By Thomas H. Connor, PhD

Personal Protective Equipment for Use in Handling Hazardous Drugs

Photos courtesy of Clinical IQ, LLC

Gloves with long cuffs can be placed over the cuff of the gown to cover the wrist and forearm.

HEALTH CARE WORKERS MAY BE EXPOSED TO HAZARDOUS DRUGS WHEN they compound, administer, or dispose of hazardous drugs, or handle drug vials, clean up spills, or touch surfaces that are contaminated with these drugs (OSHA 1999; NIOSH 2004; ASHP 2006). Skin contact and inhalation are the most likely ways a health care worker may be exposed to hazardous drugs. These drugs can be substantially absorbed through the skin and the activities mentioned above can create aerosols or generate dust. In addition, ingestion (from hand to mouth) or injection through a needle stick or sharps injury is also possible.

Table 1. Hierarchy of Industrial Hygiene Control

Action	Example(s)
Elimination or substitution of the hazard	Not possible in health care
Engineering controls	Biological safety cabinets (BSC), compounding aseptic isolators, dedicated ventilation systems, cleanrooms, closed-system devices
Administrative controls	Training and education of personnel, work practices, policies and medical surveillance
Personal protective equipment	Gloves, gowns, respiratory protection, eye protection, sleeve, hair, and shoe covers

The basic occupational health approach to minimize exposure to any workplace hazard is known as the hierarchy of industrial hygiene control methods. This hierarchy (*See Table 1*) has been applied to many occupational settings and is applicable to the health care setting as well.

Historically, employers and workers, including those in health care, have often incorrectly viewed personal protective equipment (PPE) as a first line of protection against chemical exposure. The use of gloves, gowns, and other types of PPE should be seen as a final barrier to exposure, after all other measures to eliminate or control exposures have been implemented, because PPE is actually the least reliable of these measures.

PPE to Use When Handling Hazardous Drugs

Gloves: It has been demonstrated in numerous published reports that most, if not all, surfaces in and around areas where hazardous drugs are present are contaminated with these drugs. The drug vials and their packing cartons may also be contaminated with the drugs. When research studies have been performed to evaluate workplaces, typically only a small fraction of the drugs that are used in health care are examined, and, since those drugs are almost always detected, it should be assumed that other drugs are present on work surfaces as well. Therefore, gloves should be worn in all areas where hazardous drugs are present. Most glove materials offer good protection from dermal exposure to hazardous drugs. However, polyvinyl chloride (PVC) exam gloves are known to offer little protection against chemical exposures.

In general, thicker gloves offer better protection. However, the thickness of the glove is not always indicative of its level of protection, and a thicker glove may make work activities difficult. Other factors, such as glove material and manufacturing processing may influence how drugs permeate the gloves.

Photos courtesy of Clinical IQ, LLC

Gowns should have closed fronts and long sleeves with tight fitting cuffs and be non-permeable to the drugs.

Gloves should be changed on a regular basis, with typical recommendations **varying from 30 to 60 minutes**.

Powder-free gloves are recommended to avoid contamination of the work area with the powder and to prevent absorption of the drugs by the powder. Gloves should be changed on a regular basis, with typical recommendations varying from 30 to 60 minutes. Whenever a glove is damaged or contact with a drug is known or suspected, the gloves should be carefully removed and disposed of properly.

Double gloves are recommended, especially when working in a BSC, because it is well documented that gloves are usually contaminated when compounding hazardous drugs, and by withdrawing the contaminated gloved hands from the BSC, the contamination is transferred to the surrounding area. Therefore, the contaminated outer glove should be removed and disposed of inside the BSC. If work is to be resumed, a new outer glove can then be donned. When working in a compounding isolator, disposable gloves must be worn inside the fixed glove assembly. Materials, such as drug vials, and the surrounding work area are most likely contaminated with drug residues, so proper protection is required outside the isolator as well. Gloves with long cuffs can be placed over the cuff of the gown to cover the wrist and forearm.

When removing gloves, they should be gently rolled off the hand, so they are inside out and so that any contamination is not transferred to the worker or the environment. It is recommended that hands be washed thoroughly with soap and water both before donning the gloves and after they are removed. Used gloves should be disposed of with other "trace" waste materials.

There is recent guidance for testing gloves to be used with chemotherapy. In 2005, the American Society for Testing and Materials (ASTM) published a standardized test procedure for these gloves (ASTM D-6978-05). There are a number of glove materials currently on the market. Some of the more common ones and their properties are listed in Table 2.

Gowns: Protective gowns used for the preparation and administration of hazardous drugs should offer maximum protection to the wearer. Gowns should not have seams that could allow the drugs to pass through and come in contact with the wearer. They should have closed fronts and long sleeves with tight fitting cuffs and should be non-permeable to the drugs. When a pharmacist or nurse has intermittent tasks to perform, it is often tempting and economical to hang the gown and reuse it for the next task. However, such a practice can lead to the contamination of the workplace and the worker from

Table 2. Types of Glove Materials

Material	Properties
Latex	Protection and elasticity are excellent, but may produce allergic reactions in sensitive individuals.
Nitrile	Protection is excellent, but elasticity is usually not as good as that provided by latex. Chemical allergens may be present.
Chloroprene (neoprene)	Protection may not be as good as nitrile, but the material offers excellent elasticity properties. Chemical allergens may be present.
Polyurethane	Protection and elasticity are excellent.
Polyvinyl Chloride (PVC, vinyl)	Protection and elasticity are below most other materials. Chemical allergens may be present.
Blends	Protection and elasticity are excellent, but chemical allergens may be present.

drug residue on the gown. Protective gowns should never be worn outside the preparation area, as this practice could transfer the drugs to surrounding areas. Spunbond polypropylene does not offer splash protection compared to some other materials. Cloth lab coats, surgical scrubs, or other absorbent materials are not suitable for use as protective gowns, as these materials are difficult to decontaminate when washing, and can hold spilled drugs against the skin and increase exposure possibilities.

Currently, there are no guidelines for testing chemotherapy gowns. Some manufacturers have undertaken testing on their own, and the test results may be available on their websites. If no permeation information is available for the gowns you use, they should be changed every four hours or when a spill or splash has taken place. Some of the gown materials currently in use are described in Table 3.

Respiratory protection: For most activities that require some type of respiratory protection, an N-95 or N-100 particle mask is sufficient. Surgical masks offer little to no protection to the wearer from drug exposure and should not be used for drug preparation or administration. For events such as large spills when an IV bag breaks or a line disconnects and leaks, a chemical cartridge-type of respirator is required. Whenever any respiratory protection is used, workers must be fit-tested and trained to use the respiratory protection according to the OSHA Respiratory Standard.

Eye protection: Proper eye protection is needed whenever there is the possibility of drug splashing in the eyes, such as when preparing a drug outside the BSC or isolator (e.g., in the operating room or in an emergency situation), working at or above eye level, or cleaning a spill. Eyeglasses and safety glasses with side shields do not offer adequate protection to the eyes from splashes. Safety goggles provide eye protection, but only face shields offer a full range of protection against splashes to the face and eyes.

Sleeve, hair, and shoe covers: Sleeve covers may be used to provide additional

Cloth lab coats, surgical scrubs, or other absorbent materials **are not suitable** for use as protective gowns.

Table 3. Types of Gown Materials

Material	Properties
Spunbond polypropylene	Relatively inexpensive and comfortable, but does not offer high level of protection
One layer of meltblown polypropylene between two layers of spunbond polyethylene	Breathable with a higher level of protection
Two layers of meltblown polyethylene between two layers of spunbond polypropylene	Breathable with a high level of protection
Spunbond polypropylene coated with polyethylene	Lightweight with a high level of protection

protection to the worker, especially when working in a BSC. The front edge of the BSC is usually the most contaminated surface in the pharmacy and sleeve covers can protect that area of the arms that come in contact with the BSC.

Hair and shoe covers are typically used to reduce the possibility of microbial contamination in cleanrooms and other sensitive areas, such as a BSC. Shoe covers should not be worn outside drug compounding areas to prevent contamination from being tracked to other areas. Their use is usually dictated by facility and institutional policy.

Factors for Selecting PPE

Two factors should be considered when selecting PPE such as gloves and gowns: penetration and permeation (*See Table 4*). Many factors can affect the level of protection of gloves and other types of PPE:

- **Degradation**: Degradation is the actual breakdown of the material by the drug. If gloves become sticky or brittle, the drug (or its solvent) is probably degrading the material.

- **Temperature**: Temperatures inside a glove can approach body temperature after just a few minutes, and permeation is temperature-dependent. ASTM recommends testing gloves at 35° C.

- **Flexing and stretching**: These shorten the protection time offered by the PPE. This can be influenced by any repeated or vigorous activity.

- **Mechanical damage**: Tears, abrasions, and needle sticks can allow drugs to pass through the PPE. Immediately after any of these events, the gloves should be carefully removed and the hands washed thoroughly with soap and water.

- **Length of use**: Since permeation is time-dependent, the longer the use, the greater the possibility the drug can permeate the material. Change gloves every 30 minutes or less, especially when contact with the drug takes place or is suspected.

Table 4. Factors that Affect PPE Selection

Penetration	The movement of a chemical (in this case the drug) through breaks (e.g. seams, tears, puncture holes, or pre-existing pin holes) in the protective material. A visual inspection of gloves or gowns can usually detect possible areas of penetration.
Permeation	The migration of the chemical into the material and its subsequent release to the other side. Permeation is chemical-, solvent-, temperature-, and time-dependent.

Summary

Personal protective equipment can provide an extra layer of protection for health care workers who handle hazardous drugs. However, knowledge of its proper use and limitations are critical for protective equipment to function properly. All items should be donned and removed with care to prevent damage and to reduce the spread of contamination from used items. Proper fit and material selection for protective equipment are also critical factors in their performance. ■

Thomas H. Connor, PhD, is a research biologist at the National Institute for Occupational Health and Safety (NIOSH) in Cincinatti, Ohio. Connor is the project officer for a study examining the potential effects of hazardous drugs on health care workers, and is also conducting an evaluation of PPE used in the healh care industry. He was a primary contributor to the NIOSH Alert on Hazardous Drugs, published in September 2004.

The findings and conclusions in this article are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health. Mention of company names and/or products does not constitute endorsement by the National Institute for Occupational Safety and Health.