARS-CoV-2 are likely to occur, and healthcare professionals should be aware of these clinical manifestations(21,23). Detection of viral RNA does not necessarily indicate infectivity, so there is an urgent need for guidance for the detection and management of mild SARS-CoV-2[21].

On February 28, 2020, a total of 705 cases of SARS-CoV-2 were confirmed among 4,061 passengers and crew on a cruise ship; 392 cases were asymptomatic, 36 people were admitted to intensive care units and 6 patients died[24].

Another SARS-CoV-2 outbreak occurred on the Diamond Princess, with 3,711 people on board. The virus was detected in a Hong Kong passenger who boarded the ship in Yokohama on January 20, 2020 and then disembarked in Hong Kong on January 25. He had a cough before boarding and was diagnosed with SARS-CoV-2 infection on February 1 in Hong Kong. The ship remained in forty for 14 days off the coast of Japan and at the end of that period, approximately 700 cases of SARS-CoV-2 were confirmed among passengers and crew[25].

The transmission routes on the ships may have occurred through aerosols distributed by the central air conditioning system[26] or contact with surfaces infected with SARS-CoV-2, such as: taps, handles, sinks and toilets in the bathrooms of ships and direct passenger-to-passenger contact[13].

SARS and hospital environments

Coronaviruses have been implicated in nosocomial outbreaks with environmental contamination as a route of transmission, as is the case with SARS-CoV-2. However, the mode of transmission by indoor air and the extent of contamination is not yet fully understood[3].

SARS-CoV is known to spread widely among healthcare professionals in several locations. For example, among 138 cases of secondary and tertiary dissemination in Hong Kong, 85 (62%) occurred among health professionals[27]; of the 144 cases in Toronto, 73 (51%) occurred among health professionals[7]. Therefore, the spread of SARS virus aerosols may be responsible for this type of transmission.

A survey revealed that sixteen (24%) of 66 medical students subsequently developed SARS-CoV, after having contacted or not with an infected patient in a Hong Kong hospital ward, however, all had been in that ward. This epidemiological re-

sult clearly suggests the transmission of the disease through indoor air[28].

Another study carried out with three patients with SARS-CoV-2 in isolation rooms for airborne infections, in Singapore, had surface samples collected, before and after cleaning. The samples after cleaning the surfaces with 1000 ppm of sodium dichloroisocyanurate were negative. Samples collected from the isolation room and bathroom of one of the patients before routine cleaning were positive for SARS-CoV-2 in the room's exhaust fans, toilet, sink and bathroom door handle[3].

Therefore, viral contamination in feces could have infected the surfaces of the bathroom and be a potential route of contact transmission, in addition, viral aerosols could have contaminated the room's exhaust fans, pointing to a SARS-CoV- 2.

Ong and collaborators[3] stated that the sample size was small and that the volume of air collected represented only a small fraction of the total volume and the air exchanges in the room would have diluted the presence of SARS-CoV-2 from the air in clean environments. Undoubtedly, cleaning the surfaces decreases the viral load in the environment, preventing the transmission of SARS-CoV-2.

Other research also suggests the spread by air of SARS-CoV in the hospital environment. A SARS patient who breathed quietly but coughed occasionally in a hospital room contaminated the surrounding air with SARS-CoV, as demonstrated by experiments carried out during the SARS outbreak in Canada in early 2003[14].

Still, according to the same study, surface samples were positive for SARS-CoV, such as headboard and television remote control used by the SARS patient. In addition, the surface of the medicine refrigerator door at the nursing station was positive for the virus. This denotes the need to remove all gloves and sanitize hands when leaving SARS patients' room.

Ong and collaborators[3] stated that the sample size was small and that the volume of air collected represented only a small fraction of the total volume and the air exchanges in the room would have diluted the presence of SARS-CoV-2 from the air in clean environments. Undoubtedly, cleaning the surfaces decreases the viral load in the environment, preventing the transmission of SARS-CoV-2.

The data provide confirmation of the generation of viral aerosols by a SARS patient, indicating the possibility of transmission by droplets and aerosols in the air, which emphasizes the need for adequate respiratory protection, as well as strict practices for cleaning and disinfecting surfaces.

Thus, health professionals who are directly involved in the diagnosis, treatment and care of patients with SARS-CoV are at risk of being infected with the virus by direct contact or by air transmission. In addition to biological risk, it is worth remembering that health professionals who take care of SARS-CoV cases suffer from anguish, due to work overload, lack of personal protective equipment and lack of specific medications[29].

A study has shown that SARS--CoV environmental contamination from infected patients peaks between 10 and 15 days after symptom onset, although this contamination continues in the convalescent phase in many cases[30].

Therefore, in isolation rooms in hospitals, the rates of renewal of indoor air, the ventilation and air conditioning system, the efficiency of air filtration, as well as any elective procedures that may result in the generation of patient aerosols should be taken into account. with SARS[14].

Furthermore, the detection of viable viruses in ambient air samples is very difficult. Methods using air impactors to collect aerosols are useful, but are not suitable for detecting low concentrations of viruses found in the clinical environment. In addition, air renewal significantly reduces viral RNA and the number of copies available for detection methods[5].

Therefore, new research should be encouraged around the world to better understand the airborne transmission of SARS-CoV-2 in order to prevent the spread of the disease.

Conclusion

The knowledge of the SARS--CoV-2 air transmission mechanisms allows a better understanding of how to prevent the spread of the disease. In hospital environments, improving indoor air quality, including not only isolation wards, but also common areas, can prevent these environments from being potential "contagion centers".

In addition, there is a need to use systems for filtering and renewing indoor air in environments such as cruise ships, fewer and greater spacing of seats in aircraft, as well as better cleaning of surfaces in these environments, in order to reduce outbreaks and transmission respiratory diseases, such as SARS-CoV-2.

In addition, international collaboration between clinicians, researchers and government agencies needs to continue in an effort to better understand and control this emerging infectious disease, especially in relation to SARS-CoV-2 air transmission. ■

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