International Journal of Enhanced Research in Management & Computer Applications
ISSN: 2319-7471, Vol. 10 Issue 11, November, 2021, Impact Factor: 7.751

Role of artificial intelligence and robotics during Covid-19 pandemic: A Review

Ashish Malik

(Extension Lecturer), Department of Computer Science, Govt. P.G College for Women, Rohtak-124001, Haryana

ABSTRACT

This study intends to identify a research agenda based on investigating service trends in today's changing times. Findings The article sets out a research agenda that includes three dimensions (Artificial Intelligence & robotics), (cleanliness & sanitation), and (healthcare and wellness). This study's findings suggest that AI and robotics may bring out definite research directions at the connection of health crisis and management, taking into account the COVID-19 crisis. AI and robotics are at the cusp of invaluable advancement that can revive the hotels while re-establish guests' confidence in safe health practices. The proposed research areas are likely to impart pragmatic lessons to various industries to fight against disruptive situations. This article stands out to be pioneer review that incorporated AI and robotics to expand the PMT and highlights how behavioral choices during emergencies can bring technological revolution.

Keywords: Artificial intelligence, robotics, COVID-19 pandemic, cleanliness, sanitation, Healthcare and wellness.

INTRODUCTION

Artificial Intelligence (AI) has played a substantial role in the response to the challenges posed by the current pandemic. The growing interest in using AI to handle Covid-19 issues has accelerated the pace of AI research and resulted in an exponential increase in articles and review studies within a very short period of time. Hence, it is becoming challenging to explore the large corpus of academic publications dedicated to the global health crisis. Even with the presence of systematic review studies, given their number and diversity, identifying trends and research avenues beyond the pandemic should be an arduous task. We conclude therefore that after the one-year mark of the declaration of Covid-19 as a pandemic, the accumulated scientific contribution lacks two fundamental aspects: Knowledge synthesis and Future projections.

In contribution to fill this void, this paper is a (i) synthesis study and (ii) foresight exercise. The synthesis study aims to provide the scholars a consolidation of findings and a knowledge synthesis through a systematic review of the reviews (umbrella review) studying AI applications against Covid-19. The literature search and screening process resulted in many included reviews. Our findings reveal patterns, relationships, and trends in the AI and robotics research community response to the pandemic. We found that in the space of few months, the research objectives of the literature have developed rapidly from identifying potential. AI applications to evaluating current uses of intelligent systems. Only few reviews have adopted the meta-analysis as a study design. Moreover, a clear dominance of the medical theme and the DNN methods has been observed in the reported AI applications [1].

Based on its constructive systematic umbrella review, this work conducts a foresight exercise that tries to envision the post-Covid-19 research landscape of the AI field. We see seven key themes of research that may be an outcome of the present crisis and which advocate a more sustainable and responsible form of intelligent

systems. The reviews of this study can be useful for the AI research community to obtain a holistic view of the current literature and to help prioritize research needs as we are heading toward the new normal.

The COVID-19 crisis has compelled the implementation of several policies that have badly affected the global economy, significantly impacting the fields of health, travel, tourism, and hospitality. According to the World Economic Forum (2020) (COVID Action Platform), nearly 100 million jobs are in jeopardy due to the pandemic's effects. These sectors are fighting to survive, let alone thrive. As events worldwide got dropped or delayed, hotel bookings plunged, giving the hoteliers a tough time. For instance, revenue at Marriot hotels dropped by almost 90% in Greater China in February 2020 and 25% in different Asia Pacific regions (Jiang and Wen, 2020). It is anticipated that revenue in the U.S., Europe, and Asia will further continue to drop as holiday and business trips are mainly postponed or dropped (Jiang and Wen, 2020). Generally, COVID-19 follows unforeseen and undesirable events, giving significantly less time to organize. This unprecedented crisis also implies a shortage of time for planning, and the customary response strategies are deficient (Sharma et al., 2020). Previous hospitality and tourism researches on a crisis like SARS, Ebola, and Influenza pandemics (provide comparable patterns to COVID-19 but on a very small scale. Although tourist behavior articles help analyze the current development, the safety perceptions of the guests and tourists during the crisis are not studied extensively. Hygiene and cleanliness play a significant role in hotel operations after the previous health crisis. These have become more important after the SARS 2003 health crisis. However, the severity of COVID-19 has changed people's perceptions [2].

COVID-19 is probably going to affect the agenda on research substantially. With these exceptional threats suffered by the various sectors during COVID-19, researchers are required to formulate effective solutions to recover from the crisis. Crises can give birth to high-tech innovations. Therefore in this current COVID-19 turmoil, the hotel sector should consider the possible advantages of AI and its applications like robotics in the industry setting. Previously, hospitality scholars have been examining the applicability of various automation and advancements in service delivery for many years; however, most of those examinations have concentrated on adopting poor technology. The new developments in AI and service robots have led to the embracing AI-driven technology in service delivery [3].

This pandemic can instigate the importance of this innovation for public wellbeing reasons. Therefore, it is significant to figure out what will make the guests return, which requires immense research efforts. This discussion puts across the following gaps. (1) The outbreak of COVID-19 brought enormous challenges for the various industries. (2) There are poor customary response strategies on the outbreak of COVID-19. (3) Cleanliness and health wellbeing are critical to health operations. However, literature in this area is limited in number. (4) Technology integration into hospitality and health operations like AI and robotics during the current crisis is under-researched and requires extensive investigation.

In view of the literature on the impact of an earlier health crisis like SARS in 2003 and the current crisis faced by the hoteliers caused by the outbreak of COVID-19, along with these identified gaps, the current article presents particular areas to present a meaningful vision to the academicians and practitioners to explore hotel management practices post COVID-19. The present research focuses on AI and robotics as a critical theme for the hospitality industry. It highlights the protective measures about the technological advancements in response to the COVID-19 health threats and details the necessity to adopt AI and robotics. While projecting the hotel industry's revival after covid-19, health and cleanliness should be the prime focus. Therefore, there is a need to examine how hotel service providers can team up with AI-driven robotics to enhance cleanliness and hygiene goals. The hospitality industry is now expected to make significant changes in its operations to ensure hotel guests' and employees' health and safety and reinforce customers' willingness to patronize the operations [3].

This pandemic is likely to have an unprecedented challenge for the hospitality industry, and scholars and experts are anticipated to develop solutions for the industry. Considering the above aspects, the article discusses the possible effect of COVID-19 on the hospitality sector and undertakes two objectives. (RQ1) How the research intent provided from three dimensions: (AI and robotics), (Cleanliness and sanitation) and (Healthcare and wellness) will foster research and knowledge development in the hospitality sector. (RQ2) How will the

proposed theoretical framework aid the guest's intent to adopt artificial intelligence and robotics as a protective measure for service delivery in response to the COVID-19 pandemic. The rest of the article is systematized as follows: Section 2 details the review of the literature. Section 3 comprises the methodology followed by the results depicted in section 4. Section 5 presents the future research agenda. Section 6 includes the conclusions, theoretical and practical implications, and limitations, and future research [4].

REVIEW OF LITERATURE

The various sectors industries are susceptible to threats and global crises. COVID-19 has all the earmarks of being another worldwide disaster like the 1918 Spanish influenza, particularly in the hospitality and tourism industry. A similar scenario appeared in 2003 due to the outbreak of SARS that caused a massive decline in GDP amounting to $20 billion in China, Singapore, Hong Kong, Vietnam, and the Far East, witnessing a drop of 70% in tourism flow (Mc Kercher and Chon, 2004). The present state of this pandemic is full of uncertainties, and its effects are much more severe than the previous pandemics [5].

The fear and shock caused due to the pandemic have resulted in negative perception and ambiguity for hospitality and tourism destinations. During the Ebola 2014 epidemic, hospitality and tourism were severely affected due to travel restrictions. People were not ready to travel to Africa's regions free from infection. Therefore, during the global disaster and worldwide travel restrictions and quarantine, the hospitality industry experiences severe implications. As the hotel industry is susceptible to risks caused due to unforeseen blows like terrorist attacks, epidemics, and natural disasters, hoteliers need to take measures to deal with such a crisis [6].

Theories from different fields have given insights into disaster and crisis management literature. From the tourism and hospitality literature, generally, researchers are inspired by management-related theories. For instance, Nguyen et al. (2017) applied the collaborative planning theory to examine the hotel stakeholder's perception and setbacks of collaboration. Few, Sociopsychological theories in hospitality and tourism were also applied in the context of crisis and disaster. For example, Wang and Wu (2018) adopted the theory of planned behavior to develop an iceberg model that depicts the causes of implicit beliefs and psychological factors on crisis planning and provides actions focusing on cultural diversity. Moreover, interdisciplinary theories are also previously implemented [7].

Brown et al. (2017) formulated a disaster management framework of natural, human, physical, economic, social, and cultural capital by applying the adaptive system theory. On the other hand, Ritchie (2008) adopted the chaos theory analyzing disaster management in tourism. The United Nations (2004) designed a framework for disaster risk reduction. Its key factors were knowledge development, early warning, risk factors, risk assessment, and recovery measures, regardless of the models and frameworks mentioned above. A new framework is required because the existing frameworks are not aligned with the health-related disaster and do not incorporate technological advancements into the theories [8].

As many people worldwide are exposed to this deadly COVID-19 disease, comprehending this risk will be a motivating factor for the individuals to adapt their behavior towards a more protective and safer medium of stay at the hotels. Few health behavior models like protection motivation theory (Rogers, 1975) and the theory of planned behavior (Ajzen, 2011) presents frameworks for understanding behavioral choices during pandemics. However, theories like the technology acceptance model, theory of planned behavior, and Chaos theory are insufficient to gauge guests' behavioral change towards adopting AI and robotics when confronted with a health threat. This paper adopts PMT as a theoretical foundation to develop a framework for the hospitality industry. The framework incorporates the components of PMT formed by Ronald Rogers in the year 1975 that describes how people get motivated to change in a self-protective way in the vicinity of a perceived health threat. As per PMT, the fear appeal would give rise to the cognitive mediating process, which will trigger the protection motivation. Severity, vulnerability, response effectiveness, and self-efficacy can give rise to fear appeal among hotel guests, leading to adopt technologies like AI and robotics as a protective response to fight against the global pandemic. The fear appeal persuades the individuals to adopt techniques that can minimize the human

touch. Touchless options like a contactless fingerprint, face recognition, contactless data entry can reduce the chances of spreading the virus [9].

Therefore, our current study suggests that researchers need to move beyond the regular perspectives on the antecedents of hygiene and cleanliness in this sector and deeply dig into the guests' view of cleaning and disinfection measures like cleaning of key cards, TV remotes, surfaces that receive frequent human contact possess a higher chance of getting contaminated through touch and can be a medium to transmit infectious diseases like COVID-19 (Chen et al., 2020). Third, COVID-19 brought massive changes in people's lifestyles concerning their health (Wang et al., 2020). This increasing wellbeing and health trend can provide many opportunities to the hoteliers to attract customers by promoting intensely relaxing and wellness focused programs like balanced diet programs, preventive healthcare programs, fasting, detoxing programs, etc. These programs focus on holidays in wellness will reduce the stress and anxiety among the guests. As stated by Majeed and Ramkissoon (2020), in the future, the provision of wellness services will be essential because guest's priority will take a move towards health-related tourism post-COVID-19 [10].

Data Driven Applications of AI & Robotics

Data are central to all medical care in general, and they are particularly vital for managing Covid-19. We analyzed reviews reporting on the data aspect and compared their results in terms of data types, sources, size, and corresponding AI methods. We recorded each AI method that has been reported by these reviews to assemble a complete picture of the extent to which algorithmic approaches have been used amid the pandemic. Commonly used traditional machine learning algorithms are Support Vector Machines, fuzzy logic system, Random Forests, Decision Trees, Logistic Regression, and Ensemble Machine Learning. Most occurred deep learning architectures (DNN) in the included reviews are Convolutional Neural Networks (CNN), Generative Adversarial Networks (GAN), Recurrent Neural Networks (RNN) notably Long /Short Term Memory (LSTM), Extreme Learning Machine (ELM). In addition of some hybrid forms of deep learning (e.g., CNN-SVM, deep ensemble algorithms) [11].

▪ Computer vision is hugely supported and powered by deep learning, most the models used are CNN and its variants (e.g., SqueezNet, ResNet, AlexNet, Google Net, and VGG Net), pre-trained networks, gray level co-occurrence matrix. In addition to data augmentation (using GAN) and transfer learning (notably fine-tuned deep transfer learning) which are used to manage small datasets.

▪ AI techniques related to Natural language processing (NLP) have also been remarkably used, such as Continuous Bag of Words model, Skip-gram models, Embeddings from Language Models (ELMo), and Porter Stemming.

▪ Robot types that have been mostly used are collaborative and social robots, stationary and mobile manipulators, drones, arms and wheeled robots.

▪ Finally, we noted that there is a considerable focus on comparing algorithms to find the best one for a particular application, some of the used metrics include Accuracy, Specificity, Sensitivity, Positive predictive value (PPV), Negative predictive value (NPV), Area Under Curve (AUC), and F1 score.

▪ A broad range of data types have been used in pandemic and allied applications. They range from textual data to numerical measurements, images, and sound. (i) Textual data encompass (a) narrative data gathered from patient's description and information, (b) clinical data gathered from hospitals, electronic health records (HER), and laboratory data, (c) embedded sensor data used in telehealth and include mobility data, physiological vital signs, and various other movement-related signals, (d) biomedical data such as viral genomic and proteomic sequences, (e) demographic and environmental data, (f) guidelines and scholarly articles, (g) mobility data and social media content. (ii) Numerical data include mainly epidemiological data in form of numerical time series data of infection cases. (iii) Image data are formed mainly by two medical imaging modalities chest X-ray and CT. (iv) Sound datasets contain mainly cough and breath sounds employed to diagnose Covid-19.

▪ To gather such data, researchers and practitioners rely on the following sources: public databases, clinical settings, government sources, literature, social media, migrated data (e.g., data from 2003 SARS epidemic data or from other countries), and open data science competitions established to promote research in this area. In this regard, most of the authors call for an urgent need to share publicly and openly Covid-19 data.

▪ Data size is not always reported in the studied works, but reviews that investigated this feature noted that the number of samples is still comparably small (less than 1,000 in half of the research studies according to (Abd-Alrazaq et al., 2020)).

Based on the precedent observations, we can assume that the diversity, size, and the lack of publicly available data are the main issues hindering the full potential of data-driven applications. Furthermore, the AI methods required to analyze Covid-19 related data vary depending on the type of data. For example, numerical time series data are mostly handled with traditional ML methods [12].

AI and Robotics in early diagnostics of COVID-19

It has been noted that 2%–8% of people infected with COVID-19 land up into fatal pneumonia. A rapid transmission rate has been observed due to a shortage of protective equipment, misinformation, and varying accessibility to point-of-care testing such as reverse transcription polymerase chain reaction (RT-PCR) techniques. RT-PCR tests are rapid and easily available, but there is increasing evidence of false negative reports and sensitivity as low as 60%–70% [13].

AI in radiology: AI has penetrated the field of radiology and several studies have been published regarding diagnostic imaging test and COVID-19. In a retrospective single-center study conducted in Italian patients; AI was compared with the radiological assessment of lung edema calculated by two experienced radiologists. The death and critical COVID-19 admission to the intensive care unit were the outcome measures. The authors found that an AI-based score of ≥30 on initial chest X ray was an independent and comparable predictor of adverse outcomes for mortality and critical COVID-19 patients.[11] The Italian Society of Medical Research considers and supports the use of AI as a predictive and prognostic decision support system and not as a first-line test to diagnose COVID-19.[12] The definitive pattern of CT chest showing ground-glass opacities progressing to consolidations are signs of deterioration in critically ill patients. AI-based diagnosis shows about 90.8% accuracy, 84% sensitivity, and 93% specificity in detecting COVID-19 pneumonia.

AI helps in supporting clinicians in assessing the severity and progression of the disease. Harmon et al. studied a diverse cohort of 1,280 patients and compared the specificity of AI-based CT reports over RT-PCR and found that deep learning–based AI algorithms can readily identify COVID-19 pneumonia from the non-COVID lung.[13] Despite the widespread adoption of AI in clinical practice, the major concern remains the lack of an open database to train AI models to professionals with limited expertise in AI. Online auto-machine learning platforms may help in training medical professionals for image recognition by uploading the examined database and performing some basic settings. This will revolutionize the fight against this new pandemic COVID-19 by allowing early detection and patient care.[14] Ardakani et al. evaluated 1,020 CT slices from 108 patients with laboratory-proven COVID-19 using AI bases technique. Recently, in another model development trail FCONet, a simple 2D deep learning frame work based on ResNet-50 was mentioned as the best model (sensitivity 99.58%, specificity 100.00%, and accuracy 99.87%) that outperformed VGG16, Xception, and Inception-v3 for diagnosing COVID-19 pneumonia in CT images and differentiating from non-COVID-19 pneumonia and no pneumonia diseases. Further information on the detail of these model systems is beyond the scope of this narrative review.

Several imaging system studies on COVID-19 patients have been performed to explore the extent of major organ tissue characterization including heart, brain, lungs, and liver using machine learning (ML) and deep learning modalities of AI in a review article. The authors have described ML architecture for stroke risk stratification, vessel characterization for cardiovascular disease, AI used for chest CT and liver disease

classification, AI-based plaque tissue characterization and risk stratification for cardiac death, DL-based system for tissue characterization and classification of COVID-19 severity with patients with comorbidities. These methods have been proposed to speed up assessments and diagnosis of COVID-19 causes, health hazards in patients with comorbidities, and risk stratification.[7]

AI in teaching and training in Anesthesia

The pandemic outbreak has replaced the classroom method of teaching with the online execution of teaching practices. Even though the real patient contact is restricted, students need to develop their clinical knowledge without any interruption. In a recently published scoping view, the authors mentioned the suboptimal state of e-health training of medical students and stressed clinical environments and innovative approach in health care for training.[8] Hence, smart technologies are reliable to cultivate skills and knowledge.

Technology-based learning: It includes audio recordings, video tutorials with online chatting, and mannequin simulators. This is possible with the help of online teaching apps such as Google meet, Zoom, Cisco Webex, Massive Open Online Course, National Digital Library of India (NDLI), etc. The NDLI is developed by the Indian Institute of Technology, Kharagpur. The library was made accessible in June 2018. The ministry of education has provided funding for the development of NDLI, which is a platform for learning resources available in almost all languages in India. The repository content includes e-books, lectures, articles, journals, thesis, videos, and simulation materials. This is made available in all fields and is free of cost.[9]

Zhou et al. conducted a study during the pandemic outbreak on 60 trainee nurses. The study was done to analyze the effectiveness of the massive online open classes (MOOC) micro-video method of distant teaching. This was compared with the conventional mode of teaching. It was observed that the overall satisfaction of both teaching faculties and students was higher among the MOOC group.[20] Virtual patients are used for developing clinical examination skills, procedural learning, and cultivating communication skills while dealing with real patients.[10]

Virtual-reality simulators are used for developing skills related to examination, surgery, and resuscitation. India being a developing country has many constraints; hence, it is important to inculcate a positive attitude amongst both students and medical educators. Medical students can educate their peers, patients, and community through self-made videos. They can propagate information regarding proper donning and doffing steps, proper mask fitting, and hand wash steps. Technology-based learning needs to be developed and executed at its earliest. This has become an integral part of our education system.[11]

Simulators: The role of simulators is gaining importance during the health crisis of the pandemic outbreak. This is acting as a supplementary learning tool for imparting clinical skills. As demands are exceeding the availability of resources, simulation focuses on carrying out a procedure effectively. Hence, resources can be used adequately along with the provision of the best patient care. Singh et al. have reviewed an article based on simulators in anesthesiology. The simulators can be device-based, patient-based, or environment-based. Simulator-based training can be for several skills such as chest compression, central venous cannulation, endotracheal intubation, tracheostomy, cricothyrotomy, etc. Studies have shown that residents who have undergone the simulation-based training program of 6 weeks duration showed much better skills when compared to those with conventional residency. Anesthesiologists well versed with video technology finds it easier to handle video laryngoscopy procedures. Proper hand-eye coordination is obtained with such simulation-based training programs. Another perspective of AI-based simulation training can be applied for evaluating newer equipment before launching into the market for its safety.[12]

The proposal of e-patients in medical education, changing demands, and opportunities will be required in medical education. The teaching guides will equip medical teachers and students with necessary background information, also assist teachers so that students can become health practitioners to deal with problems and potential of the e-patient.[13]

AI in COVID-19 patient management includes perioperative care, intensive care, pain management, drug delivery, and monitoring. The learning algorithm used in AI is mainly of three types: supervised learning, unsupervised learning, and reinforcement learning.[15]

CONCLUSION

The outbreak of the COVID-19 pandemic is unarguably the biggest catastrophe of the 21st century, probably the most significant global crisis after the second world war. The rapid spreading capability of the virus has compelled the world population to maintain strict preventive measures. The outrage of the virus has rampaged through the healthcare sector tremendously. This pandemic created a huge demand for necessary healthcare equipment, medicines along with the requirement for advanced robotics and artificial intelligence-based applications. The intelligent robot systems have great potential to render service in diagnosis, risk assessment, monitoring, tele-healthcare, disinfection, and several other operations during this pandemic which has helped reduce the workload of the frontline workers remarkably. The long-awaited vaccine discovery of this deadly virus has also been greatly accelerated with AI-empowered tools. In addition to that, many robotics and Robotics Process Automation platforms have substantially facilitated the distribution of the vaccine in many arrangements pertaining to it. These forefront technologies have also aided in giving comfort to the people dealing with less addressed mental health complicacies. This paper investigates the use of robotics and artificial intelligence-based technologies and their applications in healthcare to fight against the COVID-19 pandemic. The past pandemics emphasized the importance of hygiene and cleanliness. As technology can help provide effective cleanliness measures during COVID-19, this study addresses AI and robotics' roles in giving guests contactless services. The article highlights that implementing AI and robotics as depicted in the theoretical framework can create a technological shield that can provide contactless services and provide a competitive advantage to the hotels during and post COVID-19. Furthermore, the emerging trends among guests like wellness and environmental conservation must be addressed.

BIBLIOGRAPHY

[1]. Chen, H., Huang, X., & Li, Z. (2020), "A content analysis of Chinese news coverage on COVID-19 and tourism", Current Issues in Tourism, 1-8. doi: 10.1080/13683500.2020.1763269.
[2]. Sharma, A., Shin, H., Santa-María, M. J., & Nicolau, J. L. (2021), "HOTELS'COVID-19 innovation and performance", Annals of Tourism Research, Vol. 88, p.103180.
[3]. Zemke, D.M.V., Neal, J., Shoemaker, S. and Kirsch, K. 2015, "Hotel cleanliness: Will guests pay for enhanced disinfection?", International Journal of Contemporary Hospitality Management, Vol 27 No. 4, pp.690-710
[4]. Chen, S., Yang, J., Yang, W., Wang, C. and Bärnighausen, T., 2020, "COVID-19 control in China during mass population movements at New Year", The Lancet, Vol. 395 No. 10226, pp.764-766.
[5]. Wen, J., Kozak, M., Yang, S. and Liu, F., 2020, "COVID-19: potential effects on Chinese citizens' lifestyle and travel", Tourism Review, doi: 10.1108/TR-03-2020-0110
[6]. Choi, Y., Choi, M., Oh, M. and Kim, S., 2020, "Service robots in hotels: understanding the service quality perceptions of human-robot interaction", Journal of Hospitality Marketing & Management, Vol. 29 No. 6, pp.613-635.
[7]. Day, R. A. (1989), "The origins of the scientific paper: the IMRaD format". J Am Med Writers Assoc, Vol. 4 No. 2, pp.16-18.
[8]. Park, H., Kline, S. F., Kim, J., Almanza, B. and Ma, J. 2019, "Does hotel cleanliness correlate with surfaces guests contact?", International Journal of Contemporary Hospitality Management, Vol. 31 No. 7, pp.2933-2950.
[9]. Belanche, D., Casaló, L.V., Flavián, C. and Schepers, J., 2020a, "Service robot implementation: a theoretical framework and research agenda", The Service Industries Journal, Vol. 40 No. 3-4, pp.203-225.
[10]. Sharma, R., Singh, G., Sharma, S., Jones, P., Kraus, S. and Dwivedi, Y.K. (2020), "Digital Health Innovation: Exploring Adoption of COVID-19 Digital Contact Tracing Apps", IEEE TEM, doi: 10.1109/TEM.2020.3019033.

[11]. Cucinotta D., Vanelli M. WHO declares COVID-19 a pandemic. Acta Bio Med.: Atenei Parm. 2020;91(1):157. - PMC - PubMed
[12]. Liu Y., Gayle A.A., Wilder-Smith A., Rocklöv J. The reproductive number of COVID-19 is higher compared to SARS coronavirus. J. Travel Med. 2020:1–4.
[13]. Meyerowitz-Katz G., Merone L. A systematic review and meta-analysis of published research data on COVID-19 infection fatality rates. Int. J. Infect. Dis. 2020;101:138–148. - PMC - PubMed
[14]. Mehra M., Sharma R., Devi D. A brief review on epidemic to pandemic: Novel corona virus (COVID-19) J. Xian Univ. Archit. Technol. 2020;XII(IV):3795–3803.
[15]. Worldometer . 2021. Last Accessed: 27 August 2021. [link]. URL https://www.worldometers.info/coronavirus/