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COVID-19: Probable involvement of insects in the mechanical transmission of novel coronavirus (2019-nCoV)

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ABSTRACT

Currently, the world is faced with a novel human coronavirus disease (COVID-19) pandemic caused by a zoonotic, enveloped, single-stranded RNA novel coronavirus (2019-nCoV) causing severe human respiratory tract infections. Although severe acute respiratory syndrome coronavirus (SARS-CoV) and other related coronaviruses had been reported to be mechanically transmitted by insects, no report has so far linked the human transmission of 2019-nCoV with insects. However, the survivability of 2019-nCoV on surfaces and faeces for elongated periods would undoubtedly incriminate insects as culprits in its transmission. Once the faecal-oral transmission of 2019-nCoV is scientifically proven and established, the fate of insects as mechanical vectors in the transmission of this novel coronavirus would most likely constitute significant public health danger. The urgency for the prevention of the rapid and increasing global transmission of 2019-nCoV requires a holistic and multifaceted universal approach aimed at improving infection prevention and control, hygienic and sanitary measures hence, mitigating the likely culpability of insects in transmitting the novel coronavirus.

Introduction

Insects belong to the largest phylum in the animal kingdom, Arthropoda which accounts for 80% of known animal species in the world [1]. They are found in great abundance in areas of human activities including residential buildings, markets, farms, abattoirs, hospitals, etc. where they cause environmental disturbances, and also act as potential vectors of animal and human pathogens [2]. Globally, over 100 pathogens including bacteria, fungi, parasites and viruses which cause life-threatening and severe infections in animals and humans have been associated with insects [3,4]. Most animal viruses are transmitted biologically or mechanically by vectors which are predominantly insects [5]. Through biological transmission, the virus undergoes development in the insects (invertebrate hosts) to completes its life cycle before transmission to the vertebrate hosts (animals or humans) can occur. Mechanical transmission involves the transfer of the virus picked on the body parts or mouth of the insects (invertebrate hosts) to another animal or human (vertebrate hosts) with no developmental change of the virus on or in the insect [6,7]. Here, the insects serve as vehicles for viral transmission which is merely incidental.

In the last few decades, several viruses have emerged due to different ecological factors as well as human behavior or interaction with wildlife. The

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intensification of agriculture, the geographical expansion of the human population, climate change (which results in the disturbance of the habitats) and deforestation are major factors that facilitated the emergence of most viruses [8,9]. The majority of the emerging and re-emerging viruses affecting humans are zoonotic (with many wildlife species as reservoirs) and have constitute a global public health threat over the years [10,11]. Examples of zoonotic viruses that have emerged in the last few decades with immense public health impact are; severe acute respiratory syndrome coronavirus (SARS-CoV), middle east respiratory syndrome coronavirus ((MERS-CoV), Nipah virus (NiV), Ebola viruses (EBOV), Lassa fever virus, Marburg virus, Zika virus, Rift Valley fever virus, chikungunya virus, dengue virus, influenza viruses, Ross River virus, Crimean Congo haemorrhagic fever virus, thrombocytopenia syndrome virus and the novel severe acute respiratory syndrome coronavirus (SARS-CoV-2) or 2019-nCoV or COVID-19 virus [12-14]. Interestingly, the majority of these emerging and re-emerging zoonotic viruses can be transmitted to humans by insects (mosquitoes, houseflies, bugs, cockroaches, ticks, and sandflies) and are also known as arboviruses i.e. arthropod-borne viruses [13].

Presentation of concerns and analysis

Generally, coronaviruses are zoonotic, enveloped, positive-sense, single-stranded RNA viruses of the genus *Betacoronavirus*, order Nidovirales and family Coronaviridae which can be transmitted to humans through respiratory droplets, contact with contaminated surfaces/objects, person-to-person spread or faecal-oral route [14,15]. Although the majority of coronaviruses cause mild infections, others can, however, cause life-threatening and severe respiratory disease in animals and humans [14]. Over the years, 7 different human coronaviruses have emerged with a wide variety of pathogenicity. Human coronaviruses HKU1, NL63 (HCoVNL63), OC43 (HCoV-OC43) and 229E (HCoV-229E) have been reported to cause respiratory infections globally among adults and children [16,17]. Also, within the last 2 decades, 3 highly pathogenic coronaviruses have emerged, and they include SARS-CoV, MERS-CoV, and lately, SARS-CoV-2 or 2019-nCoV which are responsible for severe respiratory infections in humans. Although SARS-CoV and MERS-CoV emerged as epidemics with pandemic potentials, 2019-nCoV that recently emerged from Wuhan, China has spread across 215 countries and territories worldwide with high morbidity and mortality and had been declared a pandemic [18].

Like other zoonotic viruses that have recently emerged or re-emerged with devastating effects (EBOV, SARS-CoV and NiV), 2019-nCoV has been associated with bats [14]. Human infection with 2019-nCoV occurs through respiratory droplets, aerosols, person-to-person spread, contacts with contaminated surfaces/objects, and most probably faecal-oral route, although not proven [18,19]. Person-to-person transmission of 2019-nCoV has been described to occur frequently in family, public and healthcare settings [20,21].

Several studies have shown that influenza viruses and human coronaviruses including SARS-CoV and MERS-CoV can survive on objects and dry surfaces for a sufficient time to facilitate subsequent spread [22-24]. Furthermore, coronaviruses from contaminated surfaces can be transmitted through self-inoculation of the eyes, mouth, and nasal mucous membranes [15,21]. Previous studies have shown that influenza viruses, SARS-CoV and other coronaviruses can survive in foods, water, soil, sewage and other environmental reservoirs for extended periods [25-30]. Nevertheless, 2019-nCoV is yet to be reported in the environment. However, studies have reportedly shown that 2019-nCoV can survive on surfaces and objects for several hours and days depending on the nature and type of surface, humidity and temperature [16,19,21].

As previously stated, insects such as houseflies, cockroaches and bugs exist in great abundance in family, public and healthcare settings and can interact with contaminated surfaces, objects and faeces thereby mechanically (incidentally) transmitting coronavirus to humans. This study hypothesized the involvement of insects especially houseflies, cockroaches and bugs as culprits in the mechanical transmission of 2019-nCoV. Hypothetically, insects feeding on or interacting with viral contaminated surfaces, food, environment, or human secretory or excretory products could transmit the virus.

Through serological and/or molecular assays, low frequencies SARS-CoV were reported from insects and other vectors during the SARS epidemic [31-33]. Turkey coronavirus (TCV) an aetiologic agent responsible for acute, enteric and highly contagious infection in turkeys has been shown to be mechanically transmitted by houseflies [34]. The study also significantly associated higher fly densities with increase infection rates which further

demonstrated the culpability of houseflies in the mechanical transmission of TCV. Similarly, **Sohier et al.** [35] reported mechanical transmission of the Lumpy skin disease virus by both biting flies and horseflies among cattle. During the 2010 H5N1 highly pathogenic avian influenza (HPAI) outbreaks (with unknown transmission route) in Japan, entomological studies in regions with high densities of different fly species implicated blowflies in the mechanical transmission of the H5N1 virus [36]. Several insects have also been implicated in the mechanical transmission of other viruses such as rotavirus, poliovirus, and hepatitis viruses [14].

Previous studies from 2 Chinese provinces, Guangdong and Sichuan indicated that between 78% - 85% of 2019-nCoV transmissions occurred within families [37]. This depicts that the majority of 2019-nCoV transmission occurs mainly within family settings. Residential areas housing different species of insects including houseflies, cockroaches and bugs play a significant role in 2019-nCoV transmission. Of paramount importance to 2019-nCoV transmission is the prolonged persistence of the novel virus in the faeces of infected patients even after recovery [19,38,39]. Additionally, from the data generated from COVID-19 patients at the Fifth Affiliated Hospital of Sun Yat-sen University, Zhuhai, China, Wu and colleagues [19] suggested the possibility of prolonged faecal shedding of nCoV for almost 5 weeks even after patients' recovery and the absence of 2019-nCoV RNA from respiratory samples. This further implies 1) active viability and replication of 2019-nCoV within the gut of infected persons and 2) there may probably be prolonged environmental contamination and viability of the 2019-nCoV as the case is with SARS-CoV and surrogates.

With the limited knowledge on the viability and transmissibility of 2019-nCoV, the novel virus could retain its viability in environmental reservoirs for days and could be transmitted via faecal–oral as the case is with both SARS-CoV and MERS-CoV [39]. Thus, the prolonged shedding and viability of the 2019-nCoV in faeces and most probably the environment will facilitate the involvement of houseflies, cockroaches and bugs among other insects in the mechanical transmission since they often feed or peck on contaminated faeces and environment. Therefore, the culpability of insects especially houseflies, cockroaches and bugs in 2019-nCoV transmission should not be downplayed amidst global pandemic with an increasing number of cases and mortalities.

Insects feed on a wide variety of foods, wastes, sewages, secretions, excretions and even decomposing dead bodies, and through their body hairs, legs, mouthparts, vomits and faeces can transmit pathogens including 2019-nCoV. Also, insects serve as vehicles for the contamination of surfaces and objects. Their active, restless and highly mobile nature couple with robust olfactory and visual powers enable them to constantly move between animals, humans, food, secretions, excretions (including faeces), objects and surfaces freely [31,40,41].

There is no doubt that the soaring and increasing cases of COVID-19 in most developing countries and poorer regions of the world are attributed to weak healthcare systems, inadequate potable water supply and poor sanitary and hygienic practices. More so, the prevailing presence of urban slums, dense population, shared sanitary facilities (where available) and a high degree of social mixing and the presence of abundant insect species especially in residential and healthcare settings further compound the woes of these countries amidst COVID-19 pandemic [42,43]. With the prevailing poor hygienic and sanitary conditions and the interaction of insects within these regions of the world, the importance of insects in the transmission of 2019-nCoV cannot be overemphasized. The epidemiology and dynamics of a viral disease are greatly influenced if the virus is together with other means mechanically transmitted [5]. Since laboratory data would not unravel the immediate involvement of insects in the mechanical transmission of disease during epidemics or even pandemics, only the analysis of epidemiological data will clearly show the correlation existing between insects (vectors) and a disease.

Northern Nigeria for instance, is characterized by poverty and attendant poor living conditions, hygienic and sanitary practices with high population and seasonal insects' infestation [44]. Although the emergence of COVID-19 in Nigeria began from the distant southern region (Lagos state in particular), the north especially Kano, Sokoto, Jigawa and Borno states have recorded hundreds of coronavirus related deaths in the past few couples of weeks (though the government is still investigating such high deaths) [45]. Similarly, the increased number of COVID-19 cases in Iran, India, Bangladesh, Pakistan, Indonesia, Philippines, North Korea, Oman, Kuwait, Brazil, South Africa and Algeria among other developing countries could be

attributed to cluster and/or community transmission [37] via poor hygienic and sanitary practices with insects as probable culprits.

There have been increasing reports of 2019-nCoV transmission in prisons from both developed and developing countries including USA, China, Bangladesh, Philippines and Cambodia [46-49]. and other congregated settings housing a large number of people. The close contact and proximity of people in such settings with possible environmental contamination which may be facilitated by insects are relevant factors in the enhanced transmission of 2019-nCoV [37].

Currently, no known therapeutic measure or vaccines exist for COVID-19 infections. The urgency for the prevention of the rapid and increasing global transmission of 2019-nCoV requires a holistic and multifaceted universal approach aimed at improving infection prevention and control, hygienic and sanitary measures. The variability of regional climatic and environmental factors requires region-specific interventions for the control and prevention of COVID-19. The survivability of coronaviruses including SARS-CoV, MERS-CoV and 2019-nCoV on dry surfaces for extended periods may demand thorough and appropriate disinfection (alcohol-based) for effective infection control and prevention. This is necessary for the prevention of subsequent contamination of objects, equipment, or hands, which could further initiate inoculation through direct contact with body parts especially mouth, nose and eyes.

Conclusion

Finally, since insects such as houseflies, cockroaches and bugs have been shown to mechanically transmit SARS-CoV and other coronaviruses, the elimination of insects in residential areas, hospitals, public and other congregated settings become imperative in the fight against COVID-19 pandemic. Improved environmental sanitary practices such as plumbing and hygienic toilets, residential wastes disposal using waste bags/bins, safe management and disposal of sewage and healthcare wastes, and proper disposal of livestock wastes from residential areas should be maintained. Insecticides and insects repelling plants should be used for chemical and biological control of insects, and most importantly also, foods should be always closed. Further field and laboratory-based trials aimed at unraveling the insects' culpability in the transmission of 2019-nCoV will further aid in the understanding of COVID-19 epidemiology and dynamics which will proffer feasible control and preventive measures.

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All authors have over the years worked on emerging and reemerging zoonotic viral pathogens including Lassa, Ebola, rabies etc. They are trained public health microbiologists and faculty members.

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