Does Aerosol Science Support Contact Tracing for COVID–19 Spread Detection?

B. G. Shiva Prasad
Fluid Thermal Technologies

Abstract — 'Ebola' and 'COVID-19' have become dreaded diseases and captured the attention of the human race including researchers. Fluids (liquid/gas) pervade the universe and hence understanding the fluid/aero dynamic pathway of the virus needs utmost attention due to the frequent outbursts of Ebola and the present spread of the COVID-19 pandemic. Until recently, the conventional understanding of the COVID-19 pathway presumed direct contact with the body fluid and neglected air borne transport. Life span and sustainability of the virus in various environments and materials (living or nonliving) acting as carriers are other issues for consideration. Both Ebola and COVID-19 have been found to live in external environment, like surfaces of objects for several hours. Both are micron sized living matter and obviously very light in weight. Hence there is no reason why it cannot get airborne and be transmitted by air currents. Contrary to the present claims of some researchers, this paper presents arguments to conclude that both Ebola and the COVID-19 viruses can be transmitted by air in addition to other carriers and pathways. Extension of this argument perhaps leads to the possibility of water borne transmission also? With other non-contact modes of transmission becoming viable, Contact Tracing cannot determine the rate of spread of the infection. This should raise serious questions about the veracity of the Contact Tracing technique for understanding the spread of COVID-19, EBOLA and many other infectious diseases.

Index Terms— EBOLA, COVID-19, Contact Tracing, Air borne, Aerodynamics, Aerosol

1 INTRODUCTION

Fluids pervade the universe. Air and water are the most important and commonly found fluids in nature. They are not only required for sustenance of human and other species but also aid in the mechanics of transportation of living and nonliving matter. Air and water can help transport anything which can get submerged partially as in the case of ships, completely as in the case of airplanes or submarines, etc. The subject of Aerosol Science is mainly devoted to the understanding of the transport of small objects or particulates suspended in air. Aerosol science does not deal with matter with propulsive mechanisms. Motion of such objects with propulsive mechanisms are covered mostly by the science of Fluid Dynamics or Aerodynamics. To be more precise, one could say aerodynamics covers motion of objects in air with or without propulsive mechanisms, while aerosol science is a much narrower field dealing only with particulate motion driven by natural air currents.

For an object to be transported by air or water, it should become buoyant naturally as in the case of light materials or made buoyant by external forces. Further, they are either carried by the medium itself (wind/water), if they do not offer much resistance, or by external forces produced by propulsion system/s. Airplanes and ships have propulsion systems which produce thrust to overcome the resistance offered by air or water and to move forward. Similarly birds, insects, fish etc. have their own propulsive mechanisms for making them move. On the other hand, lighter objects like paper, leaves, dust particles, etc. can get airborne and be transported in windy conditions. Similarly water currents can transport small objects not experiencing much drag. However, they do transport heavy objects also, like trees, automobiles and even homes during floods, similar to transport of such objects by tornadoes.

Virus and bacteria are organisms with sizes in the range of sub-micron to a few microns and hence can be easily carried by air or water currents. Hence spread of virus through air and water have become common modes of transmission of infectious diseases. Ebola & COVID-19 viruses are no exception. They are micron sized objects and hence there is no reason why they cannot be transported by wind and water.

For air or water to become a medium of transportation, they should also be able to survive in those media. Both Ebola & COVID-19 viruses are known to survive in air for several hours and in the case of the latter, perhaps even for a few days. However, can they survive in dry air also? The other questions are whether they can withstand the toxicity present in the natural environment? Also, what is the range of temperature required for their survival? All these questions can be answered to a certain extent by conducting experiments on a laboratory scale.

Understanding the transmission modes of a virus is very important for an epidemiologist or an applied mathematician to predict the rate of spread and the virulence of any infectious disease. At the same time, it is also important for the policy makers for formulating policies and devising systems to effectively curb the rate of spread of the infectious disease on a communitywide as well as global scale. Further, it helps in formulating and advocating mechanisms to ward off the disease at an individual level.

Most of the virus and bacteria are microbial in nature and hence all natural modes of transmission – air, water and insects are quite possible, provided such virus can survive outside a human body. It is only, when they cannot survive outside the human body for even a few seconds or minutes, their

mode of transmission will be restricted to direct human to human contact, perhaps as in the case of the AIDS virus.

Both EBOLA & COVID-19 are known to survive outside a human being for a considerable length of time. Hence it is obvious that other modes like transmission by air is possible. Similarly, if experimental research shows that it can survive in water also (not just in droplets but in a large body of water), transmission by water can also get established. Further, one cannot rule out the possibility of the virus being transported by insects.

With one or more modes of transmission other than direct human to human contact being present, the method of Contact Tracing becomes ineffective, since neither the mode nor the person responsible for transmitting the virus can be tracked and determined. Also, the definition of physical distancing gets linked with the environment. Physical distancing of 1 to 2 m can only prevent the virus being transmitted through direct contact with the fluid or gaseous effusion coming out of a human body, when a person talks, coughs or sneezes and the virus or the fluid droplet is directly inhaled by anyone close to him/her. However, even those viral particles can loose water in the droplet as layers of water covering them are ripped and evaporated by the prevailing air currents, and then get exposed and are carried away by the air currents over much longer distances. Hence, individual protection with mask, PPE, etc., assumes much greater importance than physical distancing. Physical distancing alone does not guarantee airborne viruses from entering through the nose or mouth. In fact, good ventilation becomes a priority issue, particularly in buildings or other confined spaces like airplanes, ships, etc., with large number of persons and in mass gatherings. Hence in the case of COVID-19, EBOLA or any other infectious disease with other modes of transmission being a possibility, all of the models and predictions based on data derived from Contact Tracing, becomes moot.

There is considerable amount of research done concerning the technique of Contact Tracing for detection of the rate and nature of spread of infectious diseases. WHO report [1] in 2014 during the outbreak of EBOLA in Africa gave a detailed description and discussed the mechanics of Contact Tracing. This technique has found success in cases where the transmission mode is mainly through direct contact of human beings or their effluents as in AIDS. During the recent outbreak of the COVID-19 pandemic, there are similar reports and papers by various research groups including CIDRAP (see ref. [2]), which discusses the approach, methodology, implementation, problems and effectiveness. However, it also warns about the serious limitation of the technique in cases where the pathogen can get air borne. In fact, in a recent announcement even WHO has promptly revised their earlier understanding that COVID-19 is spread by direct transmission of the body fluid during close contact and accepted the recommendation made by more than 200 scientists concerning the possibility of air borne transmission.

Eames & Keeling [3] developed a model for predicting the spread of infectious diseases by using stochastic simulation and pairwise approximations. They allude to the problem of efficacy of their method being dependent on the extent of knowledge of the disease or viral pathway. The method appears to be helpful in controlling the spread in the case of diseases spread by direct human to human contact as in sexually transmitted diseases (STD) like AIDS. Even in those cases, the knowledge of the nature of interaction is important for proper prediction of the disease pathway. Edmunds et al [4] tried to apply probabilistic techniques to correlate the extent of spread of an infectious disease based on the nature of contact occurring in a heterogeneous group. This technique was particularly developed to give insights for developing control measures for curbing the rate of spread by understanding the nature of interactions which are responsible for the extent of spread of the disease. This technique has the benefit of applicability to diseases irrespective of the nature of transmission, but however it requires extensive data collection and tends to provide only qualitative results, particularly with airborne and other natural modes of transmission being present. Ganesan S. & Subramani D. [5] have reported a spatio-temporal, 6 dimensional model based on population dynamics for predicting the extent and nature of spread of COVID-19 for help in formulating policies for controlling the spread. Patient age, infection severity and incubation period were used as additional parameters to space and time.

Stadnytsky et al [6] have demonstrated the possibility of airborne transmission of any viral particle emanating from loud talk itself. Their experimental rig using a green laser sheet for photographing and visualizing the particles has demonstrated that 12 μm – 21 μm range of fluid droplets yielding a 4 μm sized nucleus, generated during a human talk can sustain in air for 8 – 14 mins. Their experiments have hence demonstrated the clear possibility of airborne transmission of the COVD-19 virus.

Any mathematical model is as good as their physical model and assumptions. Physical models need to be proved by experimentation to gain credibility. In this author's view, Contact Tracing is losing credibility at least in the case of diseases, which can spread by natural modes also without direct person to person contact.

2 Can COVID-19 Get Airborne?

For an aerosol science researcher, the answer to this question appears perhaps, easy and obvious, that being – yes, it can get airborne. Airborne could mean both floating and flying in the air, being carried by prevailing wind or natural air currents. To float in air, either an object should be light and have a density lesser than air or get supported by a device which can generate sufficient lift to overcome the gravitational force. Objects like airplane, helicopter or drones generate the lift through their aerodynamic surfaces like wings and/or propulsive devices. Birds and other flying insects also have similar propulsive mechanisms and aerodynamic surfaces for their sustenance in air through production of lift. However, these flying objects can also sustain in air without using their propulsion devices, at least for some time depending on their size and the nature of aerodynamic surfaces they have and depending on the ambient air currents or wind condition. Examples are airplanes and even big birds can glide and even navigate in air for some time depending on the wind condi-

tions. In fact, birds do not spend their energy for moving in air, when there are strong air currents and try to sail with those currents.

As the size of an object becomes small, the need for a propulsion system reduces and the ability to float in air and being carried by air current increases. Hence there is no reason why a virus or viral lump, which are micron sized objects cannot be transported by air. In fact, some viruses like the EBOLA virus have streamlined shape also, which reduces drag and aids locomotion. However, the drag of those small micron sized objects is so small that, the shape becomes immaterial for locomotion of the virus. Any body of fluid particularly when discharged from mucosal openings as a projectile, can contain small droplets (as in sprays), which can be carried away by air currents. Just as the outer layers in a fluid spray gets ripped off by shear forces, droplet size becomes smaller & smaller and finally the nucleus is transported by air currents, the viral droplets and its nucleus, which are the viruses themselves can be transported by air currents.

The COVID-19 virus being so small, even room air current is sufficient for transportation. If the patient is outside, faster air currents can take them much farther. Pollination & transport of pollens in plants is an analogous example. In fact, even few thousands of viruses huddled together as a lump can get transported by small room air currents. Fan, air conditioning system, even people moving in the room, opening and closing the door can all generate enough air current to lift them off of surfaces and transport them.

3 Are COVID-19 & Ebola Transmitted By Close Contact Only?

For entrance of any virus transported by a fluid or gaseous media, an inlet is required. In the human body, nose and mouth are the best inlets. In fact, the process of breathing in or swallowing by those organs also helps in aiding any virus to enter a human body. In fact, in the case of the EBOLA virus outburst in Africa during 2014, this author was surprised by hearing and reading incessant news reports and articles, that the virus does not get air borne and that it mostly enters through any cut or opening in the skin. This author in his paper [7] presented at the ASME Dayton Engineering Symposium raised serious questions concerning the medical community's understanding that EBOLA virus is transmitted only by close person to person contact. It had completely discarded all other natural modes of transmission (air, water & insects) and direct entry into the lungs through the nose. They had virtually ignored the science of Aerosol transport or Aerosol Science. Since EBOLA is a viral hemorrhagic disease, the easiest path for the virus to enter the blood stream is through the nose, respiratory tract and lungs. Hence the virus can be transported by air and then inhaled through the nose during the breathing in phase. The lung tissue is not only delicate enough for the easy passage of the pathogen, but is also a device for mixing outside air with blood. During this Oxygen – Carbon dioxide exchange process, there is no reason why the virus cannot mix with the blood and trigger the infection.

Similar earlier theories about the spread of COVID-19 through person to person contact is now getting dismissed gradually by many researchers presenting data and arguments contradicting those theories and establishing that it can spread through air. Bourouiba et al [8] have presented a detailed experimental and analytical work to describe the mechanism of spread of infection by viruses expelled during coughing or sneezing by any person. They have demonstrated as shown in Fig. (1), the mechanism of entrainment of the ambient air by the turbulent, multiphase jet spray generated during coughing and its growth and transport over considerable distances until they mix out completely with ambient air. They have used the above research and presented their findings in ref. [9] opposing the earlier claims by many researchers that COVID-19 spreads mainly by close contact between person to person. Another group of researchers, in their paper edited by Covaci [10], have also presented arguments in detail to prove air borne transmission. They also suggest proper ventilation for getting rid of the virus and replacing with fresh air as another important control measure which could reduce the spread of infection. This author not only supports the above researchers' views but in addition suggests not to rule out other modes of transmission (insects and water) also, until detailed experiments can disprove them.

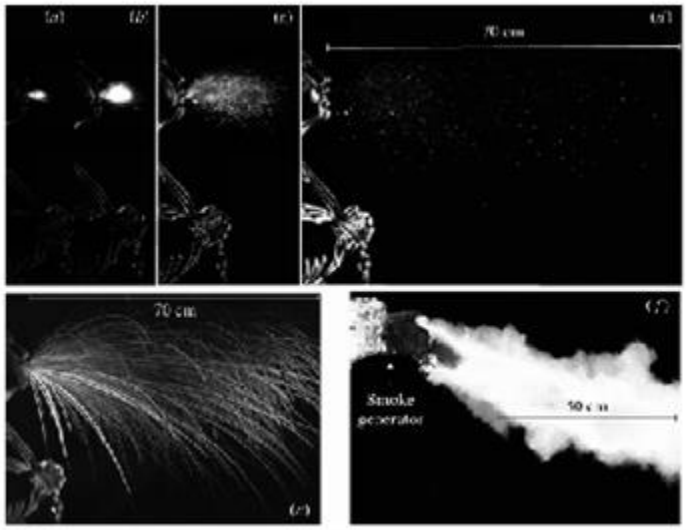

Fig. (1): High speed images of a cough recorded at 1000 frames per second (f.p.s.) reveal the dynamics of the expelled gas and liquid phases. The sequence is displayed for the times (a) 0.006 s, (b) 0.01 s, (c) 0.029 s, and (d) 0.106 s. (e) Large droplets are ejected and their trajectories shown in this streak image. (f) A typical cough airflow is visualized using a smoke generator and recorded at 2000 f.p.s. Note that (e) and (f) are the superposition of the instantaneous images of the droplets and cloud trajectories throughout the sequence.

Figure taken from Bourouiba et al; Fig. (3) of Ref. [8]

As described in some of the above references, it is not only from mere theoretical arguments, but experiments have been conducted by researchers to prove the possibility of air borne transmission of viruses. Similar experiments can be done to determine the possibility of transmission by insects and water. Experiments can be devised to establish the survival of viruses in various types of external environments and their transport by air, water and insects.

Realistically it is almost impossible to prove the mode of entry of infection of a human being by a virus or bacteria, as its path of entry and the triggering of the disease symptom inside a human being cannot be monitored on a real time basis. Hence, when a virus can survive outside the body of a human being, it is not easy to ascertain or prove the mode of transmission into human beings. This is particularly important when several types of infectious diseases are prevalent, several types of pathogens are present in the environment, and they are spread by one or more transmission modes. For all the above reasons it becomes important to be open and vigilant about the ways a disease can spread in a community rather than sticking to unproven popular theories proposed without any scientific basis.

4 Can Contact Tracing Predict the Spread of COVID-19?

Doctors normally assume infectious diseases are generally spread by close contact. Contact is a vague terminology. Although the literal meaning implies touching one another, from an epidemiologists point of view, human beings a few feet apart are also assumed to be in close contact, particularly for the spread of an infectious disease and hence for Contact Tracing. However as explained in the above section, it does not mean that infection cannot be spread by other natural modes. The technique of Contact Tracing has become a panacea. Epidemiologists, statisticians and applied mathematicians have tried to propose various theories and models for the spread of infection based on human behavioral observations concerning individual and group mingling. Thus Contact Tracing has not only become a big, developing field but an important employment sector also. Some governments with the help of the medical community support this sector to get some data and suggestions for formulating control measures to curb the rate of spread of any disease.

However, as explained in earlier sections, for Contact Tracing predictions to hold good, the disease path way from one human being to another has to be tracked, monitored and established, which is extremely difficult. This becomes all the more important if the virus or bacteria in question can survive outside the human body and can be carried away by air, water or insects. When the virus can live outside, it has all the freedom to go wherever it wants! Hence no one can be certain that a person in close proximity who emitted the virus is responsible for the neighbor catching the disease. The person in close proximity could have been infected by the virus emitted by another person far away (say several 10's of meters), if it can be carried by air. The infection could have come through water or insects also. Even ascertaining and establishing the mode of infection becomes extremely difficult, particularly when a pathogen is susceptible for transmission though all modes.

The conventional understanding is that Contact Tracing works well in countries with a small population and lower density of living. Further, even in countries with large population, it could work at the beginning and ending stages of the spread of a pandemic. However, the arguments presented in the above sections does not support that view. Even the assumption that STD infections like AIDS spread only by direct contact could pose problems for Contact Tracing, if there are a considerable number of asymptomatic persons. Hence Contact Tracing appears to be a highly unreliable technique. As a consequence, many mathematical models and analysis based on or using the data from Contact Tracing becomes questionable. This could be one reason why many governmental policies, plans and control measures based on such model predictions do not work well. In the present case of COVID-19 for example, adhering to physical distancing of 1 – 2 m was proposed by various governments, which does not help. In fact, even aerosol science experiments or computational fluid dynamics cannot suggest any particular distance, as the range and direction of motion of the virus depends on the ambient environmental conditions. This does not mean that there is no problem in persons huddling together, as when persons are close by, if one of them coughs or sneezes or even during a loud talk, the virus can escape through the gaps between the mask and the face and infect another person. However, the use of mask and good ventilation in buildings to remove the virus and replace with fresh air are perhaps the most important measures to control the spread.

However, tracking to understand the locations where a pandemic has already spread is possible, as this is purely based on statistical data collection and no guess work concerning the transmission mode is involved. This data could be used for analyzing group behavior and policies and protocols can be proposed as measures to control the spread.

2 Conclusions

This paper has presented scientific arguments supporting the recent proposals to abandon the present conventional understanding that infectious diseases like EBOLA, COVID-19, etc. are spread mainly by close contact, while ignoring other modes of transmission like air borne transmission, which is equally important. The paper further extends this knowledge to deemphasize the technique of Contact Tracing, which is perhaps responsible for some of the wrong protocols promoted by some policy makers. On the other hand, it emphasizes the importance of experimentation and advocates researchers and policy makers to keep an open mind and consider all modes of transmission of any infectious disease until good experimental data becomes available.

5. References

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