

## Ethylene Oxide Health Risks Information for Clinicians

### Summary and Action Items

- 1.) Provide clinicians with information on the health risks of ethylene oxide (EtO), including the increased lifetime cancer risk due to occupational exposures and environmental (community) emissions of EtO.
- 2.) Provide clinical guidance, including the recommended cancer screenings for workers and residents of communities near sites with industrial EtO emissions.
- 3.) Encourage clinicians to become familiar with taking an exposure history from patients. Share resources for incorporating exposure histories into clinical practice.

### Background – Ethylene Oxide Gas

Ethylene oxide (EtO) is a gas at room temperature. It is used in the manufacturing of various chemicals, as a sterilizing agent for medical and dental equipment, and as a fumigating agent for spices and certain other items. EtO is also present in tobacco smoke.

The highest levels of human exposure are in occupations involving contact with the gas in plants that manufacture or use EtO and in hospitals that sterilize medical equipment. EtO can also be inhaled by residents living near facilities that produce or use EtO or near sterilizing/fumigating facilities.

[\[U.S. Environmental Protection Agency \(U.S. EPA\) \(2016\)\]](#)

### Health Effects of Ethylene Oxide (Ref: [Agency for Toxic Substances and Disease Registry \(ATSDR\) EtO Clinician Brief](#))

Inhalation is the primary route of exposure to EtO in both occupational and environmental (community) settings; however, workers may also have dermal exposures. Workers generally have much higher exposure levels than the public. In communities near facilities that release EtO, ambient outdoor levels are very low compared to occupational levels.

#### Short-term, acute, high-level exposure (workers):

The diagnosis of acute ethylene oxide toxicity is primarily clinical, based on exposure history, symptoms of central nervous system (CNS) depression or irritation, and related physical findings. Symptoms reported from short-term occupational exposure to high levels of EtO [above 260 ppm/470 mg/m<sup>3</sup> (parts per million/milligrams per cubic meter)] include:

- Neurological effects (headache, dizziness, nausea, lethargy, muscle weakness, memory loss),
- Respiratory irritation (coughing, shortness of breath, wheezing)
- Excessive thirst and dry mouth, gastrointestinal effects (vomiting, diarrhea, due to neurotoxicity),
- Ocular effects (eye irritation) and
- Skin rashes.

### Illinois Department of Public Health

### **Chronic low-level exposure:**

#### **Non-cancer effects (workers):**

Workers exposed to low levels of EtO for several years may develop irritation of the eyes, skin, and respiratory passages and effects to the nervous system (e.g.; headache, nausea, memory loss).

#### **Cancer (workers and community members):**

Studies of workers at EtO plants with long-term (years or decades) cumulative exposure to elevated EtO air concentrations observed an increased risk of **female breast cancer and lymphohematopoietic cancers (non-Hodgkin lymphoma, myeloma, and lymphocytic leukemia)**. Long-term exposure to inhaled EtO, either from occupational or community exposures, may increase the lifetime risk of developing these cancers.

Because EtO is mutagenic, children may be at a higher risk of health effects due to incomplete development of detoxification pathways, higher respiratory rate, and more opportunities for exposure such as playing outside.

### **Illinois Communities with Industrial EtO Emissions**

The 2014 National Air Toxics Assessment, released in 2018, identified communities in Illinois with elevated cancer risks from long term exposure to modeled concentrations ethylene oxide. One facility in Willowbrook (DuPage County) closed in 2019, while two facilities in Gurnee and Waukegan (Lake) are still operating. Actions have been taken at the federal, state, and local levels to evaluate the risk and substantially reduce EtO emissions from these facilities. (See appendix A for additional details).

ATSDR released a health consultation report in 2018 evaluating the health risks of exposure to measured concentrations of EtO in outdoor air in Willowbrook. A follow up report analyzing EtO concentrations before and after the Willowbrook facility closed was released for public comment in November 2023. ATSDR is preparing a similar report for the facilities in Gurnee and Waukegan facilities.

### **Implications for Clinical Practice (Ref: [ATSDR EtO Clinician Brief](#))**

#### **Acute Exposures:**

There is no antidote to treat EtO toxicity. Treatment is supportive.

Routine laboratory studies for all exposed patients include complete blood count (CBC), glucose, and electrolyte determinations. Additional studies may be indicated, include renal and liver function tests. Chest radiography and pulse oximetry (or arterial blood gas [ABG] measurements) should be considered for severe inhalation exposure.

#### **Chronic exposures:**

##### **Noncancer symptoms:**

Non-cancer symptoms related to chronic (inhalation) exposure tend to worsen during exposure and improve when exposure stops, such as during vacation or after a job transfer. Symptomatic treatment is indicated.

##### **Cancer:**

Because long-term exposure to inhaled EtO may increase the risk of developing lymphoid and breast cancers, patients who are at high risk should have regular preventive cancer screenings as

recommended by U.S. Preventive Services Task Force ([USPSTF 2016](#)). Regular health maintenance visits may help detect abnormalities at an early stage.

### **Breast Cancer:**

The current (2016) USPSTF recommendation is for mammography screening every 2 years after age 50, a [draft recommendation](#) (not yet adopted) recommends beginning mammography at age 40 (recommendation Grade B.)

Other groups have variations of breast cancer screening guidelines, including every year beginning at age 40 ([ACOG](#), [American Cancer Society](#).)

Breast imaging, including diagnostic mammography, is also indicated for signs and symptoms of breast cancer including breast lump, skin changes, nipple retraction/discharge or other breast changes.

### **Lymphoid Cancer:**

**Adults:** Lymphoma symptoms include painless lymphadenopathy, fatigue, fever, night sweats and unexplained weight loss. Multiple myeloma symptoms include bone pain, nausea, constipation, confusion, fatigue, and weight loss.

**Children:** Lymphoma should be suspected in a child with nontender lymphadenopathy that is enlarging without obvious cause, unexplained hepatosplenomegaly, or of signs related to an expanding mass affecting a variety of systems (e.g., respiratory, gastrointestinal, CNS).

Laboratory tests like complete blood counts (CBCs) and imaging studies are the first steps in evaluating for the possibility of lymphoid cancers in adults and children. Early involvement of a hematologist/oncologist appropriate for the age of your patient is recommended.

### **Performing an Exposure History (Ref: [ATSDR Taking an Exposure History](#))**

Most environmental and occupational diseases either manifest as common medical problems or have nonspecific symptoms. Adults and youth with illnesses caused or exacerbated by exposure to hazardous substances typically obtain their medical care from clinicians who are not specialists in either environmental or occupational medicine.

Extensive knowledge of toxicology is not needed to diagnose environmental and occupational disease. The same criteria are employed as those used in diagnosing other medical problems—history, including onset, temporal pattern of symptoms, and contributing or relieving factors; physical examination; and (potentially) laboratory results.

A useful resource to learn more about incorporating exposure histories into clinical practice: [ATSDR Exposure History Form and Case Studies](#)

### **To Contact an Expert in Environmental Medicine (for *both* adults and children)**

Region 5 Pediatric Environmental Health Specialty Unit (PEHSU) University of Illinois at Chicago, Great Lakes Center for Reproductive and Children's Environmental Health

Website: <https://childrensenviro.uic.edu>

Phone: 866-967-7337

Email: [ChildrensEnviro@uic.edu](mailto:ChildrensEnviro@uic.edu)

## **Clinician EtO Resources & References:**

**CDC/ATSDR (Agency for Toxic Substances and Disease Registry)**

[ATSDR Clinical Brief: Ethylene Oxide](#) (website) – includes recommendations for patient care/follow-up

[ATSDR Clinical Overview: Ethylene Oxide](#) (video) – practical information on patient care can be found at time 20.31 minutes into the presentation.

[Toxicology Profile for Ethylene Oxide](#) – more detailed toxicology profile with links

[ATSDR FAQs on Ethylene Oxide](#) Two-page informational sheet for the public

## **U.S. EPA**

[General Ethylene Oxide Information](#) (website)

[EPA Ethylene Oxide Explained](#) – Two-page informational sheet for the public

## **Occupational Safety and Health Administration**

[OSHA Ethylene Oxide Overview](#) (website)

[OSHA Ethylene Oxide Fact Sheet](#) -Two-page informational sheet for employers

## **National Cancer Institute**

[NCI page on Ethylene Oxide](#) (website)

**Target Audience:** Health Care Providers, Local Health Departments

**Date Issued:** January 30, 2024

## Appendix A

### EtO Risk Assessments

#### U.S. EPA EtO Risk Assessment Principles

The U.S. EPA Risk Assessment Framework limits the estimated additional lifetime maximum individual cancer risk (MIR) to **no higher than 1 in 10 thousand (or 100 in a million)**. The estimated risk is in addition to people's overall risk for getting cancer for other reasons. This website describes the [U.S. EPA approach to EtO risk assessments](#) for workers and residents, including children.

#### Sterigenics, Willowbrook, IL (DuPage County) (Ceased operations February 15, 2019)

Sterigenics was a commercial sterilizer that used ethylene oxide (EtO) to sterilize medical equipment and other products in Willowbrook, Ill. It had been operating in Building 1 (7775 Quincy Street) since 1984 and in Building II (830 Midway) since 1999, prior to its closure in 2019.

- [U.S. EPA \(2019\)](#) and Agency for Toxic Substances and Disease Registry (ATSDR) [Agency for Toxic Substances and Disease Registry \(ATSDR\)](#) completed assessments of the lifetime health risks posed by community exposure to inhaled EtO.
- U.S. EPA estimated additional **resident cancer risk** from lifetime (70 years) exposure during facility operations ranged from **less than 100 in 1 million to 1,000 in a million** in areas closest to the facility.
- U.S. EPA estimated additional **worker cancer risk** from long-term (25 years) exposures during facility operations ranged from **200 in 1 million to 1,000 in a million** just outside the facility.
- ATSDR estimated an expected increase in lifetime cancer risk of **4-10 excess cancers in 10,000** for those who lived **within one mile** of the Sterigenics facility.
- [2019 Illinois Department of Public Health - Cancer Incidence Investigation](#) on cancer incidence among people living near the Sterigenics plant found an elevated incidence of **female Hodgkin lymphoma** and **breast cancer**, and an elevated incidence of pediatric **lymphoma among girls**. These findings, in the context of the studies limitations, were unable to establish a clear association with assumed ethylene oxide exposure and cancer incidence in the populations examined.
- Questions about the IDPH study can be submitted to [ethyleneoxide-cancer@Illinois.gov](mailto:ethyleneoxide-cancer@Illinois.gov)
- ATSDR concluded there is no increased risk of noncancer health effects from EtO exposure near the plant.
- After sterilization work at the plant ended on February 15, 2019, no additional EtO was released. People who moved to or began work in the area after this date are not at increased risk.

#### Additional Information

1. [U.S. EPA Sterigenics Willowbrook Facility](#) – Full report of monitoring and analysis
2. [U.S. EPA EtO Risk Assessment \(Sterigenics\)](#) – Summary of findings
3. [ATSDR Sterigenics Health Consultation](#) – Full report
4. [ATSDR Evaluation of Ethylene Oxide near Sterigenics](#) - factsheet on the investigation
5. [2019 Illinois Department of Public Health - Cancer Incidence Investigation](#)

## Appendix A

### EtO Risk Assessments

#### **Medline Industries, Inc., Waukegan, IL (Lake County)** (Uses EtO to sterilize medical equipment)

#### **Vantage Specialty Chemicals, Gurnee, IL (Lake County)** (Uses EtO in the production of other chemicals)

In August of 2018, U.S. EPA released the 2014 National Air Toxics Assessment (NATA) which identified the Waukegan-Gurnee area, in Lake County, Illinois, as potentially having elevated cancer risk, with EtO identified as the predominant pollutant driving the elevated estimate. This was based on a new metric introduced by US EPA in 2016, after revisiting the public health science.

In response, the Lake County Health Department, Village of Gurnee, and City of Waukegan, contracted for EtO sampling in 2019 and 2020 near the facilities, with guidance from Illinois EPA.

Based on these samples, U.S. EPA concluded: [US EPA 2021 letter Lake County EtO Risk](#)

- Both Medline and Vantage contributed to 24-hour concentrations at some sampling locations that
  - 1) were above background levels; and
  - 2) would result in a cancer risk above 100-in-a-million beyond the fence line of these facilities (If these concentrations persisted continuously for 70 years).
- Significant emissions reductions from facility modifications implemented at both Medline and Vantage, as required under the 2019 Illinois [Public Act 101-0022](#) and [Public Act 101-0023](#), have reduced this risk.
- Modeling indicates neither Medline nor Vantage would now contribute more than 100-in-a-million to cancer risk to any resident or worker, even if emissions were at maximum permitted levels.
- [2021 Illinois Department of Public Health - Cancer Incidence Investigation](#) on cancer incidence among people living near the two plants showed a statistically significant elevation of **myeloma** incidence among females relative to the Lake County average, but the difference was reduced to non-significant when compared to the Cook County average. There was no increase in breast cancer and other lymphohematopoietic cancers. No childhood cancers were elevated. These findings, in the context of the studies limitations, were unable to establish a clear association with assumed ethylene oxide exposure and cancer incidence in the populations examined.
- Questions about the IDPH study can be submitted to [ethyleneoxide-cancer@illinois.gov](mailto:ethyleneoxide-cancer@illinois.gov)

#### **Additional Information**

[US EPA Addressing Ethylene Oxide Emissions in Lake County, Illinois](#)

[Illinois EPA information on Ethylene Oxide](#)

[Lake County Health Department Ethylene Oxide Information](#)

[2021 Illinois Department of Public Health - Cancer Incidence Investigation](#)