ARCHAEOLOGY IN THE POST-COVID-19 ERA

IMPLEMENTING PERSONAL PROTECTIVE EQUIPMENT (PPE) AT ARCHAEOLOGICAL SITES

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The year 2020 brought with it many challenges and changes to our daily lives because of the global COVID-19 pandemic, including a growing awareness of the use of personal protective equipment (PPE) to prevent contact with environmental hazards. As much as PPE protects people in their everyday lives from contracting the virus, it also provides invaluable protection from environmental contaminants during archaeological projects. In light of the potential exposure to COVID-19 and contaminants, and the serious long-term health consequences that can occur, PPE use and standardized health and safety practices should be part of every archaeology project, not just those located in industrial contexts. Our results from utilizing this type of health and safety plan for archaeological research in Peru have recently been published online (Kennedy and Kelloway 2020a, 2020b, 2021). We will not summarize those articles here but will instead concentrate on the specific issue of PPE usage and implementation in archaeological projects around the globe.

COVID-19 and Archaeology

Given the widespread usage of PPE during the global COVID-19 pandemic, now is the ideal time to develop standardized health and safety practices for archaeological projects, including implementation of PPE. Mask wearing and PPE usage have never been more pronounced. Because COVID-19 is a highly contagious, droplet-spread virus, risk mitigation efforts have focused on basic health guidelines that archaeologists can easily adapt. In addition to mask wearing, these include social distancing and elimination of large gatherings, as well as frequent handwashing and staying home when sick.

For archaeologists, COVID-19 guidelines have had varied impacts to projects. In some cases, international research projects were halted due to bans on international travel. Although domestic projects were also initially shut down, many have since resumed, using newly developed health and safety plans. These include the implementation of PPE, such as face masks, face shields, and gloves, as well as workplace adjustments. Additionally, laboratory spaces have been redesigned for social distancing with access limited to a few people at a time. Laboratories also limited or eliminated the sharing of PPE and frequently wiped down shared equipment and surfaces with disinfectant. In best-case scenarios, employees who felt unsafe on the job were not required to go to work, and employers developed health and safety plans considering the comfort level and concerns from their staff.

Now more than one year into our post-COVID-19 lives, widespread vaccine inoculation in the United States is well underway, especially in high-risk populations. Many archaeologists are now looking to resume large-scale excavation projects and field schools in the coming months. As awareness of health risks to archaeological workers and volunteers is currently very high, archaeologists must conceive of and implement best practices and mitigation efforts to limit health risks at archaeological sites. Although this includes the use of PPE in excavations and laboratory settings, it should also encompass other health risk prevention measures.

A recent special issue of *Advances in Archaeological Practice* (Klehm et al. 2021) has tackled many of these issues. Articles in that compilation provide a variety of approaches to health and safety plans, including wilderness first aid, mental health training, medical kits, and heavy metal testing. Other recent publications have outlined ways to combat sexual harassment and bullying in archaeology and suggest adding codes of conduct and interpersonal training to archaeology health and safety plans (Voss 2021a, 2021b). While our article focuses primarily on heavy metal testing and PPE, we note that these are only part of what should be considered in a comprehensive wellness plan for all archaeological projects.

Identifying Risky Conditions

During our 2018 research at the colonial silver refinery of Trapiche Itapalluni (AD 1650–1800) in Puno, Peru, we planned

our work with the understanding that heavy metals were likely present, due to the site's industrial past. Through soil testing as part of a geochemical survey, we identified toxic levels of lead and mercury in surface soils across the site, necessitating the use of PPE. Other obvious sites related to heavy metals include mines, refineries, forges, and furnaces, as well as locations used for ad hoc smelting, heating of minerals, and metallurgical experimentation—all worthy of soil testing prior to excavation.

Other, less obvious sites that should be considered as potentially contaminated by heavy metals include cemeteries, which can contain lead coffins and grave goods. Arsenic may also be present at historic cemeteries, as it was a common embalming agent during the nineteenth century (Meyers et al. 2021). Further, any archaeological site near modern mining and industrial waste sites are also susceptible to heavy metal contamination, as well as sites near agricultural fields and crops, greenhouses, and urban areas, including playgrounds (Scott et al. 2013; Tian et al. 2018). Sites containing twentieth-century buildings have also been shown to contain asbestos, as well as lead dust related to lead paint and fixtures.

In addition to possible locations of heavy metal poisoning, PPE usage would be especially helpful for archaeologists working in other risky conditions. For example, silicosis is a deadly lung disease caused by breathing in small particles of silica, found in rocks and soil. This is a chronic disease that develops over decades and can predispose individuals to lung cancer (American Lung Association 2021). Although archaeology is not currently a profession deemed to be high risk for silicosis, constant exposure to dust in archaeological excavations and laboratories is a cause for concern.

Further risks that can be mitigated with PPE include wildfires, air pollution, and cave-borne diseases. Wildfires and air pollution cause small particles to remain in the air, leading to health issues such as heart and lung disease, and even death (U.S. Environmental Protection Agency 2021). Caves and rock shelters are also prone to airborne infectious diseases, such as histoplasmosis and leptospirosis, which can be mitigated through proper use of PPE (Pereira Igreja 2011). PPE can also prevent the transmission of rabies and tick-borne diseases.

Health Risks from Heavy Metals

When possible, all archaeologists should test soils at their sites for high levels of heavy metals, given that they can occur in a variety of contexts worldwide. Additionally, all projects should implement PPE for both excavation and laboratory work. Without proper protective measures, long-term exposure to heavy metals, especially arsenic, lead, and mercury, can lead to brain and nervous system damage, cancer, multiple organ failure, and even death (U.S. Agency for Toxic Substances and Disease Registry 2021).

Like airborne/aerosolized pathogens such as COVID-19, heavy metals present the highest risk to archaeologists through their presence in airborne contaminated dust. Ingestion of contaminated dust tends to occur through respiration, or through touching contaminated hands to the nose or eyes. Because of the airborne nature of dust at archaeological sites, protective glasses and N95 particulate-filtering masks are the most important PPE archaeologists can implement. Some contamination can also occur through direct skin contact, which makes the use of gloves and long pants and shirts important as well.

Using pXRF to Test for Heavy Metals

PXRF (portable X-Ray fluorescence spectrometry), a highly accessible and relatively inexpensive technology, is a great option to test soils prior to excavation. XRF spectrometry determines the chemical composition of materials (such as soils), and the handheld aspect of pXRF instruments enables their use in the field. In archaeology, pXRF has been popular for the chemical characterization of obsidian, metal, and ceramics; however, its use in soil analyses has great potential for risk assessment as well.

We recommend the use of pXRF for soil testing and risk assessment for a number of reasons. First, pXRF is commonly used to test toxic levels of heavy metals in modern urban and industrial contexts, and the methodology is easily applicable to archaeological settings. PXRF testing is also relatively inexpensive, as many archaeological projects, cultural resource management (CRM) companies, and universities have already acquired a pXRF instrument, making instrument access or rental easily achievable. PXRF instruments are small and portable, and analyses are nondestructive. It is entirely possible and plausible to rent a pXRF instrument for one week prior to excavation, use it to test soils, and make real-time decisions about unit locations, PPE use, and health and safety protocols. Because pXRF spectrometers also emit ionizing radiation, this risk should be managed through appropriate training and use protocols. National and local radiation authorities and their guidelines must also be considered.

Our 2018 pXRF soil testing of surface soils (Figure 1) revealed high levels of seven heavy metals, and four of these (arsenic, antimony, mercury, and lead) exceeded safety hazard standards for soil levels outlined by the U.S. Environmental Protection Agency (EPA). Following these results, we developed a health and safety plan for our project. This included (1) estimating human exposure risk to heavy metals using the EPA's regional screening level (RSL) calculator; (2) not excavating in areas that tested high for exposure; (3) relocating contaminated excavation units when possible; (4) implementing the use of PPE for project workers, including plastic protection glasses, N95 respirator masks, gloves, boots, and long pants and shirts; and (5) requiring the washing of boots, hands, and faces prior to

Figure 1. Sarah Kelloway uses a pXRF spectrometer to test surface soils for heavy metals prior to excavations at Trapiche. (Photo by Sarah A. Kennedy.)

leaving the excavation site, as well as the removal of PPE prior to entering vehicles and homes (Figure 2).

Challenges in PPE Use

There were challenges to PPE usage among our team, although our project occurred in 2018 prior to the COVID-19 pandemic, so some of these problems may be easier to address in current contexts. Proper N95 mask usage was the most challenging PPE measure to implement, followed closely by the proper use of clear protective eyeglasses. Both masks and glasses tended to break easily, and glasses fogged up and made vision difficult. Glasses also slipped down noses due to sweat or poor fit. Mask straps often broke, and workers tended to pull masks down to their chins to talk. Sometimes masks were only used to cover mouths, leaving noses uncovered. Due to budget limitations, we often had to extend the use of a single N95 mask for 3–4 days per person, which was not ideal.

Glove use was mixed. Many team members liked to wear gloves to avoid dirt and blisters. Others found them cumbersome, due to poor fit. Often, gloves had to be removed to take notes or photographs, which made their constant use difficult. The easiest PPE measures to adapt were long pants, long shirts, coveralls, boots, and hats. This was likely due to the cold climate of the site area in southern Peru, which was located at 13,000 feet (4,000 m) in elevation. Hats and sunglasses were also easy to implement, due to intense sun radiation at high altitude. Frequent handwashing was also common and practiced among all team members. This was easily achievable as our excavation site was next to a river, and project members brought soap.

Figure 2. Trapiche team members (from left to right) Julia Sjodahl, Javier Chalcha, and BrieAnna Langlie demonstrate PPE usage in excavation and laboratory settings. (Photos by Sarah A. Kennedy and BrieAnna Langlie.)

The length of time spent hand-washing did vary, and proper handwashing guidelines (at least 20 seconds) should be communicated prior to the start of any project.

The challenges to PPE usage that we faced on our project were very similar to early barriers faced by healthcare workers during the COVID-19 pandemic, as many health systems required health care providers to reuse masks for multiple days or to provide their own. Education on proper mask wearing has also been a significant public health issue, as many people find it uncomfortable to wear a mask over both their nose and mouth for multiple hours a day. For future archaeology projects, mask compliance may be easier than what we observed in 2018 because there now have been and are still several global public health campaigns emphasizing these issues, and mask usage has become normalized during the pandemic.

Access to high-quality masks, especially those that filter out harmful particles, has also been a challenge faced during the pandemic. Many people have had to make their own cloth masks, resulting in issues with proper fit and filtration. The U.S. Centers for Disease Control and Prevention (CDC) currently recommends the use of two masks, or masks with multiple layers, to prevent the escape of respiratory droplets. Other mask adjustments include masks with a nose wire to prevent leakage from the top of the mask, masks with additional nose fitters or braces to prevent leakage on the sides of the mask, or the addition of a nylon stocking over a mask to improve overall snugness and fit (Godoy 2020; U.S. Centers for Disease Control and Prevention 2021a).

If archaeological projects find it difficult to obtain sufficient N95 masks in the coming years, these mask adjustments could provide alternatives until higher-quality particulate masks become available. Even the use of bandanas, sunglasses, and eyeglasses would be preferable to no protection. Tighter-fitting protective glasses, or straps attached to glasses, would also be inexpensive ways to improve eyeglass protection and fit.

Lessons from Medicine

Archaeologists can learn much from our medical colleagues as we prepare to work in a post-COVID world. There has long been a practice in medicine to use what is referred to as "standard precautions" in the workplace. The CDC defines standard

precautions as the "minimum infection prevention precautions that apply to all patient care, regardless of suspected or confirmed infection status of the patient, in any setting where healthcare is delivered" (U.S. Centers for Disease Control and Prevention 2021b).

Standard precautions commonly refer to concepts such as hand and respiratory hygiene and PPE usage, regardless of known risks. Healthcare providers are also routinely provided education and training regarding these standard precautions. Archaeologists should learn from these practices and set up their own "standard precautions" for fieldwork, no matter where projects are located and no matter what type of deposits they contain. We should also implement these standard precautions in laboratory settings, as has long been standard practice in healthcare and the biological sciences to protect workers from handling materials from contaminated sites.

A silver lining to the COVID-19 pandemic has been increased global and cultural understanding of PPE, and archaeologists should capitalize on this awareness to help mitigate future risks of other exposures, like heavy metals. Below are best practices and guidelines for future archaeology projects, drawing from lessons we have learned in our prior projects. Again, although we focused on heavy metal testing and PPE usage, we endorse suggestions from our archaeological colleagues (Klehm et al. 2021; Voss 2021a, 2021b) that utilize a comprehensive wellness approach to health and safety, incorporating harassment training and mental health support, among other practices.

A "Best Practices" Guide for Future Projects

Before

- Identify risky conditions.
- Develop a health and safety plan.
- Develop a code of conduct.[1]
- Ask team members and participants to share their concerns.
- Communicate health risks to all employees, volunteers, and community members.
- Provide relevant training (pXRF,[2] CPR, first aid,[3] sexual harassment,[4] mental health[5]).
- Develop and stock a comprehensive medical kit.[6]
- When possible, test soil, water, and air quality of research area.[7]
- Soil testing with pXRF[8] is a good option to provide rapid, real-time results, and pXRF findings can be compared with soil toxicity ranges and recommendations made by the EPA and other agencies.

During

- Regularly review the health and safety plan and check in with team members.
- Use PPE[9] when near other people, when excavating, and in the lab. This should always include the use of face masks that cover the nose and mouth but should also consist of gloves, protective glasses, and long sleeves and pants.
- Implement basic hygiene in all working and living spaces, such as frequent handwashing, wiping down and sanitizing equipment and frequently used areas with disinfectant (80% ethanol solution), and staying home when sick.
- Make soap and hand sanitizer freely available.
- Practice social distancing.

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Notes

1. See Voss 2021a, 2021b.
2. See Kennedy and Kelloway 2020a, 2021.
3. See Hawkins and Winstead 2021; Peixotto et al. 2021
4. See Voss 2021a, 2021b.
5. See Eifling 2021.
6. See Hawkins and Simon 2021.
7. See Kennedy and Kelloway 2020a, 2021; Meyers et al. 2021.
8. See Kennedy and Kelloway 2020a, 2021.
9. See Kennedy and Kelloway 2020a, 2021.

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