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Thinking about aerosol-transmissible diseases in healthcare settings.

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Is It Time To Declare Ebola an Aerosol-Transmissible Disease Requiring a Respirator?

My recent Commentary published on the CIDRAP website discussed whether Ebola could be an aerosol-transmissible disease. My colleague and I described a number of features of an organism that would make it aerosol-transmissible.

After we published this Commentary, however, it quickly became clear that many people struggled with the notion that infectious organisms could be transmitted by aerosols located near a source. And it was clear that they didn't agree with our argument that the standard infection control paradigm of "droplets" and

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"airborne" doesn't fit with current knowledge about aerosols.

After trying unsuccessfully to get the Pro-Med website to publish a follow-up to our Commentary, Dr. Raina MacIntyre posted our further explanation of aerosols on her Infectious Diseases Blog at the University of New South Wales.

I would like to thank the many people who have written and called me about these posts.

But it seems that further details and repetition are necessary, as the blogosphere seems intent on disparaging the term "aerosol" in favor of almost anything else – including new terms with no scientific meaning.

So the goal of this blog is to explain, once again, what I – and many other scientists – mean when we use the term "aerosol."

First, I must note that the word "aerosol" is not an "esoteric" or unusual term — in fact, there is a whole society dedicated to the study and use of aerosols: the American Association of Aerosol Research (www.aaar.org), which was founded in 1982 by a group of renowned scientists. I recommend visiting the AAAR website, where you will

discover that this organization plays an important role in fields as diverse as toxicology, air quality, atmospheric science, pharmaceuticals, new materials development, etc.

What aerosol scientists have found is that when a liquid such as blood, urine, vomit, mucus, etc. is emitted with force, a liquid spray aerosol is created. Sprays generally contain particles in a wide range of sizes. They are created by applying a force that breaks a liquid into small particles that are dispersed into the air. Sprays are used in a lot of applications — coating surfaces (e.g. spray painting cars), delivering drugs (e.g. asthma inhalers), using cosmetics (e.g. hair spray). And sprays are created by a lot of human processes (e.g. coughing, sneezing, diarrhea, vomiting) and medical procedures (e.g. bronchoscopy, intubation, etc.).

Spray aerosols undergo a number of simultaneous processes:

1. The liquid (water) portion evaporates (very quickly), which means, overall, the aerosol will consist of smaller particles than when it was first created. This happens within milliseconds, while the aerosol is still near its source. **The result – inhalable particles near the source**

(patient) and in the breathing zone of a healthcare worker.

2. All of the particles will begin falling toward the ground (some more quickly than others depending on their aerodynamic diameter, which is determined by size, shape and density). This doesn't mean, however, that most of the particles will immediately drop to the ground – as we often hear from infection control professionals who insist that the big "droplets" near a source will rapidly fall to the floor. That will only happen for the very large particles. Many of the particles in a spray aerosol will continue to be suspended in the air for many minutes or hours as they are slowly settling due to gravity. **The result – inhalable particles near a patient and in the breathing zone of a healthcare worker.**
3. Particles are picked up by air currents and travel along with these currents. In most rooms, the travel of air will be from the air inlet (often in the ceiling) to air outlets near the floor. This type of ventilation is supposed to result in a well-mixed air space, dilution of gas and particle concentrations, and removal of unwanted contaminants. In most cases, however, there will be "short-circuiting," which means that particles can remain suspended for lengthy periods of time in pockets of air that are not well-mixed. This means that some particles (especially the smaller ones) could remain suspended in air near their

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source well beyond their gravitational settling time. **The result – inhalable particles near a patient and in the breathing zone of a healthcare worker.**

4. Very small particles will be bombarded by air molecules, which causes them to move randomly and eventually disperse throughout a space – this is called diffusion. **The result – smaller inhalable particles distributed throughout a room, including near a patient — and in the breathing zone of a healthcare worker.**

So, it should be clear that the "droplet" and "airborne" paradigm just doesn't cut it. The big particles don't just drop to the ground. And the small particles don't rapidly travel to the far reaches of the room. Close exposure to small particles is not only possible, it is likely the cause of frequent disease transmission.

The question to ask someone who insists that a disease will only be transmitted by "direct contact" is — how do they know? Because you can't tell the difference between an infection that is transmitted by a droplet "propelled" directly into the nose or deposited from the hand into the mouth — and one that is inhaled into the nose or mouth when standing near the source of a spray

aerosol. Let's say that again — there is no human epidemiology study that is going to elucidate which of these modes of transmission is responsible for an infection.

So how do we know that some diseases are able to transmit disease through inhalable particles? In the case of tuberculosis, although scientists conjectured that aerosols might be responsible for disease transmission, it was only after a series of innovative animal experiments by Dr. William Firth Wells that we had incontrovertible evidence for aerosol transmission.

In other cases, everyone in a space – both near and far – was infected by a single person with the disease. This has been shown for chickenpox, measles and norovirus, none of which cause respiratory infections. While we know these diseases are aerosol-transmissible, we don't entirely understand HOW they accomplish transmission. Meaning – we don't know very much about the exact source of the aerosol or how that aerosol causes disease in a nearby person.

Clearly, generating an aerosol and inhaling an infectious organism are only two parts of the puzzle about aerosol-transmissible diseases. Dr. Jones and I discussed other types of

evidence for aerosol transmission of Ebola in our Commentary, including the viability of the organism in air at room temperature and humidity, receptors for the organism in epithelial tissues, animal data showing infection via aerosols and scientific reports of aerosol transmission from one non-human primate species to another. All of these FACTS contribute to the evidence that Ebola is an aerosol-transmissible disease.

I will explore this topic in later posts.

The key messages I wish to emphasize here are:

1. Liquid aerosols (sprays) create particles of all sizes that can easily persist near the source and can be easily inhaled by someone standing near the source.
2. There is no easy way to tell the difference between transmission that occurs by "direct contact" (with droplets or via hands) and aerosol inhalation.

What does this mean for Ebola virus disease?

The risk factors for Ebola – caring for an infected person, sharing a bed, funeral activities, and contact with blood or other body fluids – do not rule out aerosol inhalation in favor of

any other type of disease transmission. All of these could include nearby exposure to liquid sprays, which could be inhaled. So the best we can conclude from these risk factors is that the modes of transmission include direct contact AND aerosol inhalation.

And if this is the case, then a respirator is the only option for protecting healthcare workers from Ebola aerosols.

It is time for CDC and WHO to give serious consideration to aerosols as a route of transmission for Ebola – and stop blaming healthcare worker infections on their failure to follow protocols. Instead, the blame rests with organizations that can't let go of an incorrect paradigm and recognize that their protocols are inadequate and will not protect healthcare workers from exposure to infectious aerosols.

In the meantime, I strongly urge healthcare workers to insist on respirators and training in how to use and wear them for all encounters with Ebola or suspected-Ebola patients.

Tags: aerosol, aerosol transmissible disease, airborne, droplet, Ebola transmission, health care, infection control, infectious disease, transmission | Permalink.

Top