



“Gheorghe Asachi” Technical University of Iasi, Romania



COVID-19 AND AIR CONDITIONING - IS THERE AN ENVIRONMENTAL LINK?

**Georgiana Alexandra Lacatusu¹, Cristina Vasilescu^{1*}, Ioana Florina Mihai¹,
Florina Filip-Ciubotaru², Andrei Vata^{1,2}, Carmen Manciu^{1,2*}**

¹“Sf. Parascheva” Clinical Hospital of Infectious Diseases, 2 Octav Botez Street, 700116, Iasi, Romania

²“Grigore T. Popa” University of Medicine and Pharmacy Iasi, 16 Universității Street, 700115, Iași, Romania

Abstract

As it spread globally, the new SARS-CoV-2 virus was first confirmed in Romania in February 2020, and since then over 40000 cases were diagnosed with COVID-19. Considering climate changes that showed a continuously increasing temperature and also the fact that nowadays air conditioning devices are used on daily bases not only in personal homes but also in healthcare facilities we raised the question if cooling air devices could contribute to the spread of SARS CoV-2 virus. For that, we searched data in the speciality literature regarding the potential of transmission of the virus through air conditioning.

Incorrect ventilation in indoor spaces can be associated with an increased transmission rate of respiratory infections as studies suggested. Heating, Ventilation and Air Conditioning Systems (HVAC) are used as one of the infection disease control measure. However, if those are not correctly used, they can contribute to the transmission of an airborne diseases as suggested by data from Japan, Germany, and the Diamond Princess Cruise Ship. There are no clear data that can confirm if there is a link between aerosols produced by HVAC system and transmission of SARS CoV-2 virus and further extensive studies should be performed to either confirm or infirm this hypothesis.

Key words: SARS CoV-2, pandemic, air conditioning, HVAC

Received: April, 2020; Revised final: July, 2020; Accepted: July 2020; Published in final edited form: July, 2020

1. Introduction

In December 2019, a new virus that started to cause severe acute respiratory syndrome (SARS-CoV-2) appeared in Hubei province, Wuhan, China. The virus spread rapidly at the time of the article writing 216 countries were affected and over 6.5 million cases were reported (<https://www.who.int/emergencies/diseases/novel-coronavirus-2019>; WHO, 2020). Coronaviruses (CoV) which are known to cause respiratory infections are enveloped viruses that have a single-stranded, positive-sense RNA genome (Cui et al., 2019). These viruses are characterized by club-like spike projections of protein on the surface, with a crown-like appearance under the microscope (Peiris et al., 2012)

Although the majority of coronavirus infections in human are mild, two important outbreaks of two other type of coronaviruses, known as severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV), have caused multiple deadly pneumonias, with mortality rates up to 10% in case of SARS-CoV and approximately 36% for MERS-CoV (Song et al., 2019). Even though SARS-CoV-2 has shown phylogenetic and clinical similarities with SARS-CoV, this novel coronavirus seems to have a higher transmissibility rate and lower fatality rates (Ceccarelli et al., 2020).

The pandemic caused by the SARS-CoV-2 was confirmed to have reached Romania on February 26, 2020. At the time of the article writing, over 19000

* Authors to whom all correspondence should be addressed: cs_vasilescu@yahoo.com, dmanciuc@yahoo.com

cases were diagnosed with a rate of curability at this moment, over 67%. In our country, the peak of pandemic was reached in April 11th, when 523 cases were diagnosed (Fig. 1). From that day, the number gradually deceased and in the last week a median of 169 cases were diagnosed. The fatality rate as June 1st was calculated at 6.50% and in the last week the median number of deaths was 12.85 (Fig. 2). Considering climate changes that showed a continuously increasing temperature in the last five years in the months of August (Fig. 3), and also that fact that we do not have the certainty that SARS CoV-2 virus will naturally stop its circulation we took into consideration that there is a possibility that, as the aviary flu (H5N1 flu), SARS CoV-2 could also be transmitted in the warm months.

Nowadays, air conditioning devices are used on daily bases not only in personal homes, but also in

healthcare facilities. Currently, with increasing numbers of people returning to the workplace, the chances of infection resulting from aerosol transmission through central air-conditioning systems are increasing. There is a raised the question if cooling air devices could contribute to the spread of COVID-19 by aerosolizing even more so, that some of them are old and have defective cooling systems in where blue-green algae could develop and outbreaks can start. We took in consideration the similarity of COVID-19 with legionellosis, which is caused mainly by *Legionella pneumophila* as the prototype for aerosol transmission for community acquired infection transmitted by buildings cooling towers (Walser et al., 2014). Aerosol transmission refers to the possibility that fine aerosol particles, called droplet nuclei, remain airborne for prolonged periods and involves particles of $<5 \mu\text{m}$ (WHO, 2020).

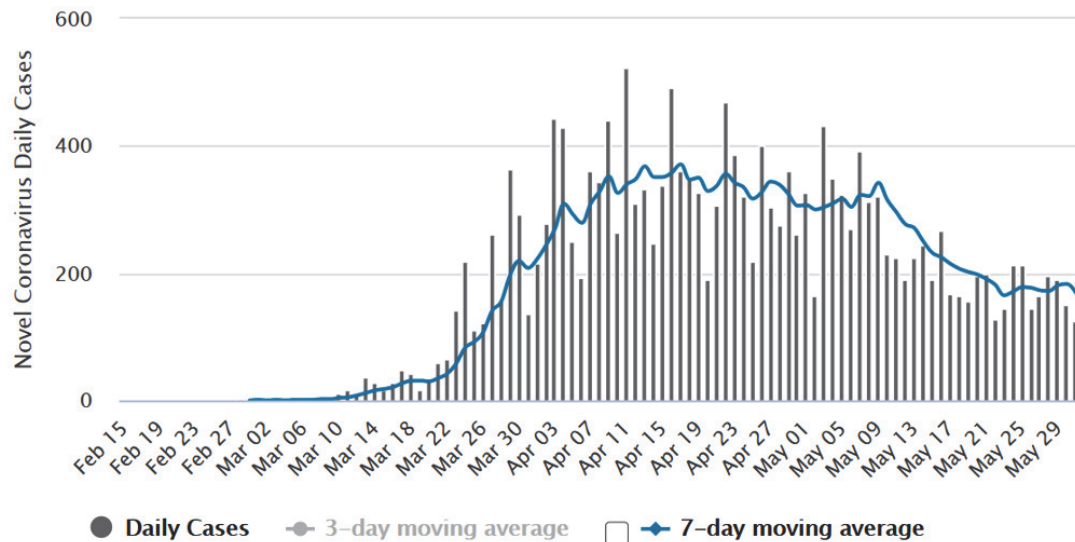


Fig. 1. Daily cases of COVID-19 in Romania
(<https://www.worldometers.info/coronavirus/country/romania/>)

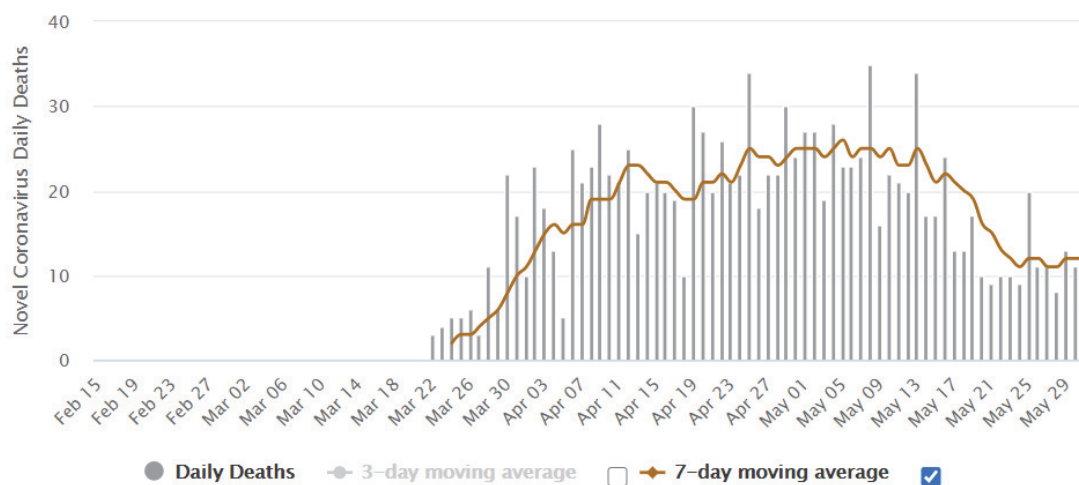


Fig. 2. Daily deaths of COVID-19 in Romania
(<https://www.worldometers.info/coronavirus/country/romania/>)

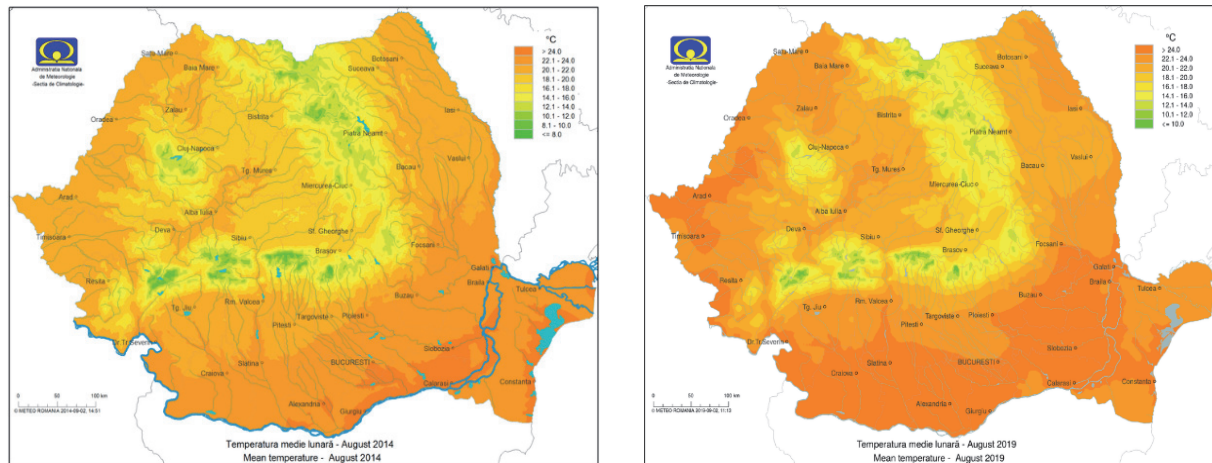


Fig. 3. Temperatures in August 2014 vs. 2019
(<http://www.meteoromania.ro/clima/monitorizare-climatica/>)

Legionella pneumophila is an aerosol transmitted pathogen that has a unique water-to-air transmission route and cooling towers are considered the source of legionellosis (Orkis et al., 2018; Prussin et al., 2017). It is a common cause of community-acquired and hospital-acquired pneumonia (Herwaldt et al., 2018). The first outbreak ever detected was linked to a Philadelphia hotel cooling tower in 1976 (Fraser et al., 1977) and since then multiple other outbreaks of legionellosis were associated with air conditioning devices (Bennett et al., 2014; Lévesque et al., 2012; Shivaji et al., 2014).

It is possible for the Heating, Ventilation and Air Conditioning (HVAC) Systems, including ductwork, to have a role in its transmission (Prussin et al., 2017). The most common symptoms of SARS CoV-2 infection are fever, dry cough, fatigue, upper respiratory tract symptoms that include odynophagia, headaches, and myalgia. There are also reports describing patients with gastrointestinal symptoms, including abdominal pain and diarrhea in children and adolescents. Patients with severe disease typically associate, dyspnea, and bilateral pulmonary infiltrates on chest imaging. Complications of COVID-19 include ARDS (Shi et al., 2020). The clinical manifestations of *Legionella* infections are primarily respiratory. The most common presentation is acute pneumonia, which varies in severity from mild illness to fatal multilobar pneumonia (Manciuc et al., 2018). Typically, patients have high, unremitting fever and cough, but do not produce much sputum. Extrapulmonary symptoms, such as headache, confusion, muscle aches, and gastrointestinal disturbances, are common (Winn et al., 2012; Manciuc et al., 2008).

Starting from the similarity of symptoms and also the fact that both can give pneumonia and acute respiratory distress syndrome (ARDS) we proposed a parallel between the two diseases, even though SARS CoV-2 is a virus and *Legionella pneumophila* is a bacterium.

2. Methods

A systematic literature reviews was conducted and PubMed/Medline, EMBASE and Google Scholar databases were used to identify potential articles. The following key-words COVID-19, SARS CoV-2, Air Conditioning, Ventilation, HVAC were included in our search.

The study included any article that presented or excluded a link between SARS CoV2 virus and air conditioning or ventilation system. The articles that did not offer any information regarding the studied subject were excluded from the study

3. Results

SARS-CoV-2 virus is included in betaCoVs category with positive-sense single-stranded RNA virus with epithelial cell and respiratory system proclivity. It has either an ellipsoidal or spherical form, but often it is pleomorphic with a diameter between 60–140 nm. COVID-19 is thought to be primarily transmitted via large respiratory droplets; however, an increasing number of outbreak reports implicate the role of aerosols in COVID-19 outbreaks. Poor ventilation in confined indoor spaces is associated with increased transmission of respiratory infections (Knibbs et al., 2011). There have been numerous COVID-19 transmission events associated with closed spaces, including some from presymptomatic cases (Rothe et al., 2020; Lu J et al., 2020).

Standard HVAC systems are using filters that often have more than 1micron with pore diameter, and only in specific locations, such as intensive care units or isolation rooms or have HEPA filters which are more efficient.

In healthcare facilities HVAC systems are utilized as a primary measure for infection disease control because improves and remove infectious agents by the diluting room air that is around the

primary source. If HVAC systems that are installed in healthcare facilities, may have a role in spreading of a pathogen, and so, if are not correctly used may contribute to transmission of diseases as proposed in the past for SARS (Francisco and Emmerich, 2014; Li et al., 2007; Qian and Zheng, 2018; Shajahan et al., 2019).

In infection with SARS CoV-2 virus, as in other diseases, there are significant debate regarding the airborne transmissibility in the absence of physical contact and droplets (Pyankov et al., 2018). Particles could have multiple trajectories, things that are influenced by their size and by the environment conditions, and also dissemination patterns. It is stipulated that for airborne transmitted infectious, particles longer distance for transmission and longer floating times are possible (Gameiro da Silva, 2020; Shajahan et al., 2019). Studies demonstrated that exactly as MERS-CoV virus (Pyankov et al., 2018), SARS-CoV-2 virus has a viability in aerosols for at least three hours also, the virus remains stable on stainless steel and plastic for up to 72 h fact that makes it plausible for easy aerosol transmission (Shiu et al., 2019). It has been demonstrated that ventilation systems have been reported as a way of transmission/spreading of infectious diseases such as measles, tuberculosis, chickenpox, influenza, smallpox and SARS (Li et al., 2007; Shiu et al., 2019).

One of the earliest studies addressing the way of transmission of SARS CoV-2 virus, which looked at certain indicators of airborne viral spread in a Wuhan hospital where patients with COVID-19 were kept in isolation viral RNA was still detected in areas of the hospital that it could only have reached through the atmosphere or the ventilation system (Ning et al 2020).

Recently, the Federation of European Heating, Ventilation and Air Conditioning associations (REHVA), published an updated guide regarding the possibility of spreading the virus, which is informing professionals how to use and operate building services in workplaces in order to prevent the spread of COVID-19. The guide suggests changes to operation of the HVAC systems in order to prevent the spread of COVID-19 depending on HVAC or plumbing systems related factors. The recommendations addressed are mainly to stop air recirculation and to increase the inflow of outdoor air (Kurnitski et al., 2020).

Some authors assessed that airborne transmission is possible and that HVAC systems when not adequately used may contribute to the transmission of the virus, conclusion that were drew after reviewed studies that described events from Japan (Correia et al., 2020), Germany (Correia et al., 2020; Rothe et al., 2020), and the Diamond Princess Cruise Ship (Shajahan et al., 2019; Zhang et al., 2020). The same study is linking the possibility of SARS CoV-2 virus being spread through air conditioning concluded that droplet transmission was prompted by air-conditioned ventilation which conducted to an

outbreak in a restaurant in China (Coreia et al., 2020; Lu et al., 2020).

Additionally, some authors consider that the spreading of the virus among patients may be facilitated in spaces where there are no HEPA filters, via common ducts (Shakoor et al., 2015). Data regarding the spread of airborne infectious particles quickly and evenly in different areas were revealed after studying different ventilation configurations in specific areas such as an operating room, using computational fluid dynamic modeling (Memarzadeh and Manning, 2002).

Likewise, there is a theoretical possibility that the aerosolized particles that contain the viral RNA, that enter the ventilation ducts from health care facilities that are providing assistance to COVID-19 patients may be expelled through ventilation system into environment and contribute to further sporadic cases, as in the case of Legionella, with cooling tower associated transmission (Yu et al., 2004).

One other study that assess the transmission potential of the COVID-19 outbreak that unfolded aboard the Diamond Princess Ship in January–February 2020 states that overall mean reproduction number in the confined setting reached values as high as ~11, which is higher than mean estimates reported from community-level transmission dynamics in China and Singapore in the range 1.1–7 and concluded that the main route for transmission was considered to be from person-to-person but other routes should not be neglected such as aerosol transmission via central air supply or drainage systems (Zhang et al., 2020).

There are missing links in transmission and possible unknown indirect infection routes in many epidemiological studies. Pure aerosol transmission is denied by WHO but several pieces of evidence support this hypothesis (Coreia et al., 2020).

4. Conclusions

There are no clear lines that can confirm if there is a link between aerosols produced by HVAC system and transmission of SARS CoV-2 virus but it is important to follow this type of spreading as environmental contamination factor especially that literature showed that could be an important mean of transmitting as proved by legionellosis.

Further extensive studies can confirm or also infirm this form of spread which will further help battle against the pandemic.

References

- Bennett E., Ashton M., Calvert N., Chaloner J., Cheesbrough J., Egan J., Farrell I., Hall I., Harrison T.G., Naik F.C., Partridge S., Syed Q., Gent R.N., (2014), Barrow-in-Furness: a large community legionellosis outbreak in the UK, *Epidemiology and Infection*, **142**, 1763–1777.
- Ceccarelli M., Berretta M., Venanzi Rullo E., Nunnari G., Cacopardo B., (2020), Differences and similarities between Severe Acute Respiratory Syndrome (SARS)-CoronaVirus (CoV) and SARS-CoV-2. Would a rose

- by another name smell as sweet?, *European Review for Medical and Pharmacological Sciences*, **24**, 2781-2783.
- Correia G., Rodrigues L., Gameiro da Silva M.C., Gonçalves T., (2020), Airborne route and bad use of ventilation systems as non-negligible factors in SARS-CoV-2 transmission, *Medical Hypotheses*, **25**, 109781, <https://doi.org/10.1016/j.mehy.2020.109781>
- Cui J., Li F., Shi Z.L., (2019), Origin and evolution of pathogenic coronaviruses, *Nature Reviews Microbiology*, **19**, 181-192.
- Francisco P.W., Emmerich S.J., (2014), ASHRAE Position Document on Airborne Infectious Diseases, On line at: <https://www.ashrae.org/File%20Library/About/Position%20Documents/Airborne-Infectious-Diseases.pdf>
- Fraser D.W., Tsai T.R., Orenstein W., Parkin W.E., Beecham H.J., Sharrar R.G., et al. (1977) Legionnaires' disease: description of an epidemic of pneumonia. *New England Journal of Medicine*, **297**, 1189-1197.
- Gameiro da Silva M.C., (2020), An analysis of the transmission modes of COVID-19 in light of the concepts of indoor air quality, On line at: <https://www.uc.pt/en/efs/Documentos/2020.04.06>.
- Herwaldt L.A., Marra A.R., (2018), Legionella: a reemerging pathogen. *Current Opinion in Infectious Diseases*, **31**, 325-333.
- Knibbs L.D., Morawska L., Bell S.C., Grzybowski P., (2011), Room ventilation and the risk of airborne infection transmission in 3 health care settings within a large teaching hospital, *American Journal of Infection Control*, **39**, 866-872.
- Kurnitski J., Boerstra A., Franchimon F., Mazzarella L., Hogeling J., Hovorka F., (2020), How to operate and use building services in order to prevent the spread of the coronavirus disease (COVID-19) virus (SARS-CoV-2) in workplaces, REHVA COVID-19 Guidance Document, On line at: https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_ver2_20200403_1.pdf.
- Lévesque S., Plante P.L., Mendis N., Cantin P., Marchand G., Charest H., Raymond F., Huot C., Goupil-Sormany I., Desbiens F., Faucher S.P., Corbeil J., Tremblay C., (2012), Genomic characterization of a large outbreak of Legionella pneumophila serogroup 1 strains in Quebec City, *PLoS One*, **9**, e103852, <https://doi.org/10.1371/journal.pone.0103852>.
- Li Y., Leung G.M., Tang J.W., Yang X., Chao C.Y.H., Lin J.Z., Lu J.W., Nielsen P.V., Niu J., Qian H., Sleight A.C., Su H.-J. J., Sundell J., Wong T.W., Yuen P.L., (2007), Role of ventilation in airborne transmission of infectious agents in the built environment - a multidisciplinary systematic review, *Indoor Air*, **17**, 2-18.
- Liu Y., Ning Z., Chen Y., Guo M., Liu Y., Gali N.K., Sun L., Duan Y., Cai J., Westerdahl D., (2020), Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals. *Nature* 582, 557-560.
- Lu J., Gu J., Li K., Xu C., Su W., Lai Z., Zhou D., Yu C., Xu B., Yang Z., (2020), COVID-19 outbreak associated with air conditioning in restaurant, Guangzhou, China, 2020, *Emerging Infectious Diseases*, **26**, <https://doi.org/10.3201/eid2607.20076>.
- Manciuc C., Dorobăţ C., Hurmuzache M., Nicu M., (2007), Leptospirosis: Clinical and environmental aspects of the Iaşi County, *Environmental Engineering and Management Journal*, **6**, 133-136.
- Manciuc D.C., Iordan I.F., Adavidoaiei A.M., Largu M.A., (2018), Risks of leptospirosis linked to living and working environments, *Environmental Engineering and Management Journal*, **17**, 749-753.
- Memarzadeh F., Manning A.P., (2002), Comparison of operating room ventilation systems in the protection of the surgical site, *ASHRAE Transactions*, **108**, 3-15.
- Orkis L.T., Harrison L.H., Mertz K.J., Brooks M.M., Bibby K.J., Stout J.E., (2018), Environmental sources of community-acquired legionnaires' disease: A review, *International Journal of Hygiene and Environmental Health*, **221**, 764-774.
- Peiris J.S.M., (2012), Coronaviruses, In: *Medical Microbiology*, Greenwood D., Barer M., Slack R., Irving W. (Eds.), 18th edition, Churchill Livingstone, Edinburgh, 587-593.
- Prussin A.J.2nd, Schwake D.O., Marr L.C., (2017), Ten questions concerning the aerosolization and transmission of legionella in the built environment, *Building and Environment*, **123**, 684-695.
- Pyankov O.V., Bodnev S.A., Pyankova O.G., Agranovski I.E., (2018), Survival of aerosolized coronavirus in the ambient air, *Journal of Aerosol Science*, **115**, 158-163.
- Qian H., Zheng X., (2018), Ventilation control for airborne transmission of human exhaled bio-aerosols in buildings, *Journal of Thoracic Disease*, **10**, S2295-S2304.
- Rothe C., Schunk M., Sothmann P., et al. (2020), Transmission of 2019-nCoV Infection from an asymptomatic contact in Germany, *New England Journal of Medicine*, **382**, 970-971.
- Shajahan A., Culp C.H., Williamson B., (2019), Effects of indoor environmental parameters related to building heating, ventilation, and air conditioning systems on patients' medical outcomes: A review of scientific research on hospital buildings, *Indoor Air*, **29**, 161-176.
- Shakoor S., Mir F., Zaidi A.K.M., Zafar A., (2015), Hospital preparedness in community measles outbreaks-challenges and recommendations for low-resource settings, *Emerging Health Threats Journal*, **8**, 1-13.
- Shi Y., Wang G., Cai X.P., Deng J.-w., Zheng L., Zhu H.-h., Zheng M., Yang B., Chen Z., (2020), An overview of COVID-19, *Journal of Zhejiang University-SCIENCE B*, **21**, 343-360.
- Shiu E.Y.C., Leung N.H.L., Cowling B.J., (2019), Controversy around airborne versus droplet transmission of respiratory viruses: implication for infection prevention, *Current Opinion in Infectious Diseases*, **32**, 372-379.
- Shivaji T., Sousa Pinto C., San-Bento A., Oliveira Serra L.A., Valente J., Machado J., Marques T., Carvalho L., Nogueira P.J., Nunes B., Vasconcelos P., (2014), A large community outbreak of Legionnaires disease in Vila Franca de Xira, Portugal, October to November 2014, *EuroSurveillance*, **19**, 20991, <http://doi.org/10.2807/1560-7917.es2014.19.50.20991>
- Song Z., Xu Y., Bao L., Zhang L., Yu P., Qu Y., Zhu H., Zhao W., Han Y., Qui C., (2019), From SARS to MERS, thrusting coronaviruses into the spotlight, *Viruses*, **11**, 59, <http://doi.org/10.3390/v11010059>
- Walser S.M., Gerstner D.G., Brenner B., Höller C., Liebl B., Herr C.E., (2014), Assessing the environmental health relevance of cooling towers - a systematic review of legionellosis outbreaks, *International Journal of Hygiene and Environmental Health*, **217**, 145-154.

- Winn W.C. Jr., (1996), *Legionella*, In: *Medical Microbiology*, Baron S. (Ed.), 4th edition, University of Texas Medical Branch at Galveston, Texas, Chapter 40.
- WHO, (2020), Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations, World Health Organization, On line at: <https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations?>
- Yu I.T.S., Li Y., Wong T.W., Tam W., Chan A.T., Lee J.H.W., (2004), Evidence of airborne transmission of the severe acute respiratory syndrome virus, *New England Journal of Medicine*, **350**, 1731-1739.
- Zhang S., Diao M., Yu W., Pei L., Lin Z., Chen D., (2020), Estimation of the reproductive number of novel coronavirus (COVID-19) and the probable outbreak size on the Diamond Princess cruise ship: A data-driven analysis, *International Journal of Infectious Diseases*, **93**, 201-204.

Web pages

- <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>
- <https://www.worldometers.info/coronavirus/country/romania/>
- <http://www.meteoromania.ro/clima/monitorizare-climatica/>