Aerosols: Why do I need to be aware of them if I work with biohazards?

Aerosols are solid or liquid particles suspended in air. In laboratories they are created anytime energy is imparted to a culture.

During the COVID-19 pandemic everyone learned a great deal about aerosols as a factor of how the coronavirus is transmitted.

There are many factors that impact aerosol formation, spread, survival and transmission. We'll focus on a few simple ones, size and weight.

Larger aerosols will settle or fall out of the air relatively quickly after they are created. Think of "bowling balls." These heaver particles present a risk of surface contamination and cause exposure by directly contacting facial mucous membranes, and open wounds. By contaminating surfaces and items, they present a risk of self-inoculation if touched by a researcher before these surfaces are disinfected.

Smaller aerosols (think feathers and very tiny specs of dust) are the ones that are a more significant problem if generated in a laboratory. Very small aerosols have the potential to remain suspended in the air of the lab where they have been created or they can move to other places on air currents, sometimes far away from the location where they were they were generated. The small invisible microscopic sized aerosols are a greater risk of airborne transmission.

Up to 80% of the published laboratory acquired infections have an unknown route of exposure. Aerosols are likely a contributing factor in many of these infections.

Early biosafety pioneers identified that labs can be more dangerous than nature, due to the amplification of pathogens in research and the repeating of experiments over and over. Lab spaces are also confined when compared to the massive ventilation of outdoor areas. They also identified that you can have unnatural routes of exposure in the laboratory. These pioneers were also in agreement that in the laboratory environment, aerosols must be confined as close as possible to their point of generation.

The first two laboratory acquired infections with rabies virus were transmitted by aerosols created outside of primary containment. It is likely that the aerosol generating procedure (homogenization of rabid goat brains that were not sufficiently fixed in a standard kitchen blender that lacked containment) created airborne viral particles that were inhaled by the researchers. These aerosols likely had a direct avenue to the brain of the researchers through cranial nerves (olfactory and trigeminal) located in the nasal cavity. The following references provide more information on "unnatural" routes of exposure if you are interested.

What laboratory procedures create aerosols?

All of them! All lab procedures have the potential to create aerosols. Factors to consider are the amount of energy imparted, the volume of liquids and the length of the laboratory procedure (e.g. the amount of individual or repeated manipulations). Here is a brief look at some of the procedures that have been linked to aerosol creation and risk of infection in the laboratory.

Centrifugation

The high speeds and revolutions associated with centrifugation presents a significant risk of aerosol dissemination and risk of exposure to researchers. The use of open tubes, cracked tubes, snap-cap tubes that are not sealed, inappropriate or expired tubes, overfilled tubes, not using secondary containment or overfilling tubes are examples of risk factors when centrifuging biohazards.

Most centrifuge manufacturer's have designed leak-proof secondary containment safety buckets or have gasketed sealed rotors to confine aerosols if they were created from a leak during a centrifuge run. These safety buckets and sealed rotors are then designed to be opened inside a biosafety cabinet which would further contain any aerosols if there had been a leak inside the centrifuge during a run with biohazards.

Porton Down labs in the UK it the leading test agency for containment of centrifuges. They utilize a protocol that involves a cracked tube and then examines if the secondary containment buckets or rotors will contain the leak. Look for Porton Down certification of your safety bucket or sealed rotor when purchasing new centrifuges. You can also call the EHS Biosafety Office for assistance with your centrifuge containment questions.

Pipetting

Pipetting is done day in and day out in microbiological and biomedical laboratories. Most performing these procedures are unaware that pipetting also can create aerosols, especially if laboratorians are working too quickly and not carefully. Dr. Mark Chatigny counted the aerosols generated from researchers at the NIH in one of his studies and the results were eye-opening. See the table below to look at the risk that pipetting biohazards may represent in your laboratory. Use a biosafety cabinet to confine aerosols when pipetting them.

Recovery of Aerosols from Pipetting

Cell sorting

High speed cell sorters use very high pressures to create a single stream of individual cells for separating specifically labeled cells for research purposes. Some of these units can represent a significant risk of aerosol formation if there is a clog or deflection during a sort.

The following video demonstrates how significant the aerosol formation can be.

Companies that make cell sorters have built in containment features and have worked with other companies to develop enclosures that help confine aerosols within the cell sorter when in use.

ISAC also has a lot of biosafety information for researchers regarding containment when sorting biohazards.

Spills

Kenny and Sabel, in their 1968 study where they dropped a flask of culture then measured the aerosols created by this action, led biosafety officers to create emergency spill response protocols to have everyone immediately evacuate the laboratory in the event of a spill or release of biohazards outside of

primary containment. Alan Bennet of the UK has also studied biohazard aerosols in a variety of different spill scenarios to continue to demonstrate the risks that spills present to those.

Kenney and Sabel, 1968

Aerosols from Lab Spill Video

If a spill occurs involving a biohazard in your laboratory, please get everyone out and notify Yale EHS of the incident on the EHS emergency line at 203-785-3555.

Homogenizing, vortexing, blending

There are many other equipment risks for aerosols in the laboratory. Due to the potential energy imparted, these three procedures may also represent a significant risk. Wherever possible, these procedures should be performed within a biosafety cabinet. Contact the Yale EHS Biosafety Office for more information on containment for homogenizers or blenders if needed for use with biohazards.

How do we control or confine aerosols?

Performing all procedures that generate aerosols inside a biosafety cabinet is the primary way that we can work safely in the laboratory. If procedures are performed on the bench, practices must be performed very carefully and meticulously to minimize aerosol formation and spread. Please work with the Yale EHS Biosafety Office to have your procedures evaluated before working with biohazards on the bench.

Take a look at the following resources for how to confine aerosols when working with biohazards.

BSL2 enhanced work practices video

https://ehs.yale.edu/trainings/bsl2-enhanced-work-practices

Biosafety Training Part 1 and Part 2

https://ehs.yale.edu/trainings/biological-safety-training-part-1

https://ehs.yale.edu/trainings/biological-safety-training-part-ii

Safety and effective use of the biosafety cabinet video

https://ehs.yale.edu/safe-use-biological-safety-cabinet

BSL2 enhanced work practices handout (pictorial and words)

https://ehs.yale.edu/sites/default/files/files/bsl2-work-practices.pdf