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Nutrition and Covid-19: A Systematic Review

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Abstract: Nutrition plays a vital role in maintaining the health, helps to build stronger immune system and have a crucial role in combating Covid-19. A robust, balanced and diversified diet is essential for good health and boost immune system to fight against the virus. But, dietary requirements of individual are affected by number of factors such as age, health status and life style. This review summarizes the symptoms, transmission and nutritional status and its role in combating the disease.

Keywords: Nutrition, Covid-19, Immunity

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Introduction

Corona virus (CoV) has affected the life around the globe from past twenty years. In 2002, first epidemic due to corona virus originated in China, causing a severe acute respiratory syndrome (ARDS), called SARS-CoV (Da Costa *et al.*, 2020). Subsequently, in 2012, a new viral outbreak with characteristics almost like SARS-CoV was observed within Middle East (Qatar, Jordan, Saudi Arabia, and the United Arab Emirates), in Europe (UK, France, and Italy), and in Africa, and was called as Middle East Respiratory Syndrome (MERS) (Calder *et al.*, 2020). Later, in December 2019, a new type of corona virus (COVID-19) causing pneumonia and death was identified in Wuhan, China (Leung, 2020; Wu *et al.*, 2020). This new corona virus is called SARS-CoV- 2 because its genetic constitution is very much similar to SARS-

CoV. It causes the severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) which raised the public concern (James *et al.*, 2021). SARS-CoV-2 is the seventh known human corona virus (Chen *et al.*, 2020). It was declared as the outbreak of a global pandemic in March 2020 by World Health Organization (WHO, 2020).

Almost within two weeks the virus's gene sequence was identified and a testing method was developed (Zhu *et al.* 2020), so as to develop a protective vaccine (Yan *et al.*, 2020). Earlier, other testing methods were also developed which involves the measurement of infection (using RT-PCR) and antibodies formed after being infected (using immunoassays) (Elfaitouri *et al.*, 2005; Souf, 2016, Morawska and Cao, 2020). However,

attempt are still going on to explore the most effective preventative and curative methods against Covid-19 (Bousquet *et al.*, 2020; Gralinski and Menachery, 2020; Park *et al.*, 2020; Zhou *et al.*, 2020). As the pandemic unfolds, it exacerbates the risk factors for malnutrition in all its forms (Headey *et al.*, 2020; Akseer *et al.*, 2020). Disruption to agricultural production, market linkages, and seasonal labor movements contribute to food price increases (Torero, 2020; Philip *et al.*, 2021), making nutritious food even more expensive for those most at risk of micronutrient deficiencies and under nutrition. Due to delay and cancellation in micronutrient distributions, school meal programs, nutrition counseling programmes and vaccine rounds have accentuated the vulnerability (Perez-Escamilla *et al.*, 2020; Dunn *et al.*, 2020). There was also increase in physical and psychological barriers to healthy eating and exercising due to lockdown creating an obesogenic environment for many (Di Renzo *et al.*, 2020; Muscogiuri *et al.*, 2020; James *et al.*, 2021).

This review involves the collection of research papers and review articles from different sites/forums available on Google search up to 30.07.21. The important points of various studies are summarized in this review.

Corona viruses and Symptoms:

Corona viruses are a large group of single-stranded RNA viruses that are common among mammals and birds. They cause respiratory and, less frequently, gastrointestinal diseases (Weiss and Leibowitz, 2011; Su *et al.*, 2016). Common symptoms of the disease include fever, sore throat, cough, loss of taste or smell, difficulty in breathing, muscle aches and tiredness. Severe cases might experience shortness of breath (low oxygen level), high grade fever, pneumonia, acidosis, blood clots, heart problems, lung damage (acute respiratory distress syndrome), kidney damage, multiple organ failure and death. But, the severity of disease varies from one person to another. Some

are completely asymptomatic, some might experience only mild symptoms, while some people have severe symptoms that can lead to hospitalization, and in severe cases death takes place (Fernandez-Quintela *et al.*, 2020). The most serious clinical conditions are characterized by acute respiratory distress syndrome (ARDS), cardiac insufficiency, and septic shock (Zhou *et al.*, 2020; Pomara *et al.*, 2020; Salerno *et al.*, 2020), causing tissue damage at the alveolar level, resulting into pathological tissue alterations, hyperplasia and infiltration. In addition, the existence of different comorbidities in patients infected with SARS-CoV-2 may elevate the response of the immune system, aggravate the risk of adverse effects and mortality (D'Errico *et al.*, 2020; Cipolloni *et al.*, 2020; Sessa *et al.*, 2020). In patients suffering from non-communicable diseases (such as diabetes and arterial hypertension), systemic inflammation is strictly related to severe symptoms after the SARS-CoV-2 infection (Cavaliere *et al.*, 2019; Gupta *et al.*, 2020; Moscatelli *et al.*, 2021).

The risk of disease is proportional with age i.e. older people are more prone to corona virus. However, people with existing medical conditions also have a higher susceptibility of catching infection resulting into serious illness.

Transmission/Infection:

Covid-19 virus is communicable and easily spreads from one person to another. The virus is present in respiratory droplets and can be transmitted through breath, cough and sneeze and even talking with affected person if there is close contact. The virus can also be transmitted when the contaminated surfaces or objects are touched by uninfected people. The virus can enter through mouth, nose or eyes of a person. According to UKRI (2020) SARS-CoV-2 can survive in air droplets for maximum three hours and for up to three days on hard surfaces. Therefore, WHO (2020a) recommended frequent hand-washing and maintaining a distance of at least one meter as main safety precautions against the COVID-19.

Besides this, the COVID-19 virus can also spread through droplets or aerosols (i.e. airborne transmission) that remain present in the air for several minutes or hours. There is not much evidence to air borne transmission but, several studies explained the route of transmission (Olsen *et al.* 2003; Li *et al.*, 2005; Yu *et al.*, 2005; Booth *et al.* 2005; Xiao *et al.*, 2017). Therefore, it is highly likely that airborne transmission causes the spread of virus in the indoor cases studied. WHO (2009) in a review of the evidence stated that aerosols (e.g. airborne infections) are responsible for the transmission of viral infections across distances in the indoor environments resulting into large clusters of infection in a short period of time. As there are the many similarities between the two SARS viruses and the evidence on route of virus transmission, it is concluded that the SARS-CoV-2 virus also spreads through air (Fineberg, 2020; Morawska and Cao, 2020).

Nutrition and its role in Covid-19:

Proper diet is essential to maintain good health and sustainable way to strengthen the immune system to defeat the virus. Strong Immune system of human being depends upon optimal nutrition and dietary nutrient intake, which affects through gene expression, cell activation, and signaling molecules modification. Nutrients like zinc, iron, and vitamins A, B₁₂, B₆, C, D and E are essential for supporting, strengthening and maintenance of immune function (Aman and Masood, 2020). The healthy maintenance of the immune system strictly depends upon vitamins such as D, C, A (including β -carotene), and those of group B (particularly B₆, B₁₂ as well as folate) as listed by The European Food Safety Authority (EFSA) scientific panel. Zinc, copper, iron and selenium also have similar roles (Mentella *et al.*, 2021). Similarly, Carder (2020) enlisted that a number of vitamins (A, B₆, B₁₂, folate, C, D and E) and trace elements (zinc, copper, selenium, iron) have important roles in the maintenance of human immune system and thereby reducing risk of viral infections. Apart from these, essential nutrients

such as other vitamins, amino acids, fatty acids and trace elements are also included.

Galmes *et al.* (2020) have published an updated report on the relevance of optimum nutrition as an important factor to enhance an immune system. Results from their review emphasize the importance of preserving a well-balanced level of these ten nutrients, especially the key role played by vitamin D and iron in the current pandemic. Inadequate intake of iron and vitamins B₁₂, C and D and other relevant micronutrients have shown inverse correlation with higher disease incidence and fatality rate, especially in populations showing genetic predisposition to poorer micronutrient status. Further, Calder *et al.* (2020) reported that an adequate nutrition regimen is essential in the defense against viral threats. They reported that vitamin C is pivotal in supporting and boosting the immune system. It is one of the major constituents of water soluble vitamins which tend to make a strong immune system. The daily recommended dietary requirement for vitamin C is 90 mg/d for men and 75 mg/d for women. Therefore, balanced nutrition is essential in maintaining regulated immune homeostasis.

On the other hand, global COVID-19 outcomes are affected by the wide prevalence of malnutrition and trace element deficiency (Fedele *et al.*, 2021, Mentella *et al.*, 2021). Recent studies have reported how malnutrition is one of the crucial elements that may be predictive of slower recovery or no recovery at all, for the affected subjects (Bold *et al.*, 2020). Malnutrition refers to the incorrect intake of energy rich foods as well as foods that are deficient in macronutrients (carbohydrates, proteins, fats), and micronutrients (minerals and vitamins). Moreover, deficient energy rich food includes those foods that fails to meet the individual's body energy requirement, whereas lack of vitamins and minerals which are needed, in small amounts, for healthy growth and development is referred as micronutrient deficiency. Although it might seem contradictory,

individuals might be overfed in terms of energy but be deficient in one or more micronutrients in their routine diet. Inadequate intake of these nutrients lowers the resistance to infections and, consequently increases the seriousness of the disease (Calder *et al.*, 2020). Recently, two studies were conducted and compared the effect of malnutrition in elderly patients and COVID- 19. Firstly, Li *et al.* (2020) conducted a study on 182 elderly hospitalized COVID- 19 patients (≥ 65 y in 1 center) in Wuhan, China. They found that 53% patients were classified as malnourished and 28% were at risk of malnutrition. The second study analyzed nutritional status among 141 COVID- 19 elderly patients (>65 y) in 1 hospital in China. They found severity of disease in patients that had comparatively longer hospital stay, poor appetite and greater weight loss as compared to patients not at nutritional risk (Liu *et al.*, 2020).

Therefore, in the current situation, it is utmost important to include the specific types of food that can boost our immune system (Anton and Miller, 2005; Haug *et al.*, 2007). Here are some professional and authentic dietary guidelines which should be included in the diet (Khayyatzadeh, 2020; Aman and Masood, 2020) to withstand COVID-19:

- Daily 2 cups (4 servings) fruits- (e.g. seasonal fruits such as, guava, apple, banana, strawberry, grapefruit, pineapple, papaya, orange etc.).
- Daily 2.5 cups of vegetables (5 servings)- Seasonal fresh vegetables (e.g. bell peppers, garlic, ginger, lime, coriander, broccoli etc.), legumes (beans and lentils).
- Avoid junk food and irregular snacking, replace it with fresh fruits and raw vegetables. Foods that are high in sugar, salt or fat should be avoided.
- Unprocessed grains, e.g. maize, oats, wheat, millet, brown rice or roots such as yam, potato, taro or cassava (180 g).
- Nuts like almonds, raisins coconut, and pistachio must be included in the diet.

- Optimal diet should have food from animal sources (e.g. fish, eggs, and milk) and Red meat (once or twice per week) and poultry (2–3 times per week).
- Vegetables should not be overcooked as important nutrients such as vitamins and minerals will be lost.
- In case of dried or canned fruits and vegetables, without added sugar or salt should be preferred.
- Food should be prepared and served at optimum and acceptable temperatures i.e. ≥ 72 C for 2 min.
- Maximum 5 g of salt per day.
- Use unsaturated fats (present in avocado, fish, nuts, soy, olive oil, canola, corn oil, and sunflower) instead of saturated fats ((present in butter, fatty meat, coconut and palm oils, cheese, ghee, and cream).
- Water helps in the transport of nutrients in the blood, eliminates waste, and also regulates the body temperature. Hence, drink 8–10 glasses of water per day.
- Avoid drinks that contain sugar i.e. fizzy, carbonated and concentrated juices etc.
- Exercise, meditation, and regular sleep in order to maintain a healthy lifestyle which will help to build immune system stronger.
- Avoid eating outside as it will reduce the chance of being exposed to COVID-19.

Butler and Barrientos (2020) reported that the diseases such as obesity and type 2 diabetes due to unhealthy life style and consumption of food stuffs rich in saturated fats, sugars, and refined carbohydrates, could increase the risk for severe COVID-19 pathology and mortality. Unhealthy diet has adverse consequences in case of peripheral inflammation caused by COVID-19 that may have long-term consequences in those that recover, likely through neuroinflammatory mechanisms, resulting into chronic medical conditions such as dementia and neurodegenerative disease. Moreover, some studies also suggest that diseases due to unhealthy life style have adverse effects on

acquired immunity as well. In case of SARS-CoV-2 there was no underlying existing natural immunity against it, as it is new to the human immune system. The disease (diabetes, non-alcoholic fatty liver disease), neurodegeneration and in some cancers can cause an excessive inflammatory response when infected with corona virus. Although inflammation is part of the innate immune response and innate, but an excessive inflammatory response can lead to impairments in acquired immunity. Further, unhealthy life style can lead to obesity, resulting in more severe COVID-19. Further, according to a French report 85.7% of SARS-CoV-2 infected obese individuals required mechanical ventilation as compared to 47.1% of infected healthy weight individuals (Simonnet *et al.*, 2020; Calder, 2020).

Conclusion

The review concludes the importance of balanced and proper diet for maintaining health, building immune system to protect and fight against the corona virus and recovery time will be faster.

References

Akseer N, Kandru G, Keats EC and Bhutta ZA. (2020) COVID-19 pandemic and mitigation strategies: implications for maternal and child health and nutrition. *Am J Clin Nutr.* 112:251-256.

Aman F and Masood S. (2020) How nutrition can help to fight against COVID-19 Pandemic. *Pak J Med Sci.* 36 (COVID19-S4): S121-S123.

Anton SD and Miller PM. (2005) Do negative emotions predict alcohol consumption, saturated fat intake, and physical activity in older adults? *Behav Modif.* 29:677-688.

Bold J, Harris M, Fellows L and Chouchane M. (2020) Nutrition, the digestive system and immunity in COVID-19 infection. *Gastroenterol Hepatol Bed Bench.* 13:331-340

Booth TF, Kournikakis B, Bastien N, Ho J, Kobasa D and Stadnyk L. (2005) Detection of airborne severe acute respiratory syndrome (SARS) coronavirus and environmental contamination in SARS outbreak units. *J Infect Dis.* 191:1472-1477.

Bousquet J, Anto JM, Iaccarino G, Czarlewski W, Haahtela T, Anto A, Akdis CA, Blain H, Canonica GW and Cardona V. (2020) Is diet partly responsible for

differences in COVID-19 death rates between and within countries? *Clin Transl Allergy*10:16.

Butler MJ and Barrientos RM. (2020) The impact of nutrition on COVID-19 susceptibility and long-term consequences. *Brain Behav Immun.* 87: 53-54.

Calder PC, Carr AC, Gombart AF and Eggersdorfer M. (2020) Optimal nutritional status for a well-functioning immune system is an important factor to protect against viral infections. *Nutrients* 12:1181.

Calder PC. (2020) Nutrition, immunity and COVID-19. *BMJ Nutrition Prevention Hlth.* 3:e000085.

Cavaliere G, Trinchese G, Penna E, Cimmino F, Pirozzi C, Lama A, Annunziata C, Catapano A, Mattace Raso G and Meli R. (2019) High-fat diet induces neuroinflammation and mitochondrial impairment in mice cerebral cortex and synaptic fraction. *Front Cell Neurosci.* 13: 509.

Chen Y, Liu Q and Guo D. (2020) Emerging coronaviruses: genome structure, replication, and pathogenesis. *J Med Virol.* 92: 418-423.

Cipolloni L, Sessa F, Bertozzi G, Baldari B, Cantatore S, Testi R, D'Errico S, Di Mizio G, Asmundo A and Castorina S. (2020) Preliminary post-mortem COVID-19 evidence of endothelial injury and factor VIII hyperexpression. *Diagnostics* 10: 575.

D'Errico S, Zanon M, Montanaro M, Radaelli D, Sessa F, Di Mizio G, Montana A, Corrao S, Salerno M and Pomara, C. (2020) More than pneumonia: Distinctive features of SARS-CoV-2 infection. From autopsy findings to clinical implications: A systematic review. *Microorganisms* 8: 1642.

Da Costa VG, Moreli ML and Saivish MV. (2020) The emergence of SARS, MERS and novel SARS-2 coronaviruses in the 21st century. *Arch Virol.* 165: 1517-1526.

Di Renzo L, Gualtieri P, Pivari F, Soldati L, Attina A, Cinelli G, Leggeri C, Caparello G, Barrea L and Scerbo F. (2020) Eating habits and lifestyle changes during COVID-19 lockdown: an Italian survey. *J Transl Med.* 18: 229.

Dunn CG, Kenney E, Fleischhacker SE and Bleich SN. (2020) Feeding low-income children during the Covid-19 pandemic. *N Engl J Med.* 382:e40.

Elfaitouri A, Mohamed N, Fohlman J, Aspholm R, Frisk G and Friman G. (2005) Quantitative PCR-enhanced immunoassay for measurement of enteroviral immunoglobulin M antibody and diagnosis of aseptic meningitis. *Clin Diagn Lab Immunol.* 12:235-241.

Fedele D, De Francesco A, Riso S and Collo A. (2021) Obesity, malnutrition, and trace element deficiency in

- the coronavirus disease (COVID-19) pandemic: An overview. *Nutrition* 81: 111016.
- Fernandez-Quintela A, Milton-Laskibar I, Trepiana J, Gomez-Zorita S, Kajarabille N, Léniz A, Gonzalez M and Portillo MP. (2020) Key aspects in nutritional management of COVID-19 patients. *J Clin Med* 9: 2589.
- Fineberg HV. (2020) Rapid Expert Consultation on the Possibility of Bioaerosol Spread of SARS-CoV-2 for the COVID-19 Pandemic. The National Academies Press, National Research Council, 2020.
- Galmes S, Serra F and Palou A. (2020) Current state of evidence: Influence of nutritional and nutrigenetic factors on immunity in the COVID-19 pandemic framework. *Nutrients* 12: 2738.
- Gralinski LE and Menachery VD. (2020) Return of the coronavirus: 2019-nCoV. *Viruses* 12: 135.
- Gupta R, Hussain A and Misra A. (2020) Diabetes and COVID-19: Evidence, current status and unanswered research questions. *Eur J Clin Nutr* 74: 864-870.
- Haug A, Brand-Miller JC, Christophersen OA, McArthur J, Fayet F and Truswell S. (2007) A food "lifeboat": Food and nutrition considerations in the event of a pandemic or other catastrophe. *Med J Aust* 187: 674.
- Headey D, Heidkamp R, Osendarp S, Ruel M, Scott N, Black R, Shekar M, Bouis H, Flory A and Haddad L. (2020) Impacts of COVID-19 on childhood malnutrition and nutrition-related mortality. *Lancet North Am Ed* 396:519-521.
- James PT, Ali Z, Armitage AE, Bonell A, Cerami C, Drakesmith H, Jobe M, Jones KS, Liew Z, Moore SE, Morales-Berstein F, Nabwera HM, Nadjm B, Pasricha SR, Scheelbeek P, Silver MJ, Teh MR and Prentice AM. (2021) The role of nutrition in covid-19 susceptibility and severity of disease: A systematic review. *J Nutr* 151(7):1854-1878.
- Khayatzadeh SS. (2020) Nutrition and infection with COVID-19. *J Nutr Food Security* 5(2): 93-96.
- Leung C. (2020) Clinical features of deaths in the novel coronavirus epidemic in China. *Rev Med Virol* 30: e2103.
- Li T, Zhang Y, Gong C, Wang J, Liu B, Shi L, Duan J. (2020) Prevalence of malnutrition and analysis of related factors in elderly patients with COVID-19 in Wuhan, China. *Eur J Clin Nutr* 74:871-5.
- Li Y, Huang X, Yu I, Wong T and Qian H. (2005) Role of air distribution in SARS transmission during the largest nosocomial outbreak in Hong Kong. *Indoor Air* 15: 83-95.
- Liu G, Zhang S, Mao Z, Wang W and Hu H. (2020) Clinical significance of nutritional risk screening for older adult patients with COVID-19. *Eur J Clin Nutr* 74:876-883.
- Mentella MC, Scaldaferrì F, Gasbarrini A and Miggiano GAD. (2021) The role of nutrition in the COVID-19 pandemic. *Nutrients* 13(4):1093.
- Morawska L and Cao J. (2020) Airborne transmission of SARS-CoV-2: The world should face the reality. *Environ Intern* 139:105730.
- Moscattelli F, Sessa F, Valenzano A, Polito R, Monda V, Cibelli G, Villano I, Pisanelli D, Perrella M, Daniele A, Monda M, Messina G and Messina A. (2021) COVID-19: Role of nutrition and supplementation. *Nutrients* 13: 976.
- Muscogiuri G, Barrea L, Savastano S and Colao A. (2020) Nutritional recommendations for COVID-19 quarantine. *Eur J Clin Nutr* 74:850-851.
- Olsen SJ, Chang HL, Cheung TYY, Tang AFY, Fisk TL and Ooi SPL. (2003) Transmission of the severe acute respiratory syndrome on aircraft. *New Engl J Med* 349: 2416-2422.
- Park M, Cook AR, Lim JT, Sun Y and Dickens BL. (2020) A systematic review of COVID-19 epidemiology based on current evidence. *J Clin Med* 9: 967.
- Perez-Escamilla R, Cunningham K and Moran VH. (2020) COVID-19, food and nutrition insecurity and the wellbeing of children, pregnant and lactating women: A complex syndemic. *Matern Child Nutr* 16: e13036.
- Philip TJ, Zakari A, Andrew EA, Ana B, Carla C, Hal D, Modou J, Kerry SJ, Zara L, Sophie EM, Fernanda MB, Helen MN, Behzad N, Sant-Rayn P, Pauline S, Matt JS, Megan RT and Andrew MP. (2021) The role of nutrition in COVID-19 susceptibility and severity of disease: A systematic review. *J Nutr* 151(7): 1854-1878.
- Pomara C, Li Volti G and Cappello F. (2020) COVID-19 deaths: Are we sure it is pneumonia? Please, Autopsy, Autopsy, Autopsy! *J Clin Med* 9: 1259.
- Salerno M, Sessa F, Piscopo A, Montana A, Torrisi M, Patanè F, Murabito P, Li Volti, G and Pomara C. (2020) No autopsies on COVID-19 deaths: A missed opportunity and the lockdown of science. *J Clin Med* 9: 1472.
- Sessa F, Bertozzi G, Cipolloni L, Baldari B, Cantatore S, D'Errico S, Di Mizio G, Asmundo A, Castorina S and Salerno M. (2020) Clinical-forensic autopsy findings to defeat COVID-19 disease: A literature review. *J Clin Med* 9: 2026.

- Simonnet A, Chetboun M and Poissy J. (2020) High prevalence of obesity in severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) requiring invasive mechanical ventilation. *Obesity* 28: 1195-1199. doi:10.1002/oby.22831.
- Souf S. (2016) Recent advances in diagnostic testing for viral infections. *Biosci Horizons: Intern J Student Res.* 9: 1-11.
- Su S, Wong G and Shi W. (2016) Epidemiology, genetic recombination, and pathogenesis of coronaviruses. *Trends Microbiol.* 24: 490-502.
- Torero M. (2020) Without food, there can be no exit from the pandemic. *Nature* 580:588-589.
- UKRI. (2020) How long can coronavirus survive outside of the body? UK research and innovation. <https://coronavirusexplainedukri.org/en/article/public0008/>
- Weiss SR and Leibowitz JL. (2011) Coronavirus pathogenesis. *Adv Virus Res.* 81: 85-164.
- WHO. (2009) Natural ventilation for infection control in health-care settings. https://www.who.int/water_sanitation_health/publications/natural_ventilation/en/ ededs: World Health Organization.
- WHO. (2020) WHO announces COVID-19 outbreak a pandemic. World Health Organisation, 2020. <http://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/news/news/2020/3/who-announces-covid-19outbreak-a-pandemic>).
- WHO. (2020a) Coronavirus disease (COVID-19) advice for the public. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public>).
- Wu D, Wu T and Liu Q. (2020) The SARS-CoV-2 outbreak: what we know. *Int J Infect Dis.* 94:44-48.
- Xiao S, Li Y, Wong TW and Hui DS. (2017) Role of fomites in SARS transmission during the largest hospital outbreak in Hong Kong. *PLoS ONE* 12 (7): e0181558.
- Yan R, Zhang Y, Guo Y, Xia L and Zhou Q. (2020) Structural basis for the recognition of the 2019-nCoV by human ACE2. *Science* 367(6485): 1444-1448.
- Yu IT, Wong TW, Chiu YL, Lee N and Li Y. (2005) Temporal-spatial analysis of severe acute respiratory syndrome among hospital inpatients. *Clin Infect Dis.* 40: 1237-1243.
- Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, Xiang J, Wang Y, Song B and Gu X. (2020) Clinical course and risk factors for mortality of adult in patients with COVID-19 in Wuhan, China: A retrospective cohort study. *Lancet North Am Ed.* 395:1054-1062.
- Zhu N, Zhang D, Wang W, Li X, Yang B and Song J. (2020) A novel coronavirus from patients with pneumonia in China. *New Engl J Med.* 382: 727-733.