# BIOSAFETY AND RESPIRATORY TRANSMISSION OF INFECTIOUS DISEASES

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# Biosafety and respiratory transmission of infectious diseases
# Biossegurança e transmissão respiratória de doenças infecciosas

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## ABSTRACT

**Introduction:** The topic of biosafety for the systematization and implementation of various measures to prevent contamination with agents that cause infectious and parasitic diseases requires measures to combat viable transmission mechanisms used by microorganisms, which is so important today. **Objective:** to analyze the available evidence on biosafety measures to prevent diseases transmitted by droplets and aerosols. **Method:** For this study, a bibliographic review was carried out in the electronic databases: U.S. National Library of Medicine (Pubmed), Literatura Latino-Americana and Scientific Electronic Library Online (Scielo). The descriptors for the search were chosen according to the Health Sciences Descriptors (DeCS/MeSH) of the Virtual Health Library, used with the Boolean operator "AND": "Aerosols", "Biosafety", "Containment of Biohazards" (preferred term to the previous one), "Disease Transmission, Infectious", "Infectious Disease Transmission, Patient-to-Professional" and "Respiratory Protective Devices" in the period until March 31, 2021. **Results:** Seven scientific papers were selected following inclusion and exclusion criteria. These works address the relationship between the risk of transmission of respiratory infectious diseases and biosafety aspects, as well as investigating failures that may indicate the need for interventions related to preventive measures in the face of exposure to biological risks. **Final considerations:** the possibility of identifying the importance of the study regarding the transmission of diseases through particles in the air, in the light of biosafety, seeking to give visibility to the protection measures already developed, raising awareness among health professionals, managers and politicians.

**Keywords:** Biological hazards; Biosafety; Infectious Diseases.

## RESUMO

**Introdução:** A temática da biossegurança para sistematização e implementação de diversos cuidados para prevenção da infecção por agentes causadores de doenças infecciosas requer medidas de grande importância nos dias atuais. **Objetivo:** analisar as evidências disponíveis sobre as medidas de biossegurança para prevenção de doenças transmitidas por gotículas e aerossóis. **Método:** Para este estudo, realizou-se uma revisão bibliográfica nas bases de dados eletrônicas: *U. S. National Library of Medicine* (Pubmed), Literatura Latino-Americana e *Scientific Electronic Library Online* (Scielo). Os descritores para a busca foram escolhidos segundo os Descritores em Ciências da Saúde (DeCS/MeSH) da Biblioteca Virtual em Saúde, empregadas com o operador booleano "AND": "*Aerosols*", "*Biosafety", "Containment of Biohazards"* (termo preferencial ao anterior)*, "Disease Transmission, Infectious"*, "*Infectious Disease Transmission, Patient-to-Professional*" e *"Respiratory Protective Devices*" no período até 31 de março de 2021. **Resultados:** Sete obras científicas foram selecionadas após critérios de inclusão e exclusão. Tais obras abordam a relação entre o risco de transmissão de doenças infecciosas respiratórios e aspectos de biossegurança, como, também, investigam as falhas que podem indicar a necessidade de intervenções relacionadas às medidas de prevenção diante a exposição aos riscos biológicos. **Considerações finais:** a possibilidade de identificar a importância do estudo referente à transmissão de doenças por partículas no ar, a luz da biossegurança, buscando dar visibilidade as medidas de proteção já desenvolvidas, conscientizando profissionais de saúde, gestores e políticos.

**Palavras-chave:** Biossegurança; Doenças Infecciosas; Riscos Biológicos.

## INTRODUCTION

According to the National Health Surveillance Agency (ANVISA), biosafety is defined as "the condition of safety achieved by a set of actions designed to prevent, control, reduce or eliminate risks inherent in activities that may compromise human or animal health or the environment" (Lessa, 2014). According to the World Health Organization (WHO), biosafety is: "a strategic and integrated approach to analyzing and managing relevant risks to human, animal and plant life and health and the associated risks to the environment" (Brazil, 2021a).

According to the Centers for Disease Control and Prevention (CDC), biosafety is: "the application of safety precautions that reduce a laboratory's risk of exposure to a potentially infectious microbe and limit contamination of the work environment and, ultimately, the community" (CDC, 2021). In addition, it is important to note the need for each health professional to take care of themselves and other colleagues, through procedures, protocols and techniques in their work routine.

The idea of biosafety gained momentum in the 1970s, when practices linked to genetic engineering emerged (Penna et al., 2010). The first procedure developed in this area was the introduction of the insulin synthesis gene into the bacterium *Escherichia coli* (Penna et al., 2010). Still on the subject of biotechnology, the National Technical Biosafety Commission (CTNBio) was set up in Brazil in 1995, with the intention of creating a regularized transgenic matrix (Pedroso and Colli, 2019). In this context, discussions about laboratory safety in genetic engineering practices came to the fore.

In Brazil, on February 19, 2002, the Health Biosafety Commission (CBS) was set up with the aim of promoting measures for action, evaluation and monitoring of biosafety practices, seeking a better link between the Ministry of Health and the institutions that deal with these issues (Penna et al., 2010). It was only in the third year of the health biosafety commission that Ordinance No. 485 - Regulatory Standard 32 (NR 32) - Safety and Health at Work in Health Services - was approved on November 11, 2005, with the aim of establishing guidelines for health protection measures for health professionals (Silva et al., 2012).

It should be noted that NR 32, like all other NRs, refers to a technical standard, but what makes it mandatory is Ordinance No. 3,214 of June 8, 1978. Thus, it is observed that: "The Minister of State for Labor, in the use of his legal attributions, considering the provisions of art.

200, of the Consolidation of Labor Laws, with wording given by Law no. 6.514, of December 22, 1977, resolves: Art. 1 Approve the Regulatory Norms - NR - of Chapter V, Title II, of the Consolidation of Labor Laws, relating to Occupational Safety and Medicine" (Brazil, 1978).

Regulatory Standard 32 is considered a milestone in the standardization of guidelines on biosafety measures to be implemented to protect health workers. However, although health professionals are aware of the occupational risks to their health, these biosafety measures are not implemented correctly (Silva, 2017).

According to ANAMT (National Association of Occupational Medicine), the health sector leads the ranking of occupational accidents in Brazil (ANAMT, 2016). On this occasion, it is worth noting the lack of protocols in place to deal with the occurrence of accidents at work of all kinds with sharp instruments in hospitals and outpatient clinics in the vast majority of our institutions.

In addition, as of September 27, 2021, Brazil ranked 7th in deaths from COVID-19 per million inhabitants (Ritchie et al., 2020). Specifically in this disease, the pandemic brought exposure to Biological Risk by health professionals, which would be equated to an accident at work: "Depending on the factual context, Covid-19 can be recognized as an occupational disease, applying in this case the provisions of § 2 of article 20 of Law No. 8,213, of 1991, when the disease results from the special conditions in which the work is performed and is directly related to it" (Brasil, 2020).

Among the routes of transmission of infectious agents are: the dermal route, overcome by bites, punctures and lesions; the sexual route, reached for example by Syphilis, Hepatitis B and Acquired Immune Deficiency Syndrome (AIDS); the oral fecal route, which causes diarrhea; transmission via the placenta, which turns out not to be totally efficient against some infections, such as toxoplasmosis and rubella; and finally the respiratory route, the focus of this study (Bahia, 2001).

Communicable diseases of the respiratory tract are spread through droplets and aerosols, which are small particles that carry microorganisms (PAHO, 2010). Droplets are produced - mainly - during speech, singing, coughing or sneezing, as well as procedures such as aspiration, bronchofibroscopy and sputum that induce particle formation. The particle has a size greater than 5μm and is capable of reaching the upper respiratory tract of another individual for up to one meter through the air (Lacerda et al., 2014). Aerosols, on the other hand, are capable of remaining suspended in the air for long periods, reaching up to 8 m distances, due to their size being less than 5 μm, and thus reaching the lower respiratory tract, reaching its endings, the alveoli (Bourouiba, 2020).

The main diseases transmitted by droplets are: epidemic parotitis, whooping cough, diphtheria, meningococcal disease, erythema infectiosum, influenza, rubella and COVID-19. Aerosols, on the other hand, stand out as a form of transmission for measles, pulmonary and laryngeal tuberculosis, chickenpox and COVID-19 (Lacerda et al., 2014; Siqueira-Batista et al., 2020). This data is relevant for understanding which processes, mechanisms and devices are capable of interfering as preventive barriers against the entry of pathogens into the human body. Although this knowledge has already been developed on a scientific basis, it is still little practiced by some health professionals: due to negligence, malpractice and a lack of technique. By health managers: allocation of resources, administrative measures and engineering measures. By the general population: the culture of peoples.

Based on these considerations, the aim of this manuscript is to analyze the available data on biosafety measures to prevent diseases transmitted by droplets and aerosols, thus helping to improve the awareness of health professionals and health service managers.

## METHODOLOGY

The integrative literature review was adopted because it contributes to the process of systematizing and analyzing the results, with the aim of understanding a given topic based on other independent studies. The integrative literature review proposes the establishment of well-defined criteria for data collection, analysis and presentation of the results, right from the start of the study, based on a previously prepared and validated research protocol. To this end, the following stages were adopted to set up the integrative review: 1) selecting the research question; 2) defining the criteria for including studies and selecting the sample; 3) representing the selected studies in table format, taking into account all the common characteristics; 4) critically analyzing the findings, identifying differences and conflicts; 5) interpreting the results and 6) clearly reporting the evidence found. The strategy for identifying and selecting the studies was carried out in the following electronic databases: *U. S. National Library of Medicine*

(Pubmed - https://pubmed.ncbi.nlm.nih.gov/) and Latin American Literature and *Scientific Electronic Library Online* (Scielo - https://www.scielo.org/). Initially, the search focused on original articles, with no date restriction, and included the following descriptors: "*Aerosols*", *"Biosafety"*, *"Containment of Biohazards"* (preferential term to the previous one), "*Disease Transmission, Infectious"*, *"Infectious Disease Transmission, Patient-to-Professional*" and *"Respiratory Protective Devices*" (Chart 1).

Chart 1 - Search strategy used in the literature review and the results found in the databases

| SEARCH STRATEGY (ENGLISH) | PUBMED | SCIELO |
|---|---|---|
| "*Biosafety*" AND "*Disease Transmission, Infectious*" | 23 | 01 |
| "*Biosafety*" AND "*Infectious Disease Transmission, Patient-to-Professional*" | 25 | 00 |
| "*Containment of Biohazards*" AND "*Disease Transmission, Infectious*" | 10 | 01 |
| "*Containment of Biohazards*" AND "*Infectious Disease Transmission, Patient-to-Professional*" | 32 | 01 |
| "*Respiratory Protective Devices*" AND "*Disease Transmission, Infectious*" | 30 | 02 |
| "*Respiratory Protective Devices*" AND "*Infectious Disease Transmission, Patient-to-Professional*" | 165 | 00 |
| **TOTAL CITATIONS** | 285 | 05 |

Source: prepared by the authors (July 31, 2023).

### Characteristics of the study, selection of articles and inclusion/exclusion criteria

After searching the PubMed and Scielo databases - deadline: July 31, 2021; no restrictions regarding language or location - two hundred and ninety citations were obtained (Table 1). The selection of studies was based on the following criteria: (I) Original articles, (II) Information on the transmission of respiratory diseases and (III) Biosafety for diseases transmitted by droplets and aerosols. In this sense, all manuscripts that could be considered to belong to at least one of the following items were excluded: (a) articles not characterized as original; (b) a focus on other routes of transmission of infectious diseases; and (c) an approach to themes other than biosafety, in reference to respiratory-transmitted diseases.

At first, the researchers read the title and abstract in order to select those that met the inclusion criteria, and two hundred and sixty-eight articles were selected. The articles that could not be included by reading the abstract, due to a lack of data, were included for reading in full.

In the second stage, the researchers read the articles in full and twenty met the objectives of this study and were included in the final sample for in-depth review. The final selection process yielded a total of ten articles for the manuscript.

## RESULTS AND DISCUSSION

The articles listed in Table 2 were read and the data obtained from the texts was organized into three sections: (a) Droplet-borne diseases: biosafety measures; (b) Aerosol-borne diseases: biosafety measures; and (c) Droplet and aerosol-borne diseases: vaccination - which will be presented below.

Chart 2 - List of the seven studies selected by the literature review

| ARTICLE | Research Method | Problems addressed | Results |
|---|---|---|---|
| COVID-19 and respiratory protection for healthcare providers (Sozkes and Sozkes, 2021) | Perspective | It investigated healthcare facilities' considerations for using reusable respirators as an alternative to disposable respirators during the COVID-19 pandemic. | By providing higher protection factors, reusable elastomeric respirators are recommended for use by HCPs under controlled cleaning and disinfection protocols. |
| Medical face masks offer self-protection against aerosols: An evaluation using a practical in vitro approach on a dummy head (Sterr et al., 2021) | Case studies | Compare respirators, medical face masks and cloth masks and determine whether it is advisable to use masks to protect the wearer from inhaling airborne aerosols. | Medical face masks with EN 14683 type II certification have shown protective efficacy against aerosols accompanied by minimal additional respiratory resistance. |
| Efficacy of face mask in preventing respiratory virus transmission: A systematic review and meta-analysis (Liang et al., 2020) | Systematic review and meta-analysis (PRISMA) | Use of masks and the relationship with protection in the spread of respiratory viruses. | Evidence of the value of protection with the use of masks. |
| Aerosol production during autopsies: The risk of sawing in bone (Pluim et al., 2018) | Exploratory study | To explore the potential effects of saw blade frequency and saw blade contact load on the number and size of bone particles produced in the air. | Respiratory protection equipment, such as respirators and biosafety protocols, are recommended to be put in place to protect forensic professionals from acquiring pathologies or other biological risks when performing autopsies. |
| Influenza aerosols in UK hospitals during the H1N1 (2009) pandemic - the risk of aerosol generation during medical procedures (Thompson et al., 2013) | Case studies | Investigation into whether or not the "aerosol generating procedures" (AGPs) defined by the World Health Organization (WHO) increase the risk of aerosol transmission to healthcare workers. | AGPs do not significantly increase the probability of sampling a positive H1N1 aerosol. |

| | | | |
|---|---|---|---|
| Nosocomial *Mycobacterium tuberculosis* transmission among healthcare students in a high incidence region, in Vitoria, State of Espirito Santo (Maciel et al., 2007) | Open comparative study | To assess whether the prevalence of a positive tuberculin test among health students could be used as a sentinel event for nosocomial transmission in highly endemic locations. | The data reinforces the need to implement biosafety programs for this target population. |
| Occupational accidents involving biological material among health professionals in public hospitals in the Federal District, Brazil, 2002/2003 (Caixeta and Barbosa-Branco, 2005) | Case studies | We studied the occurrence of occupational accidents among health professionals in 2002/2003 and the influence of biosafety measures and acceptance of chemoprophylaxis on the risk of occupational HIV transmission. | The situations related to accidents at work with the greatest acceptance and adherence to the use of chemoprophylaxis were positive serology and intense viral load in the source patient (99.6-99.0%), as opposed to negative serology in the source patient and a small proportion of accidents (36.8-55.6%). |

Source: prepared by the authors (2021).

## Droplet-borne diseases: biosafety measures

In the case of droplets, the recommendations regarding ventilation are poorly defined, and the necessary measures are: restricting the patient's circulation in a private room, with exits only when necessary, in addition to the use of a surgical mask, both by the hospitalized patient and by the health professional (Liang et al., 2020; Pluim et al., 2018; Thompson et al., 2013). In addition, distancing infected and susceptible people during the incubation period helps to reduce the transmissibility of the disease (Lacerda et al., 2014).

In necropsy procedures, care must be taken with droplet-borne diseases, such as meningococcal disease. There is evidence that not only droplets but also aerosols were produced during the necropsy of an individual who died from this disease. For this reason, if the professional does not use personal protective equipment (PPE) correctly, such as an N95 facepiece respirator, chemoprophylaxis with antibiotics is recommended (Brooks and Utley-Bobak, 2018). Table 3 describes the post-exposure measures for the main droplet-borne diseases.

Table 3 - Post-exposure measures for droplet-borne diseases

| Illness | Etiology | Average incubation time | Period of Transmissibility | Post-exposure prevention | Comments |
|---|---|---|---|---|---|
| VIRAL DISEASES | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Infectious erythema | Parvovirus B19[a] | 4-14 days | It gradually subsides after the onset of the rash [d] | No | --- |
| Influenza | *Influenza* virus | 1-4 days | 24 to 48 hours before the onset of infection there is transmission, but at lower levels than in the symptomatic period, between 24 and 72 hours of infection is the peak of transmissibility and declines until the 5th. Immunosuppressed people can excrete the virus for weeks or months. Children, compared to adults, also excrete the virus earlier, with a higher load viral and for long periods | Oseltamivir phosphate, for 10 days. **Adults and children weighing more than 40kg** - 75mg/day. **Children weighing 23 to 40kg** - 60mg/day. **Children weighing 15 to 23kg-** 45mg/day **Children weighing less than 15kg-** 30mg/day **Children aged 9 to 11 months-** 3.5mg/kg **Children aged 0 to 8 months-** 3mg/kg | It is indicated for people at high risk of complications, unvaccinated or vaccinated less than two weeks ago, after exposure to a suspected or confirmed case of influenza. |
| Infectious parotitis (mumps) | *Paramyxovirus* | 16-18 days (may vary from 12-25 days) | From 7 days before the first manifestations until 9 days after the onset of the clinical picture | No | In hospital environments, respiratory isolation of patients should be adopted, as well as the use of personal protective equipment (PPE) |
| Rubella | *Rubivirus* | 17 days. (Range 12-23 days) | 7 days before onset of *rash*, up to 7 days after onset of *rash* | No | Susceptible pregnant women and children under the age of 6 months should be kept away from their environment. with suspected and confirmed cases and their contacts, during the period of transmissibility and incubation of the disease |
| COVID-19 | *Coronavirus* | 2-14 days | According to WHO studies, transmission can occur in the symptomatic and asymptomatic phases | No | |
| Pertussis | *Bordetella pertussis* | 5-10 days (can vary | From the 5th day after exposure until 3 weeks | **Azithromycin (1st option)** | |

| | | | | | |
|---|---|---|---|---|---|
| | | from 4 to 21 days, but there are reports of up to 42 days) | after the onset of paroxysmal crises. In infants, it can last up to 4 **to** 6 weeks | <6 months 10 mg/kg once a day for 5 days It's the favorite for this age group<br>≥6 months 10 mg/kg (maximum 500 mg) in one dose on day 1 and 5 mg/kg (maximum 250 mg) in one dose a day from day 2 to day 5<br>Adults 500 mg in one dose on day 1 and 250 mg in one dose a day from day 2 to day 5<br>**Sulfamethoxazole-Trimethoprin (SMZ-TMP), in case of macrolide intolerance**<br><2 months contraindicated<br>Every 12 hours for 7 days:<br>≥6 weeks - 5 months SMZ 100 mg and TMP 20 mg<br>≥6 months - 5 years SMZ 200 mg and TMP 40 mg<br>6 to 12 years SMZ 400 mg and TMP 80 mg<br>Adults SMZ800 mg and TMP 160 mg | |
| Diphtheria[a] | *Corynebacterium diphtheriae* | 1-6 days (can be longer) | On average, up to two weeks after the onset of symptoms. Adequate antibiotic therapy eliminates, on the most cases, the diphtheria bacillus from the oropharynx, 24 to 48 hours after its introduction | Erythromycin:<br>**Children** - 40 to 50 mg/kg/day divided into 4 equal doses, for 7 days, orally;<br>**Adults** -500 mg, every 6 hours, for 7 days, orally | Antidiphtheria serum is a very effective measure for treating diphtheria |
| Meningococcal disease | *Neisseria meningitidis* | 3-4 days (can vary between 2 and 10 days)[b] | It persists as long as *N. meningitidis* remains in the individual's nasopharynx. 24 h of antibiotic therapy can eliminate | Rifampicin (600 mg, 12 h, 2 days), ceftriaxone (250 mg, IM, single dose) or ciprofloxacin (500 mg, VO, single dose) | The use of corticosteroids in shock is debatable due to their uncertain influence on improving the prognosis |

Source: Brazil. Ministry of Health (2019).

**Comments:**
a - Transmission can also occur through contact.
b - The patient stops transmitting the pathogen after 24 hours of adequate antibiotic therapy.
c - The possibility of viral transmission by aerosols (i.e. by air) is described.
d - Immunosuppressed patients can eliminate parvovirus for a prolonged period.
e - Pregnancy should be avoided within three months of rubella vaccination.

## Aerosol-borne diseases: biosafety measures

This section is organized into the following subtopics: (I) Evidence of aerosol transmission; (II) Administrative measures; (III) Engineering measures; and (IV) Personal protection measures (Sozkes and Sozkes, 2021; Sterr et al., 2021).

### *Evidence of aerosol transmission*

For an aerosol infection to be plausible under natural conditions, three steps must take place: (1) the aerosols must be generated by a contaminated vector, (2) the etiological agent must have the means to survive and remain on surfaces or in the air, (3) there must be the means to access the target body tissue (Jones and Brosseau, 2015).

As with SARS-CoV infection, there is evidence of the virus's ability to infect *Homo sapiens*: (1) patients with SARS-CoV acute respiratory syndrome are able to release numerous aerosol particles through coughing and respiratory tract procedures. In addition, fecal material also contains the virus, and toilet flushing is a means of emitting aerosols (Jones and Brosseau, 2015); (2) there are experimental studies that have verified the ability of the virus to remain viable for infection in fecal material and contaminated surfaces. Epidemiological data indicate the pathogen's ability to remain suspended in the air for long periods of time, with the capacity to promote infection (Jones and Brosseau, 2015); (3) there are animal studies that have proven SARS-CoV infection after inserting infectious strains into the nasal region of animals, this procedure was important for establishing a dose-response relationship for the risk in humans (Jones and Brosseau, 2015).

In the case of aerosols, care for air quality becomes more important, with the use of administrative, engineering and personal protection measures, within which there are conventional capacity measures (used regardless of the situation), contingency measures (used temporarily in times of crisis) and crisis measures (extreme measures, used as a last resort) (CDC, 2021).

***Administrative measures***

Administrative measures are the most effective in biosafety; they aim to improve practices related to the reception of patients suspected or diagnosed with an aerosol disease (Bahia, 2001). These measures include: triage; identification; a single flow of people within the place of care; investigation routines, follow-up and isolation, when necessary. These measures reduce the chances of disease transmission to patients and health professionals (Bahia, 2001).

In necropsies, care should be taken when cutting bone tissue with saws, as cutting bone material is capable of producing particles that carry pathogens, being directly proportional to the frequency of the cut and inversely proportional to the force. It follows that, in order to reduce the spread of particles, it is necessary to make slower and more intense cuts (Pluim et al., 2018).

There are some administrative measures recommended by the *Centers for Disease Control and Prevention* (CDC), especially in this context of SARS CoV-2 infections, regarding conventional capacity strategies, among which are: limit the flow of patients with suspected contagious respiratory disease in hospitals and primary health care units; carry out the initial examination in a room with good ventilation; use telemedicine for the control and screening of patients who are suspected or confirmed cases or contact with contaminated persons to reduce the flow in health facilities; limit the circulation of professionals not linked to direct patient care, for example, the delivery of food to the patient should be carried out by the health professionals themselves linked to direct patient care (CDC, 2021).

It is also important to limit visits to those that are essential for the physical and emotional well-being of patients, and whenever possible to encourage and prioritize the use of the online environment, through virtual visits; in the hospital environment, the origin of entries must be controlled, this measure consists of the use of PPE for face protection (*face shield*) by professionals, even if it is not related to contamination by respiratory diseases, as this reduces the spread of diseases; grouping patients infected with the same pathogen in the same ward or room (cohort), when individualized rooms are impossible; all employees who provide direct or indirect care to patients must be instructed and trained to adopt standard precautions and their respective personal protective equipment, and the N95/PFF2 mask for aerosol precautions (CDC, 2021).

As for contingency capacity strategies, it is necessary to reduce the length of the patient's hospitalization, and discharge is indicated when the patient is clinically stable and the home environment is able to receive them safely (CDC, 2021). With regard to crisis capacity strategies, it is recommended that professionals in institutions with the potential to be infected by respiratory infections be removed (CDC, 2021).

***Engineering measures***

Engineering measures are linked to practices that seek to ensure better ventilation conditions in areas where people who are diagnosed with or suspected of having diseases transmitted by aerosols circulate (Bahia, 2001). Some places offer greater risks of transmission: places with poor ventilation, patient care or waiting rooms, respiratory precaution rooms, bronchoscopy and induced sputum examination rooms, necropsy rooms, bacteriology laboratories, emergency services, radiology and diagnostic imaging sectors (Furlan and Bazzo, 2016).

Some measures help to improve air quality, such as: opening windows, using a fan in a position that expels the air to the outside area through an open window or door, using exhaust fans and HEPA - *High Efficiency Particulate Arrestance - filters*, the latter being ideal. If exhaust fans or HEPA filters are used, keep the doors and windows closed and the air in through diffuser grilles at the bottom (Motta et al., 2021a; Motta et al., 2021b).

Ceiling fans are not recommended, and air conditioning is only recommended in bronchoscopy rooms and private rooms under negative pressure and with HEPA filters. In outpatient rooms for patients with tuberculosis, measles and active varicella-zoster virus infections, there should be fan-induced air circulation between the patient and the professional, with the device positioned at table height and directed towards a window or door (Oppermann and Pires, 2003). Waiting rooms should be positioned in open environments, such as balconies, with plenty of natural air circulation.

In addition, there are important measures to control aerosols, especially in the context of SARS CoV-2 infection, including: placing patients with suspected or confirmed infection by the pathogen in rooms with airborne infection precautions (AIIR) to perform aerosol-generating procedures, in addition, the air generated should go directly to the outside environment; use curtains, glass or plastic as a barrier between patients and receptionists at the reception desk (CDC, 2021).

***Individual protection measures***

As far as personal protective measures are concerned, it is recommended that healthcare workers - in closed environments - wear N95/PFF2 particulate respirators or equivalent (approved and certified by the *National Institute for Occupational Safety and Health* - NIOSH, USA). In principle, their use to prevent measles and chickenpox in patients immune to these diseases is unnecessary. In situations where demand is greater than what is available or in a crisis, the N95/PFF2 respirator or equivalent has been used beyond the expiry date recommended by the manufacturer, as long as care is taken to protect it from moisture and impurities and an assessment is made of dirt, moisture, tears and creases before use, as these are conditions that contraindicate reuse (CDC, 2021).

There are some measures that should be taken when deciding to buy N95/PFF2 respirators or equivalent from another country (CDC, 2020). These include decisions regarding the product, such as being sure of the origin and quality of the filter and the seal of the mask on the face; the buyer should perform fit tests on the product to check its adaptation to different faces; the conditions of use should be evaluated, analyzing whether there is prolonged time of use; check if there is effectiveness above or equal to 95%; if the equipment has straps to adjust the ears, it is essential to analyze the ability to fit different people (CDC, 2020).

In addition to the N95/PFF2 respirator or equivalent, NIOSH also approves the use of other filter masks (N99, N100, P95, P99, P100, R95, R99, R100). Many facepiece respirators are not recommended in surgery, as the exhalation valves can compromise the sterile field (CDC, 2021). Elastomeric respirators are made of rubber or synthetic material that can be washed and reused, and the filter can be changed, but they should not be used in surgeries because they also compromise the sterile field (CDC, 2021).

Surgical masks are useful in preventing the dispersion of droplets, which is why it is important for all users of the healthcare system to wear them. The mask is a piece of equipment designed to protect the professional's mouth and nose (CDC, 2020), but certain precautions must be taken during its use; therefore, the mask should not be worn for a long period of time or touched successively, as well as being kept permanently around the neck, as in addition to not providing protection against droplets and aerosols, it can become a reservoir of microorganisms (Tipple et al., 2003).

As for inpatient units, there is a need for health professionals to take care of their own physical integrity in terms of getting sick from particles produced by the patient. Eyes, nose and oral mucosa are all sites for infection, and there is protective equipment for each anatomical region: for the eyes there are eye protectors, they are lightweight, making them easy to use, but they can blur vision or cause pressure damage to the skin; the use of N95/PFF2 masks has already been mentioned, they provide good protection for the mouth and nose, but can cause skin lesions, ear damage, headaches, as well as impairing communication; Elastomeric Half Facepiece Respirators (EHFRs) are alternatives to N95/PFF2 masks and have anti-fogging properties, however, they also impair communication and must be decontaminated before use; *Powered Air Purifying Respirators* (PAPRs) guarantee a high level of protection for the user, are comfortable and are great in risk situations, however, they have a high cost, require some training for use and also impair communication (Díaz-Guio et al., 2020). Table 4 describes the post-exposure measures for the main aerosol-transmitted diseases.

Table 4 - Post-exposure measures for aerosol-transmitted diseases

| **Disease** | **Etiology** | **Average incubation time** | **Transmission Period** | **Post-exposure prevention** | **Comments** |
|---|---|---|---|---|---|
| **VIRAL DISEASES** | | | | | |
| Measles | Morbillivirus | It can vary between 7 and 21 days | 6 days before to 4 days after the rash appears | Measles vaccine (live attenuated virus) up to 72 hours after exposure[b] Measles immunoglobulin, 0.25mL/kg (maximum 15mL), up to 144h after exposure. | Immunosuppressed people should be evaluated before being vaccinated [c] Immunoglobulin should be used in this case. |
| Chickenpox and disseminated herpes zoster[a] | Human herpes virus type 3[d] | It can vary from 10 to 21 days | Transmission occurs from two days before the onset of the rash until all the lesions have crusted over | Anti-varicella vaccine 120 hours after exposure[e] . Anti-varicella-zoster immunoglobulin (VZIG), 125U/10kg (maximum 625U) up to 96h after exposure. | Prophylaxis with acyclovir[f] until the second week after exposure is an alternative (Asano et al., 1993; Lin et al., 1997). |

| BACTERIAL DISEASES | | | | | |
|---|---|---|---|---|---|
| Pulmonary or laryngeal tuberculosis (confirmed or suspected) | *Mycobacterium tuberculosis* | Two to 12 weeks (for the tuberculin test). Illness can occur at any time in life | Several months or weeks, depending mainly on whether the patient is bacilliferous. | Isoniazid 10mg/kg/day (maximum 300mg/day), for six months | Chemoprophylaxis is indicated for those exposed with a tuberculin test. |

Source: Brazil. Ministry of Health (2019).

**Comments:**
a - Transmission can also occur through contact.
b - Patients who have received immunoglobulin less than three months previously should not be vaccinated.
c - Immunosuppressed patients are mainly those with lymphomas, leukemias, untreated active tuberculosis, AIDS, third-degree malnutrition and those taking immunosuppressants and/or corticosteroids.
d - Other names include Varicellovirus or varicella-zoster virus.
e - Contraindicated in immunosuppressed patients and pregnant women; in these cases, VZIG should be used.
f - The published series are too small, in terms of casuistry, to make valid comparisons, but there is undoubtedly a possible indication for acyclovir administered between 7 and 14 days after exposure in vulnerable patients who have missed the optimum time for VZIG administration (Hambleton and Gershon, 2005).

With regard to tuberculosis, studies indicate that the professionals most at risk of becoming infected with the disease are those who work in healthcare facilities. Furthermore, the delay in clinical and laboratory diagnosis, the area and place of work, and not using the recommended respiratory protection, such as the N95/PFF2 respirator or equivalent, all contribute to higher rates of infection (Moreira, Zandonade and Maciel, 2010). Positivity for the tuberculin test reaches 54.1% in health workers who work with tuberculosis control programs, showing the high transmissibility in this population (Lacerda et al., 2014).

## Diseases transmitted by droplets and aerosols: vaccination

Pre-exposure prophylactic measures, such as vaccinations, also play an important role in the prevention of diseases transmitted by droplets and aerosols, and it is essential that health professionals are encouraged to use them, since active immunization through vaccination generates prolonged immunity (Maciel et al., 2007; Caixeta and Barbosa-Branco, 2005; Cavalcante, 2008). Table 5 describes the main vaccines recommended for healthcare workers.

Table 5 - Main vaccines recommended for health professionals [a]

| Recommended Vaccine | Scheme | Observations |
|---|---|---|
| **MMR: measles, mumps and rubella** | All those who have received two doses at least one month apart, applied after 12 months of age, are considered to be immunized.<br>In measles outbreaks, one dose should be given to individuals from 6 months of age, and two doses of | In patients taking immunosuppressants, vaccination is recommended one month after stopping the medication.<br>In patients undergoing chemotherapy, vaccination is recommended three months after treatment has stopped.<br>In patients who have received a bone marrow transplant, vaccination is |

| | | |
|---|---|---|
| | the above regimen are required from 12 months.<br>Older children, adolescents and adults without proven doses should be given two doses one to two months apart. | recommended 12 to 24 months after surgery.<br>In febrile patients, vaccination should be postponed until improvement. |
| **Bacterial triple - diphtheria, tetanus and pertussis - adult acellular type (dTpa)** | Boosters are recommended for 4-5 year olds, adolescents, adults and the elderly.<br>Vaccination is recommended for pregnant women in their 20th week of pregnancy, or one dose as soon as possible after delivery.<br>It is recommended for people who live with children under 2 years old. | In febrile patients, vaccination should be postponed until improvement.<br>If there is an intense local reaction, you should check for possible boosters after 10 years.<br>No care is needed before vaccination. |

| Recommended Vaccine | Scheme | Observations |
|---|---|---|
| **Chickenpox** | First dose at 12 months and second between 15 and 24 months of age, which can be replaced by two doses of SCR-V due to the proximity of its application<br>For children up to 11 years old, the interval between doses is at least 3 months. For adolescents and adults, the interval is one to two months.<br>In the event of an outbreak, a dose should be given at 9 months, without skipping doses at 12 months and between 15 and 24 months of age. | In children taking immunosuppressants, vaccination is recommended one month after stopping the medication.<br>In children undergoing chemotherapy, vaccination is recommended three months after the treatment has stopped.<br>In children who have received a bone marrow transplant, vaccination is recommended 12 to 24 months after surgery<br>In febrile patients, vaccination should be postponed until improvement |
| **Influenza** | For children between 6 months and 8 years of age, two doses are given, one month apart, with annual revaccination thereafter.<br>From 9 years of age single annual dose | In febrile patients, vaccination should be postponed until improvement<br>Patients with hen's egg allergies and signs of anaphylaxis should remain at the point of care for 30 minutes.<br>If there is a history of Guillain-Barré syndrome within six months of the previous dose, the next dose should be evaluated by a doctor. |
| **Meningococcal conjugate** | For children, vaccination should start at 3 months, with two doses in the first year of age, boosters between 12 and 15 months, between 5 and 6 years and at 11 years of age<br>For adolescents, two doses five years apart are recommended<br>For adults, a single dose is recommended, depending on the risk | In febrile patients, vaccination should be postponed until improvement |

| | | |
|---|---|---|
| **COVID-19** | Licensed in 2021 for emergency use<br>The monitoring of those vaccinated so far has not provided any information for recommendations on boosters. **See update on the ANVISA website**. | The vaccines have shown a good safety profile, with only mild to moderate symptoms, such as fever, headache, pain in the body and at the application site. Anaphylactic reactions are rare<br>The Fiocruz/Oxford/AstraZeneca and Instituto Butantan/Sinovac vaccines are safe in their tests |

Source: Table adapted from the *Occupational Vaccination Calendar* - SBIm Recommendations - 2020/2021.

**Note**:
a - Health professionals: Doctors, nurses, nursing technicians and assistants, pathologists and pathology technicians, dentists, speech therapists, physiotherapists, pharmacists, hospital support, maintenance and cleaning staff, stretcher-bearers, ambulance drivers, X-ray technicians and other professionals who work in or regularly attend health services, such as health students, representatives of the pharmaceutical industry and others.

In the context of 2021 in Brazil, in the priorities defined by the Ministry of Health, vaccination for COVID-19 was defined by priority groups. People aged 60 and over and institutionalized disabled people were the first two groups, followed by indigenous people living on indigenous lands and then health workers, followed by the general population up to 75 years of age, riverine and Quilombola populations, people up to 60 years of age, people with comorbidities and pregnant and postpartum women with comorbidities. After vaccinating the priority groups, vaccination was extended to adults and adolescents up to the age of 12 (Brazil, 2021b).

**Diseases transmitted by droplets and aerosols: Epidemics and outbreaks**

With the SARS-CoV-2 pandemic, countries needed to prepare for this type of crisis by adopting specific measures against the virus, considering the knowledge about its transmission routes (Petersen et al., 2020). Among the measures adopted were restrictions on the entry of people from other countries, the implementation of the International Health Regulations (IHR), which mandate serological testing for individuals entering or leaving the country; in Hong Kong, truck drivers had to present documents proving they were not infected with COVID-19 before crossing the border; in South Korea, a two-week quarantine was imposed on anyone entering the country. Additionally, discussions regarding the reopening of non-essential businesses and institutions that promote large gatherings were advised only after the peak incidence had stabilized (Petersen et al., 2020).

In outbreaks where detecting the viral pathogen is challenging, such as the 2013 SARS pandemic in Hong Kong and southern China, transmission electron microscopy was used for diagnosis, underscoring the importance of this technique in identifying specific and unknown outbreaks (Petersen et al., 2020).

## FINAL CONSIDERATIONS

The mechanisms used by pathogens to cause infections in humans are diverse, which explains the wide variety of body systems that can be affected. Among these mechanisms are droplets and aerosols, which, due to their small size, can invade the airways. According to biosafety standards, these are referred to as respirable particles. Today, various practices have been implemented to improve working conditions in hospital and outpatient settings, including measures before and after exposure, which are categorized into administrative, engineering, and personal protection measures. These contribute to the control of occupational respiratory infections, positively impacting the health of healthcare system workers, as evidenced by improvements in both the quality and quantity of life. It is crucial to acquire knowledge that translates into behavioral changes through healthy habits and enhanced professional skills. However, good biosafety practices must be supported by both personal protective equipment (PPE) and collective protective equipment.

The importance of studying disease transmission through airborne particles, from the perspective of biosafety concepts, lies in the promotion and development of protection measures, and raising awareness among health professionals, managers, policymakers, and the general public. The literature lacks recent studies that analyze the primary causes of non-adherence to biosafety standards among healthcare workers, which presents a limitation to this study.

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