IUCN SSC BAT SPECIALIST GROUP

GUIDELINES FOR FIELD HYGIENE

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EXECUTIVE SUMMARY

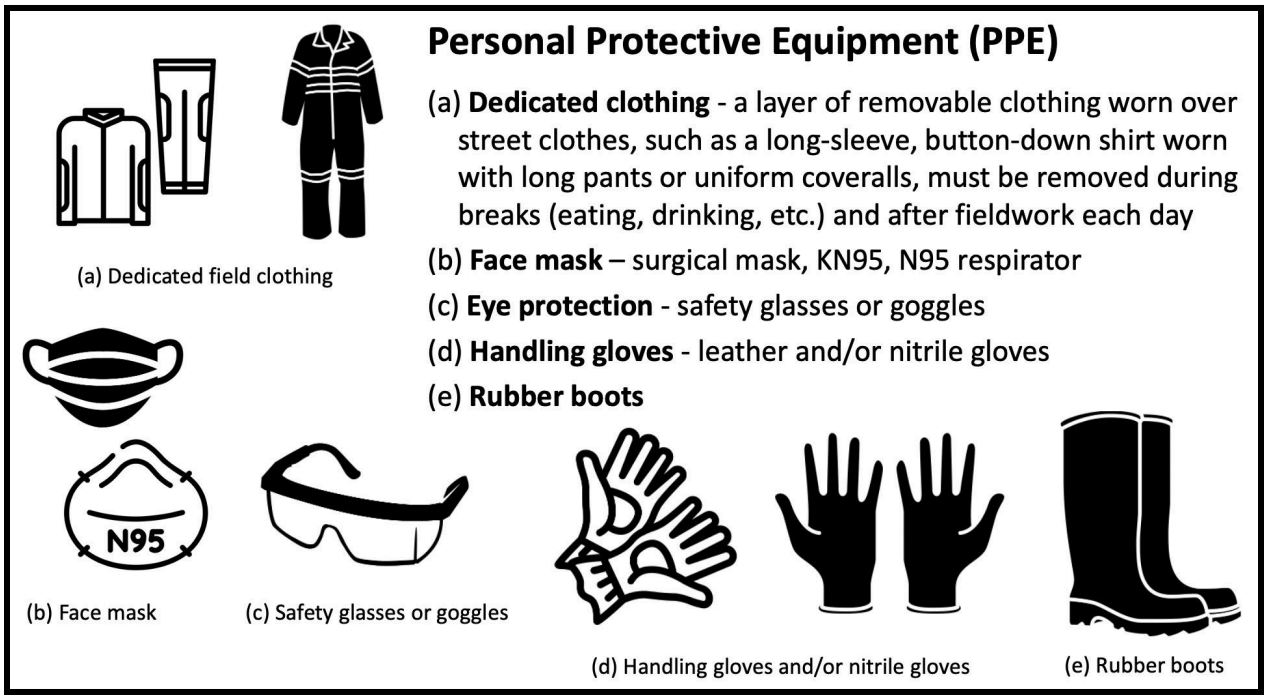
These guidelines are intended for all people who do fieldwork with bats in the field anywhere in the world. They update our previous IUCN Bat Specialist Group guidelines, which were developed specifically to address bat-related fieldwork during the COVID-19 pandemic. These guidelines address "ordinary" circumstances and aim to minimize the risk of pathogen transmission in all directions – humans to bats, bats to humans, and between bat species or populations, facilitated by humans. **These guidelines exist as much to protect bat populations as the humans who study them.**

The guidelines require an assessment of the risk of zoonotic disease exposure based on location, the bat species encountered, and research activities. Under most circumstances, if you are working in close proximity (< 2 meters) to bats or within or under roosts in the field, you should:

- Secure approval from **all** relevant bodies (regional and/or national regulatory bodies or permitting agencies, your institution, etc) for all planned activities
- Be fully vaccinated against rabies and establish anti-rabies titers if possible. Where establishing anti-rabies titers is not possible, a rabies booster is required every few years[1,2]; consult your physician and follow the guidelines of your medical authority for specific schedules
- Be fully vaccinated against SARS-CoV-2 with the most up-to-date vaccine available to you
- Check for symptoms of infectious disease daily (e.g., fever, sore throat, sneezing, coughing, congestion, etc.), and do not work with bats if you have any symptoms
- Use BASIC PPE (disposable gloves, mask, dedicated field clothes, and closed-toed footwear that can be disinfected; eye protection is highly recommended but optional)
- Disinfect all equipment and tools
- Do not blow on bats
- Keep bats in individual, clean bags
- Do not eat, drink, or smoke in proximity to bats
- Dispose of all biohazardous waste appropriately

For fieldwork posing a higher risk of potential pathogen transmission, follow all of the above **AND**:

- Use BASIC PPE+ (disposable gloves, fitted N95 or equivalent mask, clothing that is disposable (e.g., Tyvek) or can be sprayed down with disinfectant (e.g., weatherproof rain suits), eye protection, and closed-toed footwear that can be disinfected)



Personal protective equipment (PPE) to be worn during fieldwork with bats. Basic PPE includes dedicated field clothing, gloves, a mask, and shoes that can be disinfected. Eye protection is optional but highly recommended. BASIC+ for higher-risk situations adds disposable or sterilizable clothing, higher-grade mask or respirator, and mandatory eye protection.

The guidelines are organized around actions (steps) to be taken before, during, and after fieldwork.

Before Fieldwork

Step 0: Secure institutional compliance, permits, and vaccinations.

Step 1: Evaluate potential transmission risks between bats and researchers using available information about: (1) geographic region; (2) bat species that occur in your study area and any known or likely pathogens that those species may carry; (3) level of risk posed by your research activities, including consideration of the activity

location (e.g., enclosed roost vs open air).

➔ *Be aware that data is still lacking for many bat species in many regions of the world and bat populations may host as-yet unknown pathogens.*

Step 2: Use the level of risk (Step 1) to select appropriate Personal Protective Equipment (PPE).

Step 3: Prepare PPE needs and a Field Safety Plan in advance of fieldwork. This should include a protocol for daily symptom check (fever, congestion, coughing, sneezing) and a strategy for monitoring illness or symptoms after fieldwork for all team members

Step 4: Train all personnel in the use of PPE and the Field Safety and Hygiene Plan.

During Fieldwork

Step 0: Check team health and readiness before each night of fieldwork.

Step 1: Establish separated working spaces, with distinct and separated areas for living (if camping/eating) and working with bats.

Step 2: Prepare the processing station(s).

Step 3: Bat collection.

Step 4: Bat processing.

Step 5: Bat release.

Step 6: Lab space cleaning and breakdown.

Once Fieldwork is Completed At a Site

Disinfect all equipment and clothes, properly dispose of biohazard waste and sharps, and check that the processing area is clear of any debris. Stay in contact with all team members and monitor team health.

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INTRODUCTION

Over the past decades, there has been a remarkable growth of interest in and research on bats. While this has been a positive development, it has also put more people in closer contact with bats. As a precaution during the COVID-19 pandemic, the IUCN Species Survival Commission's Bat Specialist Group (BSG) convened a working group, now known as the IUCN BSG One Health Working Group, to provide recommendations and guidelines for minimizing the risk of transmitting SARS-CoV-2 (the virus that causes COVID-19) to bats when working with them. The most recent, revised guidelines for researchers were released in July 2021 and are available on the IUCN BSG website.

However, since then, there has been a growing recognition of the need for more general guidance on best practices for working with bats outside the specific context of the COVID-19 pandemic. Therefore, we have developed the following guidelines to promote safe research practices in general that protect bats from people and the pathogens we may spread to them, as well as people from the pathogens that bats may carry.

Bats, and disease and pathogen pollution

Bats, like nearly all mammals, may carry microbes, including viruses, bacteria, or other parasites, that could potentially infect people. However, there are ~1500 known bat species, distributed on all continents except Antarctica. Different bat species in different regions generally host different microbes, and the distribution of potential pathogens may vary throughout the range of any given species[3]. In contrast, some pathogens, such as the rabies virus and other members of the genus *Lyssavirus*, may be found in many different species and much of the world[4]. While the risk of becoming infected with a bat-borne disease is generally low, the consequence (or impact) of the transmission of these pathogens can be very high. For example, Nipah virus in Southeast and South Asia and Marburg virus in sub-Saharan Africa, can have very high fatality rates and few to no available medical countermeasures. For example, the human fatality rate across 20 studies of people infected with Nipah virus was 61%[5]. Therefore it is extremely important to wear appropriate personal

protective equipment (PPE) while working with bats in order to reduce exposure to and prevent pathogen transmission[6].

It is equally important to minimize the risk that our research activities transmit potential pathogens to bats. This process of people transmitting pathogens to new species or places is known as pathogen pollution or reverse zoonosis[7]. Recent research has shown that pathogen pollution is so ubiquitous that humans have transmitted twice as many viruses to animals as animals have transmitted to humans[8]. Pathogen pollution can cause severe population declines and cause regional or even global extinctions[9].

Bats have been directly impacted by pathogen pollution with the introduction to North America of the fungus *Pseudogymnoascus destructans* that causes the disease white-nose syndrome (WNS)[10]. WNS has killed millions of bats in North America, with some species losing greater than 90% of their populations[11]. The fungus, first detected in a New York cave in 2006, is believed to have been brought by people to North America from Eurasia[10,12,13]. It has since spread across nearly all of the United States (USA) and southern Canada[14].

The first set of field hygiene guidelines and recommendations for working with bats were developed by the IUCN BSG OneHealth Working Group in response to the COVID-19 pandemic, primarily to protect bats from the SARS-CoV-2 virus. Since then, SARS-CoV-2 has demonstrated a broad host range, to date affecting 34 diverse species, ranging from ferrets (*Mustela* spp.) to white-tailed deer (*Odocoileus virginianus*) to tigers (*Panthera tigris*), in over 900 separate events[15]. SARS-CoV-2 was even transmitted *back* to humans from farmed European mink (*M. lutreola*)[16] and wild white-tailed deer[17,18].

Bat species host diverse coronaviruses and five of the seven coronaviruses with human-to-human transmission can trace their ancestry to bat coronaviruses[19,20]. Thus, one major concern is that bats might be generally susceptible to infection by coronaviruses, including SARS-CoV-2. Possible infection of bats with SARS-CoV-2 could have unforeseen consequences. First, bats might be competent viral reservoir hosts for SARS-CoV-2 allowing for virus maintenance or even amplification, challenging control strategies of the disease in humans. The establishment of a reservoir in bats could also lead to divergent evolution of the virus compared to humans, a scenario that

could lead to new variants with different abilities to infect and cause disease, as well as having different responses to therapies and prophylactics[21]. In addition, natural infection in individual bats of most species with their own species of coronavirus could increase the chance for co-infections with SARS-CoV-2 , potentially leading to the generation of novel coronaviruses through recombination. Finally, SARS-CoV-2 could be pathogenic for bats and, as such, pose a health risk to them too. So far, infection studies have revealed that Mexican free-tailed bats (*Tadarida brasiliensis*) and Egyptian rousette bats (*Rousettus aegyptiacus*) can be infected by SARS-CoV-2[22], whereas big brown bats (*Eptesicus fuscus*) cannot[23]. Studies using predictive modeling and cell-culture models predict that other bat species may also be susceptible to infection, although there is no bat-monitoring data to show their susceptibility to SARS-CoV-2[24,25]. The receptivity of bats and other wildlife to infection by human microbes (apart from SARS-CoV-2, which continues to circulate in human populations), is largely unknown. In light of the current scientific evidence and unknown potential risks, we follow the **precautionary approach** in advocating the use of protective equipment and practices to minimize pathogen pollution and protect bats.

Potential Transmission Routes During Fieldwork

Transmission from bats to humans

The most likely route of transmission of potential pathogens is **direct contact or ingestion** of bat excretions, such as feces, urine, saliva, or blood from a bat. This could happen via: a bite or scratch from a bat; contact with bat excreta (e.g., feces or urine) during sample collection or handling (for example through a needle stick); entering roosts or other closed environments with bats (feces on cave/dwelling floors and walls, urine and feces within the air column from bats roosting in caves or dwellings or large tree roosts); or from samples (blood, saliva) getting into a person's mucous membranes (eye, mouth, nose).

A second possible route of transmission is **inhalation of aerosolized feces or urine**. This happens when droplets or very small solids become suspended in the air instead of falling to the ground. Such droplets, and any potential pathogens they may contain, can then be breathed in. With this in mind, precautions should be taken when

handling such samples or when working in environments that may contain aerosolized feces or urine, such as enclosed spaces (caves, large tree hollows, roosts in human dwellings, flight cages) and under large exposed roosts.

Finally, transmission could occur via **bat ectoparasites** such as mites, ticks, bat flies (families Nycteribiidae, Streblidae), and bat bugs (*Cimex* spp.). While there are currently no known cases of disease transmission from bat ectoparasites, these arthropods could potentially crawl or land on humans while handling bats or when entering bat-roosting habitats, such as caves. Generally, these ectoparasites are species-specific, but opportunistic human infestations are known. For example, bat bugs feed on both bats and humans[26], and *Argas vespertilionis*, an argasid tick associated with bats and bat habitats in Europe, Africa, and Asia, has been reported to bite humans [27]. There have also been several exploratory studies on the microbiome of these ectoparasitic arthropods. Bacterial species in the genera *Bartonella* and *Rickettsia* have been detected in them, but there is limited understanding of whether these parasites can infect or cause disease in humans[28–31]. Several viruses, including *Bunyavirales, Paramyxoviridae, Filoviridae, Reoviridae,* and *Picornavirales*[32–34]have also been detected in arthropods that infest bats. Again, although there have been no cases of these bat-ectoparasite viruses causing disease in humans, precautions are needed to reduce the possibility of such a case occurring.

Human-facilitated transmission of pathogens to bats

Capturing, handling, and sampling bats inherently implies a risk of directly or indirectly transmitting microbial agents to bats from humans or from the environment. Humans can transfer pathogens that are adapted to some bat species or populations in specific geographic regions to susceptible, naïve species or populations in other regions via fomites. This is exactly what happened when humans brought *P. destructans* (the causative agent of WNS) from Eurasia to bat caves in the northeastern USA[12]. While there are currently no documented cases of pathogens being directly transmitted from humans to bats, there have been several instances of humans infecting other mammals (reverse zoonoses)[35], including SARS-CoV-2 infections in white-tailed deer[18], tuberculosis infections in cattle[36,37], and influenza A in pigs[38]. Any potential pathogens could be transmitted from humans to bats via the same routes as those in which bats could transmit to humans:

direct contact with excretions (most likely saliva), transfer via hands or equipment, or aerosolized droplets entering bats' respiratory systems, gastrointestinal tracts or mucous membranes (eyes, nose or mouth). Bats' behaviors could also "link" routes of transmission, for example, bats may groom after handling and ingest potential pathogens transmitted to their fur or membranes. These risks can be mitigated via use of basic PPE.

Activities that may expose bats to human, environmental, or other currently unknown pathogens include:

- Handling bats
- Breathing, blowing, or coughing on bats
- Placing bats in dirty bags or placing multiple bats into one holding bag
- Bats coming into contact with contaminated clothes
- Feeding bats before their release (using contaminated food stocks or using the same pipette to feed multiple bats, especially from different species, populations, or locations)
- Invasive procedures such as pit tags, sutured transmitters, temperature sensor implants
- Not disinfecting traps between capturing events and sites
- Not disinfecting clothes and boots before entering/leaving capturing sites and especially before/after entering caves.

What is field hygiene and who is it for?

Field hygiene is a set of practices that reduce the potential for exposure to and ultimately transmission of microbes from (or via) humans to bats and from bats to humans, and even bats to bats during fieldwork. Field hygiene practices also protect collected samples from environmental and cross-contamination. These practices include **what we wear**, **what we do** and **what we do not do** when conducting field research on bats. Researchers in other disciplines who may come across bats or bat droppings (e.g., in caves) may also want to refer to this document for reference. We ask that bat rehabilitators and carers continue to refer to our Covid-19 MAP recommendations.

The guidelines provide the minimal set of best practices that should be followed by any researcher working near or handling bats, or entering roosts to minimize the risk of transmission of pathogens from

people to bats, and bats to people. In some contexts, particularly higher-risk areas and work with bats that are known reservoirs of highly virulent pathogens (e.g., *Rousettus aegyptiacus* in Uganda), or known pathogens to bats (e.g., *Pseudogymnoascus destructans* in North America) additional precautions and personal protective equipment (PPE) should be used. Researchers should follow any additional guidelines and directives given by their institutional biosafety committee (IBC) and Institutional Animal Care and Use Committee (IACUC). Also, note that there is a lack of surveillance for potential pathogens worldwide in bats and that just because a pathogen has not been detected does not mean it is not present. In addition, researchers regularly identify new microbes in bats but do not know the potential of these microbes to cause disease in bats, humans, or other species.

Note that the risk of microbe transmission to or from bats can never be reduced to zero; our goal is to reduce this risk as much as practically possible by providing barriers to primary routes of transmission, regular use of disinfectants, and changing fieldwork behaviors.

FIELD HYGIENE GUIDELINES

To facilitate the adoption of field hygiene measures, we organize these guidelines as a series of steps that are ordered chronologically (before, during, and after fieldwork) and grouped by activities.

Before Fieldwork

Develop a field safety and hygiene protocol specific to your bat research

Step 0: Secure institutional compliance, permits, and vaccinations.

- Check with your institution and the authorities of all jurisdictions (countries, states / provinces / regions) where you will be conducting fieldwork regarding animal care and use protocols and permits.
- Field safety and hygiene protocols specific to bat research always include up-to-date vaccinations for **rabies** and **SARS-CoV-2**. Bring Covid-19 testing kits if possible.
    - Establish anti-rabies titers if possible. Where establishing anti-rabies titers is not possible, get a rabies booster vaccine every few years[1,2]; consult your physician and follow the guidelines of your medical authority for specific schedules
    - Current WHO recommendations for rabies vaccination are for three doses, administered one week apart. Protection is not immediate after the final dose, so vaccination should be planned accordingly[39].
    - Vaccination against rabies (genus *Lyssavirus*) is considered effective to protect against Rabies Virus (RABV) and all Phylogroup I lyssaviruses, which are antigenically closer to RABV than other lyssaviruses. Note that compared to RABV, higher antibody titers are needed to protect against other Phylogroup I lyssaviruses, although there is currently no approved cutoff level for titres for protection against viruses other than RABV[40].
    - Be aware that rabies vaccination provides no protective immunity against lyssaviruses in Phylogroup II (Lagos bat virus, and Shimoni bat virus) or other highly divergent lyssaviruses (Matlo bat virus, Lleida bat lyssavirus, West Caucasian bat virus)[40].
    - Keep documentation of all vaccinations and titers.
        - *TIP: If no official documentation is offered, the box or paperwork coming with vials may be useful.*
    - Identify a health clinic nearby that offers post-exposure prophylaxis,

should an exposure (bite) occur in the field.

Step 1: Evaluate potential transmission risks between bats and researchers using available information about the: (1) geographic region; (2) bat species occurring in your study area and any known or likely pathogens that those species may carry; (3) level of risk posed by your research activities, including the type of site(s) visited:

(1) **Geographic region**. Are you working in a region with a known risk of bat-borne zoonosis (e.g., Nipah) or where bats are known to be susceptible to diseases (e.g., WNS)?

- Check for regulations that may be context and region-dependent, e.g., decontamination protocols for WNS in North America and Europe, or biosafety protocols for working with hosts of Nipah virus in South and Southeast Asia.
- Check for alerts and updates from national or global authorities (e.g., WHO) on recent outbreaks and, if available, how exposures have occurred.
- Be aware that outbreaks may go undetected / unreported or that an outbreak of a currently unknown pathogen may occur.

(2) Level of risk posed by the **bat species** you may encounter. Are there known associations between pathogens and the **bat species** occurring in the study area (diversity studies) or for the focal species? Are any associated viruses known to be pathogenic in people?

- Use a species checklist and cross-reference known pathogens with the most current literature.
- The Database of Bat-Associated Viruses (DBatVir; http://www.mgc.ac.cn/cgi-bin/DBatVir/main.cgi) and the Global Virome in One Network (VIRION) database (https://viralemergence.github.io/virion/) provide continuously updated information on viruses hosted by different bat species. Note that VIRION is in the alpha version and still contains some bugs. The SpillOver tool (https://spillover.global/) provides information on viruses more generally.
- Although bacterial, macroparasitic, and fungal pathogens are all known to infect some bat species, a similarly comprehensive database for these microbes currently does not exist. We therefore recommend that researchers check the most recent literature.
    - A high risk would be posed by working with species known to harbor zoonotic pathogens that have high mortality and no available vaccines (e.g., Nipah virus, Hendra virus, Marburg virus, lyssaviruses without vaccine coverage), especially when working in areas where

there have been known human or animal outbreaks of bat-borne pathogens.

(3) Level of risk posed by the **research activities**. This requires consideration of the potential transmission routes from humans to bats and bats to humans. Generally, the research team should consider: how close they are to bats; if there is a risk that either humans or bats will have contact with body fluids, excretions, or aerosols from the other, and whether the research requires creating barriers between individual bats. For example, for research occurring inside roosts, the risk assessment should consider the proximity to bats, the level of contamination with bat droppings (e.g., if there are passages where one cannot avoid touching fecal material), and airflow.

- Activities with a lower risk of **bat-to-human** microbe transmission :
    - Mist-netting in an open-air setting in a geographic area where the bat species likely to be encountered are not known to carry known pathogens for which there is no vaccine.
- Activities with a higher risk of **bat-to-human** microbe transmission include but are not limited to:
    - working under or within a large, active bat roost with falling urine and feces. Such roosts may be open environments (e.g., trees and bridges) or closed (e.g., caves, mines, tunnels, buildings)
    - collecting feces and urine from roosts, even if bats are absent
    - handling bats, particularly when taking biological samples (buccal swabs, urine, feces, blood, etc.)
    - Note: Certain viral families may be more likely to be shed in some sample types than in others (e.g., coronaviruses in feces or rectal swabs, or paramyxoviruses in urine), creating specific exposure potentials.
- Activities with a higher risk of **human-to-bat** microbe transmission :
    - handling bats, particularly when taking biological samples
    - working in any type of enclosed environment with bats, especially when visiting multiple roosts
- Activities with a negligible risk of **bat-to-human** and **human-to-bat** microbe exposure include:
    - observational work or counts of bats made from outside a roost (and out of the flight path)
    - acoustic studies (if detectors are not under/in roosts)
    - research in areas where bats forage but are present at very low densities

Step 2: Use the level of risk (STEP 1) to select appropriate Personal Protective Equipment (PPE)

The cardinal rule for working with bats is the creation of **disposable or fully disinfectable barriers**. These barriers will protect not only researchers but also bats. While we explained why there is a need for these barriers in the introduction to this document, it is important to remind ourselves that Field Hygiene is designed not just to reduce the risk of microbe transmission between researchers and their subjects but also as a set of best practices that can improve how we approach field research. Medical and dental professionals wear PPE while dealing with healthy patients. This reasoning should be used when explaining the need for PPE during field research to curious bystanders and young researchers beginning their training.

There is no one-size-fits-all solution to PPE. You should modify what you wear according to your level of risk of exposure based on considerations in **Step 1.**

No PPE: Activities in which bidirectional transmission is negligible because researchers and bats do not come into direct contact with each other, or with fluids or aerosols, e.g., "lower risk" activities in **Step 1** such as acoustic monitoring or distant roost counts.

Basic PPE: Whenever researchers capture and conduct basic handling of bats we recommend they adopt BASIC PPE (**Figure 1**):

- **Gloves** (at minimum thick nitrile gloves, add cut-resistant or leather gloves for bats that can bite through nitrile). If possible, wear nitrile gloves *over* leather gloves. If leather gloves are too large to fit under nitrile gloves, they should be disinfected.
- **Face coverings** to reduce respiratory transmission of microbes. Best practices include FFP3, FFP2, N95, and KN95 facial masks. When these options are unavailable, surgical masks can be used as they provide comparable protection for the bats (*but lower protection for the researchers*). Dual-layer cloth masks or face covers (covering the mouth and nose) can be substituted for surgical masks in circumstances where respirators or surgical masks are not available. Materials used as a filter should allow unobstructed breathing, should not saturate with moisture easily, and should not extrude fibers or other materials that might be inhaled. DO NOT USE VALVED MASKS. The valve allows the exhalation of <u>unfiltered</u> breath.
- **Dedicated field clothes.** These clothes need to stay at the field site, and/or are dedicated to wear only when doing field work. They are removed after finishing field work each day and not worn home. They should be

changed/disinfected when visiting multiple roosts during the same trip. Long-sleeved shirts and pants/trousers are suitable, cloth boiler suits are another option. While disposable equipment could be the best option for high-risk activities, it is crucial to always consider sustainability and select reusable material.
    - Disinfection: Wash dedicated field clothing based on the level of soiling, but soak in a 10% bleach solution at least every 3-4 days.
- **Dedicated close-toed shoes** that can be disinfected/sterilized using a 10% bleach solution (e.g., rubber boots)
- **Optional but recommended: Eye protection** (goggles, safety glasses, face shield)

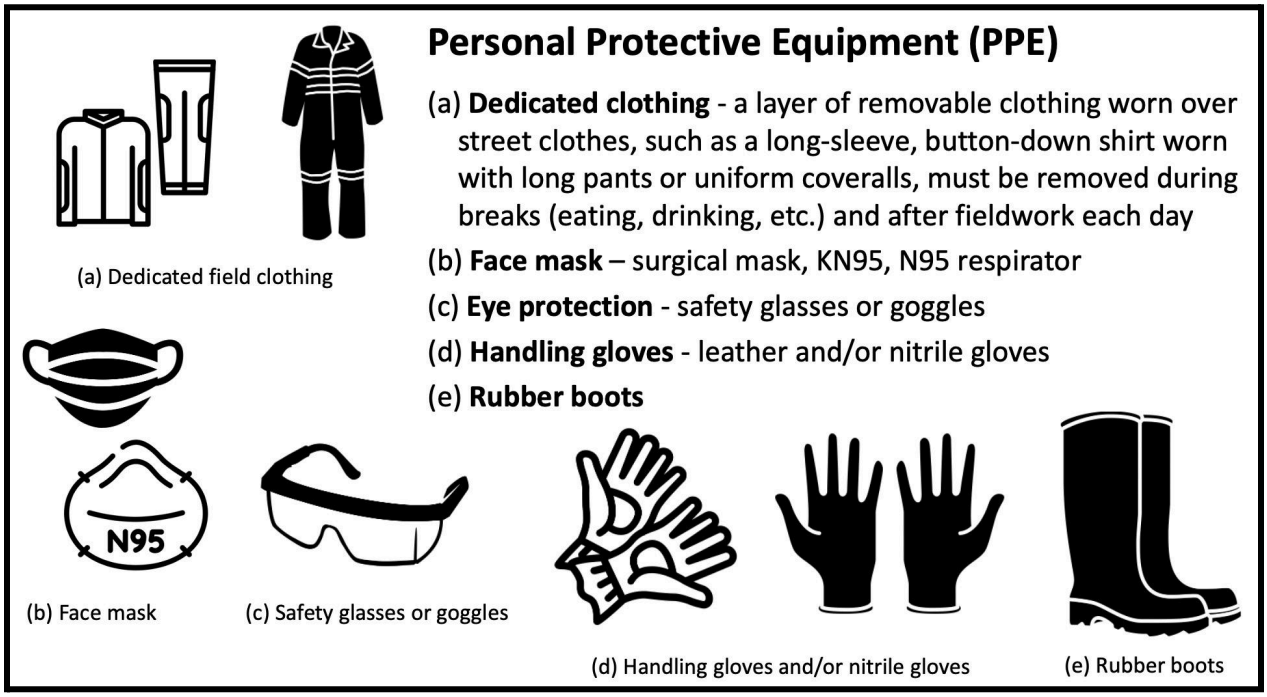

Figure 1. Personal protective equipment (PPE) to be worn during fieldwork with bats. Basic PPE includes dedicated field clothing, gloves, a mask, and shoes that can be disinfected. Eye protection is optional but highly recommended. BASIC+ for higher-risk situations adds disposable or sterilizable clothing, higher-grade mask or respirator, and mandatory eye protection.

BASIC+ PPE: For situations with higher risk, as evaluated in Step 1, **BASIC+** adds disposable or sterilizable clothing, higher-grade mask or respirator, and mandatory eye protection to the BASIC PPE set:

- Tyvek suit/coverall or disposable rain suit over dedicated clothing, or non-disposable hooded rain suit that can be rigorously sprayed down with

bleach. All suits should be hooded to minimize exposure of skin, hair, and clothing. One-piece suits (coveralls) are preferred over two-piece suits (jacket and pants/trousers) to minimize possible gaps in coverage.

    - Note that conventional Tyvek is not waterproof and so might not work well in very dirty, moist environments. In these cases, Tychem or the new Tyvek® 800J could be more appropriate
- Face mask (fitted N95 or P100 respirator), half-face respirator, or Powered Air Purifying Respirator (PAPR). The seal between the respirator facepiece and the wearer's face should be verified using qualitative tests (based on scent detection) or quantitative tests (compare particle concentrations inside a respirator against ambient air).
- Eye protection (goggles, disposable face shields, or safety glasses)
- Gloves (thick nitrile gloves for handling bats, otherwise latex is sufficient for roost samples)
- Closed-toe shoes (that can be disinfected)
- Boot covers (optional depending on activity)

TIPS: PPE

- Wear weather-appropriate street clothing under dedicated field clothing
- Well-fitting facemasks and well-fitting eyewear will prevent fogging of eyewear
- Additional measures to prevent fogging include smearing a thick layer of defogging solution, baby shampoo, or dishwashing detergent inside the eyewear
- Handling gloves and / or nitrile gloves should be well-fitting to maintain dexterity

Step 3: Prepare PPE needs and a Field Safety Plan in advance of fieldwork

- **Make a Field Safety Plan:**
    - Identify the closest medical facility that can provide emergency care in case of accidents or need for treatment in case of exposure to rabies, including the availability of vaccines and monoclonal antibodies (see exposure events).
    - Gather contact and emergency contact details for all team members and ask for any medical information relevant to fieldwork conditions and treatment in an emergency.
    - Prepare a log of potential (e.g., if a bat appears in poor condition or diseased) and actual exposure events and create a contact sheet of all relevant authorities that would need to be notified.

- **Estimate your PPE needs:** Every field operation is context-specific, but you will always need to use some level of PPE (see Step 2). It is important to prepare your stock well in advance. Consider the size and composition of your team and the sizes of clothing and gloves they will require, how often you dispose of PPE, and how many days you will be in the field. A good measure is to add at least an extra 15% of PPE as a buffer.
- **Source your PPE**: Once you have estimated your needs, determine what can and cannot be supplied locally. Source, order, and possibly ship to field location.
- **Keep biohazard waste separated and clearly labeled**: Different colored bags are the preferred method to identify biohazard material (red colored bags with the international sign for biohazard waste). If different colors cannot be sourced locally, then all biohazard bags should be properly labeled using tape and large signs. Seal or tie off the bag when not in use. Do not leave an unsealed biohazard waste bag unattended. Dispose of any sharps in an appropriate sharps container.
- **Pathogen-inactivation of biohazard waste**: All PPE and biohazard waste should be adequately pathogen-inactivated before disposal, ideally through autoclaving or chemical disinfection. Chemical inactivation in the field can be achieved by soaking in a 10% bleach solution for 10 minutes in a well-ventilated space out of direct sunlight.
- **Make a biohazard waste disposal plan**: All used PPE and biohazard waste should be disposed of following proper waste-management protocols, different from normal waste. Ideally, biohazard waste is incinerated in medical-grade incinerators. For researchers working in remote locations, one viable option is to partner with local research labs, hospitals, or clinics that may have access to waste incinerators. If there are no institutions in the area or the proper chain of custody to an incinerator cannot be guaranteed, the last resort is to dig a hole and incinerate the materials *in situ* following proper guidelines. **NEVER LEAVE BEHIND BIOHAZARD WASTE IN THE FIELD SITES.**

Step 4: Train all personnel in the use of PPE and the Field Safety Plan

- Practice sequential steps for putting on (donning) and removing (doffing) PPE prior to commencing fieldwork (Figure 2). See also CDC guidance on donning and doffing full PPE.
- Test the team's understanding and application of field safety protocols.
- Ensure that PPE fits each person properly (e.g., handling gloves should fit

snugly to maintain dexterity, fit testing of face masks).
    - Note: A beard might impair the fit of masks.
- Plan exactly when and where PPE is put on and removed.
- Set up a buddy system for putting PPE on and taking it off.
- Train/retrain research teams before each field season. Explicitly train personnel to avoid touching any part of their faces (eyes, mouth, and nose) or using their mobile phones, when wearing gloves and handling bats.

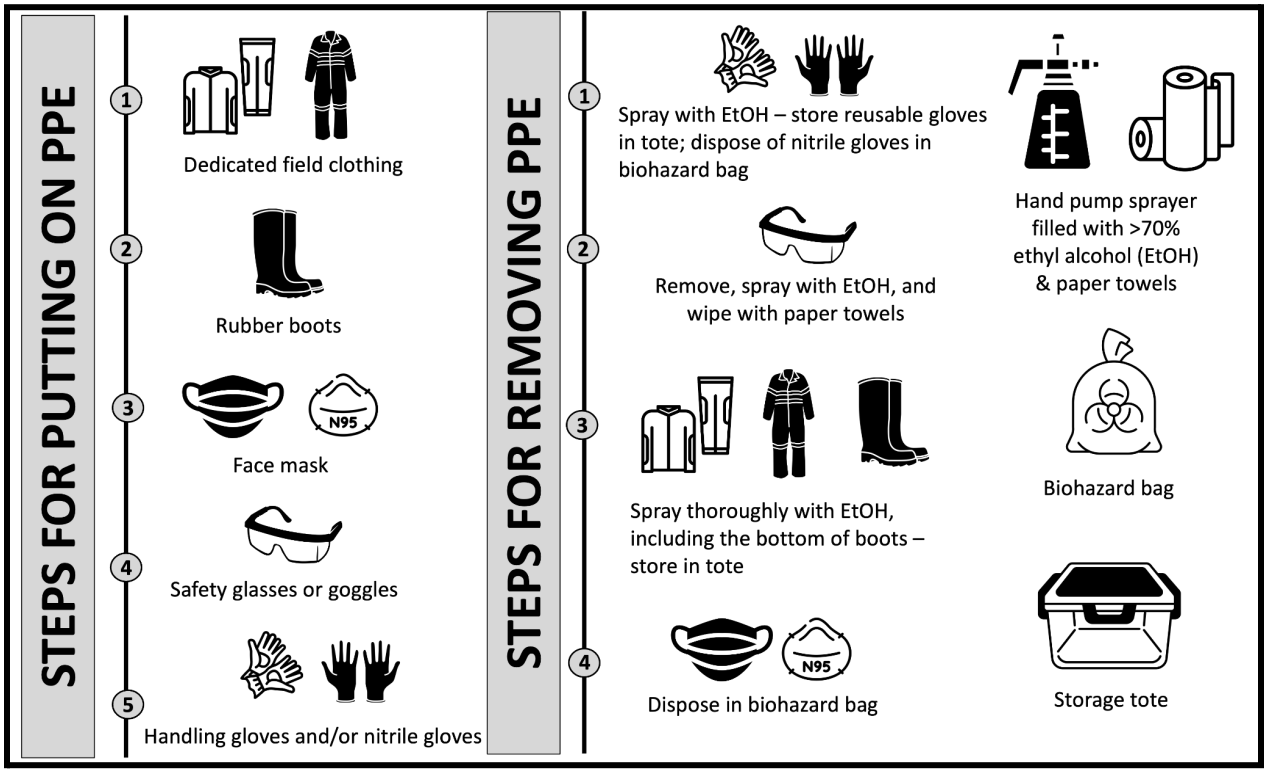

Figure 2. Ordered steps for putting on personal protective equipment (PPE) - donning - and removal of PPE - doffing, including disinfection and disposal protocols for PPE.

- Additional resources can be found on the American Biological Safety Association (ABSA) website: https://absa.org

TIP: *Team members are more likely to comply if they understand the rationale and need for field hygiene. During training, consider using breakout group discussions around prompts, with all-group reporting out (Figure 3). This can be engaging and effective.*

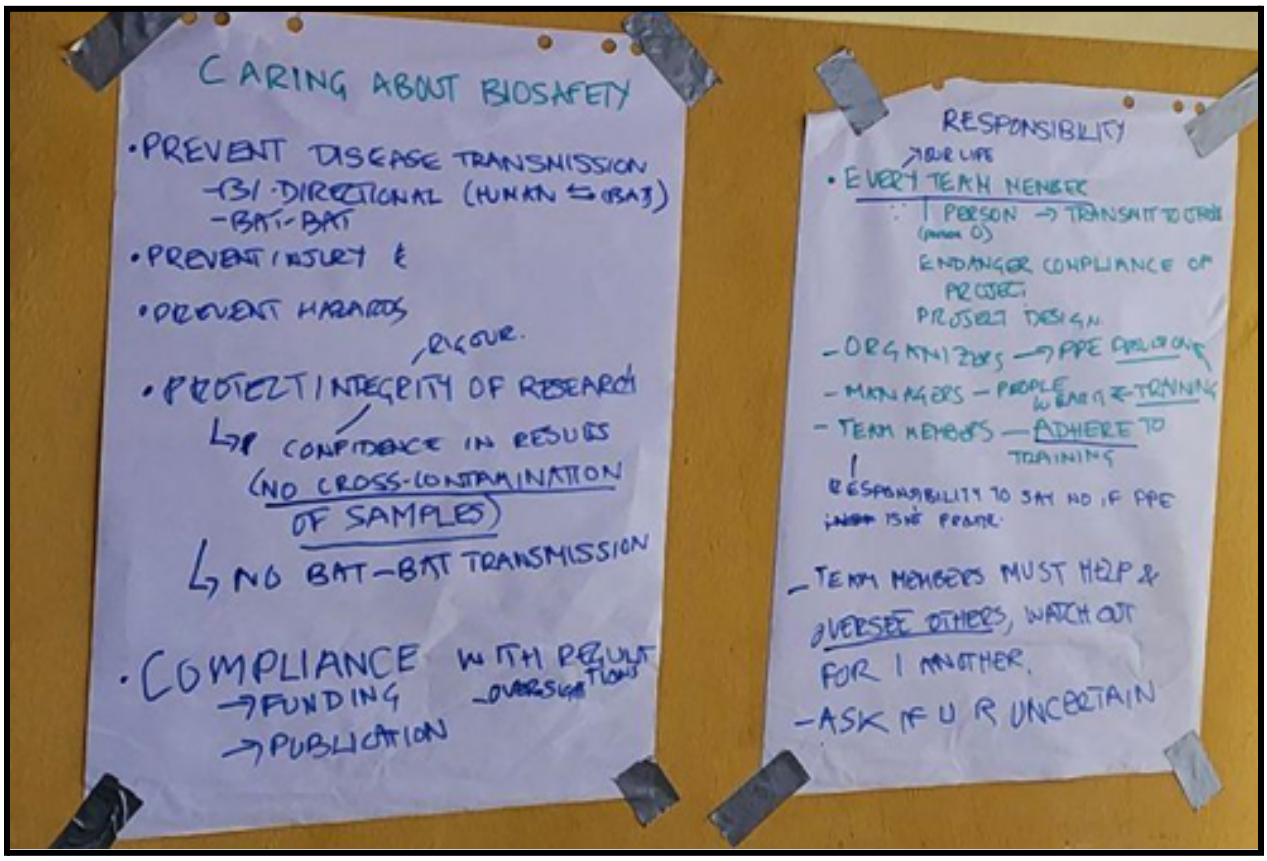

Figure 3. Output of small group discussions during field hygiene and biosafety training in response to the questions "Why do we care about biosafety when working with bats" and "Who has responsibility for biosafety".

During Fieldwork

Step 0: Check team health and readiness

- Perform daily symptom checks (fever, sore throat, congestion, coughing, sneezing, etc) with all team members prior to handling bats.
- Do not handle animals if you are feeling ill.
- Designate a team member to be the "field hygiene monitor", and make sure everyone in the team understands the field protocol and the procedures for putting on and taking off PPE
- Remind the entire team that only trained personnel can be in the working area.

Step 1: Establish separated working spaces

Establish a base camp with clearly separated spaces for living (if camping/eating) and working with bats:

- Processing station (Figure 4) ("field lab")
- Donning and doffing areas
    - *TIP: use caution tape to make it clear what people should and should not be doing)*
- Storage area where clean materials and equipment are kept near but separate from the processing station
- Biohazard area
- Clean human resting/eating area

Do not eat, drink, or smoke near bats or on the same surfaces or spaces where you are handling bats.

Step 2: Prepare the processing station(s)

- Before bats have been captured, set up the processing station(s) (e.g., Figure 4). Spray down table(s) with disinfectant and then prepare all equipment, sampling tubes, disinfectant, waste-disposal containers.
    - *TIP: Use a fresh plastic sheet for the table(s) each night*
- Clean gear and surfaces first with a 10% bleach solution and follow with spraying 70% ethanol, which should be allowed to sit on the surface for five minutes before wiping down[6]. Be aware that bleach can be a pollutant so use care, especially if working near water bodies. Disinfecting wipes can be useful for disinfecting small supplies and surfaces (see **APPENDIX: DISINFECTANT RECOMMENDATIONS**).
- Prepare containers for disposal of gloves, sharps, or other contaminated materials.
- Prepare enough cloth bat bags for single use between washes (estimate using the probable nightly catch rate and access to laundry).
    - Consider placing a bucket of diluted bleach near the processing table so that used bat bags can go directly into it for disinfection
- Set up nets and/or traps wearing gloves (unless disinfecting nets/traps between uses).
- Ensure stable seating and good lighting for all members of the processing team, but particularly those handling bats and taking any samples (swabs, punches, blood, etc.).

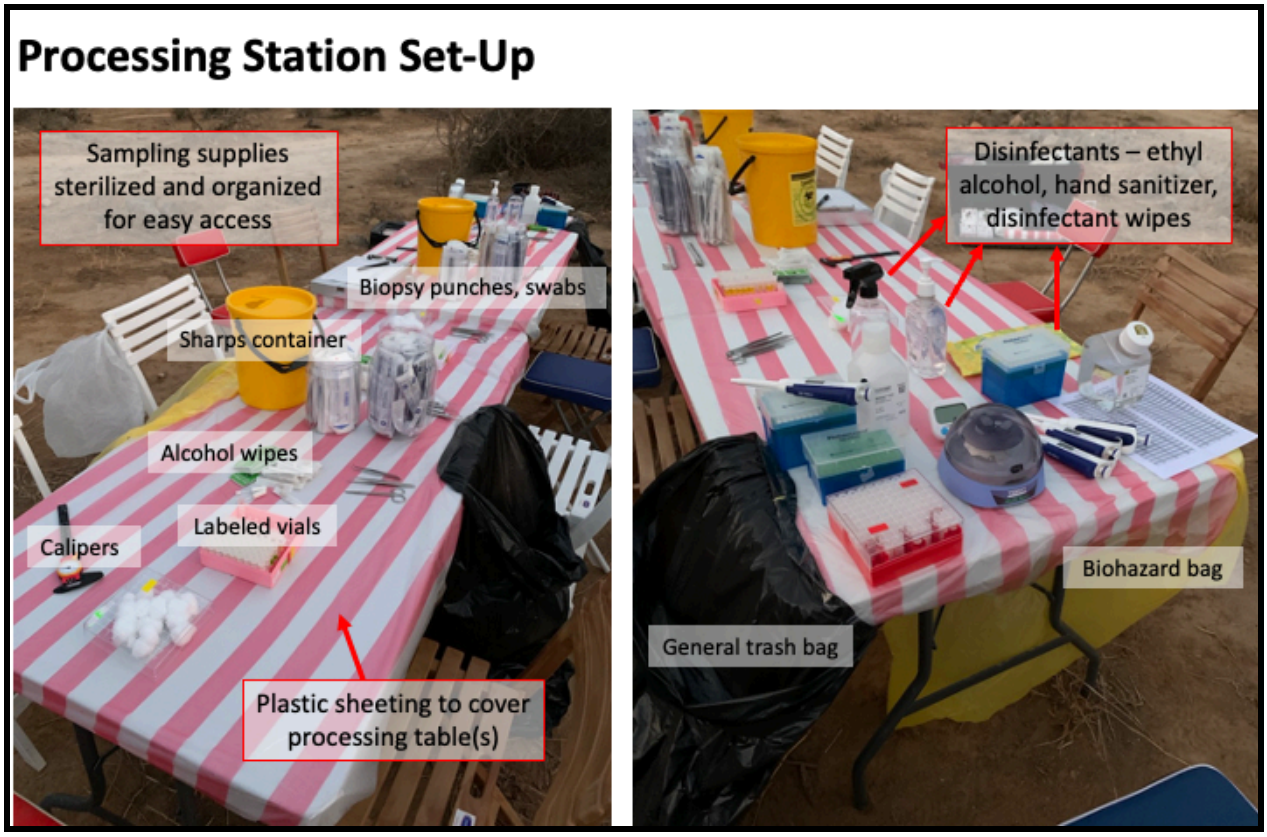

Figure 4. Example processing station set-up with standard supplies needed to collect samples from captured bats, including disinfectants and biohazard waste disposal (i.e., sharps container and biohazard bags).

Step 3: Bat collection

- Collect bats wearing PPE (Basic or Basic+)
- Place one bat per holding bag. Before each use, bags should be disinfected or autoclaved.
- Holding area for bats to be processed should be organized and within sight of the team to reduce the risk of harm to bats caused by predators (wild predators, feral cats, etc.), being forgotten, etc.

Step 4: Bat processing

- Change or disinfect gloves after any contact with fluids or feces, and regularly throughout processing (see **APPENDIX: DISINFECTANT RECOMMENDATIONS, Table 1**)
- **Do NOT** touch your face with your gloved hands.
- **Do NOT** use mobile phones with your gloved hands.
- Disinfect surfaces and tools used to process bats with a 10% bleach solution, followed by 70% ethanol or equivalent as often as possible. Notably, any surfaces or tools that come into contact with bats' body fluids (urine, feces,

blood) must be cleaned and disinfected right away. If you regularly sample fluids with possible spills (e.g., blood), consider working on a new disposable square of sterile paper or cloth for each bat.

- Before taking a sample (wing biopsy or blood sample), swab the surface with isopropanol or alcohol-prepped pads, or a cotton swab dipped in 70% ethanol.
- Any used sharps (needles, scalpels, etc.) must be IMMEDIATELY disposed of in the sharps container. **Never** put used sharps on the table and **never** re-cap them. **NEVER** reuse needles.
- If reusing biopsy punches, then disinfect them between bats (e.g., let them soak in 70% ethanol for 10 min). Dispose of used biopsy punches in a sharps container.
    - *TIP: Have two disinfectant containers and two sets of instruments (punches, forceps, etc.). Rotate between them, to ensure that each soaks for at least 10 minutes. Change this disinfectant at least once nightly and dispose of it in the biohazard bag.*
- In the event of an exposure (bite, needle-stick) refer to (see exposure events).
- If providing bats with water or sugar water, use a fresh syringe or pipette/pipette tip for each bat. Dispose of used syringes with biohazard waste.

Step 5: Bat release

- After processing, release bats ideally at the point of capture, or near the processing area.
- Continue to wear PPE while releasing bats.
- If releasing bats near the sampling/processing area move to an open area so that when you release the bat, it flies away from the processing area and people.
- Make sure to carefully count the number of bats being released and ensure that this matches the number captured or processed. Check that all holding bags or containers used to hold bats are empty after release.

Step 6: Lab space cleaning and breakdown.

After all bats have been released, the processing station should be dismantled, as follows. Safety is always the guiding principle. If the field lab has been set up following all the steps suggested above, then this task should be easy and organized.

- Do not remove PPE to clean the processing station; but change your outer glove layer and properly dispose of the used gloves in the biohazard bag. Have all disinfecting solutions ready for use.

- Set up a fresh and properly cleaned area, where all freshly cleaned equipment and tools will be placed.
    - *TIP: If using multiple tables, clear and disinfect one of them for use as the clean area.*
- In the clean area, prepare a CLEAN, deep puncture-proof plastic or glass container with 10% bleach solution (or any other recommended disinfectant (**APPENDIX: DISINFECTANT RECOMMENDATIONS, Table 2**). Place all submersible and reusable items (e.g., forceps, tweezers, biopsy punches, scissors) in the disinfection solution. The specific disinfection protocol will vary depending on each disinfectant, so make sure to follow the recommendations for your disinfectants properly, ensuring the correct contact time between surfaces and the disinfectant.
- Thoroughly spray down all non-submersible equipment (e.g., calipers, securely sealed sharps containers, pipettes) with disinfectant and, again, allow for sufficient contact time.
- Wipe each sprayed or submerged item individually with paper towels. Once an item has been cleaned, transfer it to the clean table and let it dry completely. Dispose of used paper towels in the biohazard bag.
- Once all items and boxes have been cleaned, remove any used plastic sheets from the tables and place them in the biohazard disposal bags.
- Lastly, spray down any other surfaces that might have been in contact with "dirty" hands (e.g., chairs, tables, storage boxes) with disinfectant. Allow for sufficient contact time before wiping down with paper towels, which should be disposed of in the biohazard bags.
- It is also good practice to thoroughly spray the inside and outside of the biohazard bag with 10% bleach solution, secure the opening with tape, and place it inside a secondary biohazard bag.
- After all equipment has been cleaned and biohazard bags securely closed, proceed with the removal of the PPE (see Figure 2).

NOTE: Activities such as preparing specimens, taking blood or other tissue samples, and entering caves require additional PPE, biosafety protocols, and more stringent field hygiene practices.

Things not to do:

- **Do not eat, drink, or smoke while wearing PPE, near bats, or on the same surfaces or spaces where you are handling bats.**
- **Avoid using phones, cameras, laptop computers or tablets or any other hand-held electronics while wearing PPE, unless they can be disinfected following protocols for all other equipment.**

Once Fieldwork is Completed At a Site

- **Disinfect** all field gear (including nets and traps), wearable equipment (boots, headlamps, helmets, etc.), and clothes at the end of a research expedition and before moving between field sites, regions, countries, and continents. (See **APPENDIX: DISINFECTANT RECOMMENDATIONS, Tables 2 and 3**).
- Properly dispose of all biohazard waste (any materials that have been in contact with animals or their excretions and fluids, or any other samples) and sharps containers following local government and funding agency guidelines.
- **Leave nothing** behind; scour the processing area to ensure that all debris has been removed.
- Stay in contact with all team members, and monitor team health following the Step 0 Before Fieldwork protocols.
    - Be aware that while in the field, team members could be exposed to diseases not specifically related to bats (e.g., Dengue fever, malaria, Lyme disease, tick-bite fevers, etc.).

Exposure Events

- If you are bitten or scratched by a bat or have a needlestick, immediately wash the wound thoroughly with soap and running water (for 15 minutes) or water and disinfect with detergent, 70% ethanol, iodine (tincture or aqueous solution), or other substances with virucidal activity[41].
- Immediately seek medical attention to assess the need for rabies postexposure prophylaxis (PEP).
    - Note: The World Health Organization (WHO) recommends PEP for any person with a bite or scratch from a bat, with specific protocols depending on the event and the pre-exposure vaccination status.

- If any potentially infectious material (e.g., saliva, urine, feces) from a bat gets into your eyes, nose, mouth, or a wound, wash with water and soap if possible and seek medical attention immediately.
- Bleeding is not a good indicator of exposure — small bites/bite indentations and microabrasions also present an exposure risk and should be treated in the same way as a bite[42]
- Report any exposure event to your supervisor and perform a post-event analysis to determine why it happened, how it can be prevented and to potentially set up a re-training to prevent recurrences.
- Keep a log of potential and actual exposure events and report incidents to relevant authorities that would need to be notified.
- Even if no known exposures occur, monitor the health of all team members according to the Step 0 Before Fieldwork protocol.

TIP: *If a bat bites you while you are wearing nitrile gloves, fill the glove(s) with water to test for punctures.*

Final Considerations

Research conditions are context-dependent, and our guidance represents **general and basic best practices for field hygiene for standard bat survey work involving the capture and handling of bats**. Protocols addressing any special considerations and needs should be developed with the guidance of your institution on environmental health and safety protocols. Remember that local, national, or federal governmental regulations take precedence over any other guidance. When the measures required by those authorities exceed our recommendations, researchers should strictly adhere to those regulations.

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APPENDIX: DISINFECTANT RECOMMENDATIONS

Skin, clothes, and all equipment and tools must be cleaned and disinfected to minimize exposure to pathogens for bats and humans. Disinfectants should be broadly effective against a wide spectrum of microbes, non-irritant to the skin and respiratory system, and applied/used according to the manufacturer's instructions.

Before handling bats, researchers should ensure that all equipment and tools have been disinfected. The tables below provide a non-exhaustive list disinfectants, representing recommendations from the Government of Western Australia (Department of Biodiversity, Conservation and Attractions SOP Managing Disease Risk in Wildlife Management) and the United States Fish and Wildlife Service white-nose syndrome decontamination protocols. There are several additional resources on disinfectants listed at the end of this document.

Table 1. Disinfectants for skin and gloves (external use only)

Name of agent	**Concentration**	**Usage**	**Concern**
Alcohol-based hand rubs and sprays	~70%	Rub on hands	For disinfection of surfaces, first use a 10% bleach solution and then spray with the 70% ethanol. May dry skin and irritate open wounds
F10 SC veterinary disinfectant (liquid or gel)	1:100 dilution in water	Spray on hands/gloves and rub for >30 seconds. Contact time for most bacteria = 10 min.	
Povidone iodine (Betadine)	Comes as 10% concentration	Apply to skin	Eye irritation
Dilute Chlorhexidine (Savlon or Hibitane)	Use according to manufacturer's instructions		Less effective on bacteria and ineffective in presence of organic material

Table 2. Disinfectants for submersible clothing and equipment, e.g. bat bags, mist nets, harp trap bags, processing instruments (biopsy punches, forceps, scissors). Allow at least 10 minutes' contact time with disinfectant. For processing instruments, after disinfection, spray with 70% ethanol and wipe dry with paper towels. Most other items can be rinsed in water and hung to dry after disinfection.

Name of agent	**Concentration**	**Usage**	**Concern**
Virkon - Available from veterinary sector	1:200	Soak for >10 minutes, then rinse in water and dry	Expensive, expires quickly; should be prepared fresh each time
F10 SC veterinary disinfectant (liquid or gel)	1:250 dilution in water	Soak clothes for 30 minutes, then rinse in water and dry	Expensive
Bleach (hypochlorite bleach)	10% bleach (1 part bleach:9 parts water)	Soak for 10 minutes, then rinse in water and dry	Corrosive at high concentrations. Do not mix with ammonia compounds. Can irritate the respiratory system with heavy usage. Use fresh bleach mixture and store concentrate in shaded conditions as sunlight degrades bleach. Be aware that bleach can be a concern for water quality, soils, and wildlife, particularly when working near water bodies
Laundry detergent		Keep clothing in water that is >50°C or 122°F with detergent for >20 minutes	Difficulty maintaining temperature if hand washing

Table 3. Disinfectants for non-submersible equipment and instruments (calipers/rulers/field tables/harp traps). If possible, clean surfaces with soap and water before disinfecting. For harp traps, clean lines, soak parts in disinfectant (if possible) for 10 minutes, then rinse and dry.

Name of agent	**Concentration**	**Usage**	**Concern**
3% Quaternary ammonium (Lysol)	1:128 ratio in water	Contact time based on manufacturer recommendations. Rinse with water, then air dry	Irritant
Virkon	1% solution (1:100 with 10g to 1L water)	Contact time based on manufacturer recommendations. Rinse with water, then air dry	Do not expose metal items for more than 10 minutes. May leave slight pink color on plastic items
Bleach (hypochlorite bleach)	10% bleach (1 part bleach : 9 parts water)	Contact time based on manufacturer recommendations (>10 minutes preferred). Rinse with 70% ethanol or water, then air-dry	Corrosive at high concentrations. Do not mix with ammonia compounds.
Ethanol	70-90%	With ethanol as a disinfectant, the contact time is important, and the higher the concentration, the faster it will evaporate.	Flammable