NIOSH List of Antineoplastic and Other Hazardous Drugs in Healthcare Settings, 2016

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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NIOSH evaluation of hazardous drugs does not cover NIOSH classification of chemical carcinogens. Although NIOSH hazardous drug evaluation includes consideration of carcinogenicity and genotoxicity, this evaluation is tailored to identify and evaluate data from human toxicity profiles, animal studies and in vitro studies unique to evaluating therapeutic agents. For example, NIOSH consults a variety of resources including, but not limited to, safety data sheets, product labeling approved by the U.S. Food and Drug Administration and databases such as DailyMed and DrugBank. For more information on NIOSH classification of chemical carcinogens see "NIOSH Chemical Carcinogen Policy," http://www.cdc.gov/niosh/index.htm.

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List of Acronyms

AHFS	American Hospital Formulary Service
ASHP	American Society of Health-System Pharmacists (formerly, American Society of Hospital Pharmacy)
BCG	Bacillus Calmette–Guérin
BSC	Biological safety cabinet
CACI	Compounding aseptic containment isolator
CFR	Code of Federal Regulations
CSTD	Closed system drug-transfer device
DPI	Drug package insert
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
HEPA	High-efficiency particulate air
HIPEC	Heated intraperitoneal chemotherapy
IARC	International Agency for Research on Cancer
IV	Intravenous
MRHD	Maximum Recommended Human Dose
MSHG	Manufacturer's safe handling guidance
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
ONS	Oncology Nursing Society
PPE	Personal protective equipment
SC	Subcutaneous
SDS	Safety Data Sheet (formerly Material Safety Data Sheet)
USP	United States Pharmacopeial Convention

Preamble: The *National Institute for Occupational Safety and Health (NIOSH) Alert: Preventing Occupational Exposures to Antineoplastic and Other Hazardous Drugs in Healthcare Settings* was published in September 2004 (http://www.cdc.gov/niosh/docs/2004-165/). In Appendix A of the Alert, NIOSH identified a sample list of hazardous drugs. The list was compiled from information provided by four institutions that had generated lists of hazardous drugs for their respective institutions, as well as a list from the Pharmaceutical Research and Manufacturers of America (PhRMA). The 2004 list was updated in 2010, 2012, and 2014. The current update (2016) adds 34 drugs, five of which have safe-handling recommendations from the manufacturers. In 2014, a new format was developed for the list of hazardous drugs, as described below. The review process for the addition of the new listings is described in the Federal Register: http://www.cdc.gov/niosh/docket/review/docket233a/pdfs/233a_2015-12857.pdf.

Drugs Considered Hazardous

I. General Approach to Handling Hazardous Drugs

Early concerns about occupational exposure to antineoplastic drugs first appeared in the 1970s. Although the antineoplastic drugs remain the principal focus of the Alert, other drugs may also be considered hazardous because they are potent (small quantities produce a physiological effect) or cause irreversible effects. As the use and number of these potent drugs increase, so do opportunities for hazardous exposures among healthcare workers. For example, antineoplastic drugs such as cyclophosphamide and methotrexate have proved beneficial for treating nonmalignant diseases such as rheumatoid arthritis and multiple sclerosis.

In the Alert (NIOSH 2004) and updates to the hazardous drug list (NIOSH 2010 and 2012), NIOSH had previously recommended standard precautions (universal precautions) be taken in handling hazardous drugs. Given the addition of new drug formulations and drugs in tablet and/or capsule form to the list, no single approach can cover the diverse potential occupational exposures to the drugs. All listed drugs are considered hazardous, but safe-handling precautions can vary with the activity and the formulation of the drug. Table 5 provides some guidance on engineering controls and personal protective equipment (PPE) that applies to all listed drugs. The current NIOSH approach involves three groups of drugs:

- Group 1: Antineoplastic drugs (AHFS Classification 10:00) [ASHP/AHFS DI 2016]. Note that many of these drugs may also pose a reproductive risk for susceptible populations (Table 1).
- Group 2: Non-antineoplastic drugs that meet one or more of the NIOSH criteria for a hazardous drug. Note that some of these drugs may also pose a reproductive risk for susceptible populations (Table 2).
- Group 3: Drugs that primarily pose a reproductive risk to men and women who are actively trying to conceive and women who are pregnant or breast feeding, because some of these drugs may be present in breast milk (Table 3).

All hazardous drugs, regardless of the formulation, should be labeled as such to prevent improper handling. The majority of the reproductive risks associated with the drugs listed in Table 3 apply to women, but some can apply to men only (such as reduced fertility or sperm count) or to both men and women. Although all hazardous drugs should be handled according to recommended procedures, especially if they must be prepared aseptically, some populations of workers may not be at reproductive risk from handling drugs in Group 3. These include workers who are excluded from the susceptible populations for specific reasons such as age or infertility. In addition, drugs for which the manufacturer includes safe-handling guidance in the DPI are indicated. NIOSH carries out a hazard identification on each drug on the basis of the NIOSH criteria for a hazardous drug. No attempt has been made to perform risk assessments on each drug or to propose exposure limits. NIOSH has provided guidance for personal protective equipment and ventilated engineering controls for some of the various scenarios in which a drug may be handled in healthcare settings (Table 5). This guidance does not cover all possible situations but provides general recommendations for the typical handling situations in healthcare.

With the increased availability of oral antineoplastic and other hazardous drugs, additional precautions are required in order to prevent worker exposure to these formulations. Some drugs defined as hazardous may not pose a significant risk of direct occupational exposure because of their dosage formulation (for example, coated tablets or capsules—solid, intact medications that are administered to patients without modification of the formulation). However, they may pose a risk if the formulations are altered, such as by crushing tablets or making solutions from them outside a ventilated cabinet [Simmons 2010; Goodin et al. 2011]. Uncoated tablets may present a risk of exposure from dust by skin contact and/or inhalation when the tablets are counted [Shahsavarani et al. 1993; Ahmad et al. 2014]. Tablet and capsule forms of hazardous drugs should not be placed in automated counting machines, which subject them to stress and may introduce powdered contaminants into the work area [Fent et al. 2014]. Counting and pouring of hazardous drugs should be done carefully, and clean equipment should be dedicated for use with these drugs. Crushing tablets or opening capsules should be avoided and liquid formulations should be used whenever possible.

During the compounding of hazardous drugs (e.g., crushing, dissolving, or preparing a solution or an ointment), workers should wear nonpermeable gowns and double gloves (Table 5). Guidelines for the safe compounding, administration, and disposal of hazardous drugs have been developed by several organizations [NIOSH 2004; ASHP 2006; ONS 2011; USP 2016, OSHA 2016]. However, the lack of proper training for handling antineoplastic drugs in other specialty areas may be an issue that needs to be addressed [Abel 2000; Polovich and Giesker 2011; Menonna-Quinn et al. 2013].

II. Defining Hazardous Drugs

Hazardous drugs include those used for cancer chemotherapy, antiviral drugs, hormones, some bioengineered drugs, and other miscellaneous drugs. The NIOSH definition of hazardous drugs used in the Alert is based on a definition originally developed in 1990 by the American Society of Hospital Pharmacists [ASHP 1990], currently known as the American Society of Health-System Pharmacists. Thus, the NIOSH definition may not accurately indicate the potential toxicity criteria associated with some of the newer-generation pharmaceuticals used in healthcare. For example, bioengineered drugs target specific sites in the body, and although they may or may not pose a risk to healthcare workers, some may pose a risk to patients.

NIOSH and other organizations are still gathering data on the potential toxicity and health effects related to highly potent drugs and bioengineered drugs. Therefore, when working with any hazardous drug, healthcare workers should follow the approaches described in Table 5, along with any recommendations included in the manufacturer's Safety Data Sheet (SDS) or the drug package inserts (DPIs).

A. ASHP Definition of Hazardous Drugs

ASHP defines hazardous drugs in its 1990 revision of the Technical Assistance Bulletin on Handling

Hazardous Drugs* [ASHP 1990]. The bulletin gives criteria for identifying potentially hazardous drugs that should be handled in accordance with an established safety program [ASHP 2006; Massoomi et al. 2008; Eisenberg 2009; ONS 2011]. The criteria are prioritized to reflect the hierarchy of potential toxicity described below. Since the hazardous drugs covered by the Alert were designed as therapeutic agents for humans, human toxicity profiles should be given more weight than data from animal models or in vitro systems. Additional guidance for defining hazardous drugs is available from the following sources: carcinogenicity [61 Fed Register 17960–18011 (1996b); IARC 2014], teratogenicity [56 Fed Register 63798–63826 (1991)], developmental toxicity [56 Fed Register 63798–63826 (1991)], and reproductive toxicity [61 Fed Register 56274–56322 (1996a)].

B. NIOSH Revision of ASHP Definition

1. The 1990 ASHP definition of hazardous drugs was revised by the NIOSH Working Group on Hazardous Drugs for the Alert. Drugs considered hazardous include those that exhibit one or more of the following six characteristics in humans or animals:

   - Carcinogenicity
   - Teratogenicity or other developmental toxicity†
   - Reproductive toxicity†
   - Organ toxicity at low doses†
   - Genotoxicity‡
   - Structure and toxicity profiles of new drugs that mimic existing drugs determined hazardous by the above criteria

2. Determining Whether a Drug is Hazardous

Many hazardous drugs used to treat cancer (for example, alkylating agents) bind to or damage DNA. Other antineoplastic drugs, some antivirals, antibiotics, and bioengineered drugs interfere with cell growth or proliferation, or with DNA synthesis. In some cases, the nonselective actions of these drugs disrupt the growth and function of both healthy and diseased cells, resulting in toxic side effects for treated patients and their offspring. These nonselective actions can also cause adverse effects in healthcare workers who are inadvertently exposed to hazardous drugs. However, drugs other than those used to treat cancer may have toxic properties similar to those of the antineoplastic drugs. For some other drugs, adverse reproductive effects are the primary characteristic of concern for occupational exposure. NIOSH evaluates the potential of proposed additions to the list on the basis of these and other characteristics of the drugs.

This document presents criteria and sources of information for determining whether a drug is hazardous. When a drug has been judged to be hazardous, the various precautions outlined in the Alert should be applied when handling that drug. Also included is a list of drugs that should be handled as hazardous. When applying the criteria for a hazardous drug as outlined above, NIOSH takes the following approach.

*ASHP [1990] definition of hazardous drugs:
1. Genotoxicity (i.e., mutagenicity and clastogenicity in short-term test systems)
2. Carcinogenicity in animal models, in the patient population, or both, as reported by the International Agency for Research on Cancer (IARC)
3. Teratogenicity or fertility impairment in animal studies or in treated patients
4. Evidence of serious organ or other toxicity at low doses in animal models or treated patients.

†All drugs have toxic side effects, but some exhibit toxicity at low doses. The level of toxicity reflects a continuum from relatively nontoxic to production of toxic effects in patients at low doses (for example, a few milligrams or less). For example, a daily therapeutic dose of 10 mg/day or a dose of 1 mg/ kg per day in laboratory animals that produces serious organ toxicity, developmental toxicity, or reproductive toxicity has been used by the pharmaceutical industry to develop occupational exposure limits (OELs) of less than 10 µg/m^3 after applying appropriate uncertainty factors [Sargent and Kirk 1988; Naumann and Sargent 1997; Sargent et al. 2002]. OELs in this range are typically established for potent or toxic drugs in the pharmaceutical industry. Under all circumstances, an evaluation of all available data should be conducted to protect healthcare workers.

‡In evaluating mutagenicity for potentially hazardous drugs, responses from multiple test systems are needed before precautions can be required for handling such agents. The EPA evaluations include the type of cells affected and in vitro versus in vivo testing [51 Fed Register 34006–34012 (1986)].

Reproductive and Developmental Toxicity

NIOSH takes into account the dose for animal testing of reproductive and developmental toxicity. If adverse effects are observed in animal testing near, at, or below the maximum recommended human dose (MRHD), NIOSH considers it to be highly relevant. If doses producing an adverse effect are many times the MRHD, usually NIOSH does not consider them in its evaluation.

For reproductive and developmental effects, NIOSH notes if there was maternal toxicity, in addition to the dose. Effects on the fetus in the absence of maternal toxicity are considered relevant. Many drugs with an FDA pregnancy category X rating meet the criteria for a hazardous drug and are listed, but each drug is evaluated individually. Similarly, for Category D, these drugs are often listed because many meet the criteria for being hazardous. Any available human data are considered significant. In June 2015, the FDA removed the pregnancy letter categories (A, B, C, D, and X) in prescription drug labeling. The new labeling was renamed "Pregnancy," "Lactation," and "Females and Males of Reproductive Potential" [FDA 2015]. The plan for the new labeling is to be phased in gradually for drugs approved on or after June 2001, but it went into effect immediately for drugs and biologic products submitted after June 2015. Therefore, the pregnancy letter categories are still in effect for most of the drugs described in this document, for the immediate future.

Carcinogenicity

In addition to dose, for carcinogenicity testing NIOSH looks for tumors in more than one species and sex. It looks for tumors in multiple organs and for tumors that are not rodent-specific. Any available human data are considered significant.

Genotoxicity

For effects of genotoxicity, NIOSH gives greater weight to in vivo testing than in vitro testing. However, adverse outcomes in several in vitro tests will be considered in its evaluation.

Organ Toxicity

For organ toxicity, the low-dose criterion in the definition (a daily therapeutic dose of 10 mg/day or a dose of 1 mg/kg per day in laboratory animals) is used as a benchmark.

Other

Drugs with safe-handling guidelines from the manufacturer are automatically put on the list because the manufacturer has determined their properties warrant special handling.

A NIOSH internal committee performs an initial review of all new FDA drug approvals and new warnings on existing drugs for a two-year period. Following this review, an expert panel consisting of peer reviewers and stakeholders reviews the proposed additions (and deletions, when applicable), using information in DrugBank, DailyMed, and the DPIs and SDSs. Additionally, a Federal Register Notice is published requesting comments on the proposed changes to the list. A final review of all information is performed by NIOSH, and the updated list is published on the NIOSH Hazardous Drug Topic Page (http://www.cdc.gov/niosh/topics/hazdrug/) and in the Federal Register.

In addition to using the list of hazardous drugs presented here, each organization should create its own list of drugs considered to be hazardous, based on drugs in its formulary. This document presents guidance for making such a facility-specific list (see section entitled How to Generate Your Own List of Hazardous Drugs). Subsequently, newly purchased drugs should be evaluated against the organization's hazardous drug criteria and added to the list if they are deemed hazardous. Organizations have developed various approaches to identifying and classifying hazardous drugs [Chaffee et al. 2010; Badry et al. 2013; Kaestli et al. 2013]. Although the classification schemes may differ somewhat, the drugs listed as hazardous are quite similar.

Individual organizations may not have adequate resources for determining their own list of hazardous drugs. If so, the list of hazardous drugs in this document will help employers and workers to determine when precautions are needed. However, reliance on such a published list is a concern because it quickly becomes outdated as new drugs continually enter the market or listed drugs are removed when additional information becomes available. NIOSH will update this list periodically by adding

drugs that meet its criteria and removing those that no longer meet its criteria. This hazardous drug list will be posted on the NIOSH website at www.cdc.gov/niosh/topics/hazdrug/. In addition, drugs that have safe-handling guidance from the manufacturers in the DPIs will be posted on this website after they are approved by the FDA.

III. How to Generate Your Own List of Hazardous Drugs

A. OSHA Hazard Communication

The OSHA hazard communication standard [29 CFR 1910.1200] requires employers to develop a hazard communication program appropriate for their unique workplaces. An essential part of the program is the identification of all hazardous chemicals a worker may encounter in the facility. Compliance with the OSHA hazard communication standard entails developing a list of hazardous chemicals (in this case, drugs) as part of the written hazardous communication program and informing workers where that list can be obtained. The criteria OSHA uses to identify hazardous chemicals, including hazardous drugs, are provided in that standard. Institutions may wish to compare their lists to the listing in this document or on the NIOSH website.

It is not likely that every healthcare provider or facility will use all drugs that have received U.S. Food and Drug Administration (FDA) approval. Instead, compliance requires practice-specific assessments for drugs used at any one time by a facility. However, hazardous drug evaluation is a continual process. Each facility must assess each new drug that enters its workplace to determine if it needs to be included in the Hazard Communication program and, when appropriate, reassess its list of hazardous drugs when new toxicological data become available. Toxicological data are often incomplete or unavailable for investigational drugs. However, if their mechanism of action suggests that there may be a concern, it is prudent to handle them as hazardous drugs until adequate information becomes available to exclude them.

B. NIOSH List of Hazardous Drugs

The following list (Tables 1–3) contains those drugs that NIOSH has reviewed according to the criteria in the NIOSH definition of a hazardous drug. The list was compiled from the following:

- the 2014 NIOSH update to the list
- the NIOSH 2016 update to the list, for which 34 drugs were added (including five with the manufacturers' safe-handling warnings).

The OSHA hazard communication standard requires a written program including a list of chemicals that meet the Hazard Communication definitions for hazardous, labelling, and employee training. The mandate applies not only to healthcare professionals who provide direct patient care but also to others who support patient care by participating in product acquisition, storage, transportation, housekeeping, and waste disposal. Institutions may want to adopt this list or compare theirs with the list on the NIOSH website.

CAUTION: Drugs purchased and used by a facility may have entered the marketplace after the list below was assembled. Therefore, this list may not be all-inclusive.

If you use a drug that is not included in the list of hazardous drugs, check the available literature to see whether the unlisted drug should be treated as hazardous. Check the SDS from the manufacturer or the DPI. You may also check with other institutions that might be using the same drug. If any of the documents mention carcinogenicity, genotoxicity, teratogenicity (Section 13 in the DPI), or reproductive or developmental toxicity (Section 8), or if the DPI contains safe-handling warnings (Section 16), then use the precautions stipulated in the Alert. If the drug meets one or more of the criteria for hazardous drugs in the NIOSH definition, handle it as hazardous.

The list of hazardous drugs will be updated periodically on the website http://www.cdc.gov/niosh/topics/hazdrug/.

This list supersedes the lists from 2004 (http://www.cdc.gov/niosh/docs/2004-165/), 2010, 2012, and 2014 (http://www.cdc.gov/niosh/docs/2014-138/).

C. Where to Find Information Related to Drug Toxicity

Practice-specific lists of hazardous drugs (usually developed by pharmacy or nursing departments) should be comprehensive, including all hazardous medications routinely used or very likely to be used by a local practice. Here are some of the resources that employers can use to evaluate the hazard potential of a drug:

- Safety Data Sheets (SDSs, formerly Material Safety Data Sheets)
- Product labeling approved by the U.S. FDA (DPIs)
- International Agency for Research on Cancer (IARC): http://www.iarc.fr
- DrugBank: http://www.drugbank.ca/
- DailyMed: http://dailymed.nlm.nih.gov/dailymed/
- Special health warnings from drug manufacturers, FDA, and other professional groups and organizations
- Reports and case studies published in medical and other healthcare profession journals
- Evidence-based recommendations from other facilities that meet the criteria defining hazardous drugs

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NIOSH performs a hazard identification for each of the drugs in the following tables, based on its criteria as described above. The actual risk to healthcare workers depends on toxicity of the drugs, how the drugs can enter the body (e.g., dermal, inhalation, or ingestion), and how the drugs are handled—how they are manipulated, how often they are handled, and the exposure controls in place, such as the type of engineering controls and personal protective equipment (PPE) (see Table 5). For example,

- Dispensing a single tablet to a patient may pose a relatively low risk to the healthcare worker. A single pair of gloves may be adequate.
- Repeatedly counting, cutting, or crushing tablets may pose a higher risk for worker exposure than dispensing a single tablet and contamination to the workplace if exposure controls are not in place. If a containment device such as a BSC (Class II biological safety cabinet) or CACI (compounding aseptic containment isolator) is not available, then double gloves, a protective gown, respiratory protection, and a disposable pad to protect the work surface should be used.
- Preparing several intravenous doses of an antineoplastic drug typically poses a higher potential risk to the worker. In addition to double gloving and a protective gown, an engineering control such as a BSC or CACI, possibly supplemented with a CSTD (closed system drug-transfer device), is necessary to protect the drug, environment, and healthcare worker.

The drugs in **Table 1** meet one or more of the NIOSH criteria for a hazardous drug. In addition to many of these drugs being cytotoxic, the majority are hazardous to males or females who are actively trying to conceive, women who are pregnant or may become pregnant, and women who are breast feeding, because they may be present in breast milk.

These drugs represent an occupational hazard to healthcare workers and should always be handled with use of recommended engineering controls and personal protective equipment (PPE), regardless of their formulation (IV [intravenous], SC [subcutaneous], topical, tablet, or capsule). Unopened, intact tablets and capsules may not pose the same degree of occupational exposure risk as injectable drugs, which usually require extensive preparation. Cutting, crushing, or otherwise manipulating tablets and capsules will increase the risk of exposure to workers. The manufacturer's safe-handling guidance (MSHG) is typically in Section 16 of the DPI. See Table 5 for safe-handling recommendations.

Abbreviations and footnotes. AHFS = American Hospital Formulary Service; MRHD = maximum recommended human dose.

[*]Drugs in red font were added in 2016.

National Toxicology Program classifications (http://ntp.niehs.nih.gov/pubhealth/roc/index.html): [**]Known To Be Human Carcinogens; [***]Reasonably Anticipated To Be Human Carcinogens.

[†]International Agency for Research on Cancer (www.iarc.fr): Group 1, Carcinogenic to Humans; Group 2A, Probably Carcinogenic to Humans; Group 2B, Possibly Carcinogenic to Humans.

[‡]BCG, although classified as a vaccine, is used in the treatment of certain cancers. BCG should be prepared with aseptic techniques. To avoid cross-contamination, parenteral drugs should not be prepared in areas where BCG has been prepared. A separate area for the preparation of BCG suspension is recommended. All equipment, supplies, and receptacles in contact with BCG should be handled and disposed of as biohazardous. If preparation cannot be performed in a containment device, then respiratory protection, gloves, and a gown should be worn to avoid inhalation or contact with BCG organisms.

[‡‡]MSHG was removed in 2015 by the manufacturer.

Table 1. Group 1: Antineoplastic drugs, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
abiraterone	10:00 antineoplastic agents		Women who are pregnant or may be pregnant should not handle without protection (e.g., gloves); FDA Pregnancy Category X	DailyMed; DrugBank
ado-trastuzumab emtansine	10:00 antineoplastic agents	yes	Conjugated monoclonal antibody; FDA Pregnancy Category D	DailyMed; DrugBank
afatinib*	10:00 antineoplastic agents		Special warnings on contraception for females while taking and 2 weeks post-treatment; FDA Pregnancy Category D	DailyMed; DrugBank

(Continued)

Table 1 (Continued). Group 1: Antineoplastic drugs, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
altretamine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
amsacrine	NA antineoplastic agents	yes	IARC Group 2B†	DrugBank
anastrozole	10:00 antineoplastic agents		FDA Pregnancy Category X	DailyMed; DrugBank
arsenic trioxide	10:00 antineoplastic agents	yes	IARC Group 1 carcinogen; NTP**; FDA Pregnancy Category D	DailyMed; DrugBank
axitinib	10:00 antineoplastic agents		Teratogenic, embryotoxic and fetotoxic in mice at exposures lower than human exposures; FDA Pregnancy category D	DailyMed; DrugBank
azacitidine	10:00 antineoplastic agents	yes	IARC Group 2A carcinogen; NTP***; FDA Pregnancy Category D	DailyMed; DrugBank
Bacillus Calmette Guerin (BCG)	80:12 vaccines	yes	See special handling requirements‡; FDA Pregnancy Category C	DailyMed
belinostat	10:00 antineoplastic agents	yes	May cause teratogenicity and/or embryo-fetal lethality because it is a genotoxic drug and targets actively dividing cells; FDA Pregnancy Category D	DailyMed; DrugBank
bendamustine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
bexarotene	10:00 antineoplastic agents		FDA Pregnancy Category X	DailyMed; DrugBank
bicalutimide	10:00 antineoplastic agents		FDA Pregnancy Category X	DailyMed; DrugBank
bleomycin	10:00 antineoplastic agents	yes	IARC Group 2B; FDA Pregnancy Category D	DailyMed; DrugBank
bortezomib	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank

(Continued)

Table 1 (Continued) Group 1: Antineoplastic drugs, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
bosutinib	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
brentuximab vedotin	10:00 antineoplastic agents	yes	Conjugated monoclonal antibody; FDA Pregnancy Category D	DailyMed; DrugBank
busulfan	10:00 antineoplastic agents	yes	IARC Group 1 carcinogen; FDA Pregnancy Category D	DailyMed; DrugBank
cabazitaxel	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
cabozantinib	10:00 antineoplastic agents		Embryolethal in rats at exposures below the recommended human dose; FDA Pregnancy category D	DailyMed; DrugBank
capecitabine	10:00 antineoplastic agents	yes	Metabolized to 5-fluorouracil; FDA Pregnancy Category D	DailyMed; DrugBank
carboplatin	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
carfilzomib	10:00 antineoplastic agents		Special warnings on contraception while taking and 2 weeks post- treatment; FDA Pregnancy category D	DailyMed; DrugBank
carmustine	10:00 antineoplastic agents	yes	IARC Group 2A carcinogen; NTP***; FDA Pregnancy Category D	DailyMed; DrugBank
chlorambucil	10:00 antineoplastic agents	yes	IARC Group 1 carcinogen; NTP**; FDA Pregnancy Category D	DailyMed; DrugBank
cisplatin	10:00 antineoplastic agents	yes	IARC Group 2A carcinogen; NTP***; FDA Pregnancy Category D	DailyMed; DrugBank
cladribine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
clofarabine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank

(Continued)

Table 1 (Continued). Group 1: Antineoplastic drugs, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
crizotinib	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
cyclophosphamide	10:00 antineoplastic agents	yes	IARC Group 1 carcinogen; NTP**; FDA Pregnancy Category D	DailyMed; Drugbank
cytarabine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
dabrafenib	10:00 antineoplastic agents		Special warnings on contraception for females while taking and 2 weeks post-treatment; FDA Pregnancy Category D	DailyMed; DrugBank
dacarbazine	10:00 antineoplastic agents	yes	NTP***; FDA Pregnancy Category C	DailyMed; Drugbank
dactinomycin	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
dasatinib	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; Drugbank
daunorubicin	10:00 antineoplastic agents	yes	IARC Group 2B, AKA daunomycin; FDA Pregnancy Category D	DailyMed; Drugbank
decitabine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; Drugbank
degarelix	10:00 antineoplastic agents	-‡‡	FDA Pregnancy Category X	DailyMed; Drugbank
docetaxel	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
doxorubicin	10:00 antineoplastic agents	yes	IARC Group 2A carcinogen; NTP***; FDA Pregnancy Category D	DailyMed; DrugBank
enzalutamide	10:00 antineoplastic agents		Embryo-fetal toxicity in mice at exposures that were lower than in patients receiving the recommended dose; FDA Pregnancy Category X	DailyMed; DrugBank

(Continued)

Table 1 (Continued). Group 1: Antineoplastic drugs, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
epirubicin	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; Drugbank
eribulin	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
erlotinib	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
estramustine	10:00 antineoplastic agents	yes	FDA Pregnancy Category X	DailyMed; Drugbank
etoposide	10:00 antineoplastic agents	yes	IARC Group 1 carcinogen; FDA Pregnancy Category D	DailyMed; DrugBank
everolimus	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; Drugbank
exemestane	10:00 antineoplastic agents		FDA Pregnancy Category X	DailyMed; DrugBank
floxuridine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
fludarabine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
fluorouracil	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
flutamide	10:00 antineoplastic agents		Indicated only for men; FDA Pregnancy Category D	DailyMed; DrugBank
fulvestrant	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
gemcitabine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
gemtuzumab ozogamicin	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
goserelin	10:00 antineoplastic agents		FDA Pregnancy Category X	DailyMed; Drugbank
histrelin	10:00 antineoplastic agents		Can cause fetal harm when administered to a pregnant patient, with the possibility of spontaneous abortion; FDA Pregnancy Category X	DailyMed; DrugBank

(Continued)

Table 1 (Continued). Group 1: Antineoplastic drugs, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
hydroxyurea	10:00 antineoplastic agents	yes	Special warning on handling bottles and capsules; FDA Pregnancy Category D	DailyMed; DrugBank
idarubicin	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
ifosfamide	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
imatinib	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
irinotecan	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
ixazomib	10:00 antineoplastic agents	yes	Male and female patients of childbearing potential must use effective contraceptive measures during and for 3 months following treatment	DailyMed; DrugBank
ixabepilone	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
letrozole	10:00 antineoplastic agents		FDA Pregnancy Category X	DailyMed; DrugBank
leuprolide	10:00 antineoplastic agents	yes	FDA Pregnancy Category X	DailyMed; DrugBank
lomustine	10:00 antineoplastic agents	yes	IARC Group 2A carcinogen; NTP***; FDA Pregnancy Category D	DailyMed; DrugBank
mechlorethamine	10:00 antineoplastic agents	yes	NTP***; FDA Pregnancy Category D	DailyMed; DrugBank
megestrol	10:00 antineoplastic agents	yes	Nursing should be discontinued if megestrol is required; women at risk of pregnancy should avoid exposure; FDA Pregnancy Category X	DailyMed; DrugBank
melphalan	10:00 antineoplastic agents	yes	IARC Group 1 carcinogen; NTP**; FDA Pregnancy Category D	DailyMed; DrugBank

(Continued)

Table 1 (Continued). Group 1: Antineoplastic drugs, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
mercaptopurine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
methotrexate	10:00 antineoplastic agents	yes	FDA Pregnancy Category X	DailyMed; DrugBank
mitomycin	10:00 antineoplastic agents	yes	IARC Group 2B; FDA Pregnancy Category D	DailyMed; DrugBank
mitotane	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
mitoxantrone	10:00 antineoplastic agents	yes	IARC Group 2B; FDA Pregnancy Category D	DailyMed; DrugBank
nelarabine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
nilotinib	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
omacetaxin	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
oxaliplatin	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
paclitaxel	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
panobinostat	10:00 antineoplastic agents	yes	Special warnings on contraception for females while taking and 1 month post-treatment;	DailyMed; DrugBank
pazopanib	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
pemetrexed	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
pentostatin	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
pertuzumab	10:00 antineoplastic agents		Black Box warning on embryo-fetal death and birth defects; FDA Pregnancy Category D	DailyMed; DrugBank

(Continued)

Table 1 (Continued). Group 1: Antineoplastic drugs, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
pomalidomide	10:00 antineoplastic agents	yes	Females of reproductive potential must use two forms of contraception or continuously abstain from heterosexual sex during and for 4 weeks after stopping treatment; FDA Pregnancy Category X	DailyMed; DrugBank
ponatinib	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
pralatrexate	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
procarbazine	10:00 antineoplastic agents	yes	IARC Group 2A carcinogen; NTP***; FDA Pregnancy Category D	DailyMed; DrugBank
regorafenib	10:00 antineoplastic agents		Black Box warning on severe and sometimes fatal hepatotoxicity; total loss of pregnancy at doses lower than recommended human dose; FDA Pregnancy Category D	DailyMed; DrugBank
romidepsin	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
sorafenib	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
streptozocin	10:00 antineoplastic agents	yes	IARC Group 2B; NTP***; FDA Pregnancy Category D	DailyMed; DrugBank
sunitinib	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
tamoxifen	10:00 antineoplastic agents		IARC Group 1 carcinogen; NTP**; FDA Pregnancy Category D	DailyMed; DrugBank
temozolomide	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
temsirolimus	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank

(Continued)

Table 1 (Continued). Group 1: Antineoplastic drugs, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
teniposide	10:00 antineoplastic agents	yes	IARC Group 2A carcinogen; FDA Pregnancy Category D	DailyMed; DrugBank
thioguanine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
thiotepa	10:00 antineoplastic agents	yes	IARC Group 1 carcinogen; NTP**; FDA Pregnancy Category D	DailyMed; DrugBank
topotecan	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
toremifene	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
trametinib	10:00 antineoplastic agents		Embryotoxic and abortifacient at doses less than recommended human dose; FDA Pregnancy Category D	DailyMed; DrugBank
trifluridine/tipiracil (combination only)	10:00 antineoplastic agents	yes	Embryo-fetal lethality and embryo-fetal toxicity at doses lower than or similar to exposures at the recommended human dose	DailyMed; DrugBank; DrugBank
triptorelin	10:00 antineoplastic agents		FDA Pregnancy Category X	DailyMed; DrugBank
valrubicin	10:00 antineoplastic agents	yes	FDA Pregnancy Category C	DailyMed; DrugBank
vandetanib	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
vemurafenib	10:00 antineoplastic agents		FDA Pregnancy Category D	DailyMed; DrugBank
vinblastine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
vincristine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank
vinorelbine	10:00 antineoplastic agents	yes	FDA Pregnancy Category D	DailyMed; DrugBank

(Continued)

Table 1 (Continued). Group 1: Antineoplastic drugs, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
vismodegib	10:00 antineoplastic agents		Black Box warning on embryo-fetal death or severe birth defects; recommend effective contraception for females during therapy and for 7 months after treatment; present in semen; no sperm donation during and 3 months post-treatment; FDA Pregnancy Category D	DailyMed; DrugBank
vorinostat	10:00 antineoplastic agents	yes	Adverse embryo-fetal effects at less than the recommended human dose; FDA Pregnancy Category D	DailyMed; DrugBank
ziv-aflibercept	10:00 antineoplastic agents		Embryotoxic and teratogenic in rabbits at exposure levels lower than human exposures at the recommended dose, with increased incidences of external, visceral, and skeletal fetal malformations; FDA Pregnancy Category C	DailyMed; DrugBank

The drugs in **Table 2** meet one or more of the NIOSH criteria for a hazardous drug. Some of these drugs may represent an occupational hazard to males or females who are actively trying to conceive, women who are pregnant or may become pregnant, and women who are breast feeding, because they may be present in breast milk.

Unopened, intact tablets and capsules may not pose the same degree of occupational exposure risk as injectable drugs, which usually require extensive preparation. Cutting, crushing, or otherwise manipulating tablets and capsules will increase the risk of exposure to workers. The manufacturer's safe-handling guidance (MSHG) is typically in Section 16 of the DPI. See Table 5 for safe-handling recommendations.

Abbreviations and footnotes. AHFS = American Hospital Formulary Service; MRHD = maximum recommended human dose.

*Drugs in blue font meet one or more criteria for a hazardous drug and also pose a potential reproductive hazard.
National Toxicology Program (http://ntp.niehs.nih.gov/pubhealth/roc/index.html): **Known To Be Human Carcinogens; ***Reasonably Anticipated To Be Human Carcinogens.

†International Agency for Research on Cancer (www.iarc.fr): Group 1, Carcinogenic to Humans; Group 2A, Probably Carcinogenic to Humans; Group 2B, Possibly Carcinogenic to Humans.

‡Drugs in red font were added in 2016.

Table 2. Group 2: Non-antineoplastic drugs that meet one or more of the NIOSH criteria for a hazardous drug, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
abacavir	8:18.08.20 nucleoside and reverse transcriptase inhibitors		FDA Pregnancy Category C; malignant tumors observed in male and female mice and rats; genotoxic in in vivo micronucleus test	DailyMed; DrugBank
alefacept	84:92 skin and mucous membrane agents, miscellaneous		Increased frequency of malignancies observed in treated patients; FDA Pregnancy Category B	DailyMed; DrugBank
carbamazepine	28:12:92 anticonvulsants, miscellaneous		Black Box warning for aplastic anemia; congenital malformations in offspring of mothers who took drug; rapid transplacental passage; FDA Pregnancy Category D*	DailyMed; DrugBank
apomorphine	28:36.20.08 non-ergot-derivative dopamine receptor agonists		FDA Pregnancy Category C; genotoxic in several in vitro assays	DailyMed; DrugBank

(Continued)

Table 2 (Continued). Group 2: Non-antineoplastic drugs that meet one or more of the NIOSH criteria for a hazardous drug, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
azathioprine	92:44 immunosuppressants	yes	IARC Group 1 carcinogen†; NTP**; FDA Pregnancy Category D	DailyMed; DrugBank
chloramphenicol	8:12:08 chloramphenicols		IARC Group 2A carcinogen; NTP***; FDA Pregnancy Category C	DailyMed; DrugBank
cidofovir	8:18:32 nucleosides and nucleotides	yes	FDA Pregnancy Category C	DailyMed; DrugBank
cyclosporine	92:44 immunosuppressive agents		IARC Group 1 carcinogen; NTP**; FDA Pregnancy Category C	DailyMed; DrugBank
deferiprone	64:00 heavy metal antagonists		Genotoxic in vitro and in vivo; FDA Pregnancy Category D	DailyMed; DrugBank
dexrazoxane	92:56 protective agents	yes	FDA Pregnancy Category C; secondary malignancies observed in patients treated long term with Razoxane (a racemic mixture containing dexrazoxane); genotoxic in vitro and in vivo; in laboratory studies, testicular atrophy observed at or below the human dose	DailyMed; DrugBank
diethylstilbestrol	NA		IARC Group 1 carcinogen; NTP**; FDA Pregnancy Category X	DrugBank
divalproex	28:12:92 anticonvulsants, miscellaneous		Black Box warning for teratogenicity; FDA Pregnancy Category D; tumors seen in laboratory studies at doses below MRHD	DailyMed; DrugBank
entecavir	8:18:32 nucleosides and nucleotides		FDA Pregnancy Category C	DailyMed; DrugBank

(Continued)

Table 2 (Continued). Group 2: Non-antineoplastic drugs that meet one or more of the NIOSH criteria for a hazardous drug, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
estradiol	68:16:04 estrogens		Black Box warning for malignant neoplasms; increased risk of endometrial cancer, breast cancer, and ovarian cancer; in laboratory studies, increased frequency of carcinomas of the breast, uterus, cervix, vagina, testis, and liver; present in breast milk; FDA Pregnancy Category X	DailyMed; DrugBank
estrogen/ progesterone combinations	68:12 contraceptives		IARC Group 1 carcinogen; NTP**; FDA Pregnancy Category X	DailyMed
estrogens, conjugated	68:16:04 estrogens		Black Box warning for endometrial cancer and cardiovascular risks; long-term use in women and laboratory studies increases frequency of several cancers; NTP**; FDA Pregnancy Category X	DailyMed; DrugBank
estrogens, esterified	68:16:04 estrogens		Black Box warning for endometrial cancer and cardiovascular risks; NTP**; FDA Pregnancy Category X	DailyMed; DrugBank
estropipate	68:16:04 estrogens		Black Box warning for endometrial carcinoma in postmenopausal women and use during pregnancy; FDA Pregnancy Category X	DailyMed; DrugBank
fingolimod	92:20 biologic response modifiers		FDA Pregnancy Category C; in laboratory studies, increased malformations and embryofetal deaths at less than the recommended human dose; malignant lymphomas observed in male and female mice	DailyMed; DrugBank
fluoxymesterone	68:08 androgens		Tumors in mice and rats and possibly humans; FDA Pregnancy Category X	DailyMed; DrugBank

(Continued)

Table 2 (Continued). Group 2: Non-antineoplastic drugs that meet one or more of the NIOSH criteria for a hazardous drug, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
fosphenytoin	28:12.12 hydantoins		Metabolized to phenytoin; FDA Pregnancy Category D	DailyMed; DrugBank
ganciclovir	8:18:32 nucleosides and nucleotides	yes	FDA Pregnancy Category C	DailyMed; DrugBank
leflunomide	92:36 disease-modifying antirheumatic agents		Teratogenic in laboratory studies at 1/10 human dose (HD); marked postnatal survival at 1/100 HD; FDA Pregnancy Category X; severe liver injury reported in patients; carcinogenicity observed at doses below HD	DailyMed; DrugBank
lenalidomide	92:20 biologic response modulators	yes	Analog of thalidomide; FDA Black Box warnings for limb abnormalities; Pregnancy Category X; in laboratory studies, caused thalidomide-type limb defects in monkey offspring	DailyMed; DrugBank
liraglutide recombinant	68:20.06 incretin mimetics		FDA Pregnancy Category C; Black Box warning for thyroid C-cell tumors, with supporting evidence in laboratory studies; also in laboratory studies, teratogenic at or below the MRHD	DailyMed; DrugBank
medroxyprogesterone acetate	68:32 progestins	yes	IARC Group 2B; FDA Pregnancy Category X	DailyMed; DrugBank
methimazole‡	68:36:08 antithyroid agents		Appears in human breast milk; FDA Pregnancy Category D	DailyMed; DrugBank
mipomersen	24:06:92 antilipemic agents, miscellaneous		Black Box warning on hepatotoxicity; FDA Pregnancy Category B	DailyMed; DrugBank

(Continued)

Table 2 (Continued). Group 2: Non-antineoplastic drugs that meet one or more of the NIOSH criteria for a hazardous drug, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
mycophenolate mofetil	92:44 immunosuppressive agents		Black Box warning for embryo fetal toxicity, malignancies, and serious infections; increased risk of first-trimester pregnancy loss and increased risk of congenital malformations; FDA Pregnancy Category D; Special warning: Tablets should not be crushed and capsules should not be opened or crushed. Avoid inhalation or direct contact with skin or mucous membranes of the powder contained in capsules and oral suspension (before or after constitution). If such contact occurs, wash thoroughly with soap and water; rinse eyes with plain water.	DailyMed; DrugBank
mycophenolic acid	92:44 immunosuppressive agents		Black Box warning for first trimester pregnancy loss and an increased risk of congenital malformations; FDA Pregnancy Category D; Black Box warning for lymphomas and other malignancies; genotoxic in vitro and in vivo	DailyMed; DrugBank
nevirapine	8:18.08.16 nonnucleoside reverse transcriptase inhibitors		FDA Pregnancy Category B; in laboratory studies, hepatocellular adenomas and carcinomas at doses lower than human dose	DailyMed; DrugBank
ospemifene	68:16:12 estrogen agonists-antagonists		Black Box warning on increased risk of endometrial cancer in certain populations; risk of adverse outcomes during pregnancy and labor; FDA Pregnancy Category X	DailyMed; DrugBank
oxcarbazepine	28:12:92 anticonvulsants, miscellaneous		Tumors observed in laboratory studies at 1/10 MRHD; FDA Pregnancy Category C	DailyMed; DrugBank

(Continued)

Table 2 (Continued). Group 2: Non-antineoplastic drugs that meet one or more of the NIOSH criteria for a hazardous drug, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
palifermin	84:16 cell stimulants and proliferants		FDA Pregnancy Category C; potential for stimulation of tumor growth	DailyMed; DrugBank
paliperidone	28:16:08:04 atypical antipsychotics		Metabolite of risperidone; excreted in human breast milk; FDA Pregnancy Category C	DailyMed; DrugBank
phenoxybenzamine	12:16:04:04 non-selective alpha-andrenergic blocking agents		IARC Group 2B; FDA Pregnancy Category C	DailyMed; DrugBank
phenytoin	28:12.12 hydantoins		IARC Group 2B; NTP***; FDA Pregnancy Category D	DailyMed; DrugBank
pipobroman	NA		FDA Pregnancy Category D	DrugBank
progesterone	68:32 progestins		IARC Group 2B; NTP***	DailyMed; DrugBank
progestins	68:12 contraceptives		FDA Pregnancy Category X	DailyMed
propylthiouracil	68:36.08 antithyroid agents		IARC Group 2B; NTP***; FDA Pregnancy Category D	DailyMed; DrugBank
raloxifene	68:16:12 estrogen agonists-antagonists		Abortion and developmental abnormalities seen at low doses in laboratory studies; evidence of tumors at low doses in laboratory studies; FDA Pregnancy Category X	DailyMed; DrugBank
rasagiline	28:36 antiparkinsonian agents		FDA Pregnancy Category C	DailyMed; DrugBank
risperidone	28:16:08:04 atypical anti-psychotics		Evidence of tumors at low doses in laboratory studies; may be prolactin-mediated; FDA Pregnancy Category C	DailyMed; DrugBank
sirolimus	92:44 immunosuppressive agents		AKA rapamycin; increased risk of lymphomas and other malignancies; embryotoxic and fetotoxic at 0.2 human dose; FDA Pregnancy Category C	DailyMed; DrugBank

(Continued)

Table 2 (Continued). Group 2: Non-antineoplastic drugs that meet one or more of the NIOSH criteria for a hazardous drug, including those with the manufacturer's safe-handling guidance (MSHG)

Drug	AHFS classification	MSHG	Supplemental information	Links
spironolactone	24:32.20 mineralocorticoid receptor antagonists		FDA Pregnancy Category C; Black Box warning for tumorogenicity in laboratory studies	DailyMed; DrugBank
tacrolimus	92:44 immunosuppressive agents		Increased risk of lymphomas and other malignancies; reproductive effects seen in laboratory studies below the MRHD; excreted in breast milk; FDA Pregnancy Category C	DailyMed; DrugBank
teriflunomide	92:20 immunomodulatory agents		Black Box warning on severe hepatotoxicity and teratogenicity, including major birth defects; FDA Pregnancy Category X	DailyMed; DrugBank
thalidomide	92:20 biologic response modulators	yes	FDA Pregnancy Category X	DailyMed; DrugBank
tofacitinib	92:36 disease modifying antirheumatic drugs		Black Box warning for lymphoma and other malignancies; FDA Pregnancy Category C	DailyMed; DrugBank
uracil mustard	NA	yes	FDA Pregnancy Category D	DrugBank
valganciclovir	8:18:32 nucleosides and nucleotides	yes	FDA Pregnancy Category C	DailyMed; DrugBank
zidovudine	8:18:08 antiretroviral agents		IARC Group 2B; FDA Pregnancy Category C	DailyMed; DrugBank

The drugs in **Table 3** primarily meet the NIOSH criteria for reproductive hazards. They represent a potential occupational hazard to males or females who are actively trying to conceive, women who are pregnant or may become pregnant, and women who are breast feeding, as they may be present in breast milk. Unopened, intact tablets and capsules may not pose the same degree of occupational risk as injectable drugs that usually require extensive preparation. Cutting, crushing, or otherwise manipulating tablets and capsules will increase the risk of exposure to workers. The manufacturer's safe-handling guidance (MSHG) is typically in Section 16 of the DPI. See Table 5 for safe handling recommendations.

*Drugs in red font were added in 2016.

Table 3. Group 3: Non-antineoplastic drugs that primarily have adverse reproductive effects

Drug	AHFS classification	Supplemental information	Links
acitretin	88:04 vitamin A	Black Box warning on adverse reproductive effects; FDA Pregnancy Category X	DailyMed; DrugBank
alitretinoin	84:92 skin and mucous membrane agents, miscellaneous	FDA Pregnancy Category D	DailyMed; DrugBank
ambrisentan	24:12:92 vasodilating agents, miscellaneous	Black Box warning on adverse reproductive effects; reduced sperm counts in patients; FDA Pregnancy Category X	DailyMed; DrugBank
bosentan	24:12:92 vasodilating agents, miscellaneous	Black Box warning on adverse reproductive effects; Pregnancy Category X	DailyMed; DrugBank
cabergoline	28:36:20:04 ergot-derivative dopamine receptor agonists	Inhibition of conception and embryo fetal effects at doses below recommended human dose; FDA Pregnancy Category B	DailyMed; DrugBank
cetrorelix	92:40 gonadotropin-releasing hormone antagonists	FDA Pregnancy Category X	DailyMed; DrugBank
choriogonadotropin	68:18 gonadotropins	FDA Pregnancy Category X; may cause fetal harm when administered to a pregnant woman	DailyMed; DrugBank
clomiphene*	68:16:12 estrogen agonist-antagonists	FDA Pregnancy Category X	DailyMed; DrugBank
clonazepam	28:12:08 benzodiazepines	Increased risk of congenital abnormalities when taken in first trimester; FDA Pregnancy Category D	DailyMed; DrugBank

(Continued)

Table 3 (Continued). Group 3: Non-antineoplastic drugs that primarily have adverse reproductive effects

Drug	AHFS classification	Supplemental information	Links
colchicine	92:16 anti-gout agents	FDA Pregnancy Category C; published animal reproduction and development studies indicate it causes embryofetal toxicity, teratogenicity, and altered postnatal development at exposures within or above the clinical therapeutic range	DailyMed; DrugBank
dinoprostone	76:00 oxytocics	Hazardous only for women in late pregnancy; FDA Pregnancy Category C	DailyMed; DrugBank
dronedarone	24:04:04 antiarrythmics	Teratogenic in laboratory studies at ½ MRHD; FDA Pregnancy Category X	DailyMed; DrugBank
dutasteride	92:08 5-alpha reductase inhibitors	Women warned not to handle; FDA Pregnancy Category X	DailyMed; DrugBank
eslicarbazepine	28:12:92 anticonvulsants, miscellaneous	Fetal malformations, fetal growth retardation, embryolethality, and reduced body weights observed in animal studies; excreted in human breast milk; FDA Pregnancy Category C	DailyMed; DrugBank
ergonovine/methylergonovine	76:00 oxytocics	Use is contraindicated during pregnancy because of its uterotonic effects; FDA Pregnancy Category C	DailyMed; DrugBank; DrugBank
finasteride	92:08 5-alpha reductase inhibitors	Women should not handle crushed or broken finasteride tablets when they are pregnant or may potentially be pregnant, due to potential risk to a male fetus; FDA Pregnancy Category X	DailyMed; DrugBank
fluconazole	8:18.08 azoles	FDA Pregnancy Category C; case reports describe congenital anomalies in infants exposed in utero to maternal fluconazole (400–800 mg/ day) during most or all of the first trimester, similar to those seen in animal studies	DailyMed; DrugBank

(Continued)

Table 3 (Continued). Group 3: Non-antineoplastic drugs that primarily have adverse reproductive effects

Drug	AHFS classification	Supplemental information	Links
ganirelix	92:40 gonadotropin-releasing hormone antagonists	FDA Pregnancy Category X	DailyMed; DrugBank
gonadotropin, chorionic	68:18 gonadotropins	Defects of forelimbs and central nervous system and alterations in sex ratio have been reported in laboratory studies; FDA Pregnancy Category C	DailyMed; DrugBank
icatibant	92:32 complement inhibitors	FDA Pregnancy Category C; in laboratory studies, premature birth and abortion rates increased at a dose that was less than 1/40th the MRHD, and delayed parturition and fetal death occurred at 0.5 and 2-fold, respectively, the MRHD	DailyMed; DrugBank
lomitapide	24:06:92 antilipemic agents, miscellaneous	FDA Pregnancy Category X	DailyMed; DrugBank
macitentan	48:48 vasodilating agents	Black Box warning for embryo-fetal toxicity; special warnings on contraception for females while taking and 1 month post-treatment; FDA Pregnancy Category X	DailyMed; DrugBank
mentropins	68:18 gonadotropins	FDA Pregnancy Category X	DrugBank
methyltestosterone	68:08 androgens	FDA Pregnancy Category X	DailyMed; DrugBank
mifepristone	76:00 oxytocics	When given to pregnant women, results in termination of pregnancy; FDA Pregnancy Category X	DailyMed; DrugBank
misoprostol	56:28.28 prostaglandins	FDA Pregnancy Category X	DailyMed; DrugBank
nafarelin	68:18 gonadotropins	Note: Given only as nasal spray; no potential for occupational exposure; FDA Pregnancy Category X	DailyMed; DrugBank
oxytocin	76:00 oxytocics	Hazardous only for women in 3rd trimester; FDA Pregnancy Category C	DailyMed; DrugBank

(Continued)

Table 3 (Continued). Group 3: Non-antineoplastic drugs that primarily have adverse reproductive effects

Drug	AHFS classification	Supplemental information	Links
pamidronate	92:24 bone resorption inhibitors	Embryo-fetal toxicities at doses below the recommended human dose; FDA Pregnancy Category D	DailyMed; DrugBank
paroxetine	28:16:04:20 selective serotonin uptake inhibitors	Increased risk of congenital abnormalities when taken in first trimester; complications in pregnancy when taken in third trimester; FDA Pregnancy Category D	DailyMed; DrugBank
pasireotide	68:29:04 somostatin agonists	Increased implantation loss and decreased viable fetuses, corpora lutea, and implantation sites at doses less than the human recommended dose; FDA Pregnancy Category C	DailyMed; DrugBank
pentetate calcium trisodium	NA	Severe teratogenic effects in laboratory studies in dogs; supplied in ampule, which can lead to occupational exposure; FDA Pregnancy Category C	DailyMed
peginesatide	20:16 hematopoietic agents	Adverse embryo-fetal effects, including reduced fetal weight, increased resorption, embryo-fetal lethality, and cleft palate, observed in doses below the recommended human dose; FDA Pregnancy Category C	DailyMed; DrugBank
plerixafor	20:16 hematopoietic agents	Teratogenic in laboratory studies; FDA Pregnancy Category D	DailyMed; DrugBank
ribavirin	8:18:32 nucleosides and nucleotides	Teratogenic and embryotoxic effects in several laboratory studies; contraindicated in women who are pregnant and in the male partners of women who are pregnant; FDA Pregnancy Category X	DailyMed; DrugBank

(Continued)

Table 3 (Continued). Group 3: Non-antineoplastic drugs that primarily have adverse reproductive effects

Drug	AHFS classification	Supplemental information	Links
riociguat	48:48 vasodilating agents	Exclude pregnancy before the start of treatment, monthly during treatment, and 1 month after stopping treatment; FDA Pregnancy Category X	DailyMed; DrugBank
telavancin	8:12:28 glycopeptides	Black Box warning for potential risk to fetus and adverse reproductive outcomes; reduced fetal weights and increased rates of digit and limb malformations in three species at clinical doses; FDA Pregnancy Category C	DailyMed; DrugBank
temazepam	28:24:08 benzodiazepines	Increased risk of congenital malformations associated with treatment during the first trimester of pregnancy; FDA Pregnancy Category X	DailyMed; DrugBank
testosterone	68:08 androgens	Children should avoid contact with unwashed or unclothed application sites on skin; FDA Pregnancy Category X	DailyMed; DrugBank
topiramate	28:12.92 anticonvulsants, miscellaneous	FDA Pregnancy Category D	DailyMed; DrugBank
tretinoin	84:16 cell stimulants and proliferants	Black Box warning for severe birth defects; Special FDA distribution system; FDA Pregnancy Category X	DailyMed; DrugBank
ulipristal	68:12 contraceptives	FDA Pregnancy Category X	DailyMed
valproate/valproic acid	28:12:92 anticonvulsants, miscellaneous	Black Box warning for teratogenicity; congenital malformations, including neural tube defects; teratogenic in multiple species; FDA Pregnancy Category D	DailyMed; DailyMed; DrugBank
vigabatrin	28:12:92 anticonvulsants, miscellaneous	Malformations seen in laboratory studies below the MRHD; FDA Pregnancy Category C	DailyMed; Drugbank
voriconazole	8:14.08 azoles	FDA Pregnancy Category D	DailyMed; DrugBank

(Continued)

Table 3 (Continued). Group 3: Non-antineoplastic drugs that primarily have adverse reproductive effects

Drug	AHFS classification	Supplemental information	Links
warfarin	20:12.04.08 coumarin derivatives	FDA Pregnancy Category D	DailyMed; DrugBank
ziprasidone	28:16:08:04 atypical antipsychotics	Developmental toxicity, including possible teratogenic effects at doses similar to human therapeutic doses; an increase in the number of pups born dead and a decrease in postnatal survival at less than MRHD; FDA Pregnancy Category C*	DailyMed; DrugBank
zoledronic acid	92:24 bone resorption inhibitors	Number of stillbirths increased and survival of neonates decreased in laboratory studies at low doses; FDA Pregnancy Category D	DailyMed; DrugBank
zonisamide	28:12:92 anticonvulsants, miscellaneous	Teratogenic in multiple miscellaneous animal species; FDA Pregnancy Category D	DailyMed; DrugBank

Table 4 would list drugs that were deleted from the 2014 NIOSH hazardous drug list for the 2016 update; however, there are no deletions to report.

Table 5 provides general guidance for some of the possible scenarios that may be encountered in healthcare settings where hazardous drugs are handled, but it cannot cover all possible situations.

Abbreviations and footnotes. BSC = Class II biological safety cabinet; CACI = compounding aseptic containment isolator; CSTD = closed system drug-transfer device; HIPEC = hyperthermic intraperitoneal chemotherapy.

*This guidance applies to the drugs in Tables 1–3. For more detailed information on safe-handling practices, see the reference list [NIOSH 2004; ASHP 2006; ONS 2011; USP 2016; OSHA 2016].

†For nonsterile preparations, a ventilated engineering control such as a fume hood or Class I BSC or a HEPA-filtered enclosure (such as a powder hood) is sufficient if the control device exhaust is HEPA filtered or appropriately exhausted to the outside of the building. It is recommended that these activities be carried out in a control device, but it is recognized that under some circumstances, it is not possible. If the activity is performed in a ventilated engineering control that is used for sterile intravenous preparations, a thorough cleaning is required following the activity.

‡Required if patient may resist (infant, unruly patient, patient pre-disposed to spitting out, patient who has difficulty swallowing, veterinary patient) or if the formulation is hard to swallow.

§Sterile gloves are required for aseptic drug preparation in BSC or CACI.

¶Intravenous tubing already attached and primed.

Table 5. Personal protective equipment and engineering controls for working with hazardous drugs in healthcare settings*

Formulation	Activity	Double chemo-therapy gloves	Protective gown	Eye/face protection	Respiratory protection	Ventilated engineering control
All types of hazardous drugs	Receiving, unpacking, and placing in storage	no (single glove can be used, unless spills occur)	yes, when spills and leaks occur	no	yes, when spills and leaks occur	no
Intact tablet or capsule	Administration from unit-dose package	no (single glove can be used)	no	no	no	N/A
Tablets or capsules	Cutting, crushing, or manipulating tablets or capsules; handling uncoated tablets	yes	yes	no	yes, if not done in a control device	yes†
	Administration	no (single glove can be used)	no	yes, if vomit or potential to spit up‡	no	N/A

(Continued)

Table 5 (Continued). Personal protective equipment and engineering controls for working with hazardous drugs in healthcare settings*

Formulation	Activity	Double chemo-therapy gloves	Protective gown	Eye/face protection	Respiratory protection	Ventilated engineering control
Oral liquid drug or feeding tube	Compounding	yes	yes	yes, if not done in a control device	yes, if not done in a control device	yes†
	Administration	yes	yes	yes, if vomit or potential to spit up‡	no	N/A
Topical drug	Compounding	yes	yes	yes, if not done in a control device	yes, if not done in a control device	yes†, BSC or CACI (Note: carmustine and mustargen are volatile)
	Administration	yes	yes	yes, if liquid that could splash‡	yes, if inhalation potential	N/A
Subcutaneous/ intra-muscular injection from a vial	Preparation (withdrawing from vial)	yes	yes	yes, if not done in a control device	yes, if not done in a control device	yes, BSC or CACI
	Administration from prepared syringe	yes	yes	yes, if liquid that could splash‡	no	N/A
Withdrawing and/or mixing intravenous or intramuscular solution from a vial or ampoule	Compounding	yes§	yes	no	no	yes, BSC or CACI; use of CSTD recommended
	Administration of prepared solution	yes	yes	yes; if liquid that could splash‡	no	N/A; CSTD required per USP 800 if the dosage form allows

(Continued)

Table 5 (Continued). Personal protective equipment and engineering controls for working with hazardous drugs in healthcare settings*

Formulation	Activity	Double chemo-therapy gloves	Protective gown	Eye/face protection	Respiratory protection	Ventilated engineering control
Solution for irrigation	Compounding	yes	yes	yes, if not done in a control device	yes, if not done in a control device	yes, BSC or CACI; use of CSTD recommended
	Administration (bladder, HIPEC, limb perfusion, etc.)	yes	yes	yes	yes	N/A
Powder/solution for inhalation/ aerosol treatment	Compounding	yes	yes	yes, if not done in a control device	yes, if not done in a control device	yes, BSC or CACI
	Aerosol administration	yes	yes	yes	yes	yes, when applicable
	Administration	yes	yes	yes, if liquid that could splash‡	yes, if inhalation potential	N/A
Drugs and metabolites in body fluids	Disposal and cleaning	yes	yes	yes, if liquid that could splash	yes, if inhalation potential	N/A
Drug-contaminated waste	Disposal and cleaning	yes	yes	yes, if liquid that could splash	yes, if inhalation potential	N/A
Spills	Cleaning	yes	yes	yes	yes	N/A

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