THREATS TO PASSENGER FLIGHT SAFETY RELATED TO BIOLOGICAL AGENTS

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ABSTRACT

Passenger flights became nowadays a generally available mode of transportation for the majority of the population in both economically developed and developing countries. Their attractiveness is based on a fairly low price of the ticket, high comfort of traveling and covering long distances in a short time and saving travelers' time. Obvious benefits resulting from this type of people's movement are accompanied by the issues of the safety of passenger flights, and the dangers resulting from the nature of this type of human transportation. One of the many threats are biological agents which are transferred to various corners of the world as a result of people's traveling by an aircraft. Although diseases in endemic areas often occur as common diseases, when transferred to other countries, continents and to other human population, they can become deadly diseases. Therefore, commercial airlines are classified as means of transportation that have adequate conditions for the easy spread of pathogens carried by passengers, crew, food or air filters in a closed circuit. An additional problem is the deliberate use of a biological agent by terrorists as a biological weapon that can be employed by them for the purposes of an ideological war that has been going on for many years in the world.

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KEY WORDS

Air transport, biological agents, human factor, airborne pathogens, biological weapon, environmental control system.

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Introduction

The widespread availability of passenger plane travel and human mobility leads to a number of situations in which it is possible to transmit infectious diseases during passenger flights by aerosol, by food served on the plane and aircraft ventilation systems, so this is an important public health issue, but also a factor conducive to the spread of the epidemic. An additional issue is the use of dangerous pathogens as a biologi-

cal weapon by terrorists to cause panic and a number of future consequences[1].

Both passenger planes and the entire airport infrastructure are the appropriate environment for the spread of pathogens, such as tuberculosis, SARS, common cold, influenza carried by passengers or crew and all ground handling services. The environmental control system in the aircraft in the form of HEPA filters should limit the spread of pathogens transmitted by aerosol route, but this is not a 100% guarantee[2].

The probability of transferring a contagious disease from passenger to passenger during a flight is very high, but reports and statistics on its occurrence are incomplete. This is due to the fact that the majority of diseases have a longer incubation period than air travel and after the journey, few of the symptoms that occurred in the passenger are associated with the flight. Thus, consideration of the issues related to passenger flights security threats caused by biological agents must take into account not only the transmission of infectious diseases among passengers of an aircraft by the interior ventilation systems but also by the food served in them by the flight attendants.

Selected diseases transmitted by droplets during passenger flights

Diseases that are potentially transferable from person to person during air passenger flights are usually transmitted by droplets and include, among others: tuberculosis, SARS, common cold and potential biological weapons in an aerosol form.

Tuberculosis is a disease caused by *Mycobacterium tuberculosis* transmitted by a droplet and one of the diseases that is a global threat. It is estimated that in one third of the population on the ground there is a carrier, symptoms of the illness and finally the illness itself.

Transfer of the *Mycobacterium bacillus* by aerosol is a model example of the spread of this pathogen on a passenger plane. Epidemiological investigations of passenger airplanes were conducted already in the 1990s and two of the seven investigations revealed correlations between the on-board transmission and subsequent illnesses of passengers[3].

In 1992, tests were carried out to perform a tuberculin test in passengers of several aircraft used by passengers with pulmonary tuberculosis. Many of them had positive tuberculin test results, but there have been no cases of tuberculosis. Although there is a risk of tuberculosis infection in the aircraft, the probability of full-blown tuberculosis after contact between passengers is as much as 1 to 1000[4].

SARS (*Severe Acute Respiratory Distress Syndrome*) is an atypical pneumonitis caused by a coronavirus, spread by air or in direct and indirect human contact with an infected person. The global spread of the disease through plane travel has been documented numerous times. Many flights that were associated with SARS infections were investigated and proved to be associated with on-board equipment responsible for the air exchange inside an aircraft. The number of infected passengers examined during 40 flights was 300. It should be noted that they continued to infect other people after landing[5].

[1] Kucharek D., Osiak B., Selected aspects of hazard analysis in the air transport of hazardous, Security Forum, Dąbrowa Górnicza 2017, pp. 67-73.

[2] Hocking M.B., Passenger aircraft cabin air quality: trends, effects, societal costs, proposals, Chemosphere 41(2000), pp. 603-615.

[3] Mangili A., Gendreau M.A. Transmission of infectious diseases during commercial air travel. Lancet 2005, p. 992.

[4] McFarland J.W. , Hickman C., Osterholm M. , MacDonald K.L., Exposure to Mycobacterium tuberculosis during air travel. Lancet, 342 (1993), pp. 112-113.

[5] Ibidem.

Common cold outbreaks are considered to be a harmless and ubiquitous infection of the upper respiratory tract that can be caused by various types of bacteria and viruses. Common cold is not associated with infections transmitted during air travel and this condition is attributed to difficulties in the study of this type of outbreaks in the world, and difficulties in their monitoring. This does not mean that it is not transferred by this type of transportation. In the conducted research, it was found that air recirculation in the aircraft cabin does not constitute a risk of infection and cold symptoms, and that the filter system is sufficiently tight to prevent the spread of this type of infection.

Influenza is an acute infectious disease of the respiratory system caused by an infection by the influenza virus. It spreads between people by droplets (for example when sneezing), causing severe symptoms that lead to a serious illness, complications and even death. Death occurs especially in children, the elderly and those suffering from other, additional serious diseases. The highest number of cases occurs during seasonal epidemics in autumn months (October to January) and spring season (from March to April). Influenza outbreaks cause significant social costs and sometimes have continental or global coverage, which is why flu requires global epidemiological coordination[6].

Research has proven that the plane is a global vector that causes the flu virus to be transmitted in a passenger flight that occurs worldwide. In 1979, passengers flying one plane in which ventilation was damaged were infected with a type A flu virus. After this incident, 72% of flu infections were recorded within 72 hours. The consequence was also the occurrence of an additional 20% infected within 2 weeks among the families of passengers of this aircraft. We can see in this one example that the scale of spreading of the flu virus by passenger airplanes is huge, which indicates a huge threat of spreading this disease worldwide, and thus the occurrence of more and more dangerous mutations of this virus, which results in millions of infections per year among our population[7].

The examples of diseases that are easily transmitted from person to person by means of droplets during passenger flights prove how easy it is to transfer the disease to another city, country, to another continent. Tuberculosis, SARS, influenza virus, cold are a few of many examples of diseases that due to their nature of spreading are extremely dangerous not only for people traveling by plane, but people from their further environment.

Causes of the spread of biological agents in passenger planes

Every year over 2 billion passengers travel by airlines, which is why transmission of infectious diseases is an important global health problem. Transmission of the disease while traveling by plane is highly likely, and often even documented. A respiratory disease, both bacterial and viral, is a frequent on-board infectious agent in an aircraft. This is related to the closeness of people and high-density seating on board of the aircraft, the circulation of air in a closed circuit, long flights, which promote the spread of the disease.

Infection at a distance from the index case indicates other factors, such as airflow, movement of passenger/crew members, fomites and contacts between passengers in the departure gate before boarding, or after deplaning[8].

[6] https://pl.wikipedia.org/wiki/Grypa, access:10/06/2018

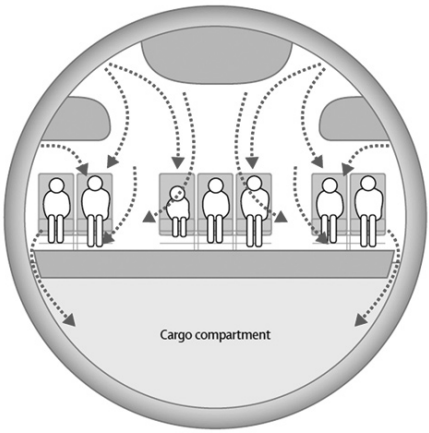
[7] Ibidem.

[8] Hertzberg S.V., Weiss H., On the 2-Row Rule for Infectious Disease Transmission on Aircraft, Annals of Global Health, Vol. 82, No. 5, 2016, pp. 819-821.

The factors conducive to the spread of bacteria and viruses in the aircraft include: closed environment, internal circulation of ventilation and filtration, close contact of passengers with each other; the parameters: pressure, humidity and dryness of the air and hypoxia. These factors are regulated during the internal flight, fully automated system controlling the pressure, temperature and air in the aircraft. However, it is possible to manually control the number of air changes per hour, the temperature in the passenger compartment and the mixing of air from the pilot cabin.

An example of air circulation in a typical airline passenger cabin is given in Figure 1, where arrows indicate the distribution of air currents. The air flow is directed from the top to the passenger and the entire deck of the plane through regulated ventilation to provide oxygen, then the air goes to the outlets and is sucked into the cargo compartment, where the filters in the closed HEPA filters clean it for reuse. Fresh air is supplied by special tubes from engines that heat, cool and transfer them to the internal ventilation system of the aircraft. It should be noted that the air circulation in the passenger cabin is divided into sections, which is to prevent the spread of biological agents throughout the whole aircraft, and thus transfer them to all passengers, to prevent an epidemic. It is assumed that the sucked air from the outside at high cruising altitudes is sterile. In addition, when the aircraft is stationary at the terminal, fresh air is supplied by auxiliary power units to the interior of the aircraft.

Figure 1. Air circulation pattern in typical airline passenger cabin



Source: Mangili A., Gendreau M.A. Transmission of infectious diseases during commercial air travel. Lancet 2005, p. 989.

HEPA filters are installed in every aircraft, which are high-efficiency particulate filters in passenger compartments of up to 97-99% efficiency and permeability of particulates up to 0.3 microns in diameter. These filters are designed to remove dust, bacteria, fungi, viruses and vapors. World standards provide for 15 to 20 air changes per hour in airplanes, where only 12 exchanges are allowed in typical buildings and office buildings[9].

The efficiency of these filters depends on the type of aircraft (4-7 l / s of filtered air) and its speed depends on the type of a cabin in the aircraft, i.e. the first class and economy class. However, not all aircrafts are equipped with HEPA filters, which is regulated by the relevant operational standards and this is allowed by the Civil Aviation Authority and the Federal Aviation Administration[10].

[9] Hocking M.B., Passenger aircraft cabin air quality: trends, effects, societal costs, proposals, Chemosphere 41(2000), 603-615.

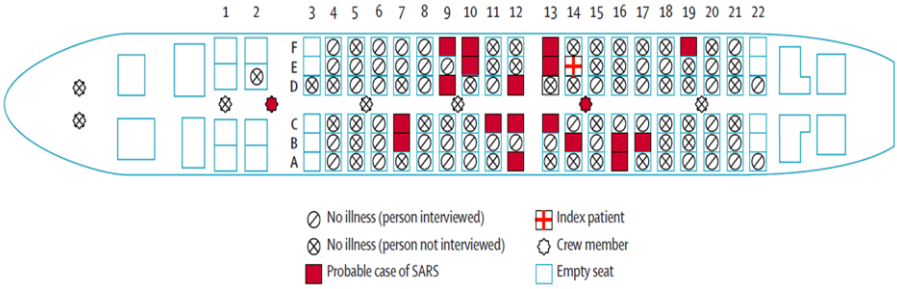
[10] US General Accounting Office. Aviation safety: more research needed on the effects of air quality on airliner cabin occupants. Washington, DC: US General Accounting Office, 2004. http://www.gao.gov/cgi-bin/getrpt?GAO-04-54.pdf (access: June 15.2018.)

The spread of the biological agent in the aircraft also depends on the way the disease is transmitted. There are four types: contact, airborne, common vehicle, and vector-borne. All these routes may have to be taken into account when it comes to the spread of microorganisms in an airplane. Direct contact of passengers sitting close to each other on the plane is conducive to infecting a healthy person. Sneezing, coughing, speaking, or airway facilitate the passage of microorganisms into the mucosa from the sick person to the neighbor in the form of a spray. This path is the most dangerous due to the dispersed form of biological agents in the air. We cannot forget about water and food served during passenger flights, and can be the source of many infections such as: *Salmonellosis, Staphylococcus* food poisoning*, Shigellosis, Cholera*.

In contrast, the transmission by the vector results from the spread of diseases by insects and pests, for example: *Malaria, Dengue*. The pathogenicity of a given micro-organism, the period of exposure, conditions, environmental conditions and the general health of the host are also very important factors.

An example of the spread of infection on an aircraft may be a 3-hour flight from Hong Kong to Beijing on March 15, 2003, with 120 passengers aboard, with SARS outbreak (Figure 2). The spread of the SARS virus on board of this aircraft caused the infection of potentially 22 to 37 passengers, which was revealed after the journey. There were 16 laboratory-confirmed cases, two probable cases, but due to the dispersion of passengers around the world, no specific numbers were given. It is suspected that about 300 people both, connected and unrelated to the flight to Beijing were affected by this infection. The distribution of infection can be a model of the spread of airborne diseases on a plane during a long, more than eight-hour flight and the distribution of passengers in two rows of seats. After this incident, WHO issued guidelines on limiting the spread of SARS in airplanes, to reduce the spread of serious infectious diseases in planes in the 21st century to a minimum.

Figure 2. Schematic diagram of SARS outbreak aboard Hong Kong to Beijing flight



Source: Mangili A., Gendreau M.A. Transmission of infectious diseases during commercial air travel. Lancet 2005, p. 991.

A separate aspect of the spread of biological agents through the air is bioterrorism. Bacteria and viruses that are a potential biological weapon can be used by terrorists to be moved to different parts of the world through passenger transport by airplanes, but can also be sprayed at airports where there is a large concentration of people. The most dangerous are the viruses of hemorrhagic fevers: Dengue, Hanta, Ebola,

Lassa, which have a fulminant effect on humans, causing in most cases, death of the infected, but also have a great ease in transmitting by droplets, there are also no vaccines[11].

Conclusion

The analysis of biological agents that can affect the safety of passenger flights is based on the International Health Regulations adopted worldwide by the IATA – *International Air Transport Association,* the WHO - *World Health Organization* and CDC - *Centers for Disease Control and Prevention*[12]. The limitation of the international spread of diseases is constantly adjusted to provide immediate notification of any epidemics of international importance. These new regulations and constant vigilance from the majority of countries, sanitary authorities, airlines and passengers will minimize, but will not eliminate the risk of spreading the disease by airplanes. Both medical services and the aerospace industry should educate the public about health problems related to air travel control and infections.

Another aspect is the tightening of provisions regarding the bringing of biological weapons and other types of weapons of mass destruction on board an aircraft. This regime is enforced by many sanitary and epidemiological institutions[13].

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