Mitigation strategies to fight the COVID-19 pandemic—present, future and beyond

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Abstract

Purpose – The latest novel coronavirus disease 2019 (COVID-19) pandemic continues to have a significant social and financial impact globally. It is very essential to study, categorize and systematize published research on mitigation strategies adopted during previous pandemic scenario that could provide an insight into improving the current crisis. The goal of this paper is to systematize and identify gaps in previous research and suggest potential recommendations as a conceptual framework from a strategic point of view.

Design/methodology/approach – A systematic review of Scopus and Web of Science (WoS) core collection databases was performed based on strict keyword search selections followed by a bibliometric meta-analysis of the final dataset.

Findings – This study indicated that the traditional mitigation techniques adopted during past pandemics are in place but are not capable of managing the transmission capability and virulence of COVID-19. There is a greater need for rethinking and re-engineering short and long-term approaches to prevent, control and contain the current pandemic situation.

Practical implications – Integrating various mitigation approaches shall assist in flattening the pandemic curve and help in the long run.

Originality/value – Articles, conference proceedings, books, book chapters and other references from two extensive databases (Scopus and WoS) were purposively considered for this study. The search was confined to the selected keywords outlined in the methodology section of this paper.

Keywords Novel coronavirus, COVID-19, Bibliometric analysis, Systematic review

Paper type Review

Introduction

Global pandemics provoke and disperse potential risks of short-term and long-term fiscal harm prompting healthcare systems to find newer and stronger coping strategies and techniques. The nature of the morbidity and mortality of a pandemic can lead to serious economic disruption and disaster if individual nations do not come up with a strong collective preparedness and a decisive response plan [1]. Zoonotic infections from both domestic and

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wild animals have been the primary cause of recent pandemics, largely due to increased animal to human interactions [2, 3]. However, zoonotic pathogens take time to associate and infect humans, but a few intermittent events of spillover have led to localized outbreaks due to mutated strains that are capable of searching a human host [4]. Hence, every such organism generates a spark and spread risk that depends on the population, poverty level, trade and travel, health systems and other environmental factors specific to each region [1,5].

Previous pandemic encounters

Around 20–50 million people succumbed to the 1918 influenza pandemic that devastated the world with its long-term consequences. Failure in containing the outbreak, political mismanagement and manipulated media coverage were the major mistakes that failed humanity in the past [1]. Influenza viruses can transmit from human to human with ease and create a severe global pandemic, unlike H5N1, Nipah and Ebola that caused only regional epidemics [6]. Previously, severe acute respiratory syndrome (SARS) (2002–2003) and Middle East respiratory syndrome (MERS) (2012) outbreaks were first transmitted from bats via palm civets (Guangdong Province) and dromedary camels (Saudi Arabia), respectively. They caused lower respiratory tract disease along with fever and cough often ending up in relying on supportive respiratory care and assistance. Moreover, SARS was responsible for 8096 cases and 774 deaths across 29 different countries [7].

Origin of the novel coronavirus–2019

The coronavirus disease 2019 (COVID-19) was reported to have emerged from a fish market in Wuhan City (Hubei Province), China, where there are speculations about the illicit trade of wildlife meat [8]. As of the end of March 30, 2020, there were a total of 634,835 confirmed cases and 29,957 deaths globally [9]. The intensity and rubrics of fecal-oral transmissions in COVID-19 are yet to be evaluated but were found to exceed the intensity of the SARS outbreak [10]. The WHO officially declared COVID-19 as a pandemic when the number of outbreaks spread to more than 110 countries, with between 116,000 and 120,000 confirmed cases and more than 4,000 deaths and is still believed to have the potential to reach exacerbated levels of transmission and economic crisis. Within three months (i.e, March 30 – June 23, 2020), 9,098,970 positive cases and 471,519 deaths were reported. As of June 23, 2020, the United States of America was leading the list with 2,363,825 positive cases and 122,292 deaths followed by Brazil (1,086,990 cases/50,659 deaths), Russia (592,280 cases/ 8,206 deaths) and India (430,708 cases/ 13,780 deaths) [11].

There is an urgent need to adopt strategic approaches to overcome the damage posed by this pandemic and we must learn from the different mitigation strategies suggested during past pandemics to gain insights into curbing and containing the present COVID-19 crisis. This paper provides a systematic review and bibliometric analysis of previous research work on pandemic mitigation strategies. At the end of this paper, a conceptual framework from a strategic point of view is projected to show a step-by-step integrated mitigation protocol. Furthermore, this paper also aims to cover, review and report on the considerable research publications on COVID-19 that have been published recently.

Literature review

Preventive measures during pandemic

Interconnected trading networks and teeming cities have made our globe richer but insecure. However, the focus on strengthening public health and hygiene to stop intermittent outbreaks and create situational awareness has become the fundamental idea pushing nations to accumulate ample stocks, plan pathogen testing drills and mobilize mass health

workers [12,13]. Key defense steps include tracking and tracing transmissions, mass testing, social distancing and vaccine formulation [14–16]. Countries with lower financial indexes have considerable difficulty in emulating others in compliance with the norms of the World Health Organization (WHO) in the development of infectious disease monitoring, crisis management and risk communication systems [1].

Importance of pandemic preparedness

Preparing for a pandemic is a challenge due to a multitude of causes, many of which are similar to natural disasters. Pandemics are unusual occurrences, and the probability of occurrence is affected by anthropogenic changes in the natural environment. Besides, there is widespread responsibility for preparedness, but most countries at greatest risk have restricted capacity to handle and minimize the risk of a pandemic [17]. Pandemic outbreaks cannot be confined within a consigned geographic boundary. Strong and rapid domestic and global preparedness is required to stop the spread and spark risk. An integrated approach by public health agencies, professional personnel, relevant government officials and political leaders is necessary to achieve optimum situational awareness and cost-effective outcomes [18,19].

Economic and social impact

Recurring recent events are diminishing the budget allocated to healthcare systems. The scarcity of medical equipment and medication has become a major issue. People in the hot zone are under extreme mental stress as a result of intensified government warnings, lockdown laws and stocks/services deficit leading to insecure demographic alterations in social life [20,21]. The mortality rate of the current COVID-19 pandemic is unpredictable and the containment of the spread is very difficult due to the sheer transmission capability of this pathogen. The fiscal recession and social impact is inevitable and unpredictable in this current pandemic [22,23].

Reproductive index or transmission curve of COVID-19

COVID-19 differs epidemiologically from SARS-CoV. It replicates efficiently in the upper respiratory tract and appears to cause a less abrupt onset of symptoms, similar to conventional human common colds. In contrast, in SARS-CoV most transmission is said to have occurred when infected individuals are presented with severe illness, thus possibly making it easier to contain the outbreaks [24–26]. There is a great difference in the reproduction number (R_0) between the two. The R_0 number is the average number of secondary cases produced by the standard infectious case or, in other words, the transmission parameter of that particular disease. The median value of R_0 during 1918 was 1.80 (interquartile range [IQR]: 1.47–2.27). The median R_0-value for 2009 was 1.46 (IQR: 1.30–1.70) [27]. Reproduction number, R_0, of 2019-nCoV keeping in mind the intrinsic growth rate (Δ) and the serial intervals (SI) of two other well-known coronavirus diseases, MERS and SARS, as approximations, shows a predominantly exponential increase that varies from 2.24 (95% CI: 1.96–2.55) to 3.58 (95% CI: 2.89–4.39) consistent with an 2 to 8-fold rise in the reporting rate showing the ability of 2019-nCoV to trigger larger outbreaks [28].

Methodology

The systematic review aims to collect all applicable information that reports extensively on current literature and replies to relevant research gaps. Efforts to eliminate bias in the detection, collection, synthesis and description of studies have been undertaken in this study. Meta-analysis was also done to some extent to summarize the content of the literature chosen

for the review [29]. Both Scopus and Web of Science (WoS) core collection databases were considered where they covered most of the articles published in PubMed and the COVID-19 database. The search was strictly executed with the keywords "Pandemic", "COVID-19" and "Strategy".

The search code for Scopus database was – (TITLE (pandemic) OR TITLE (COVID-19) AND TITLE-ABS-KEY (strategy) AND TITLE-ABS-KEY (strategies)) AND PUBYEAR > 2009, generating 761 entries and WoS core collection database was – TOPIC: (COVID-19) OR TOPIC: (pandemic) AND TOPIC: (strategy) OR TOPIC: (strategies) timespan: 2009-2020. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, generating 270 entries. The past ten years of literature were selected for the search (2010–2020). A total of 1031 entries that were acquired were screened for duplicates. The search results included journal articles, conference proceedings, books and other sources (book chapters). After clearly reading the title and abstract of all the entries a total of 927 entries were finalized to initiate this study. The whole dataset was selected for the review to eliminate bias in the detection, collection, synthesis and description of the collected dataset. After a detailed systematic review, a bibliometric analysis of the dataset was carried out to understand the relevance and link strengths between keywords and researchers. The entire dataset was first screened to obtain the keyword and co-author citation burst under certain criteria to get the optimal view. The criteria or parameters were set by the authors manually to avoid keyword repetitions and project only impactful research work with good relevance and linkage strengths which is clearly explained in the bibliometric section. The method as suggested by Vandenberg *et al.* [30] is adapted in this study shown in Figure 1.

Results

This section addresses the publishing pattern, publication type, language, publishing source, percentage of keywords usage, past and present strategic interventions and a conceptual framework. A bibliographic analysis of keyword clusters and co-author citations was projected later. Finally, the discussion and conclusion sections were drawn from observations

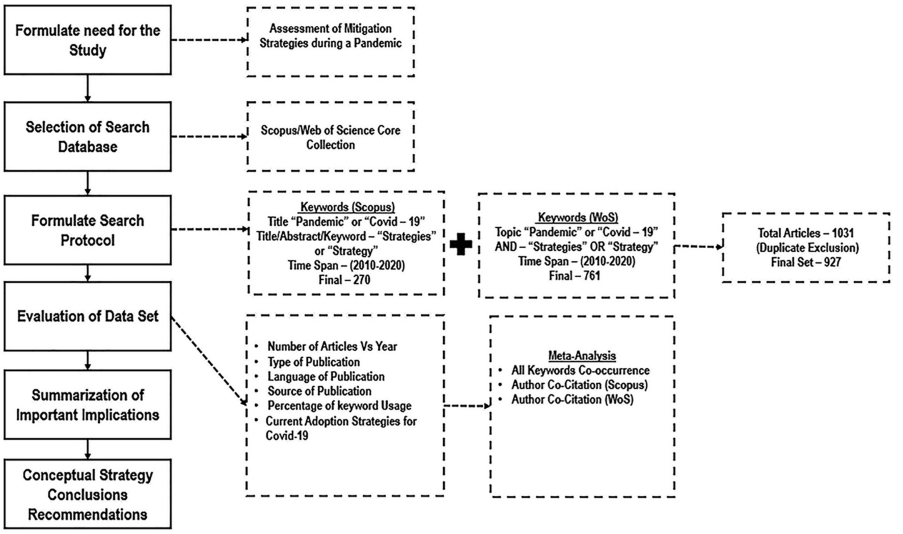

Figure 1.
Methodology

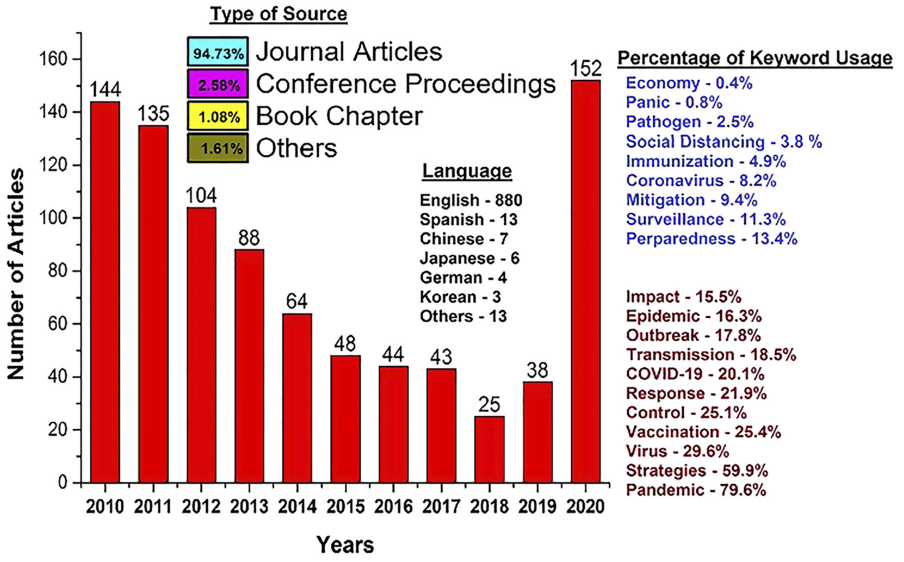

Figure 2.
Publication trends

Author	Implication
Hellewell *et al.* [31]	(1) Highly efficient communication (tracing and tracking)
Ng *et al.* [32]	(1) Prolonged monitoring techniques (fast detection and isolation) (2) Effective surveillance suppressing proliferation
Wang *et al.* [33]	(1) Healthcare staff training (2) Replenishing medical equipment
Ebrahim *et al.* [34]	(1) Cancellation of ad hoc events, travel restrictions, home quarantine, purge fake news, strategize funeral services
Anderson *et al.* [20]	(1) 60% reduction in transmission if quarantined within 1 day from the onset of symptoms (2) Social distancing set based on the stringent degree of pragmatism
Huh *et al.* [35]	(1) Dedicated walk-in-clinic, training for medical workers, specialized infrastructure, transport and test and retest, integrated surveillance and intensive testing (drive-through), case isolation, strict visitor controls, exchange and disinfect PPE, social event cancellation and domestic and international travel restriction
McCloskey *et al.* [36]	COVID-19 (action plan) (1) Combination of national emergency planning with centers for infectious disease control (2) Disease surveillance and detection and treatment (3) Community engagement (4) Public hygiene stations and gears
Berger *et al.* [37]	(1) Free testing, School and university closures, food, shelter, residency and safety to the public, improve employment rights, reimburse sick leave
Wong *et al.* [38]	(1) Increasing medical facility to manage patients, visitors and staff (2) Improved communication between staff—hybrid communication channels (3) Encrypted social media messages to top management for better decision making

Table 1.
Selective current studies addressing mitigations strategies for COVID-19

extracted from the overall analysis of the literature. The reporting on pandemic outbreaks and approaches from 2011 to 2019 has decreased significantly. Ninety-five percent of the material was in the form of journal articles and around 880 sources are written in the English language. A random selection of the top 20 keywords was chosen after a detailed review of the title and abstract of the 927 papers, and the percentage of their usage in the dataset was calculated. Some keywords in blue text as shown in Figure 2 had a lower percentage usage. For example, keywords such as "prevention", "security", "environment" and "preparedness" were less used and were lacking in research studies.

Table 1 discusses the selective mitigation strategies proposed by previous researchers.

The British Medical Journal reports 43 publications followed by PLOS One, Vaccine and BMC Public Health and Infectious Disease, Human Vaccines and Immunotherapeutics, Influenza and Other Respiratory Viruses, the Lancet and Clinical Infectious Diseases that have 35, 34, 28, 19, 13, 12 and 10 publications, respectively.

Table 1 reports strategies from past and present pandemic scenarios. The insights from Table 1 suggest new ideas and feasibilities. Since the preparation of the vaccine and trial checks are time consuming, a series of integrated non-clinical strategies are needed when core clinical interventions like medications, vaccine trials and intensive healthcare fail. An information technology-based approach that registers, traces and tracks positive cases can help nations build government-based application platforms to restrict the mobility of positive cases from the hot zone and also create better vigil in safe zones. Moreover, the transmission capacity of this COVID-19 is very high and requires strategically plotted patient arrivals, PPE usage, work shifts for staffs, funeral services, flexible and robot automated intensive care units, mass testing, e-healthcare, circular medical logistics, e-grocery, mobile clinics, movement control orders, effective financial policy, dedicated communication platforms and advanced training to the medical personnel. A cumulative set of all these strategic suggestions are put together to draw frameworks and are further detailed in the discussion section of this paper.

Bibliometric analysis

All keywords co-occurrence

The entire collection of 927 articles was fed into the bibliometric application to test run the keyword set, which in turn showed the strong relevance of the different research work [39]. Initially, 4991 keywords were present and keywords that reached a limit of 20 repetitions or above were only considered when they met requirement protocol.

Four keyword clusters were obtained after omitting the duplicates and plurals. Each cluster was designated a color and the keywords nodal burst represented a high percentage of linkage showing its proximity and the percentage of connectivity in each cluster. Keywords such as "Disease Control" "Disease Outbreak", "Epidemic", "Human", "Influenza" and "Pandemic" from cluster 1, "H1N1 Influenza", "Vaccination", "Influenza Vaccine" and "Controlled Study" from cluster 2, "Adult", "Adolescent", "Age factors", "Infant" and "School" from Cluster 3 and "Cross-sectional study" from cluster 4 were considered. Every cluster was created by its strength and proximity or relevance. Unattended topics or research areas were displayed with nodal projections with smaller diameters and farther away from the center. Many of them were invisible due to the very small amount of research conducted in those areas that are related to those respective keywords.

To explain a few, topics such as "Health Care Personnel", "Isolation and Purification Strategies", "Attitude" and "knowledge on healthcare" from the perspective of a pandemic scenario, have still not been extensively studied. Similarly, in Cluster 1, topics such as "Disaster Planning", "Morbidity", "Infection Control" and "Decision Making"; "Infection Risk Factors" based on age, gender and "Location of the Population" in Cluster 3; "Drug Efficacy" and "Safety and Antibody Response" from Cluster 2 requires attention which seems to

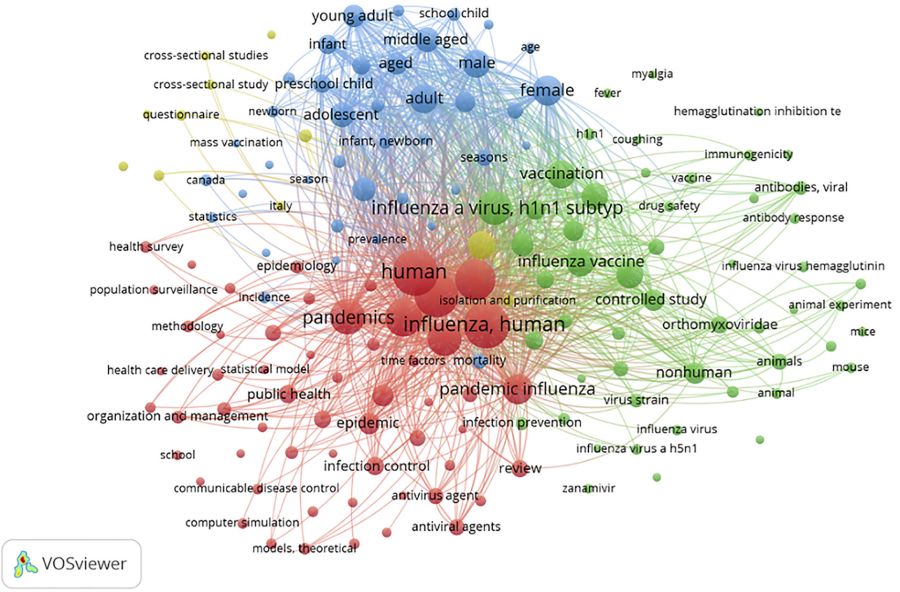

Figure 3.
All keywords co-occurrence nodal image

directly correlate with the problems faced in this current pandemic (COVID-19). The keyword nodal burst is shown in Figure 3.

Researcher co-citation Scopus and WoS

The relation and proximity between the previous researchers and their work were retrieved with the co-citation nodal burst. The total number of researchers was approximately 3591 in the entire Scopus collection where the minimum number of papers per author was fixed at 3 that gave 115 as the final number. Similarly, the WoS database of 270 entries was selected and the keywords "mitigation" or "strategies" or both together in title, abstract and keywords section were searched. A total of 467 authors were obtained which was further scrutinized to 47 by including the criteria (i.e. each researcher should have been cited at least once). A nodal burst of co-citation of researchers shows the linkage and impactful research collaborations as shown in Figure 4.

Conceptual strategic framework

After a thorough review and examination of existing literature, the authors of this paper have developed a set of logically integrated conceptual protocols and projected them as a framework that places great emphasis on contingency approaches that should be followed to address the current crisis. The framework outlined in Figure 5 shows an integrated strategy that recommends an organized approach to improvement, cloud-based tracing and tracking framework, dedicated healthcare protocol and offshore medical rigs.

Discussion

After a detailed categorization and cumulative accumulation of insights gained from this study, the authors suggest a set of strategic frameworks or protocols to mitigate the spread.

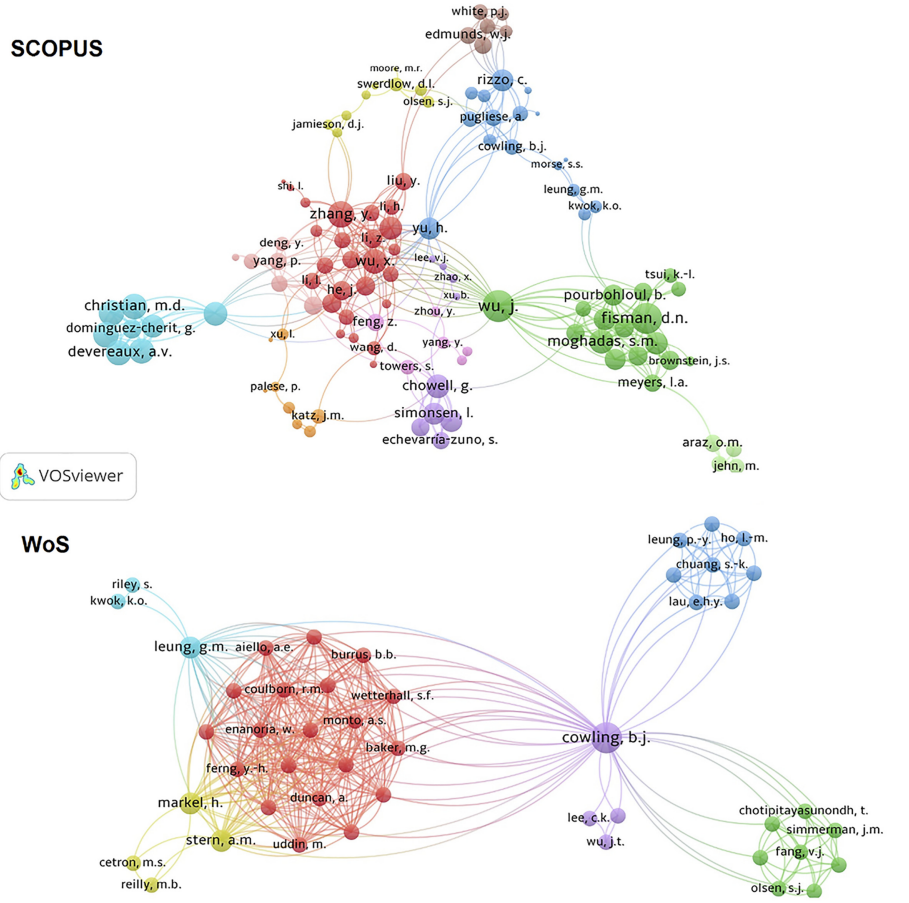

Figure 4.
Co-author-citation network

Figure 5a is an integrated step-by-step protocol for monitoring and controlling any pandemic related issues, commencing with the preparedness protocol that mainly focusses on risk assessment and containment measures. If the nation has struggled in the first phase, it could follow the monitoring and treatment protocol focusing primarily on the testing, monitoring and tracking measures adopted, followed by healthcare and treatment as shown in Figure 5a. In addition, during this recession period, new fiscal-policy measures must come into play. For example, loan buyers have been greatly hit during this recent COVID-19 pandemic and are in dire need of loan waivers and liquidity programs [40].

For effective mitigation, healthcare integrated with cloud-based medical analytics capable of measuring the outbreak role index (ORI) should be sought to provide better support and flexibility [41]. The mobile healthcare supported by the Internet of things (IoT) platform is an effective way to incorporate the system of this sort [42]. Remote continuous monitoring of patients suggested by Sareen *et al.* [43] based on radio frequency identification device (RFID), wearable sensor technology and cloud computing infrastructure was previously effective in detecting and monitoring Ebola-infected patients [44]. In Figures 5a and b suggestion for this purpose is based on the principle of QR code which is more economical than other

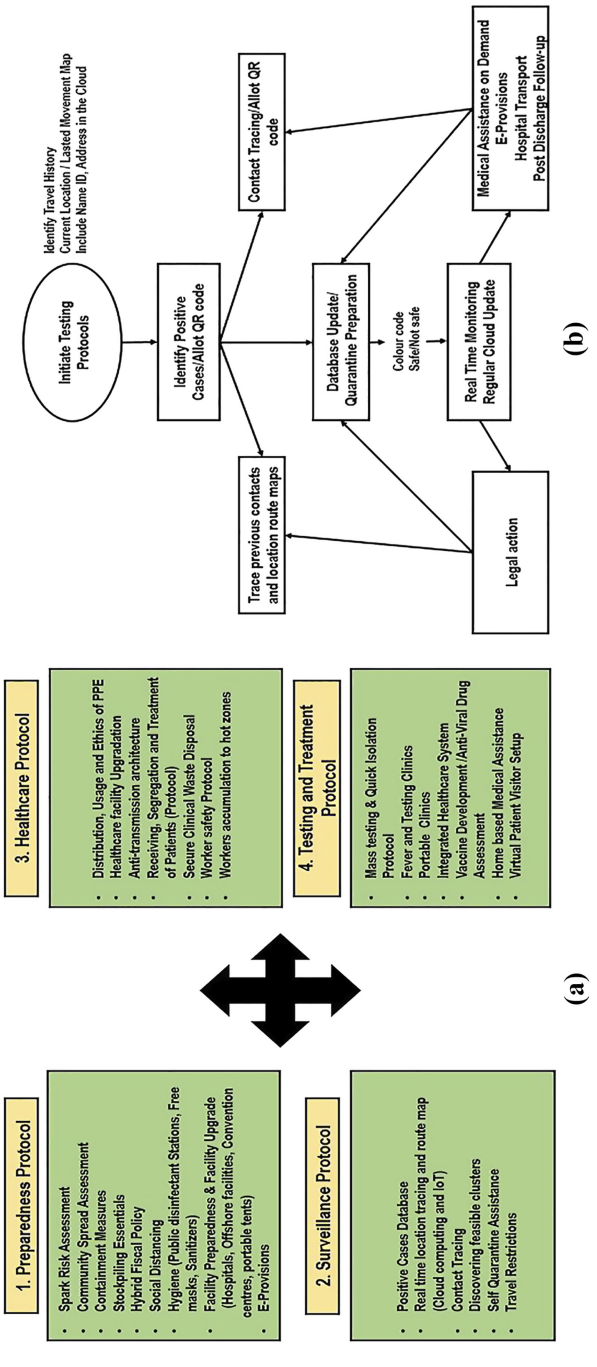

Figure 5.
Conceptual frameworks on strategic mitigation. (*5a.* integrated strategy, *5b.* cloud-based tracing and tracking framework, *5c.* dedicated healthcare protocol and *5d.* offshore medical rigs)

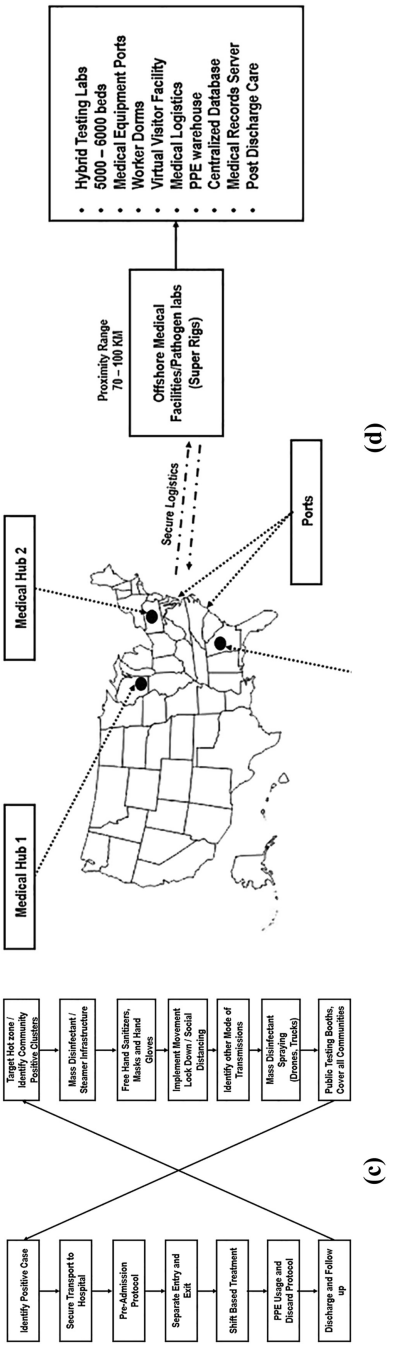
Identify Positive Case
Secure Transport to Hospital
Pre-Admission Protocol
Separate Entry and Exit
Shift Based Treatment
PPE Usage and Disard Protocol
Discharge and Follow up
Target Hot zone / Identify Community Positive Clusters
Mass Disinfectant / Steamer Infrastructure
Free Hand Sanitizers, Masks and Hand Gloves
Implement Movement Lock Down / Social Distancing
Identify other Mode of Transmissions
Mass Disinfectant Spraying (Drones, Trucks)
Public Testing Booths, Cover all Communities
(c)
Medical Hub 1
Medical Hub 2
Secure Logistics
Ports
Proximity Range 70 – 100 KM
Offshore Medical Facilities/Pathogen labs (Super Rigs)
Hybrid Testing Labs
5000 – 6000 beds
Medical Equipment Ports
Worker Dorms
Virtual Visitor Facility
Medical Logistics
PPE warehouse
Centralized Database
Medical Records Server
Post Discharge Care
(d)

Figure 5.

complexities. A dedicated QR code should be allocated to each user, registered with the cloud software application. Applicants with positive and negative test results can be categorized and given different color codes (i.e. positive, negative and symptomatic) during targeted mass population screenings. Later, with this information, travel restrictions can be imposed in vulnerable zones along with strict legal actions as stated by Rolston [45]. Nevertheless, the healthcare community should come up with mobile clinics, doorstep medical assistance and e-grocery service to the worst-hit clusters in an effort to stop their physical movement.

Furthermore, to avoid an outbreak within the medical community, protecting and safeguarding healthcare staff, PPE usage and replacement should be a top priority [35]. Proper usage of PPE, strictly following the guidelines for PPE usage and disposal, could save resources in PPE utilization [46]. Mobilizing personal protective equipment at the time of crisis is very difficult [47]. Hence, there is a stringent need for a modern and technically better way of transferring patients, replenishing surgical supplies, preadmission protocols, testing/transport, post-discharge procedures, setting up dedicated medical centers and monitoring smart medical logistics. To address this and neatly project the idea, the authors suggest a protocol to identify, transport, receive, manage and treat COVID-19 positive cases as detailed in Figure 5c.

In addition, artificial intelligence and smart algorithms are needed to build an anti-transmission and detection system such as face recognition and thermal screening in public areas [48,49]. Moreover, wide monitoring and detection in the areas of positive clusters will ease social isolation, diagnosis and care [50–52]. An e-provisional store for the online purchase of essential medical items and related logistics services to deliver them safely to hospitals and households can restrict humanitarian movement.

Moreover, there is a shortage of hospital beds and medical equipment. Licina [53] suggested that offshore ships that are converted into hospitals are a possible option, but this cannot be used indefinitely to solve the problem, nor does inclusion of other indoor arenas. Onshore or inland countermeasures will permanently overload healthcare facilities due to the unprecedented rate of positive cases and spread risks. The authors suggest an innovative and feasible long-term solution to this major problem, such as offshore rigs with specialized medical and testing laboratories as shown in Figure 5d. These proposed offshore medical rigs should ideally be a sophisticated state of the art facility especially dedicated to pandemic situations and can be utilized for multiple causes on a long-term basis. They should be designed to hold hybrid testing labs, research facilities, PPE storage warehouses, dedicated dorms for medics, secure logistics routes and patient beds. Even though this is an expensive option, it may be possible with collective international funds, upgraded citizen tax policies, initiatives from private/government health organizations and superpower nations like the USA and Germany. This could prove very effective on a long-term basis giving birth to the new notion called "The Green Countries". Countries with very minimal or no positive cases enjoy this status and can open up borders for the other green nations.

Future directions

Readiness for the long-term fight. The spark can only be curbed by imposing strict global regulations on adverse dietary habits that include zoonotic animals [54]. Countrywide off seasonal periodic checks are essential to monitoring spark risk [55]. For constant and continued diagnosis and effective surveillance, countermeasures are needed in the long run to keep a check on Influenza-Like Illness (ILI) [56,57]. Community-centered treatment is an important criterion to be noted rather than patient-centered treatment and the world healthcare associations need to have a long-term strategy [58]. The global community should prepare responsive long-term strategies, especially for pandemic outbreaks. A series of integrated, preventive and adaptive measures should become a part of governmental

guidelines. Efforts to learn more about the characteristics of this COVID-19 should be carried out by reviewing uncharted arenas and provide a unique window of interventions.

Improvising technological measures

Technological advancements in the medical field have met the quality standards but they lag in quantity during huge pandemic outbreaks [59]. Economically feasible medical packages should meet the same quality and become the main agenda of the companies that manufacture medical aids and equipment [60]. Moreover, effective and cost-effective healthcare strategies should be developed without compromising quality [61].

Conclusion

Rigorous and continued social distancing is critical at this moment. However, tight isolation and containment of COVID-19 patients, in particular, may prove to be a difficult task in the long run. Nonetheless, these are the only robust mitigation methods currently adopted [62]. Moreover, this is not just a matter of medical treatment and intensive care as the involvement and collaboration of social scientists, epidemiologists, engineering specialists, psychologists and social workers are required [58]. Rethinking and redesigning the mitigation strategies to handle this current crisis is crucial.

Data on other normal health issues should be corroborated with pandemic related databases. To do so, adopting advanced monitoring systems (e-healthcare analytics) that can help monitor citizen's health conditions based on person-related data can be sought. The results of this study show that very little research has been done in the area of COVID-19 mitigation strategies such as factors influencing PPE production, distribution and usage, automated intensive care setup, patient handling, social and healthcare sustainability protocols. More research should focus on the area of pandemic spark assessment and prior containment strategies rather than only limiting the masses to social distancing and self-containment. Circular healthcare business models, medical reverse logistics, PPE reuse/disposal protocols, non-conventional semi-automated medical facilities, healthcare humanitarian logistics, sustainable medical supply chains and innovative governmental backup requires further in-depth research. To conclude, these strategic protocols can only be successful if it is feasible for all populations across various countries from the standpoint of adaptability and cost issues. Pandemics such as COVID-19 indicate possibilities in undiscovered mutated viral strains and pathogens that can still cause further outbreaks. A long-term strategy should always be in place to meet another viral pandemic.

References

1. Madhav N, Oppenheim B, Gallivan M, Mulembakani P, Rubin E, Wolfe N. Pandemics: risks, impacts, and mitigation. In: Jamison DT, Gelband H, Horton S, Jha P, Laxminarayan R, Mock CN, editors. Disease control priorities: improving health and reducing poverty. 3rd ed. Washington, DC: International Bank for Reconstruction and Development/The World Bank; 2017. p.315-45.
2. Morse SS, Mazet JA, Woolhouse M, Parrish CR, Carroll D, Karesh WB. Prediction and prevention of the next pandemic zoonosis. Lancet. 2012 Dec; 380(9857): 1956-65. doi: 10.1016/S0140-6736(12)61684-5.
3. Johnson CK, Hitchens PL, Smiley Evans T, Goldstein T, Thomas K, Clements A. Spillover and pandemic properties of zoonotic viruses with high host plasticity. Sci Rep. 2015 Oct; 5: 14830. doi: 10.1038/srep14830.
4. Gortazar C, Reperant LA, Kuiken T, de la Fuente J, Boadella M, Martínez-Lopez B. Crossing the interspecies barrier: opening the door to zoonotic pathogens. PLoS Pathog. 2014 Jun; 10(6): e1004129. doi: 10.1371/journal.ppat.1004129.

5. Halsey NA, Griffioen M, Dreskin SC, Dekker CL, Wood R, Sharma D. Immediate hypersensitivity reactions following monovalent 2009 pandemic influenza A (H1N1) vaccines: reports to VAERS. Vaccine. 2013 Dec; 31(51): 6107-12. doi: 10.1016/j.vaccine.2013.09.066.
6. Wikramaratna PS, Gupta S. Influenza outbreaks. Cell Microbiol. 2009; 11(7): 1016-24. doi: 10.1111/j.1462-5822.2009.01320.x.
7. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72,314 cases from the Chinese Center for Disease Control and Prevention. JAMA. 2020; 323(13): 1239-42. doi: 10.1001/jama.2020.2648.
8. Guo YR, Cao QD, Hong ZS, Tan YY, Chen SD, Jin HJ. The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak - an update on the status. Mil Med Res. 2020 Mar; 7(1): 11. doi: 10.1186/s40779-020-00240-0.
9. World Health Organization [WHO]. Coronavirus disease (COVID-2019) situation reports. [cited 2020 Mar 30]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports.
10. Yang Y, Peng F, Wang R, Yange M, Guan K, Jiang T. The deadly coronaviruses: The 2003 SARS pandemic and the 2020 novel coronavirus epidemic in China. J Autoimmun. 2020 May; 109: 102434. doi: 10.1016/j.jaut.2020.102434.
11. Worldometer. Coronavirus update (Live): 9,098,970 cases and 471,519 deaths from COVID-19 virus pandemic. [cited 2020 Jun 23]. Available from: https://www.worldometers.info/coronavirus/.
12. van der Weerd W, Timmermans DR, Beaujean DJ, Oudhoff J, van Steenbergen JE. Monitoring the level of government trust, risk perception and intention of the general public to adopt protective measures during the influenza A (H1N1) pandemic in The Netherlands. BMC Public Health. 2011 Jul; 11: 575. doi: 10.1186/1471-2458-11-575.
13. Bish A, Michie S. Demographic and attitudinal determinants of protective behaviours during a pandemic: a review. Br J Health Psychol. 2010 Nov; 15(Pt 4): 797-824. doi: 10.1348/135910710X485826.
14. Liao Q, Cowling B, Lam WT, Ng MW, Fielding R. Situational awareness and health protective responses to pandemic influenza A (H1N1) in Hong Kong: a cross-sectional study. PLoS ONE. 2010 Oct; 5(10): e13350. doi: 10.1371/journal.pone.0013350.
15. SteelFisher GK, Blendon RJ, Ward JR, Rapoport R, Kahn EB, Kohl KS. Public response to the 2009 influenza A H1N1 pandemic: a polling study in five countries. Lancet Infect Dis. 2012 Nov; 12(11): 845-50. doi: 10.1016/S1473-3099(12)70206-2.
16. Larson EL, Liverman CT, editors. Preventing transmission of pandemic influenza and other viral respiratory diseases: personal protective equipment for healthcare personnel: update 2010. Washington, DC: National Academies Press; 2011.
17. Lucey DR, Gostin LO. The emerging Zika pandemic: enhancing preparedness. JAMA. 2016 Mar; 315(9): 865-6. doi: 10.1001/jama.2016.0904.
18. Houghton F, Del Monte K, Glessner D, Goff J, Hopkins E, Loney K. Zombie pandemic preparedness: a cautionary observation. N Z Med J. 2016 Apr; 129(1432): 97-9.
19. Henry B. Canada's pandemic influenza preparedness: laboratory strategy. Can Commun Dis Rep. 2018 Jan; 44(1): 10-3. doi: 10.14745/ccdr.v44i01a03.
20. Anderson RM, Heesterbeek H, Klinkenberg D, Hollingsworth TD. How will country-based mitigation measures influence the course of the COVID-19 epidemic?. Lancet. 2020 Mar; 395(10228): 931-4. doi: 10.1016/s0140-6736(20)30567-5.
21. Ferguson NM, Laydon D, Nedjati-Gilani G, Imai N, Ainslie K, Baguelin M. Report 9: impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand. London: Imperial College; 2020.
22. McKibbin W, Fernando R. The global macroeconomic impacts of COVID-19: seven scenarios. (CAMA Working Paper 19/2020). Canberra: The Australian National University; 2020.

23. Baldwin R, Tomiura E. Thinking ahead about the trade impact of COVID-19. In: Baldwin R, di Mauro BW, editors. Economics in the time of COVID-19. London: Centre for Economic Policy Research; 2020. p. 59-71.

24. Heymann DL, Shindo N. COVID-19: what is next for public health?. Lancet. 2020 Feb; 395(10224): 542-5. doi: 10.1016/s0140-6736(20)30374-3.

25. Li H, Cao B. Pandemic and avian influenza A viruses in humans: epidemiology, virology, clinical characteristics, and treatment strategy. Clin Chest Med. 2017 Mar; 38(1): 59-70. doi: 10.1016/j.ccm.2016.11.005.

26. Chan KW, Wong VT, Tang SCW. COVID-19: an update on the epidemiological, clinical, preventive and therapeutic evidence and guidelines of integrative Chinese-Western medicine for the management of 2019 novel coronavirus disease. Am J Chin Med. 2020; 48(3): 737-62. doi: 10.1142/S0192415X20500378.

27. Kucharski AJ, Russell TW, Diamond C, Liu Y, Edmunds J, Funk S. Early dynamics of transmission and control of COVID-19: a mathematical modelling study. Lancet Infect Dis. 2020 May; 20(5): 553-8. doi: 10.1016/S1473-3099(20)30144-4.

28. Zhao S, Lin Q, Ran J, Musa SS, Yang G, Wang W. Preliminary estimation of the basic reproduction number of novel coronavirus (2019-nCoV) in China, from 2019 to 2020: a data-driven analysis in the early phase of the outbreak. Int J Infect Dis. 2020 Mar; 92: 214-7. doi: 10.1016/j.ijid.2020.01.050.

29. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev. 2015 Jan; 4: 1. doi: 10.1186/2046-4053-4-1.

30. Vandenberg LN, Agerstrand M, Beronius A, Beausoleil C, Bergman A, Bero LA. A proposed framework for the systematic review and integrated assessment (SYRINA) of endocrine disrupting chemicals. Environ. Health. 2016 Jul; 15(1): 74. doi: 10.1186/s12940-016-0156-6.

31. Hellewell J, Abbott S, Gimma A, Bosse NI, Jarvis CI, Russell TW. Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts. Lancet Glob Health. 2020 Apr; 8(4): e488-e96. doi: 10.1016/S2214-109X(20)30074-7.

32. Ng Y, Li Z, Chua YX, Chaw WL, Zhao Z, Er B. Evaluation of the effectiveness of surveillance and containment measures for the first 100 patients with COVID-19 in Singapore - january 2-february 29, 2020. MMWR Morb. Mortal. Wkly. Rep. 2020 Mar; 69(11): 307-11. doi: 10.15585/mmwr.mm6911e1.

33. Wang H, Wang S, Yu K. COVID-19 infection epidemic: the medical management strategies in Heilongjiang Province, China. Crit. Care. 2020 Mar; 24(1): 107. doi: 10.1186/s13054-020-2832-8.

34. Ebrahim SH, Ahmed QA, Gozzer E, Schlagenhauf P, Memish ZA. Covid-19 and community mitigation strategies in a pandemic. BMJ. 2020 Mar; 368: m1066. doi: 10.1136/bmj.m1066.

35. Huh K, Shin HS, Peck KR. Emergent strategies for the next phase of COVID-19. Infect Chemother. 2020 Mar; 52(1): 105-9. doi: 10.3947/ic.2020.52.1.105.

36. McCloskey B, Zumla A, Ippolito G, Blumberg L, Arbon P, Cicero A. Mass gathering events and reducing further global spread of COVID-19: a political and public health dilemma. Lancet. 2020 Apr; 395(10230): 1096-9. doi: 10.1016/s0140-6736(20)30681-4.

37. Berger ZD, Evans NG, Phelan AL, Silverman RD. Covid-19: control measures must be equitable and inclusive. BMJ. 2020 Mar; 368: m1141. doi: 10.1136/bmj.m1141.

38. Wong J, Goh QY, Tan Z, Lie SA, Tay YC, Ng SY. Preparing for a COVID-19 pandemic: a review of operating room outbreak response measures in a large tertiary hospital in Singapore. Can J Anaesth. 2020 Jun; 67(6): 732-45. doi: 10.1007/s12630-020-01620-9.

39. van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics. 2010 Aug; 84(2): 523-38. doi: 10.1007/s11192-009-0146-3.

40. Faria-e-Castro M. Fiscal policy during a pandemic. (Working Paper 2020-006E). St. Louis, MO: Federal Reserve Bank of St. Louis; 2020.

41. Sandhu R, Gill HK, Sood SK. Smart monitoring and controlling of pandemic influenza A (H1N1) using social network analysis and cloud computing. J Comput Sci. 2016 Jan; 12: 11-22. doi: 10.1016/j.jocs.2015.11.001.

42. Chen M, Ma Y, Song J, Lai CF, Hu B. Smart clothing: connecting human with clouds and big data for sustainable health monitoring. Mobile Network. Appl. 2016; 21(5): 825-45. doi: 10.1007/s11036-016-0745-1.

43. Sareen S, Sood SK, Gupta SK. IoT-based cloud framework to control Ebola virus outbreak. J Ambient Intell Humaniz Comput. 2018; 9(3): 459-76. doi: 10.1007/s12652-016-0427-7.

44. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. 2020 May; 20(5): 533-4. doi: 10.1016/S1473-3099(20)30120-1.

45. Rolston H. A new environmental ethics: the next millennium for life on earth. New York: Routledge; 2012.

46. Moore M, Dausey DJ. Response to the 2009-H1N1 influenza pandemic in the Mekong Basin: surveys of country health leaders. BMC Res. Notes. 2011 Sep; 4: 361. doi: 10.1186/1756-0500-4-361.

47. Pallister-Wilkins P. Personal Protective Equipment in the humanitarian governance of Ebola: between individual patient care and global biosecurity. Third World Q. 2016 Mar; 37(3): 507-23. doi: 10.1080/01436597.2015.1116935.

48. Fair JM, Powell DR, LeClaire RJ, Moore LM, Wilson ML, Dauelsberg LR. Measuring the uncertainties of pandemic influenza. Int J Risk Assess Manag. 2012; 16(1–3): 1-27. doi: 10.1504/IJRAM.2012.047550.

49. Bednarczyk RA, DuVall S, Meldrum MD, Flynn MK, Santilli LA, Easton DE. Evaluating the most effective distribution strategies to assure administration of pandemic H1N1 influenza vaccine to New York State children and adolescents: evaluation using the New York State Immunization Information System. J Public Health Manag Pract. 2013 Nov-Dec; 19(6): 589-97. doi: 10.1097/PHH.0b013e31828002af.

50. Kazanjian P. The AIDS pandemic in historic perspective. J Hist Med Allied Sci. 2014 Jul; 69(3): 351-82. doi: 10.1093/jhmas/jrs061.

51. Towers S, Vogt Geisse K, Zheng Y, Feng Z. Antiviral treatment for pandemic influenza: assessing potential repercussions using a seasonally forced SIR model. J Theor Biol. 2011 Nov; 289: 259-68. doi: 10.1016/j.jtbi.2011.08.011.

52. Salathe M, Althaus CL, Neher R, Stringhini S, Hodcroft E, Fellay J. COVID-19 epidemic in Switzerland: on the importance of testing, contact tracing and isolation. Swiss Med Wkly. 2020 Mar; 150: w20225. doi: 10.4414/smw.2020.20225.

53. Licina D. Hospital ships adrift? Part 1: a systematic literature review characterizing US Navy hospital ship humanitarian and disaster response, 2004-2012. Prehosp Disaster Med. 2013 Jun; 28(3): 230-8. doi: 10.1017/S1049023X13000149.

54. Liu Q, Cao L, Zhu XQ. Major emerging and re-emerging zoonoses in China: a matter of global health and socioeconomic development for 1.3 billion. Int J Infect Dis. 2014 Aug; 25: 65-72. doi: 10.1016/j.ijid.2014.04.003.

55. He D, Lui R, Wang L, Tse CK, Yang L, Stone L. Global spatio-temporal patterns of influenza in the post-pandemic era. Sci Rep. 2015 Jun; 5: 11013. doi: 10.1038/srep11013.

56. Fauci AS, Lane HC, Redfield RR. Covid-19 - navigating the uncharted. N Engl J Med. 2020 Mar; 382(13): 1268-9. doi: 10.1056/NEJMe2002387.

57. Tilston NL, Eames KT, Paolotti D, Ealden T, Edmunds WJ. Internet-based surveillance of Influenza-like-illness in the UK during the 2009 H1N1 influenza pandemic. BMC Public Health. 2010 Oct; 10: 650. doi: 10.1186/1471-2458-10-650.

58. Nacoti M, Ciocca A, Giupponi A, Brambillasca P, Lussana F, Pisano M. At the epicenter of the Covid-19 pandemic and humanitarian crises in Italy: changing perspectives on preparation and mitigation. 2020 Mar. doi: 10.1056/CAT.20.0080.

59. Suhardono M, Ugiyadi D, Nurnaeni I, Emelia I. Establishment of pandemic influenza vaccine production capacity at Bio Farma, Indonesia. Vaccine. 2011 Jul; 29(Suppl 1): A22-5. doi: 10.1016/j.vaccine.2011.04.123.

60. Hamele M, Neumayer K, Sweney J, Poss WB. Always ready, always prepared-preparing for the next pandemic. Transl Pediatr. 2018 Oct; 7(4): 344-55. doi: 10.21037/tp.2018.09.06.

61. Oshitani H, Kamigaki T, Suzuki A. Major issues and challenges of influenza pandemic preparedness in developing countries. Emerg Infect Dis. 2008 Jun; 14(6): 875-80. doi: 10.3201/eid1406.070839.

62. Wilder-Smith A, Chiew CJ, Lee VJ. Can we contain the COVID-19 outbreak with the same measures as for SARS? Lancet Infect Dis. 2020 May; 20(5): e102-e7. doi: 10.1016/s1473-3099(20)30129-8.

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