CORONA VIRUSES: AUTHENTICATION OF THE RESERVOIR AND MODE OF TRANSMISSION

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ABSTRACT

COVID-19 was identified at Wuhan in December 2019 and was pronounced world pandemic in 2020. Coronaviruses is recognized to reason respiratory illnesses in people and bills for one-third of common bloodless infections. The objective of this review is to give the authentication of the reservoir and mode of transmission of coronaviruses. It should be of great awareness and importance to know the existence and infection process so as to offer the best approach and technology in breaking the chain of the novel pandemic outbreak crises. Transgenic mice pattern have been discover recently exhibiting hDPP4 with increase in susceptibility to MERS-CoV disease and this mice can express freely to show forth systemic lesions which have been invented through technological means. Rhinolophus bats as the major reservoirs harboring the diseases, transmitting it to the Camel which undergoes inter-species transmission to the Alpacas with potential zoonotic transmission to humans. Direct and Indirect transmission has successfully been grouped as the major modes of transmission in which the virus can be spread. Awareness for prevention should be made to the public on the animal that harbors the growth of this virus to avoid further transmission.

Keywords: Coronaviruses, Rhinolophus bats, Reservoir, Pandemic, Transmission, Zoonotic

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BACKGROUND

Over the last a number of months, a novel strain of coronavirus (COVID-19) has spread across the globe, with no quit in sight. While there is big cross-national variation in the damage incurred with the aid of the virus, little is recognized about the factors that make a contribution to this variation (WHO, 2020).

A lot of virus diseases have been endemic the world resulting into high mortality rate of different human lives and animals. It is usually accepted, however, that the virus transmits through social contact. Hence, viral transmission may want to extend as social contact turns into extra usual and variable. We for that reason investigated whether or not country-wise vulnerability to COVID-19 might differ systematically primarily based on social ecologies that motivate or discourage social contact (WHO, 2020).

This is surely now not the first time that an alarm has been rung by means of this family of viruses. Epidemic effect of Severe Acute

Respiratory Syndrome (SARS) as a result of SARS CoV and Middle East respiratory syndrome (MERS) via MERS CoV has engraved their place in the scientific literature (Fehr & Perlman, 2015). In general, CoV is recognized to reason respiratory illnesses in people and bills for one-third of common bloodless infections (Mirza *et al.,* 2016).

The present day outbreak by means of 2019 nCoV in the Chinese metropolis of Wuhan began in December 2019, has infected almost 102,188 with 3,491 deaths reported as of March 7, 2020, and has spread to nearly ninety two nations (Max & Hannah, 2020; Lewis, 2020) An assumed incubation duration between 2 and 14 days, with flu-like symptoms, may additionally growth into extreme pneumonia or acute respiratory distress syndrome which may also be the reason for mortality (Huang *et al.,* 2019, Chen, 2019).

While there is now not yet concrete empirical statistics to base conclusions on, we posit that different world pandemics like EBOLA Disease, Severe Acute Respiratory Syndrome (SARS), and Middle East Respiratory Syndrome (MERS) all had severe implications on meals protection and livelihoods for prone groups such as small holders, and consequently could also serve as extrapolate the consequences of COVID-19 for the terrible livelihoods (Ou *et al.,* 2020).

If the virus persists, it could create meals grant hitches and a threat to meals security for susceptible agencies (Ou *et al.,* 2020). Restrictions on transportation and people movement have also led to some meals logistics challenges. This review aims to provide the authentication of the reservoir and mode of transmission of the global pandemic infection coronaviruses.

CORONAVIRUSES

COVID-19 erupts from the family *Coronaviridae* having a morphology enveloped shaped structure, positive-sense, single-stranded RNA (ssRNA) viruses of about 80-120nm diameter and 31 kb in size (Yi *et al*., 2019). Coronavirus disease (COVID-19) is caused by Coronavirus which belong to the family of Coronaviridae and the order Nidovirales (Woo *et al*., 2009). Structurally, the virus RNA (80-100 nm) is covered by spike-like projections, resembling a crown, when viewed under electron microscope, hence the name "Corona" (Volk and Brown, 2007).

Recently, a novel coronavirus has been identified to cause severe respiratory disease in a city called Wuhan, China, in December 2019 (Cohen & Normile, 2020). Coronavirus has caused two large-scale pandemics in the last two decades: SARS and MERS (Peiris *et al*., 2004 & Zaki *et al.,* 2012).

RESERVOIR OF CORONAVIRUSES

ANIMAL RESERVOIR FOR CORONAVIRUSES RESEARCH

Many review study have been published out to broaden the scope and knowledge of the general public on the animal's pattern of Coronaviruses diseases (Baseler *et al.,* 2016).This segment will briefly enlighten and summarize in the present and recent situation of animal reservoir for Coronaviruses infection replication and reproduction.

Immediately the MERS-CoV was discovered around the year 2012 (Bermingham *et al.,* 2012), a lot of research was put in place and undergone so as to get an animal pattern in discovery genetic makeup and proof the validity of drugs (vaccines) produced. This science phenomena similarly was applied to SARS-CoV, and was found susceptible to MERS-CoV by the research carried out by rhesus macaques have demonstrated susceptibility (Munster *et al.,* 2013).

Another findings was performed by Munster illustrating the most known marmoset is as fit as a MERS-CoV pattern (Falzarano *et al.,* 2014). Furthermore, the research revealed that little animals are needed for the navigation of extensive findings (Van Doremalon *et al.,* 2015). Many mice animal have wide range of symptoms alongside with existences of viral infection which can invariably exist in the body cavity (Zhao *et al.,* 2014). Transgenic mice pattern have been discover recently exhibiting hDPP4 with increase in susceptibility to MERS-CoV disease and this mice can express freely to show forth systemic lesions which have been invented through technological means (Agrawal *et al.,* 2015).

In the demonstration of different kinds of infectious pathogens, transgenic animal patterns have been considered as an essential strategy in the advancement and technologies of researches including medical importance (Houdebine *et al*., 2007; Peck *et al.*, 2015). However, change and advancement in the mutation of mice genetic

Figures 1 illustrate on the origin and existences of the coronaviruses infection and how the transmission processes is been undergone from animals to human (Falzarano *et al.,*2014). From the above figure 1, we could see Rhinolophus bats as the major reservoirs harboring the diseases, transmitting it to the Camel which undergoes inter-species transmission to the Alpacas with potential zoonotic transmission to human.

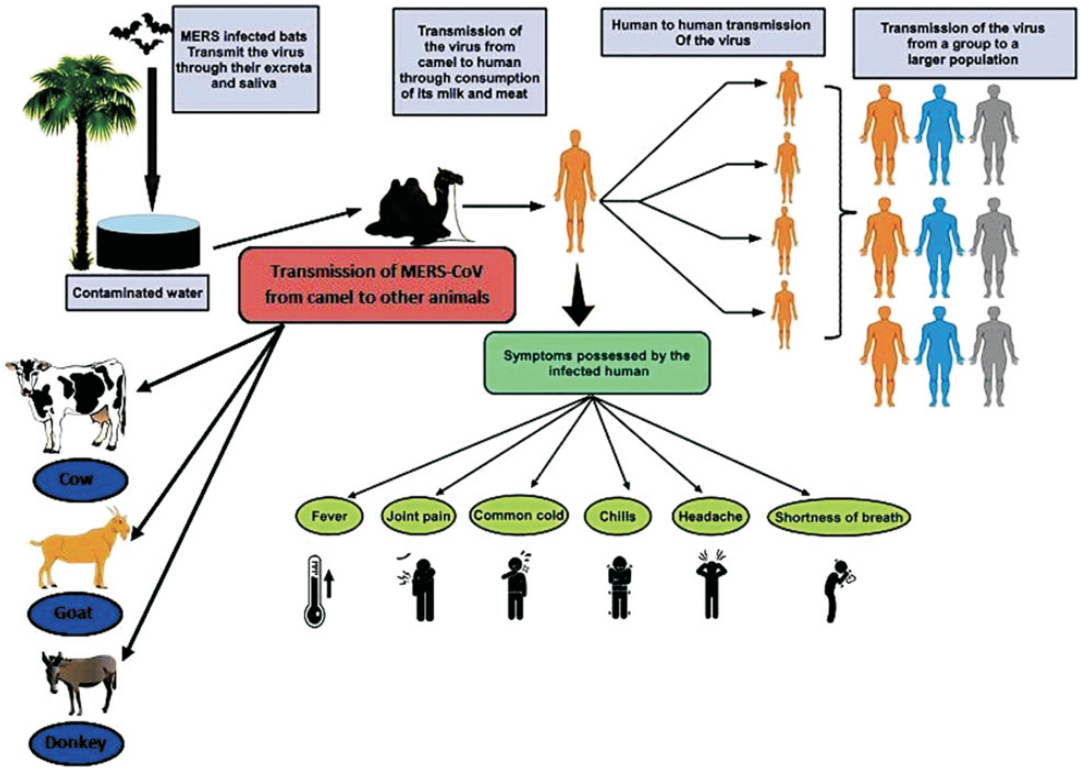

Figure 2:Coronaviruses transmission chart from animal to person and sign of symptom exhibited by an infected individual

Source: Skariyachan *et al.*, 2017

The means through which the disease is been contacted from the infected camel to the person and camel to various animals (Kandeil *et al.,* 2019); However, the disease is transferred to the rest through person to person contact as shown in figure 2 (Shehata *et al*., 2016).

3.0 TRANSMISSION MODES OF CORONAVIRUSES

The viruses COVID-19 can be can be contacted and infected in varieties of means and there are a lot of factors that are very essential in the wide epidemic of this infection that is currently a threat to global world (WHO, 2020).Since the inception of this recent pandemic outbreak crisis, World Health Organization (WHO) and Centers for Disease Control and Prevention discover and ascertain that SARS-CoV-2 is birthed through respiration and with means of production, it can spread from person to person when an infected patient with respiratory droplet either by coughing or sneezing <5μm in diameter, they are referred to as droplet nuclei (WHO, 2014 &WHO, 2020).

DROPLET TRANSMISSION

Droplet transmission can happen if a healthy personnel get in touch or contact about 100cm near the unhealthy patient (the infected person) having a respiratory signs (coughing or sneezing) (WHO, 2020).

However, it should be of great awareness that a very high amount of droplets from the virus particles are the essential means of the diseases been contacted and spread. In active response to stop the chain of the primary source of transmission via droplet, the Centre of Disease Control (CDC) to establish a preventive control of Social distancing between individual of about 6ft from the patient

material which correlates with the modification in the sequencing of hDPP4 with increase in susceptibility to MERS-CoV disease (Cockrell *et al*., 2016). Following the new created mice patterns happen to be effective in distinguishing the standard of drugs and therapeutic agents against MERS-CoVinfection (Tai *et al.,* 2016). Vaccines like VelocImmune and VelociGenehave been develop ped and invented technologically to humanized mouse pattern against MERS-CoV infection (de Benedicts *et al.,* 2014); it should be noted that all these procedures could be adopted and used against other pathogenic microorganisms in advance uprising epidemics (de Benedicts *et al.,* 2014).

BATS AS A MAJOR RESERVOIR

It should be of great awareness and importance to know the existence and infection process so as to offer the best approach technology in breaking the chain of the novel pandemic outbreak crises(Baseler*et al.,* 2016). Approaching the virus of SARS-CoV, many scientists have initially taken into consideration and deep attention towards raccoon dogs and palm civets as a major reservoir of the diseases (Baseler *et al.,* 2016).

It was recorded around the year 2001 that samples obtained from a disease free personnel residing in China, Hongkong precisely obtained a persistent rate of biomedical result of 2.5% antibiotics against SARS-infection. For this reason, SARS-infection has been pointed out in the invasion and transmission in human being prior the eruption in 2003 (Baseler *et al*.,2016).Furthermore, more researches reveals the Rhinolophus bats have been discovered in anti-SARS-CoVantibodies resulting that the bats exhibiting a gross increase in the multiplication of the viruses(Lowenthal*et al*.,2016).

After a lot of findings and studies carried out by renowned scientists and researchers in verifying and authenticating the reservoir of Coronaviruses diseases, Rhinolophus bats happens to harbor the existences and mutation of this epidemic infection which have been announce global pandemic by the World Health Organization (WHO) in the year 2020 that have been ravaging human kind as shown in figure 1 below (Lowenthal *et al*.,2016).

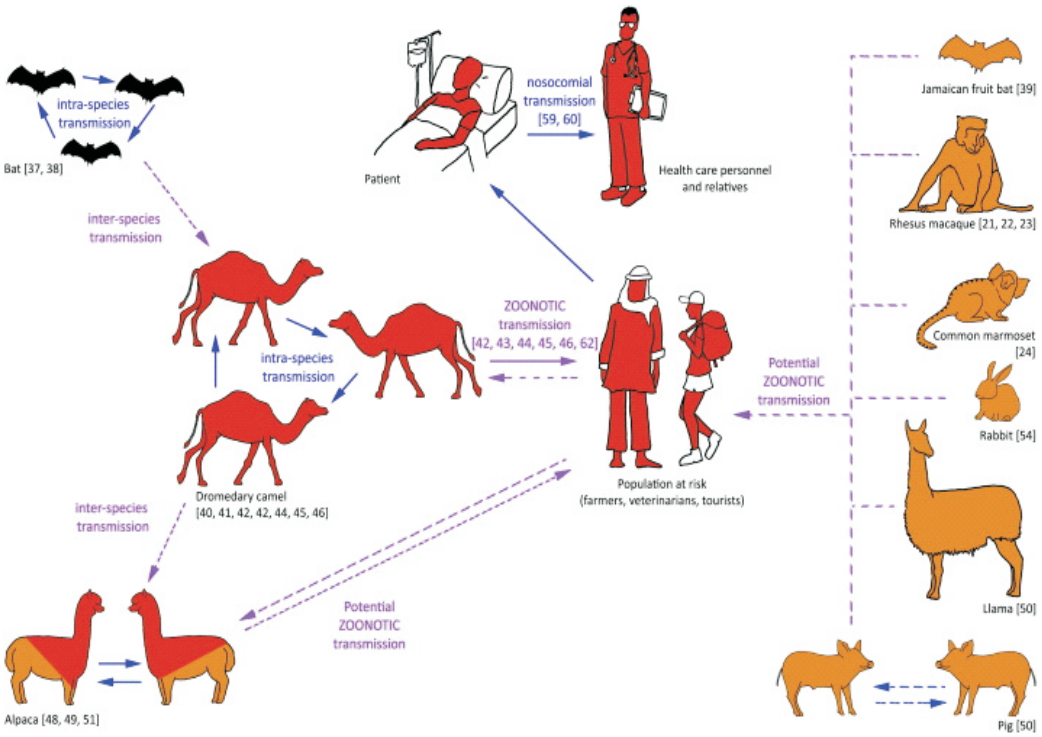

Figure 1: The major reservoirs and mode of transmission of coronaviruses
Source: Lowenthal *et al*., 2016.

with an active case (Liu *et al.,* 2020; WHO, 2020).

AEROSAL OR AIRBORNE TRANSMISSION

To avoid and prevent the disease not been contacted either via coughing or sneezing in large amount of mucus, there is a big need or awareness on how person could hold the air from transmitting the infection to nearby person. Furthermore, another striking factor is on how to discover the infection processes (Chang, 2019).Many individual transfers the disease particles in varying sizes and can be infinitesimal that we could term it as airborne transmission or aerosol with the tendency to be trapped in the for longer time and also move with the flow current in the air (Chang, 2019).

It is yet to be ascertained and confirmed from the information obtained that the transmission of coronaviruses is from airborne or aerosol, the duration in which the virus become pathogenic when trapped in the air global environment. (Zhang *et al.*,2019). Some previous work carried out by scientists, a very high amount of the disease material was not seen or apprehended by individual with an active case of the infection (Zhang *et al.,* 2019).

There is an indefinite proof of the infection contacted via aerosol means alone. For instance, through chance an individual that sneezes or coughs could infect people near to him or it can also be done by conversing with people not observing social distancing and these droplets can find expression on surfaces (WHO, 2020).

The Journal Nature Scientific carries out another research work to verify and authenticate the validity of the mode of transmission of the coronaviruses via aerosol and airborne. The report educates the entire public that an individual can transmit the disease faster when having conversation through aerosol men(Chang, 2019).

CONTACT TRANSMISSION

Another important means in which COVID-19 can spread faster in very high speed is through infected patient to healthy person contact (WHO, 2020). In the case of transmission, the disease material is produce from the activities undergone by an infected patient and drops on a land material (Ong, 2020). As a result of these activities, a healthy individual mistakenly have a contact with the land surface material saturated with the droplet of the virus particle emitted by the infected individual.

To a large view of concern, this means of transmission does not look visible but it looks and seems very real. A recent study reveals SARS-CoV-2 infection has the ability to stay for some time on materials like iron, fan, stick, nylon for close to 48-72 hours (WHO, 2020).A particle of Ribonucleic acid (RNA)from SARS-CoV-2 was discovered on a land material by some scientist inside the desks of a symptomatic and asymptomatic unhealthy individual for 18 days (Van, 2020; CDC, 2019). Therefore, the entire public is hereby advised to take cognizance of the major mode of transmission (direct or indirect mode of transmission) and to take into meticulous consideration of the preventive measures below.

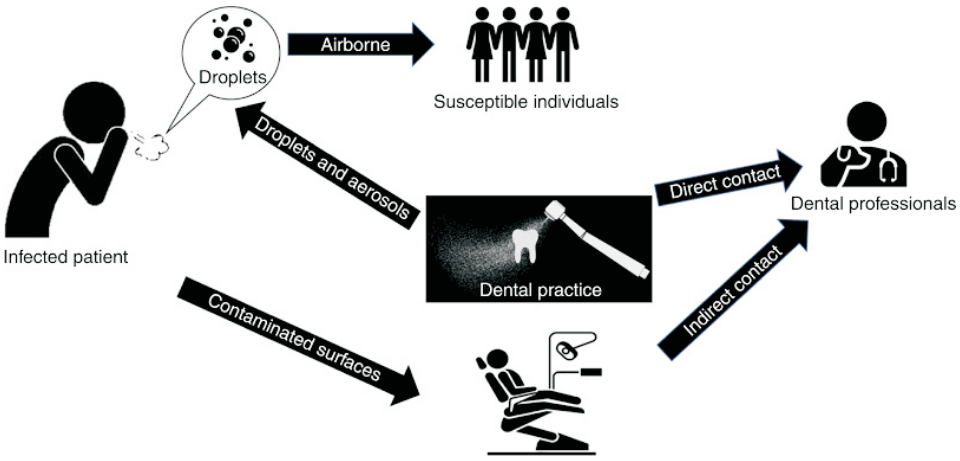

Figure 3: Coronaviruses transmission involving direct and indirect contact of infected patient

Source: Otter *et al*., 2016

Figure 3 reveals the transmission routes of droplet, airborne, direct contact, and indirect contact. (Indirect contact: routes involving a combination of hand and surface (WHO, 2020).

PREVENTIVE MEASURES

It should of great awareness that presently, remedy preferences for viral ailments that take place suddenly is not discovered (Holshue *et al.,* 2020). Having this at the back of our knowledge, these days there is no vaccine or high quality treatment to forestall furnished a profitable viral clearance (Chen *et al*., 2020).

For this purpose, a randomized control trial (MIRACLE Trial), that aimed to decide whether or not LPV/RTV-IFNb multiplied medical results existing in transmitted and confirmed patient have been enrolled (Arabi *et al.,* 2016). Although every other antiviral drug was used in the first case stated from the USA acting successful, managed studies with more instances are needed (WHO, 2020). Laboratory studies have proven that viral RNA transcription used to be to eradicate temdesivirn drugs at the occurring phase (Warren *et al.,* 2016; Jordan *et al.,* 2018).

Research reviews has a robust antiviral pastime in epithelial mobile phone cultures against SARS-CoV, MERS-CoV and related zoonotic bat CoVs (Cockrell *et al.,* 2016; Brown *et al.,* 2019). Many measures need to be taken, such as facts for removal of the source of infection, early diagnosis, reporting, isolation, supportive redress and for warding off pointless panic. NCDC reminds simple measures such as hand washing, using disinfectant solutions, fending off contact with sufferers through social distancing in order to prevent the transmission of viruses via droplets (NCDC, 2020).

Precautionary movements consisting of the provision of drug treatments provide chains, personal protective equipment (PPE), and clinic components be made in a quick time for the safety of the Nigerians, in particular in the locations with close journey ports to essential Nigeria ports (NCDC, 2020).

4.0 CONCLUSION

This article has reviewed and unveiled the authentication of the major reservoir and means through which coronaviruses can be transmitted and contacted within all organizations of live forms. It was concluded that among many others animals that could harbor the cultivation and growth of COVID-19, Bats was found to dominate and sustain the longevity of this global pandemic outbreak disease. Like other viruses in the Panic Zone, the COVID-19 has triggered sudden damage to society. Direct and Indirect transmission (Droplets transmission, contact and aerosol transmission) has successfully been grouped as the major modes of transmission in which coronaviruses could be spread. During the pandemic outbreak, most research have centered on the plausible reasons and occurrence of the virus while the statistics on the epidemic prevention is obscure. Cognizance should be strictly adhered to against the animals that can harbor the activation of the virus and preventive measure must be taken against the transmission to stop the rate of infection.

REFERENCES

Bermingham, A., Chand, M. A., Brown, C.S., Aarons, E., Tong, C. & Langrish, C.(2012). Severe respiratory illness caused by a novel coronavirus, in a patient transferred to United Kingdom from the Middle East, *Euro Surveill*.17 (40) 20290.

Agrawal, A.S.,Garron, T.,Tao, X., Peng, B.H., Wakamiya, M.& Chan, T.S. (2015). Generation of a transgenic mouse model of Middle East respiratory syndrome coronavirus infection and disease*, Journal of Virology*. 89 (7) 3659–3670.

Cockrell, A.S., Yount, B. L., Scobey, T., Jensen, K., Douglas, M., & Beall, A. (2016). A mouse model for MERS coronavirus-induced acute respiratory distress syndrome, *Nat Microbiololy*. 2 16226.

Arabi, Y., Alothman, M., & Balkhy, A.(2016). Treatment of Middle East respiratory syndromewith a combination of lopinavirritonavir and interferon (MIRACLE trial):studyprotocol for a randomized controlled trial. *Trials*;19(1); 81.

Brown, A.J. (2019). Broad spectrum antiviral remdesivirinhibits human endemic and zoonotic delta coronaviruses with a highly divergent RNA dependent RNA polymerase. *Antiviral Research*; 169: 104541.

Burke, R. M., Midgley, C. M., Dratch A., Fenstersheib M., Haupt T., Holshue M. (2020). Active monitoring of persons

exposed to patients with confirmed COVID-19—United States, MMWR Morb Mortal Wkly Rep. doi : 10.15585/mmwr.mm 6909e1external icon

Rubin, C., Myers, T. Stokes, W., Dunham, B., Harris, S.& Lautner, B.(2013). Review of institute of medicine and national research council recommendations for one health initiative. *Emerging Infectious Diseases*. 19 (12) 1913–1917.

Coleman, C.M.,Matthews, K.L., Goicochea, L. &Frieman,M.M.(2014) Wild-type and innate immune-deficient mice are not susceptible to the Middle East respiratory syndrome coronavirus, Journal of Genome Virology 95 (Pt2) 408–412.

CDC. (2019) Novel coronavirus, Wuhan, China.2020.https://www.cdc.gov/coronaviru s/2019- CoV/summary.html.Accessed 1 Feb 2020.

Chan, J., Yuan, S., &Ko, k. K. (2020).A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *Lancet*. doi: 10.1016/S0140-6736(20)30154-9.

Cheng, V., Wong, S.C., Chen, J., Yip, C., Chuang, V., &Tsang O. (2020). Escalating infection control response to the rapidly evolving epidemiology of the Coronavirus disease 2019 (COVID-19) due to SARS-CoV-2 in Hong Kong. *Infection Control and Hospital Epidemiology.*

Chen,Y., Liu, Q., GuoD. (2020). Coronaviruses: genome structure, replication, and pathogenesis. *Journal of Medical Virology*.

Cockrell, A. S.(2016).Amousemodel for MERS coronavirus-induced acute respiratory distress syndrome. Nat. Microbiol2, 16226.

Falzarano, D., de Wit, E., Feldmann, F., Rasmussen, A. L., Okumura, A. & Peng,X. (2014). Infection with MERS-CoVcauses lethal pneumonia in the common marmoset, PLoSPathog. 10 (8) e1004250.

De Wit,E., Prescott, J., Baseler, L., Bushmaker, T, Thomas, T. & Lackemeyer, M.G. (2013).The Middle East respiratory syndrome coronavirus (MERS-CoV) does not replicate in Syrian hamsters, PLoSOne 8 (7) e69127.

De Wit,E. A.L., Rasmussen, D., Falzarano, T., Bush maker, F., Feldmann, D.L.& Brining,(2013). Middle East respiratory syndrome coronavirus (MERS-CoV) causes transient lower respiratory tract infection in rhesus macaques, *Proc. Natl. Acad. Sci*. U. S. A.110 (41) 16598–16603.

Qiu, H., Sun, S., Xiao, H., Feng, J., Guo, Y. & Tai, W. (2016). Single-dose treatment with a humanized neutralizing antibody affords full protection of a human transgenic mouse model from lethal Middle East respiratory syndrome (MERS)-coronavirus infection, *Antiviral Resesrch*. 132 141–148.

Holshue, M.L., DeBolt, C.. Lindquist, S., Lofy, K.H., Wiesman, J., Bruce, H., Spitters, C., Ericson, K., Wilkerson, S., Tural, A., Diaz, G. & Cohn, A. (2020). First Case of 2019 Novel Coronavirus in the United States. *The New England Journal of Medicine*.

Huang, C., Wang, Y. &LiX, (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 395: 497–506.

Lowenthal,J. (2016). Overview of the CSIRO Australian Animal Health Laboratory. *Journal of Infections and Public Health* 9 (3) May–Jun) 236–239.

Zhao, J., Li,K., Wohlford-Lenane, C., Agnihothramn, S.S., Fett, C. & Zhao,J. (2014). Rapid generation ofa mouse model for Middle East respiratory syndrome, *Proc.Natl. Acad. Sci. U. S. A*. 111 (13) 4970–4975.

Jordan, P. C. etal.(2018). Initiation, extension, and termination of RNA synthesis by a paramy xoviruspoly merase. *PLoSPathog*. 14, e1006889.

Jones, K.E., Patel, N.G., Levy, M.A., Storeygard, A., Balk,D. & Gittleman, J.L. (2008). Global trends in emerging infectious diseases, *Nature* 451(7181) 990–993.

Pascal, K.E., Coleman, C.M., Mujica, A. O., Kamat, V., Badithe, A.& Fairhurst, J. (2015). Pre and post exposure efficacy of fully human antibodies against Spike protein in a novel humanized mouse model of MERS-CoVinfection.*Proc.Natl. Acad. Sci. U. S. A*. 112 (28) 8738–8743.

Peck, K.M., Cockrell, A. S., Yount, B.L., Scobey, T., Baric, R.S. &Heise M.T. (2015). Glycosylation of mouse DPP4 plays a role in inhibiting Middle East respiratory syndrome

coronavirus infection. *Journal Virology* 89 (8) 4696–4699.

Baseler, L., de Wit, E. & Feldmann H. (2016). A comparative review of animal models of Middle East respiratory syndrome coronavirus infection. *Veterinary Pathology*.53 (3) 521–531.

Baseler, L. J., Falzarano, D., Scott, D. P., Rosenke, R., Thomas, T. & Munster, V.J. (2016). Anacute immune response to Middle East respiratory syndrome coronavirus replication contributes to viral pathogenicity. *American Journal of Pathology*.186 (3) 630–638.

Houdebine, L.M. (2007). Transgenic animal models in biomedical research.*Methods in Molecular Biology*.360 163–202.

Li, Q., Guan, X., &Wu, P. (2020). Early transmission dynamicsin Wuhan, China, of novel coronavirus-infected pneumonia.*New England Journal of Medicine*. doi:10.1056/NEJMoa2001316.

Li, Q., Guan, X.,Wu, P., Wang, X., Zhou, L. & Tong, Y. (2020). (Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *New England Journal of Medicine*. https://doi.org/10.1056/NEJMoa2001316

Liu, J., Liao, X.&Qian, S. (2020). Community transmission of severe acute respiratory syndrome coronavirus 2, Shenzhen, China, 2020.Emerg. Infect Dis.

Mäkelä, M.J., Puhakka, T., Ruuskanen, O., Leinonen, M., Saikku, P.& Kimpimäki,M. (1998). Viruses and bacteria in the etiology of the common cold. *Journal of Clinical Microbiology*.36 (2) 539–542.

Van Doremalen, N. & Munster, V.J. (2015).Animal models of Middle East respiratory syndrome coronavirus infection, *Antiviral Research*. 122 28–38.

Wang, N., Shi,X.. Jiang, L., Zhang, S., Wang, D.&Tong, P. (2013). Structure of MERS-CoVspike receptor-binding domain complexed with human receptor DPP4, *Cell Research*. 23(8) 986–993.

Alharbi, N. K. (2016). Vaccines against Middle East respiratory syndrome coronavirus for humans and camels, Rev. Med. Virol. http://dx.doi.org/10.1002/rmv.1917 (Epubahead of print).

NCDC, (2019) Novel Coronavirus. Prevention and Treatment. Available online: https://www.ncdc.gov.ng/coronavirus/2019-ncov/about/ prevention-treatment.html (accessed on 05 March 2020)

Ong, S.W., Tan, Y.K., Chia, P.Y., Lee, T. H., Ng, O.T. & Wong, M. S. (2020). Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome ecoronavirus2 (SARS-CoV-2) from a symptomatic patient. JAMA. [Epuba head of print].

De Benedictis, P., Marciano, S., Scaravelli, D., Priori, P., Zecchin, B.& Capua, I. (2014). Alpha and lineage C beta CoVinfections in Italian bats, Virus Genes 48 (2) 366–371.

Peiris J. S., Guan Y., Yuen K.(2004).Severe acute respiratory syndrome. *Nature and Medicine*10:S88–97.

Morse, S.S., Mazet,J.A.K., Woolhouse, M., Parrish, C.R., Carroll, D. & Karesh, W.B. (2012).Predictionand prevention ofthe next pandemic zoonosis, *Lancet* 380 (9857) 1956–1965.

Su, S., Wong, G., Shi, W., Liu, J., Lai, A.C.K. &Zhou, J. (2016).Epidemiology, genetic recombination and pathogenesis of coronaviruses. *Trends in Microbiology*. 24:490–502.

Sutton, T. C. & Subbarao, K. (2015). Development of animal models against emerging coronaviruses: from SARS to MERS coronavirus, Virology479–480 247–258.

Munster, V.J., Adney, D.R., Van Doremalen, N., Brown, V.R., Miazgowicz, K.L., Milne Price,S. (2016). Replication and shedding of MERS-CoVin Jamaican fruit bats (Artibeus jamaicensis),Sci. Rep. 6 21878.

Munster, V.J., De Wit,E. & Feldmann, H. (2013). Pneumonia from human coronavirus in a macaque model, N. Engl. J. Med. 368 (16) 1560–1562.

Raj, V.S., Mou, H., Smits,S.L. Dekkers, D.H., Müller, M.A.&Dijkman, R.(2013). Dipeptidylpeptidase4is a functional receptor for the emerging human coronavirus-EMC, *Nature* 495 (7440) 251–254.

VanDoremalen N., Morris, D. & Bush maker, T. (2020). Aerosol and Surface Stability of SARS-CoV-2 as compared with SARS-CoV-1. *New England Journal of Medicine*. doi: 10.1056/NEJMc2004973

Tai, W., Zhao, G., Sun, S., Guo, Y. Wang, Y. Tao, X. (2016). A recombinant receptor-binding domain of MERS-CoVintrimeric form protects human dipeptidyl peptidase4 (hDPP4) transgenic mice from MERS-CoVinfection, Virology 499 375–382.

Warren, T. K. (2016). Therapeutic efficacy of the small molecule GS-5734 against Ebola virus in rhesus monkeys. Nature 531,381–385.

World Health Organization (2014).Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. Geneva: World Health Organization.

World Health Organization, WHO, (2016). http://www.who.int/csr/don/20162014

World Health Organization (2020). Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19) 16-24 February 2020 [Internet].Geneva: World Health Organization; Available from: https://www.who.int/docs/default-source/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf.

Yao, Y., Bao, L. Deng, W., Xu, L., Li, F. Q. Lv,F. (2014). (An animal model of MERS produced by infection of rhesus macaques with MERS coronavirus, *Journal of Infectious Diseases.* 209 (2) 236–242.

Memish, Z. A., Mishra, N. Olival, K. J., Fagbo, S. F., Kapoor, V. & Epstein, J. H. (2013). Middle East respiratory syndrome coronavirus in bats, Saudi Arabia. *Emerging Infectious Diseases*. 19 (11) 1819–1823.

Zaki A.M., Boheemen, S.V.,BestebroerT. M., Osterhaus, ADME & Fouchier, RAM.(2012). Isolation of a novel coronavirus from a man with pneumonia in Saudi Arabia. *New England Journal of Medice*. 367:1814–20.

Zhang, Y., Chen, C. &Zhu, S. (2020). Isolation of 2019-nCoV from a stool specimen of a laboratory-confirmed case of the coronavirus disease 2019 (COVID-19). China CDC Weekly.2(8):123–4.

Zhu.N., Zhang, D,, Wang. W., Li, X., Yang, B., Song, J. (2019). Anovel coronavirus from patients with pneumonia in China, 2019. *New England Journal of Medicine*. 2020. https:// doi.org/10.1056/NEJMoa2001017