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The COVID-19 paradox: Impact on India and developed nations of the world

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ABSTRACT

The world has been suffering under the horrendous effects of COVID-19 both in terms of loss of human lives and numerous tangible as well as financial losses. There has been some contrast on the magnitude of its impact in various parts of the world. The most peculiar one is the impact of COVID-19 in India as compared to other developed nations. Having the second largest population along with poor health infrastructural facilities, India has fairly performed well in its initial fight against COVID-19 as compared to the far developed and equipped countries. This variance has aroused much discussion and deliberations among the academia and medical doctors to seek possible explanations. This report elaborates on factors such as dietary habits, vaccination (BCG), exposure to unsanitary surroundings, and climatic conditions, which could be the explanation for the contrasting impact of COVID-19 in India and other developed nations.

1. Background

India has verified 820,916 COVID-19 cases, and 22,123 deaths by July 12, 2020 [1]. The mortality rate of India is 2.69%. The United States has 3,097,300 confirmed cases and 132,683 deaths with a mortality rate of 4.28% 8%. UK has an overall 288,137 cases and 44,650 deaths having a mortality rate of 15.49% %. France witnessed 161,275 overall cases and 29,907 deaths with 18.54% % [2]. Despite the heavy population burden and poor health infrastructure, the Indian mortality rate is significantly less compared to the above-mentioned countries. This pandemic has accompanied along with some unparalleled challenges making the situation much more difficult physically, emotionally as well as psychologically for the people across the globe [3].

2. Materials and methods

2.1. Dietary habits

The higher intake of refined carbohydrates, saturated fats, sugar and low level of fibres seem to be the characteristics feature of western food habits in contrast to relatively simpler dietary patterns of the subcontinent, which might have contributed towards the risk of type II diabetes and obesity, leading to inflammatory effects and impairing the immune system of the host to effectively fight against the pathogens [4]. Furthermore, the intake of a high amount of saturated fat in mice amplified macrophage permeation to alveolar lung tissue. This is especially applicable to COVID-19 patients resulting in lung tissue inflammation, a higher load of infectivity among alveolar epithelial cells, and alveolar damage in COVID-19 pathology [5].

In a National Survey commissioned by the vegetarian resource group

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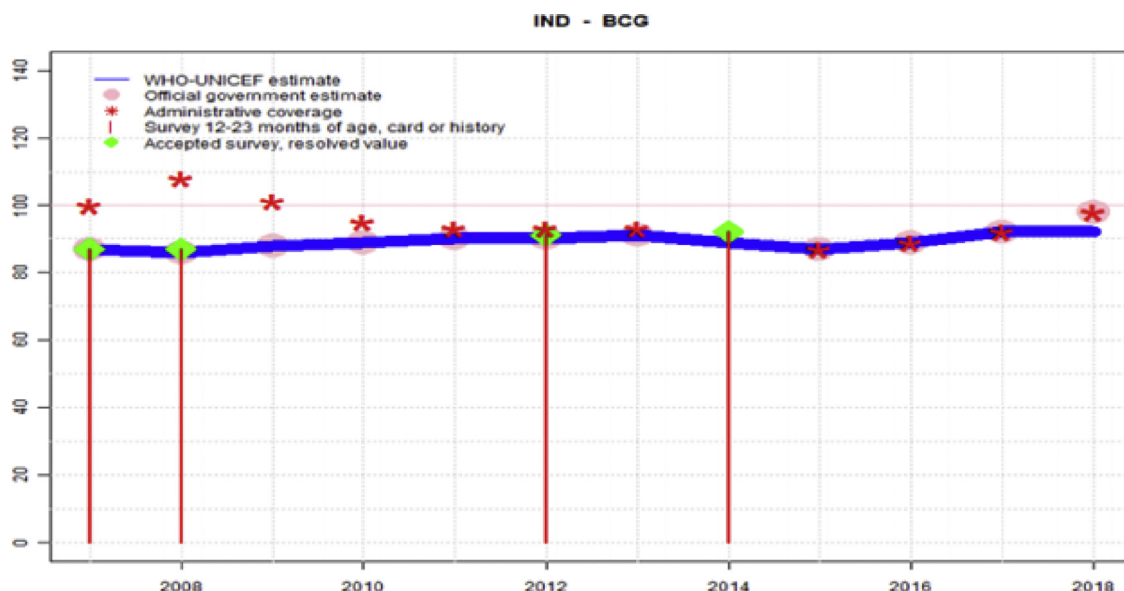


Fig. 1. WHO and UNICEF estimation of national immunization coverage of BCG in India [Reproduced from https://www.who.int/immunization/monitoring_surveillance/data/ind.pdf].

(VRG) in the USA, only around 4% of the population consume a vegetarian diet [6]. On the contrary, Indians (31–33%) consume more plant-based foods [7], which increases and helps the bacteria present in the colon and gut microbiome health to contribute up to 85% towards the immune system of the human body. While animal dietary supplements compromise good bacteria in the metabolic system, promote inflammation and weakens the immune responses that are more exposed to either communicable (coronavirus) or non-communicable diseases (Alzheimer's, etc.) [8]. Moreover, natural antioxidants present in plants work against lipid–protein oxidative depletion in meat products [9].

India is renowned as a land of spices since the medieval era and these strong herbs are part of the traditional dietary habits among the different native societies as an herbal analgesic and medicinal plants with plausible therapeutic effects in respiratory tract infections that could be useful in the prevention of COVID-19 infection as the dynamics and host-path interaction of COVID-19 causing Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) [10]. Moreover, the doctrine of signatures [11] might play a significant role in the preference of botanicals in the prevention and management of COVID-19 spread. Eucalyptus flowers (*Eucalyptus globulus* Labill), lemongrass leaves (*Cymbopogon citratus*), mint leaves (*Mentha*), lemon (*Citrus*), ginger (*Zingiber officinale*), cloves

(*Syzygium aromaticum*), wild honey (*Apis mellifera*) are generally used for the treatment of asthma, bronchitis and several other lungs related disease. Hence, these can be effectively used to strengthen one's immunological response against several virus strains, possibly including SARS-CoV-2 [12].

2.2. Vaccination (BCG)

In India, *Bacillus Calmette-Guerin* (BCG), a live attenuated vaccine, is provided routinely at the time of birth against tuberculosis [13]. Various strategies like classical epidemiological model were applied for the estimation of the reproduction number (R_0) of COVID-19 cases which helps in determining the intensity of outbreak with the average number of infected individuals [14]. Specifically, targeted programs like Mission Indradhanush have been initiated by the government of India to boost national immune coverage against chronic diseases. Fig. 1 shows the national immunization coverage of BCG in India. Various non-mycobacterium infections like yellow fever, staphylococci, and influenza can be eliminated by the trained immunity provided by BCG vaccination. The innate immune system and trained immunity can be life-saving factors to fight against bladder cancer and viruses including

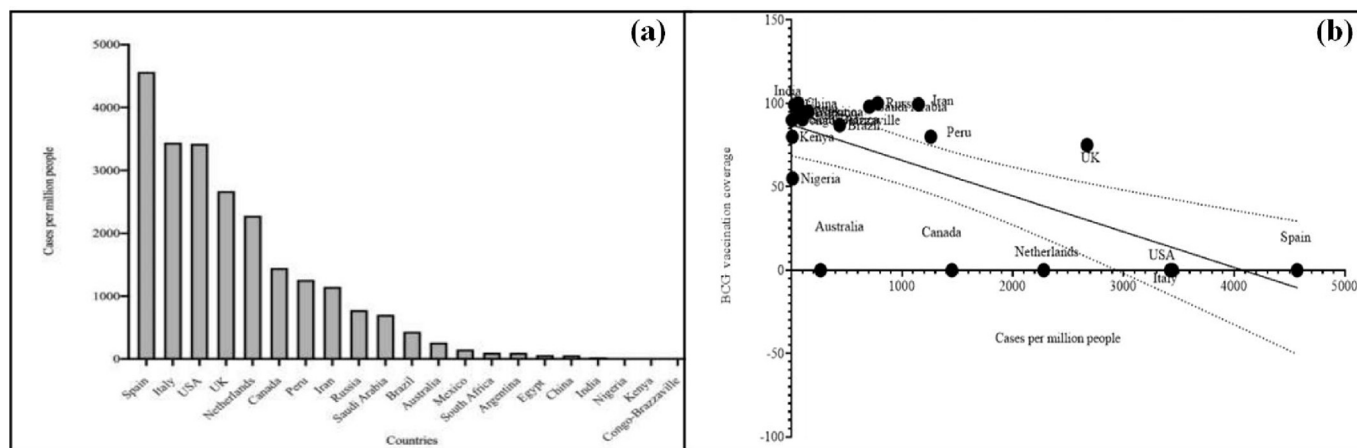


Fig. 2. (a): COVID-19 infected population (cases per million) in various countries across the globe, and (b) BCG vaccination, and the number of Covid-19 cases comparison in the aforementioned countries (reproduced from Ref. [19]).

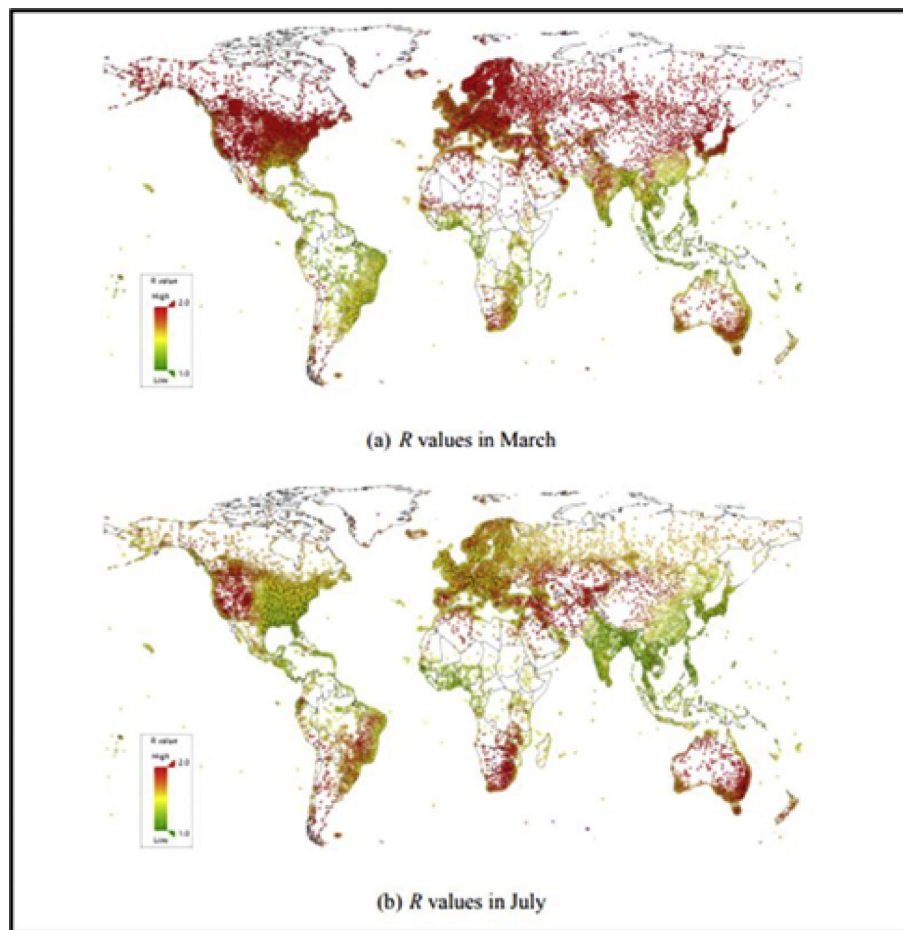


Fig. 3. Worldwide risks of COVID-19 pandemic in March and July 2020 [24].

COVID-19 [15]. The intravenous BCG ought to be sustained during this coronavirus pandemic as it remains to be the gold-standard auxiliary treatment to prevent the reappearance and progression in patients having a higher risk of non-muscle-invasive bladder cancer [16].

A recent study conducted by Sala and Miyakawa used linear regression modelling, and it has been found that the number of total cases and mortality rates per one million population were significantly interlinked with the country's policy concerning BCG vaccine administration. The level of contrast in cases and deaths explained by the BCG vaccination policy of the respective countries ranged between 12.5% and 38% [17].

Additionally, the countries having lower cases per capita of the population had one thing similar i.e., BCG vaccination (Fig. 2a). Several countries like Iran, which stopped offering a booster BCG vaccine in 1999 [18], registered a higher number of cases of Covid-19 (Fig. 2b). Yet, it is hard to certify the impact that may have had on Covid-19 incidences. Hence, countries with low TB incidences (mostly western countries) that do not administer the BCG vaccine to the general population had the highest Covid-19 cases per million people [19].

2.3. Exposure to unsanitary surroundings

Almost one-third of the Indian population lives under poor and severely degraded hygienic conditions [20]. This might seem absurd to some, but this is a basic concept of Darwinian Theory, which proposes the idea of evolution of a species according to its surroundings and other biological factors, as the people in India are living under these conditions for several decades. There is now proof that suggests the possibility that changes in the surroundings may alter the gene properties or make dormant genes active, resulting in the potential to influence signal

transduction or immune response circuits against the possible viral threats [21]. SARS-CoV-2 enters gastrointestinal epithelial cells, and the faces of COVID-19 patients are potentially infectious, which proves that unsanitary conditions may act as a catalyst in the transmission of SARS-CoV-2 [22]. Hence, due to that chance that Indian population has developed a relatively stronger immunity under these unfavorable conditions over a longer period that is not in majority of the developed nations such as USA, UK, Italy and Spain as these countries focus better on their healthcare sectors and hygienic surroundings.

2.4. Climatic conditions

India is primarily a subtropical country with much hot and humid climate, which might act as a deterrent for the existence of any pathogen in the ecosystem for a prolonged period compared to other colder regions of the globe. In recent times, research has shown that extreme conditions such as higher temperatures and humidity may be beneficial as a hindering factor for these kinds of viruses, though not fully proven by any means [23,24]. High temperature and humidity tend to decrease the influenza transmission, which may be possible due to the stability of the virus in cold temperature and the tendency to sustain longer in dry air. However, the host's immunity can be weakened by cold and dry weather conditions making them more vulnerable to the virus [25]. These mechanisms may apply to coronavirus transmission. This is also consistent with the proof that high temperatures and high relative humidity might reduce.

Fig. 3 shows the map of R (basic reproductive number) values for the worldwide cities. As expected, in March of 2020, the R values are smaller for tropical countries and greater for temperate countries. In July, the

onset of summer and rainy season in the northern hemisphere may efficiently reduce the transmission of coronavirus [24].

The basic reproduction number (R), also known as the basic reproduction ratio or rate or the basic reproductive rate, is an epidemiologic metric that is used to describe the contagiousness or transmissibility of infectious agents. The R is affected by factors like biological, socio-behavioural, and environmental aspects that govern pathogen transmission and hence, is usually estimated with various types of complex mathematical models [26].

3. Conclusions

Even though India performed well so far in its fight against COVID-19, but it should not be complacent and that one must take the valuable lessons from its other countries. Social distancing and avoiding mass gatherings are primarily necessary to avoid the trouble of a virus attack. All the health advisories must be followed affirmatively to deal with this deadly pandemic, the future of which still a mystery.

Declaration of competing interest

The authors declare no intellectual as well as financial conflict of interests.

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References

- [1] Home|Ministry of Health and Family Welfare| Government of India, 2020. <https://www.mohfw.gov.in>. (Accessed 12 July 2020).
- [2] <https://covid19.who.int>. (Accessed 12 July 2020).
- [3] S. Sharma, S. Basu, N.P. Shetti, T.M. Aminabhavi, Current treatment protocol for COVID-19 in India, *Sensors International* (2020) 100013.
- [4] M.J. Butler, R.M. Barrientos, The impact of nutrition on COVID-19 susceptibility and long-term consequences, *Brain Behav. Immun.* 87 (2020) 53–54.
- [5] Z. Xu, L. Shi, Y. Wang, J. Zhang, L. Huang, C. Zhang, Y. Tai, Pathological findings of COVID-19 associated with acute respiratory distress syndrome, *Lancet Respir Med* 2020 (2020), [https://doi.org/10.1016/S2213-2600\(20\)](https://doi.org/10.1016/S2213-2600(20)).
- [6] https://www.vrg.org/nutshell/Polls/2019_adults_veg.htm. (Accessed 14 June 2020).
- [7] https://en.wikipedia.org/wiki/Vegetarianism_by_country. (Accessed 12 July 2020).
- [8] Restrepo, M. Health Status and the Role of Nutrition on SARS-CoV/Covid-19.
- [9] A.B. Falowo, P.O. Fayemi, V. Muchenje, Natural antioxidants against lipid-protein oxidative deterioration in meat and meat products: a review, *Food Res. Int.* 64 (2014) 171–181.
- [10] S. Mahapatra, P. Chandra, Clinically practiced and commercially viable nanobio engineered analytical methods for COVID-19 diagnosis, *Biosens. Bioelectron.* (2020), 112361.
- [11] B.C. Bennett, Doctrine of signatures: an explanation of medicinal plant discovery or dissemination of knowledge? *Econ. Bot.* 61 (3) (2007) 246–255.
- [12] Kanyinda, J. N. M. Coronavirus (COVID-19): A Protocol for Prevention and Treatment (Covalyse®).
- [13] WHO Vaccine-preventable Diseases: Monitoring System, 2019 global summary, https://apps.who.int/immunization_monitoring/globalsummary/. (Accessed 13 June 2020).
- [14] N.P. Shetti, R.K. Srivastava, S. Sharma, S. Basu, T.M. Aminabhavi, Invasion of novel corona virus (COVID-19) in Indian territory, *Sensors International* (2020), 100012.
- [15] P.K. Hegarty, J.P. Sfakianos, G. Giannarini, A.R. DiNardo, A.M. Kamat, COVID-19 and Bacillus Calmette-Guérin: what is the link? *European Urology Oncology* (2020) <https://doi.org/10.1016/j.euo.2020.04.001>.
- [16] V. Ficarra, G. Novara, A. Abrate, R. Bartoletti, A. Crestani, C. De Nunzio, N. Pavan, Urology practice during COVID-19 pandemic, *Minerva urologica e nefrologica= The Italian journal of urology and nephrology* 72 (3) (2020) 369–375.
- [17] G. Sala, T. Miyakawa, Association of BCG Vaccination Policy with Prevalence and Mortality of COVID-19, *Medrxiv*, 2020.
- [18] A. Zwerling, M.A. Behr, A. Verma, T.F. Brewer, D. Menzies, M. Pai, The BCG World Atlas: a database of global BCG vaccination policies and practices, *PLoS Med.* 8 (3) (2011), e1001012.
- [19] R.M. Mariita, J.M. Musila, A study on the relationship between Bacillus CalmetteGurin (BCG) vaccination and Covid-19 prevalence: do other confounders warrant investigation? *J. Publ. Health Epidemiol.* 12 (2) (2020) 142–150.
- [20] <http://hdr.undp.org/en/countries/profiles/IND>. (Accessed 13 June 2020).
- [21] E. Rewald, M.M. Francischetti, C. González, No man is an island; no island is an island: does the immune network extend beyond the limits of skin? *Med. Hypotheses* 52 (4) (1999) 325–327.
- [22] Y. Tian, L. Rong, W. Nian, Y. He, Gastrointestinal features in COVID-19 and the possibility of faecal transmission, *Aliment Pharmacol. Therapeut.* 51 (9) (2020) 843–851.
- [23] K.H. Chan, J.S. Peiris, S.Y. Lam, L.L.M. Poon, K.Y. Yuen, W.H. Seto, The effects of temperature and relative humidity on the viability of the SARS coronavirus, *Advances in virology* 2011 (2011).
- [24] J. Wang, K. Tang, K. Feng, W. Lv, High temperature and high humidity reduce the transmission of COVID-19, 2020. Available at: SSRN 3551767.
- [25] E. Kudo, E. Song, L.J. Yockey, T. Rakib, P.W. Wong, R.J. Homer, A. Iwasaki, Low ambient humidity impairs barrier function and innate resistance against influenza infection, *Proc. Natl. Acad. Sci. Unit. States Am.* 116 (22) (2019) 10905–10910.
- [26] P.L. Delamater, E.J. Street, T.F. Leslie, Y.T. Yang, K.H. Jacobsen, Complexity of the basic reproduction number (R0), *Emerg. Infect. Dis.* 25 (1) (2019) 1.