DOI: https://doi.org/10.36094/sc.v89.2023.Looking_at_Covid-19_Pandemic_Through.Ghoshal_Banerji.27

ARTICLE

Sci. and Cult. 89 (1–2) : 27-32 (2023)

LOOKING AT COVID-19 PANDEMIC THROUGH THE LENS OF EPIDEMIOLOGICAL TRANSITION THEORY

PIA GHOSHAL[1] AND ANIRUDDHA BANERJI[2*]

The COVID-19 pandemic, the causative agent for which is the Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2), has posed severe challenges to the health industry, governments and communities to meet the pressing demands for controlling and overcoming this highly infective and constantly mutating virus. This paper seeks to discuss and analyze some possible issues related to Omran's theory of epidemiologic transition in the light of COVID-19 pandemic. We concentrate on three propositions of Omran related to the importance of mortality, the health transition from communicable to non-communicable diseases and the susceptibility of different sections of society to various diseases. As the COVID-19 pandemic has severe epidemiologic implications, there is an urgent need to adapt to new situations and to extend existing knowledge and skills in preparation to respond to possible outbreaks in the future. This paper also highlights some of the possible actions which can be taken for such a pandemic in future in light of the transition theory.

Introduction

The world has been ravaged by the COVID-19 pandemic since 2020. The pandemic has both short-term and long-term multidimensional implications with intergenerational perspectives. In this light, study of the epidemiological implications of the pandemic is of utmost importance for future preparedness, based on past experience and present literature. In this respect, one of the important epidemiological predictions which can be analyzed is the epidemiologic transition theory of Omran (1971, 1998)[1,2] which reflects the predicted phases of health transition and reversal of transition trends if any, as may be faced by the various countries of the world. As of 21st January 2022, the World Health Organization (WHO) reports 340,543,962 confirmed cases of COVID-19 globally with 5,570,163 confirmed deaths caused by this disease[3]. The implications of such events on the mortality and morbidity patterns of the current global population are understandably grave and can pose severe challenges to the expected demographic and epidemiological trends. Epidemiology involves studying health and disease patterns and the factors determining their impact on population groups. Thus, epidemiology involves scientifically studying and analyzing health care, demographic, social, technological, economic and environmental dimensions affecting health outcomes[2].

The COVID-19 pandemic, the causative agent for which is the Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) first reported in Wuhan, China, was formally declared as a global pandemic by the World Health Organization in March 2020[4,5]. The health crises brought about by COVID-19, severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) over the last two decades have led to a revision of the previously prevailing opinion that coronaviruses cause comparatively mild respiratory infections and the health and pharmaceutical industry has

1. Post Graduate Department of Economics, St. Xavier's College (Autonomous), Kolkata, 30 Mother Teresa Sarani, Kolkata 700016, West Bengal, India. Email: pia_g@rediffmail.com

2. Post Graduate Department of Biotechnology, St. Xavier's College (Autonomous), Kolkata, 30, Mother Teresa Sarani, Kolkata 700016, West Bengal, India. Email: aniruddha_banerji@yahoo.co.in

*Corresponding Author : aniruddha_banerji@yahoo.co.in

had to respond to the situations accordingly. Vaccination, observing social distancing, performing repeated sanitization and the wearing of masks are the major precautions against avoiding COVID-19 infection[4-7]. Also, in an attempt to break the chain of infections, many countries had imposed emergency quarantine conditions, lockdowns and travel restrictions some of which are still continuing at present. Controlling the pandemic has posed severe challenges because of the ability of SARS-CoV-2 to rapidly undergo genetic evolution leading to the production of multiple variants of concern (VOCs) such as Alpha, Beta, Gamma, Delta and more recently Omicron[8].

This paper seeks to discuss and analyze the possible issues related to epidemiology in the light of the COVID-19 pandemic. Here we discuss some relevant propositions of Omran's theory of epidemiologic transition which is of utmost importance to keep in focus for healthcare facilities and policy makers for minimizing the adverse impacts of COVID-19 in order to save lives and livelihoods.

SARS-CoV-2: Viral Evolution and Disease

We first discuss the nature of the SARS-CoV-2 virus, which is of relevance because of its ability to mutate into a number of variants of concern and the serious clinical effects upon infection. This can have some implications on the various stages of epidemiologic transition.

Under the electron microscope, coronaviruses are seen to have characteristic club shaped projections emerging from their otherwise spherical surface. This group of single strand RNA viruses is named as "coronavirus" as they seem to resemble a solar corona under the electron microscope[4,5,9]. The SARS-CoV-2 genome has been sequenced and the genome organization has been shown to be similar to other beta coronaviruses[4,5,10]. Overall, the genome shows around 79% genetic similarity with SARS-CoV and around 50% similarity with MERS-CoV[4,5]. For entry into human cells, SARS-CoV-2 uses human angiotensin-converting enzyme 2 (ACE2) as receptor. ACE2 are expressed in human alveolar epithelial cells and cells of the respiratory tract and also in cells of the vascular system (like cardiomyocytes and haematopoietic cells), intestine and kidney[11].

Although SARS-CoV-2 is considerably similar to SARS-CoV both at the genome and amino acid levels, there is a significant difference in spike protein RBDs. As a result of this, while both SARS-CoV and SARS-CoV-2 interact with ACE2, SARS-CoV-2 RBD has a stronger binding affinity for human ACE2[4,5,12] and antibodies or therapeutic peptides developed against the SARS-CoV spike RBD are not as effective against SARS-CoV-2[5]. Additionally, SARS-CoV-2 has been shown to infect and replicate in human lung tissues more efficiently than SARS-CoV and already COVID-19 has far exceeded SARS in the number of infected patients[5,13].

SARS-CoV-2 has given rise to a number of variants of concern (VOCs) designated by the World Health Organization (WHO) including Alpha (first reported in the United Kingdom and designated in Dec 2020 by WHO), Beta (first reported in South Africa and designated in Dec 2020), Gamma (first reported in Brazil and designated in Jan 2021), Delta (first reported in India and designated in May 2021) and Omicron (first reported in multiple countries and designated in Nov 2021)[8]. These variants may differ in infective ability, associated disease severity and in their response to vaccines and therapeutic measures. It appears that SARS-CoV-2 has a greater capacity to evolve in comparison to the other human coronaviruses[14].

Common clinical symptoms of COVID-19 infection include fever, respiratory syndromes including pharyngitis, sore throat and coughing, dyspnea, nausea, diarrhoea and the loss of olfactory and gustatory sensations. Acute respiratory distress and acute lung injury has been reported in a number of patients. Apart from the respiratory system, other organs can also be affected and multiple organ failure has been reported particularly in COVID-19 patients suffering from comorbidities. Organs including the heart, the vascular system and the gastrointestinal system can be affected. Critically ill patients may suffer from acute respiratory distress, multiple organ dysfunction, septic shock and coagulation disorders[4,5,9,15-17]. Expression of the SARS-CoV-2 receptor ACE2 on these organs could make these organs susceptible to damage in COVID-19 infections[11].

Exploring Some of Omran's Propositions in the Light of Covid-19 Pandemic

Omran's landmark 1971 paper discussed the various stages of epidemiologic transition the human civilization is expected to go through during their stages of development[1]. Subsequently, in 1998, he revisited his propositions in the light of the changes occurring around the millennium[2]. The current pandemic situation is to be visualized with respect to his predictions for the proper management and the development of preventive measures so that it does not distort gravely the predicted global demography.

Exploring Omran's Proposition One

According to Omran's Proposition One (1971), mortality is a fundamental factor in epidemiologic transition which influences population dynamics[1]. In 1998, he stated that fertility also acts as a potent co-variable in regulation of population dynamics. Fertility remains at a high level in the earlier stages before declining and effectively acting as a pace-setter of population growth[2].

Fig. 1 seeks to represent the crude death date (per 1,000 people) as an indicator of mortality where X axis represents years of study and Y axis represents crude death rate per 1,000 people. It is seen that as predicted by Omran's proposition, there has been a decline of mortality rate over the time period 1961-2019. Considering the resultant population growth rate (Fig. 2) where X axis represents years of study and Y axis represents annual percentage of population growth, it is found that there has been a slight decline from 1973. This leads us to study the crude birth rate as an indicator of fertility (Fig. 3) where X axis represents years of study and Y axis represents crude birth rate per 1,000 people. The graph indicates that crude birth rate has declined, playing its role in deciding the global population growth rate.

As shown in Fig. 1 – 3, till 2019 the crude death rates and the crude birth rates of the world were following the predictions of the existing literature which would have resulted in a stable population projection for the future. However, the COVID-19 pandemic has severely affected both factors. According to Omran's (1998) very important observation, reversal of the transition can occur due to worsening situations related to morbidity, environmental, political, economic and other crises[2]. COVID-19 pandemic can be visualized as one of such crises.

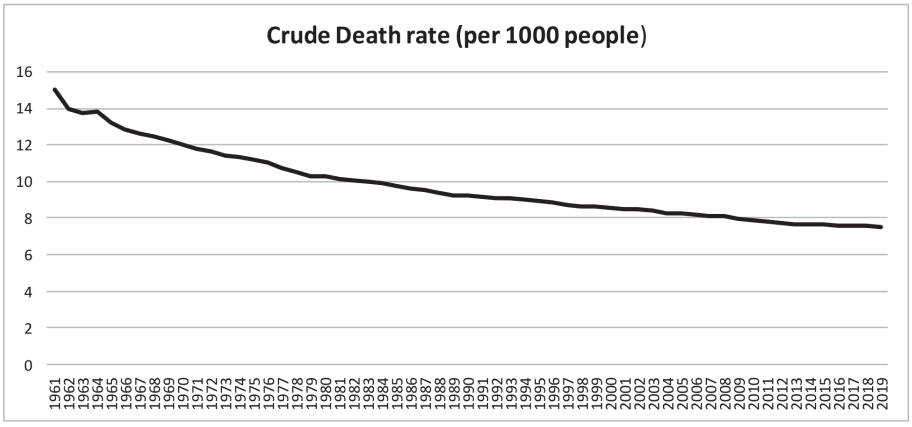

Fig. 1: Crude death rate (per 1000 people) for the period 1961-2019.

(Source: Based on authors' graphical representation of The World Bank Data Bank, World Development Indicators https://databank.worldbank.org/)[18]

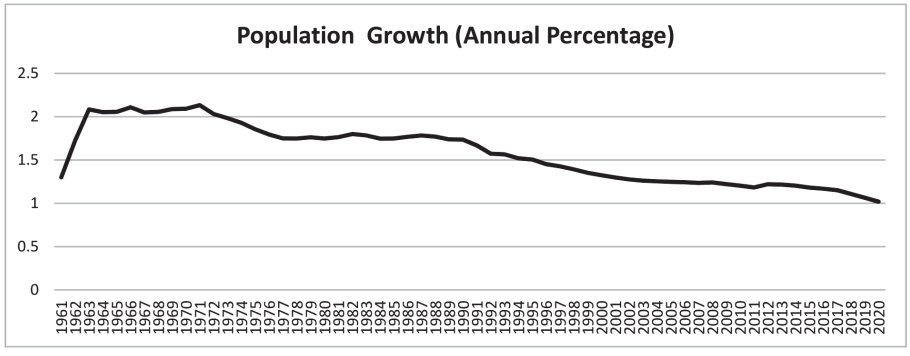

Fig. 2: Population Growth (Annual Percentage) for the period 1961-2020.

(Source: Based on authors' graphical representation of The World Bank Data Bank, World Development Indicators https://databank.worldbank.org/)[18]

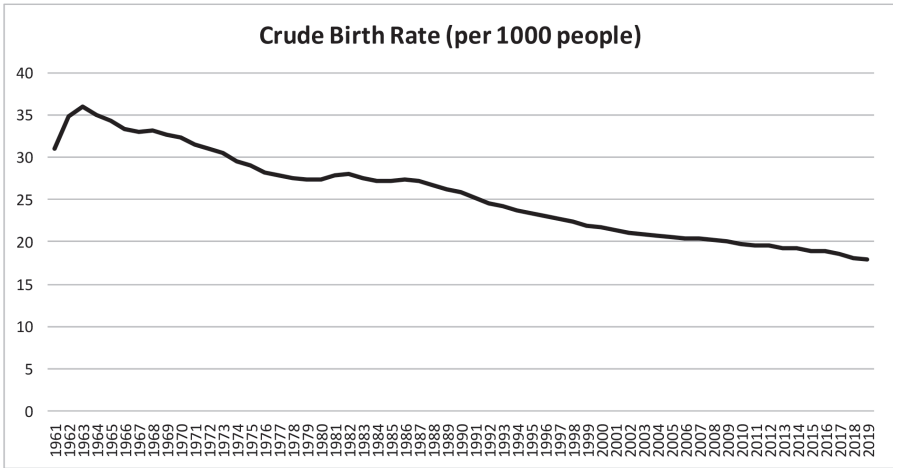

Fig. 3: Crude birth rate (per 1000 people) for the period 1961-2019.

(Source: Based on authors' graphical representation of The World Bank Data Bank, World Development Indicators https://databank.worldbank.org/)[18]

In a world where mortality and fertility were playing their respective roles in deciding population dynamics, distortions caused to both these factors will obviously have implications on global population changes. Estimates indicate that, in order to naturally replace its population, a birth rate of at least 2.1 is required. The birth rate in USA stands at 1.6 in 2020, a decline of 19% from 2007. Analyzing some other countries shows birth rates of 1.3 in China, 1.6 in Russia, 1.8 in Brazil, 2.0 in Indonesia and 2.1 in India in 2020[19]. The decline in birth rate can occur due to a variety of reasons but it seems evident that, at the current time, COVID-19 has an important impact on declining birth rates. A study on the effects of the COVID-19 pandemic on birth rates has shown a decline in crude birth rates beyond that predicted by past trends during the pandemic period with the declines being particularly well marked in Italy, Spain and Portugal (declines of 9.1%, 8.4% and 6.6% respectively)[20]. Estimates by the Brookings Institute shows that around 300,000 babies were not born in the US due to issues associated with the pandemic[19].

The difference in the total number of deaths in a crisis compared to those expected under normal conditions is termed as excess mortality. During the COVID-19 pandemic, excess mortality would account for total number of deaths directly attributed to COVID-19 infections as well as the deaths due to disruption to essential health services and travel restrictions[21]. In this regard, recent WHO estimates indicate an excess mortality of at least 3,000,000 in 2020 as compared to 1,813,188 COVID-19 deaths reported during that period[21]. Thus, the COVID-19 pandemic has thrown an appreciable challenge to the health and pharmaceutical industry as, with a significant drop in birth rates occurring globally due to the pandemic, global population changes can only be stabilized if the death rates can be brought under control.

Exploring Omran's Proposition Two

According to Omran's Proposition Two (1971, 1998), during the epidemiologic transition, shifting patterns of morbidity, mortality and disease poses severe challenges to the health system as western and non-western countries are at various stages of this transition at a certain point of time and sometimes the stages are overlapping in nature. It was expected that the pandemics of communicable diseases would be displaced by non-communicable degenerative, stress and age-related diseases[1,2]. The beginning of the millennium, according to Omran (1998) showed that such transitions were indeed occurring for the two sets of countries[2]. However, the onset of the COVID-19 pandemic has possible implications on such transition stages by its potential disruptive effects. Just when it seemed that infectious diseases had been brought under control and the focus could be gradually shifted to non-communicable diseases, the age of communicable diseases in the guise of COVID-19 has struck back.

According to Omran's Proposition Two (1971), patterns of natality and mortality distinguish three major successive stages:

1. The Age of Pestilence and Famine characterized by high and fluctuating mortality which precludes sustained population growth.
2. The Age of Receding Pandemics characterized by the progressive decline in mortality with rate of decline accelerating with the decrease in frequency of peaks in epidemics. This stage is marked by sustained population growth which exhibits an exponential trend.
3. The Age of Degenerative and Man-Made Diseases characterized by a further decline in mortality which eventually stabilizes at a relatively low level. In this stage, fertility becomes a crucial factor in regulating population growth[1].

Omran (1998) proposed a fourth and fifth stage for western countries from the beginning of the millennium where the fourth stage was characterized by the age of declining cardiovascular mortality, ageing, lifestyle modification, emerging and resurgent diseases and the futuristic fifth stage was the age of aspired quality of life[2]. As for the non-western countries, the stages would differ fundamentally from the western countries because they would be characterized by Stage 1, Stage 2 and a specific Stage 3 which is a Triple Health Burden comprising of "unfinished old health problems; rising new health problems; and ill-prepared health systems and medical training."[2]. So, during the onset of the pandemic, various western and non-western countries were at various stages of epidemiologic transition. Thus, a global spread of the SARS-CoV-2 virus had diverse impacts on various countries posing challenges for the public health policies, response from pharmaceutical industries, government policies and societal response to the same.

The non-communicable diseases have a close association with COVID-19 increasing the double burden of disease worldwide. COVID-19 infection can lead to severe illness and death in patients suffering from chronic health conditions like diabetes type 1 and type 2, cardiovascular diseases, respiratory diseases or renal diseases[4,22-25]. Such worse prognosis and outcome may

be linked to elevated expression of ACE2 and chronic inflammation in such patients and to possible organ damage from COVID-19 infection (like myocardial injury, acute coronary syndrome, arrhythmia or kidney damage) which may worsen pre-existing medical conditions[22-24]. Severe COVID-19 infection could lead to chronic illness characterized by respiratory function decline and cardiomyopathy[22,26]. For instance, an Austrian study indicated that 56% of COVID-19 patients had visible lung damage even after 12 weeks of being discharged from hospital. In milder COVID-19 infections chronic fatigue has been reported[26]. Concerns have also been raised about possible interactions between certain medications used for non-communicable diseases (like angiotensin-converting enzyme inhibitors) and COVID-19 progression and the difficulty of patients with non-communicable diseases to obtain routine diagnostic and treatment services such as dialysis due to containment measures for COVID-19 such as containment zones, lockdowns and travel restrictions[22,23].

Exploring Omran's Proposition Three

According to Omran's Proposition Three (1971, 1998), the females are favoured over the males during an epidemiologic transition where the most profound changes in health and disease patterns occur among children and young women, especially after pandemics recede[1,2]. We can observe from research studies that this COVID-19 pandemic has favoured females over males. Studies have indicated a higher susceptibility of men towards COVID-19 infection in comparison to women with clinical severity and prognosis being markedly worse in males regardless of age[11,27,28]. Studies on COVID-19 related mortality in the Italian population across 2020 indicated a lethality rate which was persistently higher in men across all age groups (13.3% in men as compared to 7.4% in women on 31st March 2020; 12% in men as compared to 8.4% in women on 14th October 2020)[11]. The worse prognosis in males could be linked to differences in immune responses as females generally have a higher expression of CD4+ lymphocytes (which could ensure a better clearance of viruses), higher levels of B cell expression and antibody production, a lesser predisposition to thromboembolism and lower production of the inflammatory cytokine IL-6 after viral infection[11,27,28]. Hormonal factors may also be involved as elevated androgens levels have been reported to be immune suppressive and the pro-inflammatory effects of testosterone (compared to the relatively anti-inflammatory effects of oestradiol) can lead to higher inflammation in males[11].

Conclusion

The COVID-19 pandemic has brought about an urgent need to adapt to new situations and to extend existing knowledge and skills for all involved in healthcare. In the wake of the pandemic, communities and individuals, as well as countries, need to be prepared to cope with the demands and consequences of essential containment and prevention measures both in the short-term as well as in the long-term[29]. Shifting epidemiological transition stages, and sometimes reversal at various areas, stresses the importance of pharmaceutical research for finding new ways to combat the pandemic. As, according to Proposition One of Omran, mortality is the principal factor in regulating population dynamics[1,2] and the COVID-19 pandemic has resulted in the phenomenon of excess deaths, creation and maintenance of strong public health infrastructure for responding to health emergency situations needs to be maintained. Public awareness regarding the falling birth rate and the excess death rate resulting from COVID-19 (which can change the structure of the population in future) needs to be created.

The previous several decades had witnessed appreciable progress in the control of infectious diseases with several former scourges like bubonic plague, small pox, cholera and malaria either on the decline or under control. Such advances could be linked to the development of modern medical treatment and health care, the discovery and use of antibiotics, improvements in sanitation, better nutrition and increased food safety. In fact, non-communicable diseases including cancers, cardiovascular diseases and diabetes had become the principal causes of death and disability in many countries, particularly the developed countries. This was much in accordance with Proposition Two of Omran which predicted that with epidemiological transition, communicable diseases as a cause of mortality would decrease and there would be the age of onset of non-communicable diseases[1,2]. In most countries, both developed and developing, prevention of non-communicable diseases had become a priority and health funds were allocated in accordance with such policies[6]. But, with the onset of the COVID-19 pandemic, infectious diseases have returned with a vengeance, seriously disturbing the predicted modelling for diseases and causing an urgent need for change in planning. In the current dualistic pattern of the disease trend, with the co-existence of communicable and non-communicable diseases, awareness of the government should be maintained to diagnose, prevent and treat COVID-19 and also deal with its long term consequences. Moreover, in such a situation, special attention needs to be given to

patients with co-morbidities (which are non-communicable in nature). In this respect, an important role is to be played by the countries to manage the COVID-19 infodemic to prevent spreading of unnecessary panic which can adversely affect lives and livelihoods.

In the COVID-19 pandemic, it was found that males were more affected than their female counterparts. Moreover, various forms of lockdown measures provided protective shields for children as public mixing in schools and colleges was at a minimum. Thus, interventionist policies taken at the international level protected the children from serious exposure to the SARS-CoV-2 virus. In compliance with Omran's Proposition Three prediction[1,2], it can be expected that, as this pandemic is gradually converted into an endemic, the women and children will benefit from the public health measures taken.

Adequate population level immunity, public awareness, availability of health care infrastructure needs to be maintained to prevent the transmission from public places. As the working population and particularly males are susceptible to such disease transmission, maintaining infection prevention measures in their working places and community engagement is of utmost importance. This measure has the potential of reducing the risk for the working population as well as the males; otherwise irreplaceable human capital loss for the countries may result. As COVID-19 still persists in various countries of the world, we should be prepared to respond to sudden outbreaks in the future based on the knowledge and experience gained during this pandemic. ❐

References

1. A. R. Omran, *The Milbank Memorial Fund Quarterly*. 49(4), 509–38(1971).
2. A. R. Omran, *World Health Statistics Quarterly*. 51, 99-119 (1998).
3. World Health Organization, Coronavirus disease (COVID-19) pandemic. Available: https://www.who.int/emergencies/diseases/novel-coronavirus-2019
4. B. Hu, H. Guo, P. Zhou, ZL. Shi, *Nature Reviews Microbiology*. 19(3), 141-54 (2021).
5. A. B. Parikhani, M. Bazaz, H. Bamehr, S. Fereshteh, S. Amiri, M. Salehi Vaziri et al., *Current Microbiology*. 78(4), 1099–114 (2021).
6. K. Mobaraki, J. Ahmadzadeh, *Biomed. J. Sci. & Tech. Res*. 25(4), 19397-99 (2020).
7. World Health Organization, Advice for the public: Coronavirus disease (COVID-19). Available:https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public
8. World Health Organization, Tracking SARS-CoV-2 variants. Available: https://www.who.int/en/activities/tracking-SARS-CoV-2-variants/
9. M. S. Sofi, A. Hamid, S. U. Bhat, *Biosafety and Health*. 2(4), 217-25 (2020).
10. R. Lu, Zhao X, Li J, Niu P, Yang B, Wu H et al., *Lancet.* 395 (10224), 565-74 (2020).
11. R. Pivonello, R. S. Auriemma, C. Pivonello, A. M. Isidori, G. Corona, A. Colao, et al., *Neuroendocrinology.*111(11), 1066-85 (2021).
12. J. Shang, G. Ye, K. Shi, Y. Wan, C. Luo, H. Aihara, et al., *Nature*. 581 (7807), 221-4 (2020).
13. H. Chu, JFW. Chan, Y. Wang, TTT. Yuen, Y. Chai, Y. Hou, et al. *Clin. Infect. Dis.* 71(6), 1400-9 (2020).
14. A. Telenti, A. Arvin, L. Corey, D. Corti, M. S. Diamond, A. García-Sastre, et al., *Nature.* 596 (7873), 495-504 (2021).
15. B. Bakhshandeh, S. G. Sorboni, A. R. Javanmard, S. S. Mottaghi, M. R. Mehrabi, F. Sorouri, et al., *Infect. Genet. Evol.* 90: 104773 (2021).
16. R. Hanna, S. Dalvi, T. Sălăgean, I. D. Pop, I. R. Bordea, S. Benedicenti, *Journal of Inflammation Research*. 14, 13–56 (2021).
17. W. Ni, X. Yang, D. Yang, J. Bao, R. Li, Y. Xiao et al., *Crit. Care.*24(1), 422 (2020).
18. The World Bank Data Bank, World Development Indicators. Available: https://databank.worldbank.org/
19. World Economic Forum, Available: https://www.weforum.org/agenda/2021/06/birthrates-declining-globally-why-matters/
20. A. Aassve, N. Cavalli, L. Mencarini, S. Plach, S. Sanders, *Proc. Natl. Acad. Sci. USA*. 118 (36), e2105709118 (2021).
21. World Health Organization. The true death toll of COVID-19, Available: https://www.who.int/data/stories/the-true-death-toll-of-covid-19-estimating-global-excess-mortality
22. X. F. Pan, J. Yang, Y. Wen, N. Li, S. Chen, A. Pan, *Engineering (Beijing)*. 7(7), 899–902 (2021).
23. M. Nishiga, D. W. Wang, Y. Han, D. B. Lewis, J. C. Wu, *Nature Reviews Cardiology*. 17(9), 543–58 (2020).
24. S. K. Alyammahi, S. M. Abdin, D. W. Alhamad, S. M. Elgendy, A. T. Altell, HA Omar. *Infect. Genet. Evol.* 87, 104647 (2021).
25. E. Barron, C. Bakhai, P. Kar, A. Weaver, D. Bradley, et al., *Lancet Diabetes Endocrinol*. 8(10), 813-22 (2020).
26. Marshall M. Nature, 585(7825), 339–41(2020).
27. A. Ortolan, M. Lorenzin, M. Felicetti, A. Doria, R. Ramonda, *International Journal of Infectious Diseases*. 99, 496-504 (2020).
28. P. Conti, A. Younes, *J. Biol. Regul. Homeost. Agents*. 34(2), 339-43 (2020).
29. D. Skegg, P. Gluckman, G. Boulton, H. Hackmann, SSA Karim, et al., *Lancet*. 397 (10276), 777-8 (2021).