

Environmental Health in Nursing

2nd Edition



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Dedication

This second edition of Environmental Health in Nursing, is dedicated to the memory of an environmental health nursing leader, Denise Briganti Choiniere. Denise was the first Director of Sustainability and Materials Management at University of Maryland Medical Center in Baltimore, Maryland. She passed away in 2017 after a courageous battle with lymphoma. We are grateful for Denise's visionary leadership in environmental health nursing.



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Note: The e-text does not have an Index, we recommend using the word find feature to find topics of interest.

INTRODUCTION:

The Alliance of Nurses for Healthy Environments (ANHE) was begun in December 2008 when a gathering of 50 nurses representing national nursing organizations met to advance environmental health in nursing. The Mission of ANHE is: Promoting healthy people and healthy environments by educating and leading the nursing profession, advancing research, incorporating evidence-based practice, and influencing policy. According to the ANHE Wingspread Statement of 2009 “The Alliance will guide the nursing profession by strengthening education, advancing research, incorporating evidence-based practice and influencing policy to promote healthy people and healthy environments.” In response to the 1995 Institute of Medicine (IOM) report, *Nursing, Health and the Environment*, ANHE developed strategies to assure that nurses have access to education about environmental health factors that affect nursing practice and the populations that nurses serve. The IOM report noted that no accrediting or regulating body mandated that environmental health content be included. This holds true today. Further, the report recommended that

- environmental health content be included into all levels of nursing education as well as for professional development;
- environmental health content be included in nursing licensure and certification examinations;
- education environmental health should be interdisciplinary;
- environmental health content be part of life-long learning and continuing education for nurses in practice; and
- resources and educational opportunities should be available through public and private organizations and agencies.

To address these recommendations the Education Workgroup of ANHE was formed and strategic goals were established.

At that time of ANHE's inception, one of the goals was to develop an open access electronic textbook for nurses and other health professionals. The offerings differ from a typical textbook in that some are written as chapters that would be familiar to most readers, others are presentations with voice added, and some are educational strategies that target academic and professional development educators. The contributors include experts in special areas salient to the environment and health. In this second edition, we have expanded environmental health science, engagement, and leadership in nursing practice, education, and research. Nurses are important in addressing safe environments for patients, families, and populations and our influence in environmental health is reflected in the second edition.

The value of this online textbook is that it can reach a wide audience of nurses across the globe, is freely accessible, and has hyperlinks built into the chapters to bring the reader directly to well established and evidence based information from governmental and non-governmental agencies and organizations. The book is organized into 81k units that address a board range of topics essential for nurse knowledge in environmental health.

Unit I Why Nursing? serves to inform the reader of the relevance of environmental health content for nursing practice as well as mandates from not only the 1995 IOM report but also inclusion of the ANA Scope and Standards of Practice (2020), Standard 17: Environmental Health.

Unit II Harmful Environmental Exposures and Vulnerable Populations provides an overview of populations across the lifespan and their specific vulnerabilities as well as specific populations such as workers, immigrants and persons with alterations in cognitive and physical abilities.

Unit III Environmental Health Sciences includes information about sciences that inform environmental health such as ecology, toxicology, epidemiology and risk assessment.

Unit IV Practice Settings addresses hazardous exposures in healthcare, Green Teams, green cleaning in hospitals, and pharmaceutical waste.

Unit V Sustainable Communities provides environmental health content that looks at communities. This includes information on green building initiatives, green cleaning in homes, transportation, Brownfields, food, antibiotic use in agriculture and environmental justice.

Unit VI Climate Change informs the reader about the impact of climate change on health and its implications for nursing practice.

Unit VII Advocacy includes information about advocacy for nursing practice, coalitions, legislative meetings and chemical policy reform.

Unit VIII Theory and Research In this revised, 2nd edition, this section covers models for environmental health research and interviews with cutting-edge nurse environmental health scientists.

The second edition of Environmental Health in Nursing reflects how the nursing profession has moved forward since the 1995 IOM report and the important role that nurses play in protecting and caring for the environment, advocating, and advancing the science of environmental health nursing and the patients and communities we serve.

Unit I:

Why Nursing?

ENVIRONMENTAL HEALTH IN ALL NURSING PRACTICE

Environment is one of four traditional concepts in nursing: nurse, patient/client, health, and environment. All nurses practice in one or more places that we can call an environment. Patients/clients live, work, learn, play, and worship in various environments. Nurses are to assist in creating healthy environments in which individuals, families, groups, and communities can thrive (American Nurses Association, 2020).

This first unit of the e-text describes environmental health, why nurses are involved in environmental health, and principles of environmental health in nursing. Environmental health nursing in homes/families, schools, communities, and faith communities is introduced. In this Unit, you will be introduced to some contemporary nurse luminaries and pioneers in environmental health. Also, the environmental health competencies expected of all nurses are presented. See Unit IV for details of environmental health for nurses in hospital and institutional practice settings.

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WHY NURSES ARE INVOLVED WITH ENVIRONMENTAL HEALTH

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WHAT IS ENVIRONMENTAL HEALTH?

“The environment is one of the fundamental determinants of individual and community health” (Institute of Medicine, 1995, p. 1). The environment along with human behavior, genetics/biology, and the health care system contribute to the health and illness among human populations (Dever, 1991).

Environmental health may be defined as that aspect of human health determined by physical, chemical, biological, and psychosocial factors in the environment (WHO, 1993, cited in Sattler & Lipscomb, 2003, p. xiii). Others define environmental health as the freedom from illness or injury...[due] to exposure to toxic agents and other [hazardous] environmental conditions” (Institute of Medicine, 1995, p. 15).

Environmental health may be defined also as “the theory and practice of assessing, correcting, controlling, and preventing factors in the environment” that negatively affect health (WHO, 1993, cited in Sattler & Lipscomb, 2003, p. xiii). Environmental factors that negatively affect health are often called environmental hazards.

“The environment is everything around us - the air we breathe, the water we drink and use, and the food we consume. It's also the chemicals, radiation, microbes, and physical forces with which we come into contact. Our interactions with the environment are complex and are not always healthy” (Centers for Disease Control & Prevention, National Center for Environmental Health, 2009).

Not only do we come in contact with our environment, our environment becomes us through the air, water, food, and other exposures. Obviously, we are dependent upon our environment for our development, growth, and survival. For example, food provides nutrients for development, growth, and energy; water composes many of our body fluids. When the physical environment is polluted, pollution is not only around us, but in us! [Watch this video](#) (22 minutes long) from the Environmental Working Group to learn eye-opening information about body burden [of chemicals] in children.

So, what are we to do to reduce environmental hazards? How can we reduce human exposure to environmental hazards? What are we to do to promote healthier environments? We can respond as nurses, workers, students, parents, family members, group members, and citizens. Why are nurses especially equipped to address environmental health?

TOP TEN REASONS THAT NURSES & ENVIRONMENTAL HEALTH GO TOGETHER

1. Nurses provide healing and safe environments for people.
2. Nurses are trusted sources of information.
3. Nurses are the largest healthcare occupation.
4. Nurses work with persons from a variety of cultures.
5. Nurses effect decisions in their own homes, work settings, and communities.
6. Nurses are trusted sources of information for policy makers.
7. Nurses translate scientific health literature to make it understandable.
8. Nurses with advanced degrees are engaged in research about the environment and health.
9. Health organizations recognize nurses' roles in environmental health.
10. Nursing education and standards of nursing practice require that nurses know how to reduce exposures to environmental health hazards (ANA, 2020).



Florence Nightingale

Nurses have always been leaders in providing healing and safe environments for people. Nurses protect their patients and their communities. (See Florence Nightingale's [Notes on Nursing](#) published in 1860.) Nurses are everywhere that other people are. We work in hospitals and other health care settings, homes, schools and occupational sites. Each of these places has hazards that can cause illness, injury, or premature death. Nurses work to protect people from hazards by eliminating or reducing the harms from hazards and by reducing or eliminating the hazards.

Nurses advocate for environments in which people cannot only survive, but thrive (ANA, 2007). Nurses are trusted sources of information. The most recent [Gallup Poll](#) of US residents shows that for the eighteenth year, nurses are ranked the most honest and ethical profession. When nurses speak, people listen. Nurses provide information to patients and the public about healthy and safe environments. These environments promote human health. They help prevent illness, disability, and premature death.

Registered Nurses (RNs) are the largest healthcare occupation. (See Department of Health and Human Services, 2020) One in every one hundred Americans is a Registered Nurse. (ANA, 2020). Therefore, most residents of the United States come in contact with nurses.

Nurses have experience working with persons from various racial, ethnic, cultural, and socio-economic backgrounds. We also work with persons across the lifespan, from pregnant women and newborns to those at the end of their life. Nurses build on these deep and broad communication networks to protect and improve human health.

Nurses have the capacity to effect decisions in their own homes, their work settings, and their communities. Nurses influence decisions in work settings---schools, clinics, homes, nursing homes, and hospitals. [Health Care Without Harm](#) is an international coalition of 473 organizations in more than 50 countries, working to transform the health care sector so it is safer for patients and workers. Nurses also help make decisions about health as members of community groups such as PTAs, churches, and other faith-based institutions. The numbers of nurses and their personal influence creates a unique opportunity to make change.

Nurses are uniformly viewed as trusted, un-biased sources of information by policymakers and the public (Sattler & Lipscomb, 2003). Nurses partner with professional and citizen groups that are addressing a wide range of environmental hazards which affect human health. Some

nurses are actively involved in policy and advocacy work at the state and federal government level. [Safer Chemicals Healthy Families](#) is a campaign that includes nurse advocates who are working to improve U.S. federal policies that protect us from toxic chemicals.

Nurses are translators of scientific health literature. Nurses help patients, families, and members of their community to understand studies about environmental health. The [Research Forum of the Alliance of Nurses for Environmental Health](#) (ANHE) is creating a library of nursing research articles on environmental health. This will better identify evidence-based practices that nurses can implement with individuals, families, and communities.

Nurses with advanced degrees are engaged in research about the environment and health. [ANHE](#) also is promoting nurse researchers and sharing information about funding sources for research. The Research Forum of ANHE has surveyed nurses to explore the priorities for research related to environmental health and nursing. Nurses with a research-focused doctorate usually have a Doctor in Philosophy (PhD) degree and are leading this research.

KEEPING PATIENTS SAFE

Health organizations recognize nurses' roles in environmental health. The World Health Organization states that it is essential for nurses to promote healthy environments, especially homes (Adams, Bartram, & Chartier, 2008). The International Council of Nurses (2007) asserts that nurses should help reduce environmental hazards and promote clean water. In 2004, the Institute of Medicine (IOM) published the report, *Keeping patients safe: Transforming the work environment of nurses*. This report advocates for making hospitals and health care facilities safer for both patients and nurses. Nurses are to "create a safe care environment that results in high quality patient outcomes" (AACN, 2008, p. 31).

In 2010, the American Nurses' Association (ANA) added an environmental standard to Nursing: Scope and Standards for all RNs. This standard advocates that "the registered nurse integrates the principles of environmental health for nursing in all areas of practice" (ANA, 2010, p. 57). Most recent editions of the Scope and Standards have continued to develop the nurses' role in environmental health.

This standard requires every nurse to have the knowledge and skills to integrate environmental health information into their daily practice. No matter what the level of nursing education, no matter what our nursing experience, each nurse needs to be current with the expanding evidence about environmental health (AACN, 2006, 2008;

NLNAC, 2008). (See Principles of Environmental Health for Nursing Practice later in this document.)

Nursing education organizations require nurses' roles in environmental health. All nurses are to serve as positive role models within healthcare settings and their community (National League for Nursing, NLN, 2000). All nurses need to know how to reduce exposure to environmental health hazards and provide safe physical environments. "Nurses use evidence-based decisions to deliver client care and [help] move clients toward positive health outcomes" (NLN, 2000, p. 14). Nurses with a diploma or an associate degree are focused primarily on the health of individuals and families (NLN). Every individual and every family have some environmental hazards.

Nurses with baccalaureate education expand their focus to include communities and population health (American Association of Colleges of Nursing, AACN, 2008; Association of Community Health Nursing Educators, ACHNE, 2010). Population health includes health promotion and disease/injury prevention with groups, communities, and populations (AACN, 2008; ACHNE, 2010).

Graduates with a master's degree in a nursing specialty or a Doctor of Nursing Practice (DNP) degree are educated to be leaders in nursing practice. As leaders in the practice arena, "DNPs provide a critical interface between practice, research, and policy" (AACN, 2006, p. 14). "The DNP graduate has a foundation in clinical prevention and population health" (AACN, 2006, p. 15). This foundation includes the nurses' ability to analyze occupational and environmental data to plan, implement, and evaluate their practice for clinical prevention and population health.

PRINCIPLES OF ENVIRONMENTAL HEALTH FOR NURSING

All nurses are to be aware of the principles of environmental health for nursing and integrate these principles into our practice, education, and research.

ANA'S PRINCIPLES OF ENVIRONMENTAL HEALTH FOR NURSING PRACTICE

1. Knowledge of environmental health concepts is essential to nursing practice.
2. The precautionary principle guides nurses in their practice to use products and practices that do not harm human health or the environment and to take preventive action in the face of uncertainty.
3. Nurses have a right to work in an environment that is safe and healthy.

4. Healthy environments are sustained through multidisciplinary collaboration.
5. Choice of materials, products, technology, and practices in the environment that impact nursing practice are based on the best available evidence.
6. Approaches to promoting a healthy environment reflect a respect for the diverse values, beliefs, cultures, and circumstances of patients and their families.
7. Nurses participate in assessing the quality of the environment in which they practice and live.
8. Nurses, other health care workers, patients, and communities have the right to know relevant and timely information about the potentially harmful products, chemicals, pollutants, and hazards to which they are exposed.
9. Nurses participate in research of best practices that promote a safe and healthy environment.
10. Nurses must be supported in advocating for and implementing environmental health principles in nursing practice.

Source: ANA's principles of environmental health for nursing practice with implementation strategies. (2007). American Nurses' Association: Silver Spring, MD. (May be purchased in booklet form at nursebooks.org)

Finally, the Alliance of Nurses for Healthy Environments has a large collection of Podcasts with environmental health nurses created by Dr. Elizabeth Schenk, PhD, RN now into Season 4. They can be viewed on the ANHE website at [New Podcasts](#) and through the years at [Podcast series](#). The podcasts provide evidence of the impact nurses are making to advance healthier environments.

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ENVIRONMENTAL HEALTH AND FAMILIES/HOMES

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Environmental Health is important throughout the life cycle. From preconception to aging populations, the environment is a contributor to health and illness. Childbearing families are particularly at risk. This is because babies developing in the womb and growing children are quite vulnerable to assaults from air pollution and chemicals present in water, food, and products.

For example,

- Epidemiological studies show that children whose parents work in the farming communities of California have a higher incidence of childhood leukemia (Wigle, Turner, & Krewski, 2009). It is suspected that exposure to pesticides is responsible.
- Air pollution has been linked to a number of adverse health effects such as preterm labor and most recently autism in children.
- The phthalate DEHP has been eliminated from many newborn nurseries and neonatal intensive care units because of evidence implicating this chemical in male reproductive changes.
- Bisphenol A (BPA), a component of many plastic products including children's toys, has been shown to be an endocrine disruptor and is linked to cancer and developmental delays.

CRITICAL WINDOWS

Critical windows of vulnerability have been defined in the literature as the following: "Periods during life when an exposure causes a stronger deficit in health later in life compared with other periods when exposure (could have) occurred" (Sanchez, Hu, & Tellez-Rojas, 2011, p. 1).

"Key developmental or reproductive life stages where the body can be more biologically vulnerable or influenced by exposures to chemicals in the environment" (Scott, 2015, p. 395).

Many of these critical windows occur as the fetus develops in utero. In this prenatal environment even small doses of chemicals can cause harm. Exposure to low-doses of chemicals rarely causes gross abnormalities that are obvious at birth. A more likely scenario is that they interfere with the programming that occurs during development, thus creating disease susceptibilities later in life.

According to the American Academy of Pediatrics, children also have unique vulnerabilities to environmental exposures because of their different metabolism, body structure, daily behavior, and lifestyle (Davis, 2007).

During puberty and adolescence the brain is still developing. Chemical exposures during this time can bioaccumulate and be passed to the baby during pregnancy and/or breastfeeding.

HOME EXPOSURES

Exposures to chemicals of concern often occur in the home. It has been estimated that Americans spend 90% of their time indoors. It then becomes important to recognize and decrease environmental stressors in the home environment. Harmful chemicals can be introduced through the foods that we eat, the water we drink, the products that we utilize, and the air that we breathe.

The foods we consume may contain pesticide residues. Plastic food wrap may expose families to phthalates such as bisphenol A (BPA). High fat foods such as meat and dairy may contain chemicals that are lipophilic such as persistent organic pollutants (POPs). Fish may be contaminated with mercury, a known neurotoxin.

Petroleum products, pesticides and fertilizers may contaminate water, especially wells. Water filtration devices may not be adequate to eliminate chemicals of concern from the water supply for safe consumption.

Phthalates are chemicals that appear in everyday household products including personal care items and cleaning products as added fragrance. They are also components of many plastic products and may show up in children's toys. These chemicals are endocrine disruptors (EDCs). EDCs have the capacity to interfere with hormone regulation and this may cause permanent disruption of metabolic processes.

Lead is a heavy metal that was present in interior paints before it was gradually phased out in the 1970's. It may still be detectable in older homes built before 1978. It is a potent neurotoxin and can accumulate in dust. Because chemicals such as lead accumulate in dust, be sure to damp clean regularly. Other possible sources for lead especially for children may include toys, jewelry, and lead in plumbing pipes (CDC, 2020).

Indoor air pollution is linked to volatile organic compounds or VOCs. Common sources of indoor VOC exposure include building materials, paints, household cleaning products, furniture made from particle board, and carpets. All of these products have the capacity to "off gas" chemicals such as formaldehyde and benzene.

NURSE RESPONSIBILITIES

Nurses must have the knowledge and skills to protect themselves, their families, and their communities, and influence others by leading by example. Nurses who work with childbearing families have a special opportunity to educate and influence choices that can have an impact for a lifetime. Evidence shows that reducing exposures to products that contain toxic chemicals can reduce body burden.

No one can completely eliminate chemicals from their lives. But making small changes especially in the home can reduce exposures. No one can do everything. But everyone can adopt at least one change (large or small) to create a healthier environment..

Studies have shown that making simple changes results in a lower body burden of chemicals of concern. Research results document that when children's diets change from conventional to organic, pesticide metabolites are reduced. Other studies show that avoiding canned foods and other dietary sources of BPA reduce levels of that chemical in the body. And simple dietary changes can also decrease exposure to phthalates.

Changes do not have to be complicated. For example, taking your shoes off at the door can help to avoid bringing offending chemicals such as lead and pesticides into the home. Keep the house well ventilated and open windows to let in fresh air even in the winter. Purchase fresh foods and buy local and organic when possible to reduce exposure to pesticide residues.

Meal planning provides another opportunity to decrease exposure to chemicals of concern. Utilize the [Environmental Working Group](#) pesticide ratings of fruits and vegetables to decide where to spend money on organics. For example apples consistently have detectable levels of pesticide residue when tested. This is a fruit to consider buying organic or locally grown. Consider planting a "kitchen garden" or favorite vegetables and herbs. This will have the added benefit of teaching children where their food comes from. Children who are assisting with the garden will enjoy partaking of the produce as well. Eat foods with less animal fat since harmful chemicals are stored in fat. This means eating more fruits and vegetables and less meat and dairy.

Because household cleaning products can be sources of indoor air pollution it is best to avoid those that contain bleach and ammonia. Many green cleaning products are plant based or you can make your own using such common items as baking soda and vinegar. The Environmental Working Group's (EWG) Guide to Healthy

Cleaning is a great resource for "greener cleaners" including vinegar. EWG gives vinegar a grade of A+ for no health concerns with use (EWG, 2020). The National Institute for Occupational Safety and Health (NIOSH) suggests using vinegar to clean windows, floors, and as a drain cleaner (NIOSH, 2014). Vinegar is naturally bacteriostatic and bactericidal (Entani et al. 1998).

Consider purchasing furniture and flooring composed of real wood. Wood composite materials off-gas VOC's as they are held together with toxic glues. Wood floors such as bamboo are also more environmentally friendly than composite or vinyl flooring and are economical as well. Look for flooring labeled no or low-VOC. Purchase paints that are labeled "low VOC" and use water-based glues.

To reduce mercury exposures, refer to the [EPA/FDA guidelines](#) which suggest eating smaller fish which contain less mercury like salmon, light tuna, and shellfish.

Don't use pesticides in your home or garden. Keep out pests by sealing cracks and holes around doors and windowsills, screens and baseboards. Vinegar can be used in a spray bottle to repel ants, mosquitos, fruit flies and other pests (Kumar, 2021). Choose plants that grow well where you live so you won't need harmful chemicals and learn about organic gardening.

Re-think your personal care products and learn to read labels. Some toothpaste contains triclosan, a chemical that is in the pesticide family. This chemical is added as a preservative to reduce bacterial contamination (FDA, n.d.). Formaldehyde and toluene are often added to nail polishes and both are linked to cancer. Buy nail formulations that are free of these additives. Avoid cosmetics that contain added fragrance. Fragrance generally contains phthalates, which are known to be endocrine disruptors. There are many "green" personal care products on the market that are cost effective. This is especially true in baby care products.

Nurses are powerful. We have the potential to change exposures for ourselves and for those we care.

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ENVIRONMENTAL HEALTH NURSING AT THE COMMUNITY LEVEL

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INTRODUCTION

Human health is influenced by an interconnected dynamic of factors from the individual's biology and genetics to the public policy that establishes access to health services. The Socio-Ecological Model (Figure 1) depicts the context of individual health within interpersonal, organizational or institutional, community, and public-policy factors (McLeroy, Bibeau, Steckler, & Glanz, 1988; Stokols, 1996).

Nurses are engaged in applying the nursing process to improve environmental health at all levels of the Socio-Ecological Model. For example, at the individual and interpersonal level, the nurse may assess a patient and family's environmental exposure history. Based on the assessment, the nurse may provide individualized education and strategies to enhance a family member's asthma control by reducing personal environmental exposures. At the organizational level, nurses may work to reduce medical waste burning practices (<https://noharm-uscanada.org/issues/us-canada/waste-management>) in their employing agency. This section introduces environmental health nursing at the community level

COMMUNITY

A population is a group of people who share at least one common characteristic. Communities include one or more populations and their shared goals over time (Maurer & Smith, 2013). Most commonly, communities refer to people living in the same geographical location, like a town or county. However, communities can be formed around a purpose or profession (e.g. medical community), education (e.g. online learning community), economic interest (e.g. small business community), a faith community (e.g. Catholic community), or other common characteristics or special interests (e.g. lesbian community). More information on describing and understanding the community can be found at the [Community Toolbox Website](#). The community health nurse applies the nursing process to the overall aggregate health of their community of focus (ANA, 2013). Most nurses who provide nursing care at the community level are educated at the baccalaureate level of nursing or higher.

Community health nurses have a focus on the systems context that is broader than direct delivery of care to patients and families alone. One of the key determinants

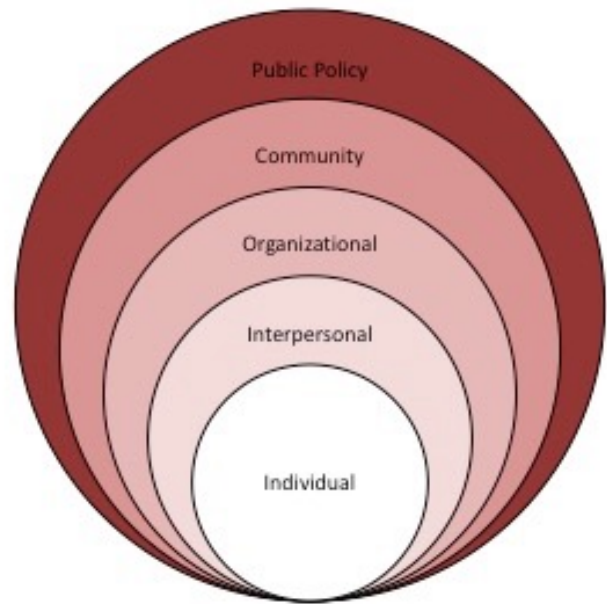


Figure 1: The Socio-Ecological Model

of health (<http://healthypeople.gov/2020/about/DOHAbout.aspx>) at the community level is the physical environment, including environmental pollution. Often, exposures to pollutants in the water, air, soil, and food supply are beyond the control of any one individual. In these circumstances, applying the nursing process at the community-level is necessary to improve health. The Nursing Practice Chapter of this eTextbook has more information on applying the nursing process at the community level.

The following video is a case example of environmental health nursing at the community level, entitled *Holding Polluters Accountable: A Community-Nurse Collaboration* (2014).



<https://www.youtube.com/watch?v=HGzBLpZmGyM>
(63:07 minutes)

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FAITH COMMUNITY: AN ENVIRONMENTAL PARTNER

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"Creation is not a property, which we can rule over at will; or, even less, is the property of only a few: Creation is a gift, it is a wonderful gift that God has given us, so that we care for it and we use it for the benefit of all, always with great respect and gratitude." Pope Francis, May 21, 2014.

Partnering with the faith community is a natural fit for nurses when educating community members about environmental health risks and advocating for improved environmental regulations with policy makers. The faith community and the nursing profession share several environmental interests that could be developed into mutual programs to improve the health of individuals, families and communities. Some of the shared interests are:

- [Stewardship of the earth](#)
- [Common good](#)
- [Climate change](#)
- [Justice/ Environmental Justice](#)
- [Sustainable practices](#)
- [Solidarity with vulnerable groups](#)
- [Workers' rights](#)

While the scope of this text does not permit covering each faith practice in detail, a general description of faith practices relative to the environment offers the nurse a basic understanding. The Abrahamic faiths of Judaism, Christianity, and Islam include an imperative to care for the earth and also acknowledge that the earth's resources are a gift from the Creator that must be appreciated (Green Prophet, 2008). Eastern religions, such as Hinduism and Buddhism, do not make a distinction between the person and the natural environment; people and the natural environment are all part of an interconnected web of life that must be cared for (Green Faith, n.d.). Like Eastern religions, Native American and indigenous peoples view themselves as part of the earth and their connectedness to the earth has influenced their survival throughout history (Sherrer & Murphy, 2006). The list of faith-based environmental organizations later in this section provides web links so you can learn more detail and perspectives of specific faith traditions related to the environment.

Some churches and other faith groups enlist the services of a parish nurse to meet the spiritual and health needs of their congregation (Whisnant, 1999). The parish nurse could be a valuable partner in collaborating to develop congregation wide environmental initiatives. If a faith community does not have a parish nurse, nurses could volunteer within their own faith communities to influence the environmental health of the congregation as well as the faith community's environmental impact. Partnering with the clergy and the leadership of the faith community can promote trust of the nurse within the congregation. Most faith communities also have resources that can assist them in serving as a center for environmental health outreach. For example churches, synagogues, mosques, and temples have meeting rooms, office space, and frequently volunteers to support environmental health initiatives. Furthermore, the faith community has a moral structure from which nurses can frame an environmental discussion (Green Prophet, 2008) to the congregation, the larger community, or policy makers.

There are many environmental faith based organizations. Some are single faith and others are multi-faith organizations. Here is a list of some faith based environmental organizations and their web sites.

Organization Name	Web Site	Organization Purpose
Catholic Climate Covenant	catholicclimatecovenant.org/about/story	Catholic teaching related to care for creation and climate change
Coalition on the Environment and Jewish Life (COEJL)	www.coejl.org/	Strengthening stewardship of the Earth through outreach, activism and Jewish learning
Green Faith	greenfaith.org	Teach & mobilize people of diverse religious backgrounds for environmental leadership
Interfaith Power and Light	www.interfaithpowerandlight.org/	Interfaith group with a focus on climate change
Islamic Foundation for Ecology & Environmental Sciences	www.ifees.org.uk/green-guide-for-muslims	U.K. based organization. Provides a "Green Guide for Muslims"

Organization Name	Web Site	Organization Purpose
National Religious Partnership for the Environment	www.nrpe.org/	Partnership of faith based environmental organizations. Good resources for various religions' environmental perspective
Pachamama Alliance	www.pachamama.org/	Influencing society to have environmentally sustainable partnerships with indigenous people
Quaker Earth Care Witness	www.quakerearthcare.org/	Network of Quakers addressing ecological and social world crises
Tribal P2: Pollution Prevention Network	tribalp2.org/	Collaborates with U.S. tribes to reduce environmental & health risks on tribal lands
Evangelical Environmental Network	www.creationcare.org/	A ministry for Evangelical Christians in the U.S. that educates, inspires, and mobilizes them in their effort to care for God's creation

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SPOTLIGHT ON NURSES

MY ROAD TO ENVIRONMENTAL HEALTH

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When I am asked how I got involved in environmental health, my first impulse is to talk about the day in 1993 when Lewis Shaw, the engineer in charge of Environmental Quality Control (EQC) at the South Carolina Department of Health & Environmental Control (DHEC) approached me. We had been colleagues on the State Health Commissioner's Executive staff for several years where he was a Deputy Commissioner and I was Assistant Commissioner and State Director of Public Health Nursing.

I will never forget his words: "I think we need a nurse." He was asking me to transfer into his deputy area which carried responsibility for the state and federally-delegated programs of Air Quality, Water, Solid & Hazardous Waste, and the Environmental Laboratory. He saw the need for someone who could be a bridge between his staff of environmental scientists and engineers and communities that were impacted by environmental events and hazards.

At that time, I had been a public health nurse for more than 20 years and from my position on the Commissioner's staff had a broad understanding of the interconnectedness of the agency's responsibility for public health and environmental protection. I also had working relationships of long-duration in most of the working units of the agency. The thought of creating a new job that would strengthen the link between health and environment as well as letting me spend time in local communities was very appealing.

For the next eight years, calls were directed to my office from citizens who were concerned about something in their environment:

- something looked unusual, smelled strange, tasted odd
- too many people around them were ill, especially with cancer
- they were uneasy about the industry nearby
- there were rumors that a landfill was coming to their neighborhood.

The list was long, and my job was to listen, to go and let them show me and talk with me about their worries. I spent a lot of my working hours at kitchen tables, country churches, and neighborhood meetings all across the state.

Then I was to follow-through to assure that our staff made an appropriate response.

Sometimes the follow-up was supplying them with the information we had and they did not, and providing for interpretation of data unfamiliar to them. Sometimes the problem called for an environmental investigation, often combined with analysis of health data for the area, particularly data from the cancer registry. Sometimes we provided public forums, with participation of experts in their issues of concern, to discuss and clarify and decide on a course of action. In these situations, I worked with the community to plan for where and when to meet and how to keep them informed over the course of resolving the issue.

Often my calls were from front-line staff in our environmental programs and district offices. There may be need to let a community know of an industry's application for an environmental permit. We may be involved in cleaning up a spill or other source of environmental contamination. In that case, my job was to alert the community, with the necessary information for them to protect themselves and/or become actively involved in the permitting or enforcement process. Sometimes the staff just wanted me to go with them to meet with some upset citizens.

My job also carried responsibility for risk communication—helping staff to understand that risk was a combination of "hazard and outrage" and our job included addressing both! (Peter Sandman's work in this area was invaluable to me. www.psandman.com) Over time, our staff came to understand how people react to risk and how we can prevent and allay fears by how we respond and communicate. Community meetings, which I often moderated, went from being situations filled with angry crowds where our staff felt they deserved "hazardous duty pay", to collaborative events. We all learned what valuable assets watchful citizens, who care about their environment, are to our work of surveillance and protection.

I was involved in planning and delivering continuing education for staff—in orientation sessions, in workshops, in immersion environmental learning experiences for local health department professionals, and in developing materials to aid the staff in responding to frequently occurring questions.

My work began to extend from a focus on our agency staff to lecturing to university classes in schools of nursing and public health. I was asked to chair the Institute of Medicine Study of Nursing, Health & Environment (1995) and then was often invited to speak about the resulting

report to numerous groups in many states. With some pioneering colleagues at the University of Maryland, we developed a chapter on Environmental Health for Stanhope & Lancaster's Public Health Nursing text. Diana Mason asked that I contribute an environmental vignette for her book on Policy and Politics in Nursing and Health Care. I served on the Enforcement Subcommittee for EPA's National Environmental Justice Advisory Council, and that led to involvement with other EPA and environmental justice initiatives, including organizing and implementing a Future Search conference in South Carolina. Being a part of the Alliance of Nurses for Healthy Environments (ANHE) has been an exciting and joy-filled experience, with new opportunities and relationships.

My career and world expanded in ways I had never imagined. I realize that my environmental health journey did not really begin with that conversation with Lewis Shaw. I began heading in this direction from my days as a nursing undergraduate when my public health nursing professor and life-long mentor, Virginia Phillips, taught me the multi-disciplinary nature of public health, modeled it in her practice and made it an integral part of my concept of the breadth of public health and my approach to solving public health problems. My graduate program in the School of Public Health at the University of SC included required course work in environment as well as multi-discipline practice seminars addressing real issues in our state. The connections between health and environment and the necessity of a variety of expertise to prevent and address problems in each domain were cemented into my DNA!

My commitment to protecting and improving our environment did not end with retirement. I am still actively involved, especially in issues of the built environment—public transportation, more livable communities with safe spaces for walking and biking, community design and development that considers access to goods and services for all of the population, and public policy decision-making that supports community involvement and sustainable living. I am active in my church's efforts to be a more "green congregation", rooted in our calling to "tend and care for all of creation."

My community knows me as an avowed "tree-hugger", and I have confirmed that again with the wonderful opportunity to work with high school students planting sequoia trees!

The first principle I learned in environmental health is that "everything is connected to everything else." That is a basic principle for the environment and health and for life itself.

ADVOCATING FOR ENVIRONMENTAL JUSTICE

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I grew up in a small southern town in Vance County, North Carolina in the 1950s and 60s. My family lived within the city limits about 100 yards from the city dump where the town's trash was burned in open space each afternoon. I vividly recall the dark smoke that would rise and the darkness and ash that would float overhead and descend over neighboring communities of African-American families. On wash day, we had to be sure to get the clothes off the line before the tall pile of trash was ignited. In the summertime, it was difficult to sit outdoors because of the dust and dirt on our street. Occasionally, a city truck would drive by and spray a solution on the street, giving us temporary relief from the dusty particles.

As a young child, I did not understand the nature of these problems. This was the way of life, and like my family, I adapted and co-existed with these environmental assaults. As I grew older and learned about the environment in secondary school, college, and beyond, I would revisit these childhood memories and be appalled by how our health and wellbeing had been threatened by such exposure.

During the 1970s, the State of North Carolina routinely dumped polychlorinated biphenyls (PCB)-laced oil, a highly toxic carcinogenic compound, on the roadbeds in certain areas of the state. After many years of protests and court action, the state removed the worn PCB-laced residue with the intention of burying it in a landfill in Warren County, NC, adjacent to Vance County. Opponents of that plan argued that Warren County was selected because the area was rural and the majority of the residents were poor, black and politically unable to determine their fate. My uncle, a well-regarded civic-minded local leader, joined other local and national civil rights leaders, community activists, and environmental groups from around the nation in protesting the intended burial of the toxic waste in the Warren County landfill. These accounts of environmental injustice stimulated my personal and professional ambitions. My interest in community health nursing and the impact of environmental, economic, political, and racially-linked exposure of toxic substances on vulnerable populations was the stimulus that increasingly matured my interest and commitment to environmental and population health.

I served as Dean of the Howard University College School of Nursing for 18 years. During that time, a small group of public/community health-minded faculty and I became involved in the Mississippi Delta Project, funded

by Agency for Toxic Substances and Disease Registry. The aim of the project was to increase awareness of environmental health concepts and practices in nursing curricula in schools of nursing in the Mississippi Delta. The Delta is a geographical area comprised of 219 counties over seven states where a plethora of corporate farms, industrial factories, petroleum refineries, and other “dirty industries,” posed hazardous exposure to the area’s residents, who were largely poor, under-educated, African-American and politically unengaged. Our work led to the development of a modular curriculum, *Environmental Health and Nursing: The Mississippi Delta Project (1999)*, comprised of six modules: demographics of the Delta, culture, toxicology, environmental justice, community assessment, and community engagement and advocacy. I authored the environmental justice module which, along with other modules, continued to evolve and opened doors for collaboration with other schools of nursing, invited presentations around the county with nursing and non-nursing groups, and led to other publications and to my appointment to the EPA National Environmental Justice Advisory Committee.

MY JOURNEY AS AN ADVOCATE FOR ENVIRONMENTAL HEALTH IN NURSING

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It takes a village to get good things done. I have been one of many nurses who have discovered environmental health and decided to do something about it. My particular strengths are that I am enthusiastic, creative, and persuasive. That alone would never be enough to sustain forward motion - that required a great many patient, detail oriented, highly organized, and dedicated colleagues who followed through with the sometimes tedious efforts required to integrate environmental health into nursing education, practice, research and policy/advocacy. I salute us all.

There are a couple of things that have been motivators to me for as long as I can remember – social justice, the environment, learning, and having fun. My interest in human health was something that developed later in my 20s when I entered nursing school. I went to a hospital-based diploma nursing program that no longer exists and early in my nursing career I was a critical care nurse first in San Francisco and then in Baltimore – ICU, CCU, ER, and Burn Unit which I really loved. At the same time, I also was very involved in my nursing union and became part of the contract negotiation team. I learned a lot about the

importance of collective action, the power of organizing, and how to work strategically to accomplish goals.

I don’t actually have any degrees in nursing, just my Diploma that allowed me to sit for the Boards and become a Registered Nurse. My degrees are BS in Political Science, and both a master’s and Doctorate in Public Health from the Johns Hopkins School of Public Health. In between my two graduate degrees, I was the Executive Director of a small non-profit, MaryCOSH (Maryland Committee on Occupational Safety and Health) that worked on a variety of occupational health issues. My main focus was helping to pass a statewide worker right to know law so that workers could find information about the toxic chemicals that they were working with. Our success was largely a function of the diversity of the coalition that we created which included unionized workers, firefighters, health professionals, and non-profit organizations like Clean Water Action and the American Lung Association. Learning to play with folks who have different agendas and yet finding a common one that we could all agree upon was a critical skill for future work.

Then I worked for the United Steelworkers Union. During that time, I went to many different kinds of worksites where I began to understand how poorly we were protecting workers from toxic exposures and, by extension, their families and communities.

My first job after graduate school was directing the National Center for Hazard Communication where I did research and worked with labor, industry, and the government on developing the best tools to train and educate people (workers, community members, health professionals) about hazardous chemicals. As early as 1991, we developed a completely on-line degree on environmental management.

I left that Center, which was at the College Park Campus of the University of Maryland and joined the faculty at the School of Medicine in the Baltimore Campus where I started the Environmental Health Education Center. My first center grants were from the U.S. Environmental Protection Agency to work on lead poisoning prevention. This work expanded into a more comprehensive healthy homes initiative and continued to grow into healthy schools and then healthy hospitals.

I was struck by a 1985 report by the Institute of Medicine (IOM) that showed how physicians did not learn about occupational and environmental health – which was equally true for nurses. Two colleagues and I made an appointment and met with Andrew Pope at the Institute of Medicine to ask for a similar study to be created to look at what nurses learned about occupational and

environmental health. We were able to compel him and the IOM. A committee was created that was chaired by Lillian Mood, a brilliant public health nurse from South Carolina who continues to do great environmental health work in her retirement.

The report, Nursing, Health, and the Environment, created a framework for thinking about how to integrate environmental health into the nursing profession. This framework has consistently guided my environmental health and nursing work ever since. It calls for nursing to integrate environmental health into nursing education (our own education and our patient/community education), practice (by both integrating environmental assessments into our clinical care and attending to the environmental healthiness of our health care settings), research, and policy/advocacy. Later, when we created the Alliance of Nurses for Healthy Environments (ANHE), these four domains became our standing committees. An overarching value that is applied to all four domains is environmental justice.

After six or so years on the faculty at the Medical School, the Dean of the University of Maryland, School of Nursing asked me to bring the Environmental Health Education Center to nursing and help to develop the first environmental health and nursing program in the country. I did this with the help of Brenda Afzal, who was my associate and “partner in crime” for many years. There were also a great many other key players at Maryland like Claudia Smith who is an active member of ANHE's Education Work Group, Robyn Gilden who now heads up the Center, and Katie Huffling who is now the Executive Director of ANHE.

At about the same time, I was able to secure a very generous grant (\$1.4 million) from the Kellogg Foundation to work with nursing faculty from Howard University to develop and deliver faculty development training on the integration of environmental health into nursing education. We trained over 200 faculty in 17 states and then provided them with two additional years of support. This helped to seed a new crop of environmental health champions within schools of nursing. Pat Butterfield did similar workshops in Montana with funding from the Agency for Toxic Substances and Disease Registry (ATSDR).

While the IOM report was clear that all nurses should learn about environmental health, it became clear to me that some nurses needed to dig deeply into this area. With a grant from the Health Services Resources Administration (HRSA), I started the first master's degree program in Environmental Health and Nursing. This was a fabulous program that helped to train some of today's

nursing leaders. The nursing students who studied with me over the years went on to become executive sustainability officers in hospitals, directors in non-profit organizations, and faculty in environmental health nursing. Many of them expressed their leadership within their nursing specialty professional organizations, helping to bring educational programs and presentations to their national meetings. Though the program was a generalist program, the students often gained significant expertise in environmental topics, for example, Brenda Afzal on drinking water and Robyn Gilden on pesticide use and children's health.

In the late 1990s I was involved in the creation of a national campaign called Health Care Without Harm (HCWH). In one of the early meetings in California, we gathered environmentalists from a variety of organizations – Greenpeace, Environmental Working Group, the Center for Environmental Health, and others – along with a couple of physicians and a small group of nurses, including Charlotte Brody who is a brilliant strategist. It was brought to our attention that one of the biggest contributors to mercury in our air was medical waste incinerator emissions. There were over 3,000 incinerators in the country at the time. Together, we ran a successful campaign that eliminated mercury thermometers in health care (and essentially everywhere else in the U.S.) and we suggested health care facilities close all but fewer than 100 medical waste incinerators.

For a few years I chaired the HCWH Nurses Work Group with my good friend and nursing colleague Susan Wilburn who was then a senior staff at the American Nurses Association in the Center for Occupational and Environmental Health. (The ANA closed that center down and changed their focus to nurses' wellness. I think they should have added wellness instead of eliminating health and safety.) We organized workshops all over the country called RN-NoHarm, helping to launch another cadre of nurses into the realm of environmental health. In this case they were often focused on greening their hospitals. The HCWH campaign morphed into a non-profit organization that spawned a range of exceptional programs like Practice Green Health and the Global Green and Healthy Hospitals.

For several years, the Beldon Fund supported a collaborative nursing approach to green hospitals and address chemical policies in the U.S. The key players were the ANA's Center for Occupational and Environmental Health, HCWH's Nurses Workgroup, and the Environmental Health Education Center at the University of Maryland. This work included educational efforts and training of nurses in advocacy skills. Nurses worked

closely with environmental and public health organizations in their state houses and capitals to advocate for sorely needed comprehensive chemical policy reform. Nurses also worked on many policies that addressed individual chemicals such as BPA and categories of products such as safe cosmetics. We worked with staff at the National Library of Medicine to include training on searching their databases for the best evidence regarding toxic chemicals. We remained scrupulous about being evidence-based in our assertions and in our writings.

We sponsored a half dozen writers' retreats/workshops for nurses who wanted to write articles about environmental health. These were both great fun and very productive and continued to build a "community" of nurses from around the country who were interested in and working on environmental health. These retreats often took place in extraordinary locations like the Northern California Coast and Martha's Vineyard at times in retreat centers, but often at ANHE member's homes.

With Beldon Funds, we organized a group of unions that represent nurses around the country to talk about how to use collective bargaining to better protect nurses from potentially toxic chemicals in hospital settings. The result was a compendium of model language that could be negotiated and inserted into contracts, thus adding another legal framework for protecting nurses (and by extension other employees and patients) from unnecessary harmful exposures in health care.

In 2008, there were a number of nurses around the country that were doing environmental health activities, but they were poorly coordinated. We were not yet building a movement. With funding from the Kendeda Fund, we organized a 4-day retreat in Oracle, AZ, with 50 nursing leaders from around the country. At the end of the retreat we decided to create a national organization, which became an official non-profit organization, called the Alliance of Nurses for Healthy Environments (ANHE). I was a founding Board member and have since then been on and off the Board. This organization has created a wealth of resources, workshops, webinars, a website, a virtual eTextbook, and has effectively engaged in political advocacy. ANHE has helped support the community of nurses who are interested in environmental health.

There are many ways that ANHE is now seen as the voice of environmental health nursing in the country. The ANA defers environmental health questions and efforts to ANHE. We helped to get the first "Environmental Standard" into the 2010 Scope and Standards of Professional Nursing Practice. After ANHE members visited with the head of the National Institute of Nursing Research and the National Institute of Environmental

Health Science, these two NIH institutes put out a joint request for nursing research in environmental health. The major national and state environmentalist organizations seek ANHE to help support policy efforts in our state houses and capitals.

Until 2014, ANHE was a US and Canada-based organization. After a working trip to Australia to meet with nursing unions on greening their hospitals and on "fracking", I realized that they were wrestling with the same issues we were in the U.S. and that we should communicate with each other and share resources. We expanded ANHE's scope and created an international Climate Change Committee that incorporates work on fracking and other fossil fuel issues, with monthly calls and nurses from the UK, Australia, Canada and the US.

After retiring from the University of Maryland in 2012, I moved to California, where I am currently a full-time Professor at the University of San Francisco. I continue to be a Board member of ANHE. I am working with the Jonas Nursing Center to develop a scholarship program for doctoral (PhD and DNP) students who are interested in environmental health. With colleagues in Australia and with Susan Wilburn of Global Green and Healthy Hospitals, I am developing a Global Environmental Health Nursing Certificate.

There are some things that "I" did regarding environmental health and nursing, but the vast majority of things "we" did. We have had some very generous funders over the years and a great many supporters. We have helped to birth nursing environmental health champions. I've been involved in 3 decades of work that is helping to form the next generation of nurses who we hope will consider environmental health a critical component of the nursing profession.

"The best way to predict the future is to design it."
Buckminster Fuller

Unit II:

Harmful Environmental Exposures and Vulnerable Populations

INTRODUCTION

Unit I highlighted various roles of the nursing profession where knowledge of environmental exposures is central to practice. In Unit 2, the focus is upon populations who are most vulnerable to harmful environmental exposures. While risks to adverse health outcomes can vary according to geography, housing, and location of environmental exposures, some people are at greater risk due to their biophysical and sociopolitical vulnerability. Unit 2 explains risk and vulnerability across the lifespan with a focus upon specific vulnerabilities and harmful effects at various developmental stages. The chapters in this unit highlight the unique vulnerabilities such as pesticide exposures to children, dental amalgams, and environmental vulnerabilities for immigrants and refugees. The influence of the social determinants of health are considered throughout Unit II, which are commonly referred to as factors where people live, learn, work, play and pray. Social determinants at neighborhood and community levels impact individual level exposures.

HARMFUL ENVIRONMENTAL EXPOSURES AND VULNERABLE POPULATIONS

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All humans are at risk for harmful effects of environmental hazards. For certain human populations the risks of harm are greater due to biologic, social, economic, or other factors. Such population groups are often referred to as vulnerable populations. A vulnerable person or group has “aggravating factors that place them at greater risk for ongoing poor health status than other at-risk persons” (Maurer, 2013, p. 528). Some vulnerable groups include children, the poor, those without homes, refugees, people living with disabilities and those with mental illness. These vulnerable populations have been identified through epidemiological studies as having poorer health outcomes. This paper will discuss various factors that make specific populations across the life span more vulnerable to poor health outcomes from environmental stressors.

RISK AND VULNERABILITY

Risk is the likelihood that a harmful health event will occur in a given population during a specific time period. Our knowledge of risk emerges from the science of epidemiology. Epidemiology is the study of health and illness in human populations. Epidemiological studies show that environmental hazards can cause poorer health.

Environmental hazards can increase human risk of illness, disability and premature death. The [Environmental Protection Agency \(EPA\)](#) defines risk as the “chance of harmful effects to human health or to ecological systems resulting from exposure to an environmental stressor” (EPA, 2021b). An environmental hazard is any physical, chemical, or biological entity that causes harm. The EPA also provides information on [risk assessment](#) for such hazards.

Some common factors that affect the risk of harmful health events cannot be changed. Such factors include age, gender, race or ethnicity. Other factors that affect the risk of harmful health events can be changed. These factors result from biophysical, environmental, psychosocial and sociopolitical circumstances (Leffers et al, 2004). When environmental threats to health are examined, all humans are at risk in relation to global climate change and the increasing use of untested and toxic chemicals.

Vulnerability can be defined as “a varying state of weakness or strength that can be mobilized when one encounters a threatening event” (Leffers et al, 2004, pg 19). This definition includes individual and experiential

factors that result in variability of outcomes across populations.

Risk and vulnerability are related to each other. Some describe vulnerability as a series of threshold factors that increase or amplify risk and lead to poorer health outcomes. Others argue that vulnerability can vary according to the capacity of the individual and may not lead to poorer health outcomes. This view says that positive attributes of those identified as vulnerable can enable them to overcome risk and vulnerability, leading to better outcomes (Leffers et al, 2004). The North Carolina Preparedness and Emergency Response Research Center (NCPERRC) makes a similar distinction between risk and vulnerability. They note that risk is directly affected by a hazard while the degree of vulnerability is defined as “the characteristics of a person or group and their situation that influences their capacity to anticipate, cope with, and resist and recover from the impact of an emergency” (NCPERRC, 2012).

The notion of “windows of vulnerability” refers to specific times during human development that have been identified for higher risks to health. For example, at times a child can have better recuperative capacity than adults. In other situations, children are at far greater risk for the detrimental effects of chemicals of concern on their developing organs (Brent, Tanski, & Weitzman, 2004; Sanchez, Hu, Litman & Tellez-Rojo, 2011; Suk & Sly, 2016; EPA, 2021a).

Various populations have been identified as more vulnerable to environmental hazards. Further, this concern has been explained in documents assessing risk for the harmful effects of climate change such as the [Climate and Health Assessment](#) of the US Global Change Research Program. As stated earlier, individual and experiential factors can lead to different vulnerability across populations. These factors include those whose biophysical characteristics make them more vulnerable such as the developing fetus, infants, children and older adults. People with acquired biophysical factors such as chronic illness, those with differences in functioning due to trauma, and those with altered immunity also become more vulnerable to poor health outcomes. Additionally those born with congenital anomalies and with variations in cognitive and physical abilities may be at more risk from specific toxic exposures.

Behavioral factors such as developmental age appropriate behavior, activities, hobbies and occupational exposures all raise vulnerability. Social factors such as where a person lives, works or spends a great deal of time can also make them more vulnerable. Recently, there is mounting concern for the impact of environmental degradation as

part of a social-ecological dimension of risk and vulnerability (Depietri, 2020).

The following discussion will address biophysical, behavioral and social factors that increase vulnerability. For each of the areas, the topic will be addressed across the lifespan from fetal development through the older adult population.

EMBRYONIC AND FETAL DEVELOPMENT

Biophysical Factors

Healthy fetal development requires precise timing and feedback for cells to divide and mature properly for necessary cell replication and differentiation. For this to occur there is an interaction between genetic and environmental factors (Brent, Tanski & Weitzman, 2004; Schettler, Solomon, Valenti and Huddle, 1999; Zheng et al, 2016). For the developing fetus the risks are acquired through exposures across the placenta from the pregnant mother. In fact, any exposure to the fetus from the mother is considered environmental (“Environmental Factors in Birth”, 2009). So, while the only exposure pathway for fetal toxic exposures is placental, the fetus is particularly sensitive to the broad range of all environmental toxins that the mother is exposed to before and during her pregnancy. As will be discussed later, the pregnant mother’s exposure risk varies throughout pregnancy due to the variations in maternal physiology during pregnancy. Toxins may affect both the structural development and biochemical function of cells in fetal organ systems. Fetal sensitivity to toxins occurs as a result of the flexibility of the cell and the capacity for changes during embryonic development (Schettler et al., 1999). For each specific exposure, many things interact to create the risk and health outcomes. The magnitude of the exposure, the dose of the toxin, the embryonic stage, and metabolism of the mother and embryo all interact to vary the risk and the outcomes. The embryo is particularly sensitive to structural damage due to these mechanisms. Additionally, the blood brain barrier is not fully developed in the embryo allowing neurotoxins greater access to the fetus (Schettler et al, 1999; CDC, 2019). Often the woman is unaware that she is pregnant during this critical period when she may be exposed to toxins. Additionally, many chemicals have not been tested for toxicity to human development (Tanner, et al, 2020). Due to the stage of fetal development the impact of these risks can be very serious and harmful, resulting in life long impairments (Dietrich, et al, 2005). The study of what are referred to as windows of vulnerability or critical developmental periods is complex and requires sophisticated data analysis (Sanchez, Hu, Litman & Tellez-Rojo, 2011; Selevan, Kimmel & Mendola, 2000).

The healthy development of children must be a priority. Tickner & Hoppin (2000) argue that children are generally more vulnerable to environmental exposures and have less control of those environments than do adults. In addition, the risks to susceptible children are not well understood scientifically. Therefore, in the absence of clear evidence the [Precautionary Principle](#) must be followed (Tickner and Hoppin, 2000).

Table I Commonly Identified Chemical Exposures and Birth Defects-I

EXPOSURE	BIRTH DEFECT OR LOW BIRTH WEIGHT
Arsenic	Cardiac Defects
Bisphenol A	Reproductive system anomalies
Dioxin	Neural Tube Defects Neurobehavioral Problems Hypospadias Oral Clefts
Lead	Cardiac Defects Neural Tube Defects Neurobehavioral Problems Hypospadias Oral Clefts
Methyl Mercury	Neural Tube Defects Neurobehavioral Problems
Particulate Matter in Air	Vascular Defects (Patent Ductus Arteriosus)
PCBs	Impaired hearing*
Sulphur Dioxide	Musculoskeletal defects Cardiac Defects
Environmental Tobacco Smoke	Low Birth Weight Attention Deficit Hyperactivity Disorder
Air Pollution	Low Birth Weight
Pesticides	Low Birth Weight Congenital Anomalies

(Swanson, Entriner, Buss, & Wadhwa, 2009; Kim & Cizmada, 2010).

*Noted in animal studies

Many adverse health outcomes for the developing fetus are referred to as birth defects. Genetic factors as well as

environmental exposures interact in ways to create problems with organ structure or function. While scientists agree that environmental exposures are not well understood, those exposures that are known require more action and those that are not known require more research (“Environmental Factors in Birth”, 2009). Reported adverse health outcomes from environmental health threats such as [toxic chemicals](#) include low birth weight infants, congenital anomalies, pregnancy loss from miscarriage, and neurodevelopmental problems (See Table I).

Also endocrine disrupting chemicals (EDCs) have been linked to altered gender development and sexual organ malformations. Common environmental estrogens that mimic estradiol and attach to estrogen receptors are certain polychlorinated biphenyls (PCBs), Bisphenol A (BPA), phthalates, and pharmaceutical estrogens. High-level exposures have been confirmed for their role in gender related effects and scientists fear that even low level exposure can also result in these birth defects (“Are EDCs blurring”, 2005). For more information about EDCs see the chapter in Unit 3 Environmental Health Sciences.

Another feature of exposure is bioaccumulation. [Bioaccumulation](#) is a process by which toxins accumulate as they move up the food chain. Humans are at the top of the food chain, absorbing chemicals from meat, fish and produce consumed in the diet and as a result carry more concentrated levels of chemicals in the body. Consequently, the pregnant woman may have large amounts of toxins in her body that are passed on to the very small fetus. Due to its small size, the developing fetus can be exposed to a greater proportion of the toxin, which can result in life-long neurological deficits (Schettler, Soloman, Valenti, & Huddle, 1999; Zenker, Cicero, Prestinaci, Bottoni, Carere, 2014)).

Scientists examine the relationship between in-utero development and adult health. Mounting evidence supports the argument that [prenatal exposures](#) lead to lifelong consequences in adulthood. These consequences include congenital anomalies, risk for hypertension, insulin resistance, kidney disease and other health conditions. Recent studies in the area of epigenetics indicate that prenatal exposure to environmental contaminants can adversely affect the fetal [epigenome](#) and put the fetus at risk of diseases and disorders throughout the lifespan and transgenerationally (Perera & Herbstman, 2011).

Finally, studies examine the likelihood of preterm birth resulting from exposures to environmental toxicants, though no consistent evidence has been found to date, there are indications that future studies might document such evidence (Ferguson, O’Neill, & Meeker, 2013).

INFANTS

Biophysical Factors

Once delivery occurs, the newborn must transition from the life sustaining physiology of the fetus to an independent process of functioning that includes respiration, nutrition and elimination. The resting respiratory rate in infants is twice that of adults; this means that infants are exposed to 2 times more toxins per body weight than are adults. Nutritionally, infants take in 2 ½ times more water and 3 to 4 times more food per body weight than adults. This increases infant exposures to pesticides and other toxins in food and water much greater than exposures in adults. Infants have less developed brain, respiratory, gastrointestinal, immune, reproductive and metabolic systems than older children and adults (Bearer, 1995; Wigle, 2003). Their gastrointestinal tract is more permeable making it easier for toxins to be absorbed. Common exposures to toxins include pesticides, heavy metals, [persistent organic pollutants](#) and phthalates.

Social Factors

Most infants are delivered in hospitals where they are exposed to chemicals used in the nursery and hospital settings, particularly [Polyvinyl Chloride](#) (PVC), [di 2-ethylhexyl phthalate](#) (DEHP) and [Bisphenol A](#) (BPA). PVC is used in medical products as a plasticizer for tubing and other devices. Most PVC medical devices are from 20-40% DEHP and are commonly used in hospital nurseries. Neonatal intensive care units often use PVC medical products for IV solutions, enteral feedings and other necessary treatments. These chemicals are known to leach out of the medical device into lipid containing fluids contained in the solutions. As reproductive and developmental toxins these chemicals can expose infants at the time when they are adjusting to extrauterine life and have immature organ systems. Due to their small size and variety of exposures, newborns in NICUs can be exposed to chemicals of concern at far greater levels comparative to adult exposures (Schettler, 2002). While nursing initiatives such as Green Birthdays by the American College of Nurse Midwives seek to improve health care settings, referred to as Green Nursing, infants continue to be exposed to environmental hazards from the moment of their birth. For many newborns the time spent in the NICU can be weeks or months increasing their exposure to these hazards. See Unit 4: Hazards in the NICU.

Additionally infants spend most of their time in a single environment for prolonged periods, such as a crib, where the exposures do not vary. However, if hazardous

materials are present, they become more concentrated in this single environment (Bearer, 1995). Infants attending day care are confined to the same environment all day where they may be susceptible to indoor air contaminants. Indoor air quality in homes is often 10-50 times more hazardous than outdoor air where infants are exposed to carcinogens, neurotoxins and pesticides. While breastfeeding is considered the best nutrition for infants, chemicals such as [polybrominated diphenyl](#) ethers (PBDEs), PCBs, organochloride pesticides and dioxins that accumulate in human fat tissue in the breast have been shown to be transmitted to the infant during breastfeeding. These chemicals can also be found in formulas made from cow's milk. Further, the skin of a newborn is a highly absorptive surface and infants are exposed to a number of toxic chemicals in the personal care products that are applied to their skin (Bearer, 1995). See Unit 4: Personal Care and Safer Cleaning Products.

CHILDREN

Biophysical Factors

Children are more susceptible to environmental toxins because their ongoing physical development and physiology put them at greater risk. Tickner and Hoppin (2000) note that children are more susceptible to environmental toxins for four important reasons:

- they undergo periods of rapid growth and development (window of vulnerability);
- they have age-related differences in absorption, metabolism, detoxification and excretion of substances;
- they incur greater exposure to environmental toxins; and
- they incur exposure from the fetal period throughout life so that the cumulative effects of toxic exposures lead to greater risk.

The actual specific period of vulnerability for adverse effects of the toxic chemical exposures depends upon the toxin itself and its mechanism for action, the dose of that toxin, the actual target tissue for the toxicant and the timetable for development in the child (Wigle, 2003). Other factors that affect exposure and risk are location of toxin and child, breathing zones, oxygen consumption, food consumption, water consumption and behavioral development (Bearer, 1995, NIEHS, 2020).

Children's developmental changes from infancy to adolescence affect the toxicokinetics of their exposures. For example, their body composition has greater water content and less lipid content that can affect chemicals that bind to lipids. While that may offer protection in the

early months, the body lipids rise rapidly after birth for the first nine months. This rise in lipids increases the child's sensitivity to lipid binding chemicals such as dioxin, a known carcinogen. Children have a larger sized liver per body weight that can allow for hepatic metabolic clearance. But the larger liver can also allow for activation of toxic metabolites. Immature enzyme function in the liver reduces the body's ability to clear/remove environmental chemicals while immature renal function slows the elimination of chemicals and metabolites. There is a long postnatal period of development for the lungs and brain. Limited serum protein binding capacity in the birth to three month period of infancy creates the potential for more toxicants and chemicals in the body when pharmaceuticals and environmental chemicals are not bound to the serum and freely circulate in the infant's body (Ginsberg, Hattis, Miller, & Sonawane, 2004). Such physiological processes of normal development create critical periods where toxic exposures can be most harmful.

Children breathe more rapidly than adults and take in more air than adults. Toddlers generally breathe twice as fast as adults while school age children under the age of 12 years breathe about 1 ½ times as fast as adults. Children consume 3-4 times more food per body weight than adults, and drink more than 2 and ½ times more water per body weight than adults. As a result, they experience greater exposures to environmental health hazards of 2 to 5 times that of an adult.

Human development continues through childhood and the digestive, excretory and reproductive systems have not reached full development during childhood. As a result the protective mechanisms of a fully developed adult gastrointestinal tract may reduce exposures while mature kidneys and liver are better able to detoxify and eliminate toxins that affect children in greater concentrations. Additionally, toxins continue to pose risk for healthy reproductive system development and can result in decreased fertility and damage to reproductive structures and function (Silbergeld & Patrick, 2005).

Behavioral Factors

[Children are more vulnerable](#) to toxins due to behavioral factors as well due to oral, dermal and inhalation exposures specific to developmental stage behaviors (Moya, Bearer & Etzel, 2004). Children play at ground level both inside on the floor and outside in grass and other play spaces. Consequently they are exposed to materials that are tracked inside onto floors, and settle from the air. Common hazards on floors are pesticides and fertilizers, cleaning supplies, lead dust in older homes, and other

household chemicals (Sattler, Afzal, Condon, Belka & McKee, 2010). Outdoor hazards include the chemicals used in lawn and garden care but also chemicals transported by water runoff that include petroleum products, automotive additives, paints, and other industrial products.

Children also use hand-to-mouth behavior to learn and explore which makes them more vulnerable to toxins on household items as well as toxins within products such as toys. Harmful chemicals such as lead, cadmium and phthalates have been found in products commonly used by children including sleep accessories such as positioners and wedges, teethingers and other [plastic toys](#). Research indicates that on average a child's hands contact contaminated surfaces up to 32 times during eating, with even more contact to food before the food enters the mouth. Approximately 20-80 % of dietary exposures come from such hand to mouth behavior (Akland et al, 2000).

While infants may spend more time in cribs and indoors, as children age they are more likely to be at play both indoors and outdoors. Indoors they are likely to sit and lay on floors while outside they are likely to play in grass or soil, which can contain harmful [pesticides](#). These can also be tracked into the home on human and animal feet. Wood playground equipment often has been treated with creosote and arsenic, which are toxic.

Other location factors include the time a school age child spends in the school setting. [Indoor air](#) in schools has been identified as a source of carcinogens, neurotoxins and endocrine disruptors (EDCs). These include chemicals such as lead, radon, pesticides, asbestos, and volatile organic compounds (VOCs) such as solvents and formaldehyde. Further, [schools](#) can be a source of environmental hazards such as cleaning products as well. See Unit 4: Safer Cleaning Products.

In addition, children live in families where they can be exposed to "[take home toxins](#)." This refers to toxins that their family members are exposed to in the work setting and carry home on their clothing and personal belongings. A commonly recognized take home toxin is asbestos, which is linked to the development of lung conditions, particularly mesothelioma. Decades later, children who have been exposed to chemicals in their home or from take home toxins are at risk of developing conditions such as mesothelioma, Parkinson's Disease, and various forms of cancer.

Nurses can aid families to anticipate childhood risks during various stages of development through the tools provided in the [Physicians for Social Responsibility](#) (PSR)

Pediatric Environmental Health Tool Kit as well as the National Institute of Environmental Health Sciences (NIEHS) [Children's Health: Why the Environment Matters](#).

ADOLESCENTS

Biophysical factors

During puberty the adolescent experiences changes in hormones and the metabolic interactions of neurochemicals for development. This poses a "window of vulnerability" for the adolescent whose endocrine, immune, musculoskeletal and reproductive systems are undergoing maturation and can be heavily exposed to chemicals known to affect many systems. According to the [Environmental Working Group](#) report, [Teen Girls' Body Burden of Hormone-Altering Cosmetics Chemicals](#), an array of sex hormones present at minute levels in the body are responsible for the transition from childhood to adulthood and current research suggests that adolescents may be at particular risk for exposure to even trace levels of hormone disrupting chemicals.

Behavioral Factors

Adolescent girls are likely to increase their use of personal care products and cosmetics increasing their exposure to toxic chemicals in such products. Studies indicate that, on average, girls have up to 13 hormone altering chemicals from four chemical families - phthalates, triclosan, parabens, and musks - in their bodies. In addition to posing serious health effects as hormone disruptors, these chemicals also have the potential to cause cancer as well. Results suggest that young women are being exposed to a wide variety of cosmetic preservatives that puts them at serious risk during this important period of development (EWG, 2016).

Adolescents also are at risk due to their occupational exposures. During this phase of life they are most likely to begin employment in a variety of settings and more than 80% do work during some part of the year (Etzl & Balk, 2003). Frequently, adolescent boys go to work in the summer in lawn care services, painting and sealing driveways. At times they begin to work as entrepreneurs creating their own summer employment in such positions that are not monitored by Occupational Safety and Health Administration (OSHA). They may be unaware of the hazardous materials to which they are exposed. Adolescents employed in a variety of settings can be exposed to environmental tobacco smoke, solvents, and other cleaning agents (Etzl & Balk, 2003). A report by OSHA noted that more than two million youth are exposed to [farm-related hazards](#). Beyond the dangers of heavy equipment injuries are adolescents' exposures to the fertilizers and pesticides used in agricultural settings.

These include chemicals known to be carcinogenic, neurotoxicants and hormone disruptors.

PREGNANT MOTHERS

Biophysical Factors

While most scientists are concerned about prenatal exposures for the fetus, there is evidence that pregnant women are also at more risk themselves for exposure to environmental toxins due to their changing physiology during pregnancy. For example, decreased motility of the gastrointestinal tract increases intestinal transit. This delay can lead to greater absorption of toxins. Due to decreased plasma albumin concentration during pregnancy, compounds that are normally bound to albumin are altered kinetically (Brent, 2004). Increased extracellular fluid volumes affect the transfer of compounds dependent upon fluid concentration. Therefore, many toxins can actually move more readily into the pregnant mother. In addition, there are changes in renal elimination, maternal liver metabolism, and variations in uterine blood flow that affect her ability to detoxify and clear toxins from her body. Elevated blood lead levels in the pregnant mother may lead to pregnancy induced hypertension, a most serious and potentially life threatening complication of pregnancy (Yazbeck et al, 2009).

ADULTS

The average weight Caucasian man is the norm to which all standards for chemical safety have been applied. As a result, the discussion of vulnerability compares the various populations across the lifespan to the healthy adult. In addition, factors that affect the overall health of an adult such as chronic illness, affect the adult's susceptibility to environmental toxins. As noted in the discussion of adolescents, the use of personal care products varies by gender, and physiologic differences between male and female genetics and hormones can alter the risk factors for men and women.

Social Factors

Where a person lives, works, attends school, worships and plays can increase the risk of toxic exposures. These are considered to be the [social determinants of health](#) and greatly impact health outcomes. These exposures can have a serious impact upon their health. The EPA [Children's Health Protection Advisory Committee \(CHPAC\) Letter](#) to the EPA Administrator examined the impact of the social determinants of health as a factor of increased risk and vulnerability.

Beyond the individual level issues or household residence, school and workplace, there are neighborhood effects that impact the health of poor and minority populations at

much higher levels of exposure. These increased exposures and negative health outcomes are commonly termed issues of [environmental justice](#). This textbook offers a chapter on Environmental Justice for further information on that important topic. However those who live in more hazardous areas suffer injustice from their greater exposure to toxins.

In addition, the various hobbies and recreational activities that a person pursues can impact the amount of toxins they are exposed to in their lifetime. If the hobby includes paint and paint thinners, for example, an individual would be placed at a similar risk to those who are exposed occupationally. Home gardeners can be exposed to pesticides used. The person who "tinkers" on cars or motorcycles may be exposed to exhaust, degreasers, solvents, and cleaners. Often these spaces may not have adequate ventilation, further increasing the exposure of the hobbyist.

Further, various traditional remedies include toxins such as mercury, lead and other heavy metals. Folk remedies that contain lead, such as "greta" and "azarcon" are used to treat an upset stomach. In many Latino communities a form of mercury azogue is ingested to relieve empacho, a form of gastrointestinal malaise (for more information: [HIDDEN DANGER Environmental Health Threats in the Latino Community](#)). In a study of traditional Asian herbal remedies, levels of arsenic, lead and mercury were found to be at toxic levels in 49% of the products and 74% of them exceeded public health guidelines for prevention of disease (Garvey, Hahn, Lee & Harbison, 2001).

Social Factors: Occupation

Workplace exposures to hazards affect almost all categories of workers globally. The Occupational Health and Safety Administration (OSHA) reports that in 2019 more than 5,000 workers in the United States alone lost their lives in work related events. Early concerns for occupational health and safety began with identification of the hazards of coal miners and the development of pneumoconiosis or black lung disease. Common examples of occupations known for serious health effects from environmental toxins are agricultural workers who are exposed to pesticides, workers in dry cleaning establishments who are exposed to solvents such as [tetrachloroethylene](#) (PERC), shipyard workers, and those who work with insulation who are exposed to [asbestos](#) (McDermott-Levy et al, 2005).

Workers exposed to chemicals such as [vinyl chloride](#), [benzene](#), copper sulfate, plastics and asbestos have higher rates of cancers such as lung cancer, kidney cancer and

leukemia and other blood related conditions. Workers exposed to environmental tobacco smoke, carbon monoxide, or solvents are at increased risk for heart disease including arrhythmias. Since the early recognition of the link between occupation and health with coal miners, a variety of other lung conditions have been linked to workplace exposures including byssinosis (Brown lung) and those who work with cotton; silicosis and those who work in sandblasting and with ceramic and cement materials; and asthma from chemicals such as chromium, aluminum, nickel and exposure to dust. Those who work in smelters or foundries and those in the pharmaceutical industry are at greater risk of neurological disorders through workplace exposure to toluene, mercury, lead, arsenic, pesticides, plastics, and carbon monoxide. (See table 2).

TABLE 2 CHEMICAL EXPOSURE AND HEALTH

CHEMICAL EXPOSURE	ADVERSE HEALTH OUTCOME
Vinyl Chloride	Liver Cancer Cardiovascular Disease
Benzene	Leukemia Aplastic Anemia Neutropenia
Benzidine (various chemical formulas)	Bladder Cancer
Copper Sulphate	Anemia and Blood Disorders
Plastics	Neurological Effects
Asbestos	Asbestosis Lung Cancer Mesothelioma
Particulate Matter Sulphur Dioxide	Asthma
Environmental Tobacco Smoke	Cardiovascular Effects Pulmonary Disease Asthma
Carbon Monoxide	Cardiovascular Disease, including Angina
Solvents	Arrhythmias Liver Damage
Cotton Fibers	Byssinosis
Dust From Cement; Sandblasting; Ceramics	Pneumoconiosis Bronchitis
Pesticides	Skin Cancer

Various federal agencies such as the [Occupational Safety and Health Administration](#) (OSHA) and [National Institute](#)

[of Environmental Safety and Health](#) (NIOSH) study, monitor, enforce standards and provide important research and education to improve worker health. The [American Association of Occupational Health Nurses](#) supports nursing efforts in occupational and environmental health. [Fundamentals of Occupational and Environmental Health Nursing](#). Nurses are exposed to many hazardous chemicals in their work in the hospital and other health care settings. It is known that various medical products that nurses are exposed to contain toxic substances. However, there has been little confirmation of the health burden this places upon a nurse's body. In a bio-monitoring study conducted by the organization, [Physicians for Social Responsibility](#), nurses and physicians in 10 states were found to have levels of chemicals with known or suspected negative health outcomes. In those tested, [bisphenol A](#) (BPA), mercury, [phthalates](#), polybrominated diphenyl ethers (PBDEs), [triclosan](#), and perfluorinated compounds (PFCs) were among the chemicals found. All persons in the study had at least five of the six kinds of chemicals tested and all had BPA and some form of phthalates in their bodies (Wilding, B.C., Curtis, K., & Welker-Hood, K. (2009).

Further, evidence suggests that previous ethnic and racial disparities in workplace exposures to toxins persist today. Historically, black workers were shown to be disproportionately exposed to silicosis, chromate, and carcinogens from coke ovens. Latinos are shown to face disproportionate risks from pesticide, lead and mercury exposure (NRDC, 2004). More recent reports of disproportionate exposures show that Latino agricultural workers, Native American mine workers and newly immigrated Asians are among those whose workplace exposures exceed that of whites (Murray, 2003).

OLDER ADULTS

Biophysical factors

It is important to note that persons older than age 65 demonstrate great variability in physical changes that affect vulnerability. Frailty of the very old, the presence of serious health conditions and residential, behavioral, and lifestyle factors contribute to differences in susceptibility (Geller & Zenick, 2005). A priority of the [National Academies of Sciences, Engineering and Medicine](#) stress the importance of research to better understand the role of environmental exposures in the development of age related diseases such as dementia, cancer and cardiovascular disease.

[Older adults](#) are at greater risk for harmful health effects from toxic exposure for two reasons. First, they experience physiological changes related to aging. The effectiveness of their respiratory system to clear inhaled

toxins is diminished due to decreased lung volume, elasticity and lowered ventilation rate. Weakened skin integrity reduces their capacity to resist dermal exposures. Liver metabolism and renal function is less effective due to reduced blood flow, effects of aging and the effect of specific age related diseases. Reduced capacity to metabolize and excrete toxins absorbed through respiratory, gastrointestinal, and dermal pathways increases the harmful effects of toxic exposures. [Polypharmacy](#) is frequent in older adults and the interaction of a large number of pharmaceutical chemicals and environmentally adsorbed chemicals puts added stress on metabolic processes. In addition, changes in immunity and other processes of aging combine with exposures earlier in their lifetime to contribute to the development of illnesses. For example, Parkinson's disease has been shown to be related to exposure to neurotoxins earlier in life.

Second, the older population experiences a greater number of chronic illnesses that can be adversely affected by exposures to environmental hazards. Conditions such as Chronic Obstructive Pulmonary Disease (COPD), asthma and other chronic lung conditions are made worse by exposure to environmental tobacco smoke, particulate matter, tobacco smoke and other criteria air pollutants. Studies indicate that air pollution and climate can have significant adverse effects on those who have cardiac disease (Gold & Samet, 2013; Di et al, 2017). For more information about the impact of climate change upon older adults see the chapter in the climate change unit following.

Behavioral factors

Older adults spend up to 90% of their time indoors exposing them to indoor air pollution, which is comprised of outdoor air contaminants as well as specific contamination in indoor settings (Davis, 2009). Outdoor air pollution includes pollutants such as sulfur dioxide, nitrogen dioxide, ozone, and particulate matter.

Most of the literature that addresses environmental risk among of people with developmental disabilities or cognitive delays examines the relationship of toxic exposures and neurodevelopment effects. More research is needed to explore the effects of toxic exposures to an individual who has some type of cognitive or developmental difference. Researchers question whether physiological factors such as alterations to the nervous system make an individual more vulnerable to added exposures. Resources are available for older adults and environmental risks to health at the [Alliance of Nurses for Healthy Environments \(ANHE\) website](#).

PERSONS WITH ALTERATIONS IN COGNITIVE AND PHYSICAL ABILITIES

Environmental exposures are associated with a number of [neurodevelopmental effects](#) (EPA, 2013). Organizations such as the [American Association on Intellectual and Developmental Disabilities](#) note that the potential for cumulative effects of hazardous chemical exposure for the population with intellectual and developmental disabilities should be addressed through ongoing research (AAIDD, 2012). People with developmental differences who are able to work can be exposed to toxins in their work setting. Those living with physical and cognitive disabilities are more likely to live in community based residential homes where they are likely to be exposed to a variety of household environmental health toxins from poor indoor air quality. These pollutants include carbon monoxide, lead, mercury, radon, pesticides and cleaning products (Davis, 2009). The American Association on Intellectual and Developmental Disabilities addresses the risks for environmental exposures in their [position statement](#) (AAIDD, 2012).

GLOBAL HEALTH

Across the globe, all humans are at greater risk from climate change in terms of changes in temperature and humidity, drought, plant life, wildfires, and changes in air quality. However, some regions of the world are experiencing the harmful effects of climate change at a greater rate. Water is becoming scarcer in many regions and the melting of the ice cap and glaciers is putting some poorer, heavily populated regions into crisis due to flooding, extreme weather events, and loss of habitat.

Researchers estimated that 25-53% of the burden of illness worldwide can be attributed to environmental health risk factors when they considered nutritional factors in food, pesticides and environmental tobacco smoke but excluded known genetic causes and behavioral factors such as smoking and diet (Smith, Corvalan & Kjellstrom, 1999). While the study was not able to confirm the estimates, the results indicate that environmental hazards contribute to disease and financial burdens worldwide (Smith, Corvalan & Kjellstrom, 1999). The World Health Organization (2015) provides methodology to [quantify the disease](#) burden attributable to environmental health risks including indoor and outdoor air pollution, lead, mercury, occupational exposures to carcinogens, environmental tobacco smoke and solar radiation. Toxins such as lead in gasoline, arsenic and high levels of fluoride in water, and DDT are exposures found in the developing world that do not occur in the United States.

Additionally, the policies of the richer countries contribute to global health disparities. Currently many pesticides banned for use in the United States and Europe are sold for use in poor tropical regions. Many developed countries have been disposing of pharmaceuticals by dumping these and electronic hazards in poorer countries (Ahsanuddin, 2012; Bradley, 2014). Currently, for example, Kenya has large electronic-waste dumps near large population centers causing exposure to many toxic chemicals including heavy metals (Schluep, Rochat, Munyea, Laissaoui, Wone, Kane, Hieronymi, 2008).

Finally, protection is more limited in many regions of the world. As developing countries adopt many of the less environmentally friendly products such as plastic bottling and bags, they are more likely to dispose of these non-recyclables by dumping and burning. Such practices increase the human risks, particularly carcinogens from air, water and soil pollution.

This overview of the vulnerability to environmental health risks by a variety of populations highlights the biophysical, behavioral and social factors that increase risk for many people. Advocacy to reduce risk of exposure to toxins and to protect health in ways the Precautionary Principle advises must be evident for all people globally. The particular needs of the vulnerable populations discussed here add evidence to the need for policy change.

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PESTICIDES AND CHILD VULNERABILITIES

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Pesticides are chemical formulations that are widely used in society and may create human health threats. The US Environmental Protection Agency (EPA) (2018) defines a pesticide as “any substance intended for preventing, destroying, repelling, or mitigating any pest,” including insect, plant, fungus, rodent, or bacteria. Pesticides include insecticides, herbicides, fungicides, rodenticides, and biocides and are ubiquitous in our environment. The usual biological targets of pesticides are the pests’ nervous or reproductive system, although they may affect other organisms, including humans.

CHILDREN

Bearer (Bearer 1995), coined the phrase that is now the axiom, “children are not little adults.” Several differences are especially important when discussing environmental exposures. For example, young children explore their world with hand-to-mouth activity (Black et al. 2005)

The research conducted by Black et al (2005) sought to evaluate the potential exposure to pesticides based on children’s activities. This study reports findings from the first phase of a 24-month longitudinal project that took place in Laredo, TX between May and August 2000. The sample included 52 children, ages 7-53 months in 29 homes. Data were collected by four hours of video taping mouthing and food handling behaviors and collecting samples of house dust, soil, hand loadings, and urine. A questionnaire was also completed by the adult in the household. The study found both object mouthing ($R_s = -0.329$, $p = .017$) and hand mouthing ($R_s = -0.301$, $p = .030$) decrease with increasing age. Playing outside differed by age ($X^2 = 8.1$, $p = .04$) and hand washing increased with age except after playing outside. The authors conclude that the EPA’s standard risk assessment estimate of 49 combined hand- and object- to mouth contacts/hour may not be protective enough of infants since 39% of less than one-year olds exceeded that limit.

Children are also closer to the ground, play outside in the dirt, eat and drink more per body weight than adults, have limited selection of food, and many of their various body systems are still developing (Bearer 1995; Black et al. 2005; Eskenazi et al. 1999; Islam et al. 2018; Reigart and Roberts 2001; Thomas 1995; Tulve et al. 2002). Children can be exposed to chemicals of concern, including pesticides in

the diet, school, gardens/yards, in the home and from take-home contact with parents’ work clothes (Hyland and Laribi 2017; Zahm and Ward 1998).

For example, a follow-up longitudinal study done by Lu et al (Lu et al. 2009) to assess children’s exposure to pyrethroid insecticides by collecting series of urine samples during summer and fall 2003, and winter and spring 2004. A total of 1757 spot urine samples were collected from 19 out of 23 children, age 3-11. Linear mixed models analysis was used and results show two urinary metabolites common to pyrethroid insecticides were present at a significant level when controlling for season, age, gender, residential use, and dietary intake.

Children also have a longer time for the effects of exposure to impact their health. In Rohlman’s cross-sectional study (Rohlman et al. 2007) researchers compared neurobehavioral (NB) performance of 119 Hispanic adolescents and adults working in agriculture to 56 Hispanic adolescents and adults not currently working in agriculture and found a significant inverse relationship between NB performance and both age and years of use ($p = .04$). They conclude that a future longitudinal study is needed to assess the cohort of adolescent agricultural workers to see if there is a more significant deterioration in NB performance when early use is added to the number of years used.

PREGNANT WOMEN/FETUS

Even more critical periods of growth and development exist for a developing fetus with the opportunity for more permanent and debilitating results. Whyatt (Whyatt et al. 2007) reported that indoor air concentrations of pesticides correlated with umbilical cord blood levels and the babies born with the highest cord blood levels of chlorpyrifos also had significantly lower weight and length at birth. The article series by Whyatt et al (Whyatt et al. 2004; Whyatt et al. 2007; Whyatt et al. 2009) are all from the same Columbia Center for Children’s Environmental Health (CCCEH) cohort that followed African American and Dominican women registered at two New York City Hospitals’ prenatal clinics who live in either North Manhattan or South Bronx. The 2004 article presents findings from 314 mother-baby pairs including maternal personal air samples collected over the last months of pregnancy, umbilical cord blood samples, and measures of fetal growth. “Specifically, birth weight decreased by 42.6 g (95% CI, -81.8 to -3.8, $p = 0.03$), and birth length decreased by 0.24 cm (95% CI, -0.47 to -0.01, $p = 0.04$) for each log unit increase in cord plasma chlorpyrifos levels” ($p = .1128-9$).

Prenatal exposures to pesticides have been linked with otitis media, respiratory distress, asthma, and cancer (Weselak et al. 2007). Exposure prior to or during pregnancy increased risk for Acute Lymphocytic Leukemia, Wilms' Tumor, and brain cancer (Daniels et al. 1997; Zahm and Ward 1998). The latest review of the literature published by Infante-Rivard (Infante-Rivard and Weichenthal 2007) updated Zahm and Ward (1998) and included 21 studies published from 1999-2004. Fifteen of these studies showed statistically significant increases for childhood cancer related to either childhood pesticide exposure or parental occupational exposure.

POTENTIAL HEALTH EFFECTS

There are many studies investigating the human health effects of pesticide exposure. There are so many possible combinations of chemicals, routes of exposures, and exposed individuals it is not surprising the results are variable. Below is a brief review of potential health effects and based on the assumptions of the Precautionary Principle (ANA, 2003), the preponderance of suggestive evidence warrants protective action.

Neurodevelopmental

Given that a main mode of action in controlling pests is targeting the nervous system, it is understandable that a high enough exposure over an extended period of time would result in neurological impact in humans. According to the National Academies of Science Report Environmental Neurotoxicology (Council 1992) less than 10% of over 70,000 chemicals in use in the US have any form of neurological testing let alone complete information. A challenge for determining neurodevelopmental effects of pesticides is that chemicals can act through a variety of mechanisms, making it difficult to confirm effects from study to study in different populations (Ray and Fry 2006).

Research indicates a link between prenatal pesticide exposure in mothers and related health effects in their children such as development attention deficit hyperactivity disorder behaviors (Yolton et al. 2014), social behavioral problems (Ribas-Fito et al. 2007), neurodevelopmental delays (Eskenazi et al. 2007; Handal et al. 2007; Ribas-Fito et al. 2003; Torres-Sanchez et al. 2007), and impaired gross and fine motor skills (Guillette et al. 1998). Additionally, research is starting to show that timing of the insult can impact outcomes, as prenatal exposure to pesticides very early on in gestation while the brain is forming neurons can lead to late-onset Parkinson disease (Iglesias et al. 2018). Prenatal and early life pesticide exposure has also been linked with difficulties in

hearing (Gatto et al. 2014) and language development (Dzwilewski and Schantz 2015)

In a cross-sectional study by Handal et al (2007), the goal was to compare neurobehavioral (NB) development of children 3-61 months of age between those who did and did not live in areas of high pesticide exposure in the flower growing region in Ecuador. The sample was 219 mothers and 283 children, 154 who lived in two communities of high pesticide exposure and 129 who lived in a community not associated with industry-related pesticide use. A questionnaire to assess NB development was administered to the children and a separate questionnaire was administered to the mothers. Anthropomorphic measures were taken on the children and mothers and a blood sample was taken from the children to assess for anemia. Findings revealed that younger children (3-23 months) from the high-exposure area were significantly delayed in three out of five NB domains. Children scored 8.8 points lower on gross motor skills ($p=.002$, Cohen's d for effect size= .4), 5.0 points lower on fine motor skills ($p=.06$, $d=.2$) and 5.8 points lower on socio-individual skills ($p=.02$, $d=.3$). For older children (23-61 months) there was a suggestive trend with 3.8 point lower performance on gross motor skills assessment ($p=.06$, $d=.2$). The effect was much more pronounced when malnourishment was combined with high pesticide exposure, indicating a possible subpopulation at even higher risk for NB delay.

Reproductive and Endocrine

As little is known about neurodevelopmental effects, even less is known about reproductive and endocrine impacts. Investigation is also complicated by multiple chemicals capable of acting in similar ways on the hormonal systems. Several studies (Damgaard et al. 2006; Virtanen and Adamsson 2012) found boys with cryptorchidism had mothers with higher levels of organochlorine (OC) pesticide metabolites in their breast milk. In a review of the environmental and health impacts of the herbicide 2,4-Dichlorophenoxyacetic acid (2,4-D), Islam et al (Islam et al. 2018) report interference with the hormone necessary for spermatogenesis. Pesticides also have been implicated in altered thyroid function (Meeker et al. 2006a), decreased testosterone (Meeker et al. 2006b), gestational diabetes (Saldana et al. 2007), menstrual irregularities (Farr et al. 2004), and fetal death related to congenital birth defects (Bell et al. 2001; Wang et al. 2016). Additionally, pre and postnatal pesticide exposure can lead to later development of diabetes and obesity (Giulivo et al. 2016).

A variety of pesticide-related immune system effects also have been investigated. Pesticides are suspected to lead to an increased risk for exposure to allergens and hay fever (Weselak et al. 2007) and be a cause or trigger for multiple chemical sensitivity (Caress and Steinemann 2003).

Weselak et al (2007) conducted a cross-sectional study to investigate the possible immunotoxic effects of exposure to pesticides prenatally. The study used Ontario Farm Family Health Study data collected in 1991. It included 3405 children out of 5853 reported pregnancies. Results show a link between herbicides (OR=1.56, 95% CI 1.15-2.11), insecticides (OR=1.48, 95% CI 1.07-2.03), and fungicides (OR=1.69, 95% CI 1.15-2.47) and allergy and hay fever. More specifically for phenoxy herbicides (OR=1.43, 95% CI 1.03-1.99) and 2,4-D (OR=1.66, 95% CI 1.11-2.49). The association held true for male children and children of both genders that were 12 years old and older at the time of the questionnaire.

In a review of literature, Colosio (Colosio et al. 2005) described existing evidence that demonstrated a wide variety of pesticides can affect the immune system, but most of the studies are of high dose exposures and that data are lacking to indicate health risk from low, chronic doses. The review also stated that it is difficult to capture reversible effects.

Respiratory

There is little research available for respiratory effects in children from pesticide exposure, but the literature base is growing. Salam (Salam et al. 2004) identified increased risk of asthma related to pesticide exposure and Spencer (Spencer and O'Malley 2006) reported pesticides as an irritant and asthma trigger. Other studies support the link between prenatal and early life exposure to pesticides and increased odds of asthma symptoms and exercise-induced breathing issues, particularly if the exposure comes during the second half of pregnancy (Raanan et al. 2015; Vrijheid et al. 2016). In a systematic review and meta-analysis, Hosseini et al. (Hosseini et al. 2017), concluded support for a link between low fruit and vegetable intake and increased odds of asthma and allergies.

Salam et al (2004) conducted a case-control study nested in a larger population-based study of children's respiratory health. One of the purposes of the research was to test the hypothesis that environmental exposures, including pesticides, led to increased occurrence of transient wheezing or persistent asthma. The sample was drawn from public school children in 12 southern California

communities from the 4, 7, and 10th grades. There were 279 cases with asthma and 412 controls. Results indicate a 4.58 times (95% CI 1.36-15.43) increased risk for asthmatic children to have been exposed to herbicides during the first year of life and a 2.39 times (95% CI 1.17 – 4.89) increased risk of exposure to pesticides. As an aside, it is interesting that the authors separate herbicides and pesticides when, in actuality, herbicides are a class under the broader category of pesticides.

Cancer

One of the most common endpoints investigated for health effects for any chemical exposure is cancer. Identification of causative mechanisms for cancer is often problematic due to multiple exposures and long latency periods.

The research thus far implicates pesticides in leukemia/lymphoma (Daniels et al. 1997; Infante-Rivard and Weichenthal 2007; Islam et al. 2018; McNally and Parker 2006; Menegaux et al. 2006; Zahm and Ward 1998). Menegaux et al (2006) conducted a hospital-based case-control study in four hospitals in France. There were 280 incident cases of acute leukemia and 288 hospitalized controls admitted between 1995 and 1999. The purpose was to analyze the relation between childhood acute leukemia and pesticide exposures. There was a significant relationship between leukemia and insecticide use at home during gestation (OR=1.8, 95% CI 1.2-2.8) and during childhood (OR=1.7, 95% CI 1.1 – 2.4). Garden pesticide use (OR=1.7, 95% CI 1.1 – 2.7), insecticide use (OR=2.4, 95% CI 1.3 – 4.3) and fungicide use (OR=2.5, 95% CI 1.0 – 6.2) were significantly associated with leukemia. Use of insecticide shampoos to treat head lice were also significantly related to leukemia (OR=1.9, 95% CI 1.1 – 3.2), especially if they contained pyrethroids (OR=2.0, 95% CI 1.1 – 3.4).

A similar national-registry based case-control study conducted in France in 2003 and 2004 (Rudant et al. 2007) had similar conclusions. Male and female cases were 764 for acute leukemia (AL), 130 Hodgkin lymphoma (HL), and 166 Non-Hodgkin lymphoma (NHL) and controls were 1,681 randomly selected from the French population using random digit dialing. Data were collected via phone interview using a structured questionnaire. Findings for maternal use of household pesticides any time during pregnancy indicate a 2.2 times increased risk for AL (95% CI 1.8 – 2.6) and 1.9 times increased risk of NHL (95% CI 1.3 – 2.6). Paternal use of insecticides during pregnancy or childhood increased risk for AL 1.4 times (95% CI 1.2 – 1.7).

Other probable cancers linked with pesticide exposure include breast (Clark and Snedeker 2005; Giulivo et al. 2016), prostate (Andreotti et al. 2009), pancreas (Andreotti et al. 2009), liver (Dharmani and Jaga 2005), kidney (Zahm & Ward, 1998; Daniels et al., 1997), lung (Zahm & Ward, 1998), brain (Daniels et al. 1997; Shim et al. 2009; Van Maele-Fabry et al. 2017; Zahm and Ward 1998), central nervous system (Georgakis 2017) and skin (Zahm & Ward, 1998).

A case-control study by Shim et al (2009) investigated the possible association between childhood brain cancer and parental exposure to pesticides at home and at work. Study participants were selected from statewide cancer registries in four east coast states as part of the Atlantic Coast Brain Cancer study during 2000-2001. Four hundred twenty-one cases and 421 controls participated. A suggestive outcome was found for astrocytoma and maternal herbicide use during the preceding two years before the child was born (OR=1.9, 95% CI 1.2-3.0).

Genetics

Genetic variations may determine how susceptible a child is to the effect of a pesticide exposure, whether prenatal or early-life. Paraoxonase-I (PON1) is an enzyme that can detoxify several insecticides including organophosphates (OPs) and pyrethroids. Research is beginning to demonstrate that different polymorphisms in PON1 can increase the odds of health risks from exposure to the insecticides the enzyme breaks down (Marsillach et al. 2016; Yoltan et al. 2013).

NURSING ACTIONS

More educational resources

- MD Pesticide Network's Pesticides and Public Health: Critical Literature on Human Health <http://www.mdpestnet.org/wp-content/uploads/2012/11/MPN-07Journal-FINAL.pdf>
- National Library of Medicine Environmental Health, Toxicology & Chemical Information <https://envirotxininfo.nlm.nih.gov/>

Practice resources

- Health Care Without Harm Pesticide Resources: <https://noharm-uscanada.org/issues/us-canada/cleaners-and-pesticides-resources#pesticides>
- Californians for Pesticide Reform
- Bio-Integral Resource Center
- Northwest Coalition for Alternatives to Pesticides

- Extoxnet's Pesticide Information Profiles
- IPM Institute of North America <http://ipminstitute.org/>
- Integrated pest management - A more conservative and less toxic approach to pest management involves assessing the problem, making structural changes first and then using the least toxic chemical pesticide as a last resort. Structural changes include removing food and water sources, sealing cracks and fixing holes in screens. Least toxic chemicals include boric acid and natural oils like citronella.
- NY State Health Department Reducing Pesticide Exposure <https://www.health.ny.gov/environmental/pests/reduce.htm>
- Prevent pests from entering your home or garden.
- Consider non-chemical methods for controlling pests.
- Select the product that best fits your needs.
- Follow label directions exactly when mixing and applying pesticides.
- Store and dispose of pesticides properly.
- Minimize environmental impacts from pesticide use.
- Pediatric Environmental Health Specialty Units, a network of experts in reproductive and children's environmental health <https://www.pehsu.net/>

Advocacy organizations

- American Academy of Pediatrics Council on Environmental Health <https://www.aap.org/en-us/about-the-aap/Councils/Council-on-Environmental-Health/Pages/COEH.aspx>
- Beyond Pesticides works with allies in protecting public health and the environment to lead the transition to a world free of toxic pesticides. <https://beyondpesticides.org/>
- Children's Environmental Health Network is a national multi-disciplinary organization whose mission is to protect the developing child from environmental health hazards has wonderful online resources. <https://cehn.org/>
- Pesticide Action Network of North America works to replace pesticide use with ecologically sound and socially just alternatives. <http://www.panna.org/>

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IMMIGRANTS AND REFUGEES AS A VULNERABLE POPULATION

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INTRODUCTION

Currently, there are 44 million people who were born in another country and have made the United States their home. They represent every country in the world; thus the United States has the largest and most diverse immigrant population (Radford, 2019). Although immigrants to the U.S. represent many nations, the foreign-born U.S. residents who immigrated to the U.S. and comprise the largest segment of the immigrant population were born in Mexico (25 %), China (6%), India (6%), Philippines (4%), and El Salvador (3%) (Pew Research Center, 2020). Climate change is influencing migration and it is expected to be a driver of rising rates of refugees and asylum seekers in the future (see climate change section on Migration in this e-text).

Those immigrating to and seeking refuge in the U.S. have primarily resided in California, Florida, Illinois, New York and Texas. There has been a recent trend, however, in which immigrants and refugees are settling throughout the country (U.S. Census Bureau, n.d.). This trend leads to greater diversity within our communities and requires the nurse to have an understanding of the needs of foreign-born populations related to their past environmental exposures and their unique environmental risks with resettlement in the U.S.

ENVIRONMENTAL EXPOSURES FROM COUNTRY OF ORIGIN

Like everyone else, we are influenced by our environments. Body burden studies have found that people living in industrialized countries, such as the U.S., have a legacy of chemical exposures (Gennings et al, 2012). Immigrants and refugees arrive in the U.S. with past environmental exposures from their native land. Depending on the circumstances of the immigrating person those environmental exposures can place an immigrant or refugee at greater health risk.

OCCUPATIONAL EXPOSURES

Workplace environmental exposures in the country of origin influence the health of people immigrating to the U.S. The World Health Organization (n.d.) has identified that people from developing countries are more likely to

be exposed airborne particulates, carcinogens, and risks of workplace injury. Those employed in agricultural jobs are at risk for pesticide exposures and depending on the climate of the country of origin, heat related illnesses such as skin cancer and renal disease (Wesseling, Crowe, Hogstedt, Jakobsson, Lucas & Wegman, 2013). Outdoor workers are particularly vulnerable to greater risk of heat related illnesses as a result of climate change. Climate change is also expected to exacerbate existing chronic diseases such as pulmonary and cardiac disease (Intergovernmental Panel on Climate Change, 2014).

It is helpful to remember that not all resettled immigrants and refugees were employed in countries with strict occupational health requirements for worker protections. Assessment of past employment activities and exposures is an important first step to determine environmental risks. In addition to the risk described for agricultural workers in the previous paragraph, workers in manufacturing may be at risk for musculoskeletal injury from repetitive activities or chemical and noise exposures from working with industrial equipment and lubricants. Those who were employed in the health care sector may have risk of biological exposures, while the extraction (mining) industry presents the risk of radiation, poor air quality, and chemical exposures (Frumkin, 2016). For more information regarding global occupational health risk see [WHO Occupational Health web site](#).

The role of many women from developing countries remains traditional and their work is in the home. This makes immigrating women from some developing countries vulnerable to household indoor smoke from indoor cook stoves that use wood or other biomass fuel. Poor indoor air quality is associated with pulmonary conditions such as acute respiratory infections, tuberculosis, and lung cancer, as well as heart disease and poor pregnancy outcomes such as low birth weight (World Health Organization, 2006). Nursing assessments should include identifying chronic diseases and previous exposures in the immigrating person's country of origin.

CULTURAL & FOLK PRACTICES

Cultural practices can put immigrants and refugees at risk for environmental hazards. For example, women from some parts of Africa, South Asia, and the Middle East may use traditional eye cosmetics known as kolh (Arabic: kuhl; Punjabi: sirma; Hindi: kajal; Telegu: katuka from: <https://theurbanmuslimwomen.wordpress.com/2008/09/22/kohl-for-the-eyes/>). Kohl can also be applied to infants' eyes at birth as it is believed to strengthen the eyes and protect the child from the evil eye. Kohl preparations may contain lead and this practice can put women and infants at risk of lead toxicity. change (See lead section in this e-text).

Furthermore, some traditional medicines that are used as part of Hispanic, Chinese, Middle Eastern, Indian and other Asian folk health practices have been noted to contain heavy metals including lead. The U.S. Center for Disease Control and Prevention (n.d.) offers detailed information about folk medications that may place immigrant and refugee families at risk for lead and other heavy metal exposures. The nurse should assess past use of traditional medicines and determine if the immigrating family continues to rely on these traditional medicines.

DISASTERS

Natural and manmade disasters have the capacity to disrupt the infrastructure that provides clean water and air as well as safe food and medicines. Consequently, immigrant and refugee families may present with health problems related to exposure to poor air and water quality as a result of disruptions of utilities. These disasters could be the reason for immigration to the U.S. Natural disasters such as volcanoes, earthquakes, tornadoes and hurricanes can create health problems for the people in the surrounding communities. For example, volcanic activity generates gasses such as sulfur dioxide, carbon dioxide and hydrogen chloride as well as particulate matter that can affect human health. The [U.S. Geological Survey website](#) describes air pollution related to volcanic activity.

With increasing development, natural disasters can influence the built environment and lead to a manmade disaster. This was the case with the 2011 earthquake and subsequent tsunami near Fukushima, Japan that ultimately led to the release of radiation from the nearby nuclear power plant. Following the Fukushima nuclear disaster, WHO (2013) conducted a health risk assessment and identified that those people living closest to the nuclear reactors at the time of the accident had an increased risk of solid cancers (4%), breast cancer (6% increase for infant females), leukemia (7% increase for infant males) and thyroid cancer (70% increase for infant females). It is important that the nurse takes the time to learn the history of the country of origin and reason for immigration so that health screening can be targeted to the patient's environmental health risks. For more information regarding environmental health impacts of disasters, please go to the Natural Disasters, Climate Change, & Preparedness section in Unit 6.

WAR AND AREAS OF CONFLICT

Disputes of our world's limited natural resources such as water rights can be an antecedent to war. War itself, a manmade disaster, presents additional environmental risks to immigrant and refugee families. Psychological trauma

and physical disability as consequence of military conflict can be complicated by environmental exposures of warfare including chemical weapons that affect military and civilian populations (Dworkin, Prescott, Jamal, Hardawan, Aras, & Sandro, 2008). Iraqi refugee families attributed congenital anomalies of children that were born following maternal exposure to chemicals used during the Iraqi war (McDermott-Levy & Al Balushi, 2015).

IMMIGRANTS & REFUGEES LIVING IN THE U.S.

Immigrants to the U.S. are less likely to have health insurance and are less likely to seek care from a health care professional. Furthermore, citizenship influences access to U.S. sponsored health insurance programs such as Medicaid and Medicare. Consequently, in 2018, 24% of lawfully present, nonelderly and 45% of undocumented immigrants were not insured (Kaiser Family Foundation, 2020).

Access to health care is further limited by language barriers, cultural differences, perception of health needs, and immigrant status (Ku & Jewers, 2013). These factors influence how an immigrant patient or family would respond to or understand the risks or impacts of environmental exposures.

LANGUAGE

Language and access to interpreters also creates barriers to health information for refugees (Morris et al., 2009) who may come to the U.S. with a variety of physical and mental health problems (Jamil, Farrag, Hakim-Larson, Kafaji, Adbulkhaleqm & Hammad, 2007; Ramos, Orozovich, Moser, Phares, Stauffer, & Mitchell, 2010). One problem for those new to the country is the ability to access environmental health information related to the area of resettlement and to read instructions on chemical labels such as pesticides and cleaning agents. The National Service Center for Environmental Publications of the EPA has environmental health resources in 23 languages and dialects to support the immigrant and refugee family. Safe and proper use of household pesticides and cleaning agents can be a problem for recent immigrants who may not be able to read instructions in English. One thing that may assist those new to the U.S. is that in 2003 the member countries of the United Nations published a harmonized chemical hazard communication system called the "Globally Harmonized System of Classification and Labeling of Chemicals" (OSHA, n.d.). As a result of harmonization, most countries rely on standardized warning symbols and standardized safety data sheets (formally MSDS). While this will not completely overcome some language barriers for recent immigrant or refugee families, standardization does provide common warning

pictographs from country to country. For more information regarding international chemical labeling standardization see Occupational Safety & Health Administration web site regarding global harmonization.

CULTURAL IMPLICATIONS IN THE U.S.

Adding to barriers of access to a health professional regarding environmental health information is the perceptions of the role of the nurse. In some cultures it is not acceptable to ask questions of the providers and nurses do not have a role other than following the physician's orders. Also the U.S. healthcare system is very complex and can be confusing to a newly arriving immigrant; therefore, someone with an environmentally related problem may not know how to access a health care provider for assistance. Nurses need to make themselves available to immigrant and refugee communities in order to educate those new to the U.S. in the role of the nurse and environmental risks and safe practices. Social organizations and the faith community are groups in which the nurse can access immigrant and refugee communities. For example, Villanova University nursing students partnered with a senior center that serviced elderly Asian immigrants to teach healthy gardening practices that did not rely on pesticides. See [How does your garden grow?](#)

ECONOMICS & HOUSING

Many immigrants and refugees arrive in the U.S. and find themselves living at a lower standard of living than they had in their home country (Morris et al., 2009). In the U.S. they may find themselves living in substandard housing, older homes in disrepair, or be victims of unscrupulous landlords. Home environmental risks that may be a problem for this population is lead based paint, carbon dioxide from poorly maintained furnaces, or pests such as roaches or rodents. The nurse should assess the age of homes, the availability and policies related to carbon monoxide detectors, and if pests are a problem for the immigrating family. If an environmental risk is identified the nurse should make appropriate referrals and educate the family in mitigation methods.

CONCLUSIONS

Immigrants and refugees may come to the U.S. with previous environmental health exposures that require assessment and management if there are health consequences. Additionally, once in the U.S., immigrants and refugees are at risk as a result of language and cultural barriers as well as potential challenges accessing the health care system. Nursing assessments should focus on the unique previous exposures and potential risks for the resettled immigrant. Once risks and health problems are

identified the nurse can make appropriate referrals and participate in interventions that promote the health of this vulnerable population.

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DENTAL AMALGAM AND VULNERABLE POPULATIONS

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INTRODUCTION

This chapter examines several vulnerable populations for whom mercury used in dental amalgams poses risk to health. The first three groups are pregnant and breastfeeding women, and children, and the fourth is the occupational setting that includes dentists, dental assistants and dental hygienists as a vulnerable group due to their occupational exposure to mercury in dental office settings. Mercury is a heavy metal that is a neurotoxin. It can affect the brain and nervous system leading to neuromuscular effects and function. People can present with headaches and tremors, to more serious effects such as disturbances in mental function or neuromuscular changes. Additional adverse health effects include difficulties with coordination, changes in vision or hearing, memory disorders (including possible links to Alzheimer's Disease), mood disorders (anxiety, depression), sleep disturbances, and fatigue (Haley & Mutter, 2013), as well as cardiac disease and hypertension in older adults (HCWH, 2018). Human exposure to mercury occurs most commonly through ingestion of seafood contaminated with mercury, dental amalgams, some vaccines that contain thimerosal such as multi-dose flu (CDC, n.d.), and air and water contaminated by mercury chloride. Fish highest in mercury levels are bluefish, grouper, marlin, salmon (farmed Atlantic), Chilean Sea Bass, swordfish, and all types of tuna (NRDC, 2021). (This textbook offers additional information in the chapter on heavy metals located in the Environmental Health Sciences Unit). Studies indicate that pregnant and breastfeeding women are at risk for mercury exposure. However, workers, such as dentists and dental hygienists, can be exposed to mercury in their occupational settings. For those working in the dental field their exposure comes from dental amalgam. Dental amalgam is composed of mercury, copper, silver and tin, often referred to as "silver" fillings. These fillings have been used for more than 180 years (FDA, 2020). Although composite resin fillings are used more frequently today for filling decayed areas of teeth, amalgam fillings are still in

use and are also replaced as the tooth and filling age, such as amalgam restoration, decay under a filling and fractures of teeth among others occur (Warwick, Young, Palmer & Ermel, 2019).

Mercury is released during dental restorations through volatilization of mercury vapor and is absorbed into the body through inhalation. (FDA, 2020, Warwick, Young, Palmer & Ermel, 2019). In the USA there are more than 400, 000 (USBL 2019) dentists and dental hygienists employed in dental offices who come in direct contact with dental amalgam (Tibau & Grube, 2019; Tucek, Busova, Cejchanova, Schlenker & Kapitan, 2020). Dental workers have been found to have increased levels of mercury and more health issues associated with mercury exposure than the general public (Warwick, Young, Palmer & Ermel, 2019). However, the Food and Drug Administration (FDA, 2020) notes that factors such as other dietary or environmental exposures to mercury, limitations in study design and execution and conflicting study findings result in contradictory data; thus, limiting the establishment of safe levels of exposure, and conclusive evidence for health recommendations (FDA, 2020).

Testing for the presence of mercury in the body can be done by testing urine, blood, or hair; however, this is not widely available, is generally not covered by insurance and can be costly. Testing can indicate toxic levels of mercury in the body but that does not lead to the cause of exposure. Additionally, dental fillings are likely to remain in the body for many years beyond the time of testing, resulting in further mercury exposure.

EVIDENCE OF RISK

Although the issue of human health risk from dental amalgam has been controversial, most studies confirm that microleakage of mercury does occur. Thus, mercury from dental amalgam can enter the body at low levels (Yip, Li & Yau, 2003). For example, studies of amalgam use for tooth decay in children followed for 5-7 years reviewed by the National Institutes of Health (NIH) (2006) reported that no detectable loss of memory, coordination, concentration or other symptoms of severe mercury exposure were noted, that children in studies in both the United States and Europe who have amalgam fillings did show elevated levels of mercury in their urine. It should be noted that no level of mercury in the human body is considered normal. Studies of dentists and dental assistants show that they are more likely to have elevated blood levels of mercury than the control group (Jamil et al, 2016; Jonidi Jafari, Esrafil, Moradi & Mahmoudi, 2020).

The FDA recommends that resin-based composites be considered for populations who can be more sensitive to the adverse effects of mercury vapor exposure. (FDA, 2020). Groups that are at higher risk include: pregnant women, breastfeeding mothers, children (particularly those under age 6), women planning to become pregnant, persons with chronic diseases such as kidney dysfunction, neurologic impairment, and those people who have a known allergy to mercury (Napierska, 2018).

Scholars claim that studies of differential treatment based upon race or socioeconomic factors in dentistry is not well established (Sabbah, Tsakos, Chandola, Sheiham & Watt, 2007; Bastos, Celeste, & Paradies, 2018) that disparities in dental care exist. Disparities in treatment options exist with studies that show differential treatment decisions based upon the person's skin color (Chisini et al, 2019, Sabbah, Tsakos, Chandola, Sheiham & Watt). Health disparities persist among those who face financial barriers for dental care than for any other form of health care (Vujcic, Buchmueller & Klein, 2016). More research into racial and ethnic disparities in treatment options related to dental amalgams and risk reduction.

REGULATION OF DENTAL AMALGAM

In the United States, the regulatory agency for health and safety for chemical safety is the Environmental Protection Agency (EPA). They regulate the safety of mercury overall but make brief reference to dental amalgam as a source of mercury exposure (EPA, 2020). However the EPA regulates mercury waste for all sources and is discussed later in this chapter. Because dental amalgam is considered a medical device it is regulated by the Food and Drug Administration (FDA). The FDA offers a recent literature review for Epidemiologic Evidence on the Adverse Health Effects Reported in Relation to Mercury from Dental Amalgams (2019). They note that the 30 studies reviewed fail to provide consistent evidence between detectable adverse clinical outcomes and dental amalgams however they recommend methodological approaches that can differentiate between exposures from diet (generally methyl mercury) and other sources of elemental mercury from occupational and other such as dental amalgams (FDA, 2019). Recommendations from the FDA (2009) indicate the need for more study about the effects of dental amalgam and due to the potential adverse impacts upon vulnerable groups that the Precautionary Principle be followed. The European Union (EU) has taken steps to phase out dental amalgam for human health safety as well as environmental health of all species and the planet (Napierska, 2018). In July 2018 a EU dental amalgam phase-out program for vulnerable populations

was put into effect. This phase-out focuses upon pregnant and breastfeeding women, children, and, (not specifically upon dental professionals) it includes vulnerability into the 2017 Regulation on Mercury (Regulation (EU) 2017/852). This regulation dictates methods for amalgam waste, requires amalgam separators, and prohibits bulk forms of amalgam in dental offices (Napierska, 2018).

AMALGAM WASTE

Common to many medical procedures, waste results in potential exposures to materials used for treatment. Dental clinics have been shown to be a point source for mercury pollution as well as silver, tin, copper, and zinc found in amalgam fillings (Shraim, Alsuhaime, & Al-Thakafy, 2011). Organizations such as Practice Greenhealth and Healthcare Without Harm were developed to address safe disposal of medical waste. The American Dental Association's publication Best Management Practices for Amalgam Waste (ADA, 2007) provides guidance for the use of amalgam separators, amalgam capture devices, and recycling to protect the environment and to reduce exposures. Dental waste management is also addressed in the European Union's 2017 Regulation (Napierska, 2018).

CONCLUSION

Advocates for safer products for use in dental restorations continue to press for research, regulation and practice changes. Advocacy groups such as the International Academy of Oral Medicine and Toxicology continue to advocate for change in policy the use of composite materials to replace amalgams as well as restrictions on the use of fluoride in public water supplies. Other organizations advocate for a precautionary approach until safe levels of exposure can be determined and for phase-out of dental amalgam over time to protect health and the environment. Nursing research can add to this discussion to investigate the influence of dental amalgam on human health.

RESOURCES:

- Food and Drug Administration Adverse reactions to dental amalgam filling <http://www.fda.gov/Safety/MedWatch/HowToReport/default.htm>.
- Health Care Without Harm Moving towards a Phase-Out of Dental Amalgam in Europe: What Dental Practitioners Need to Know.
- International Academy of Oral Medicine and Toxicology <https://iaomt.org/resources/dental-mercury-facts/understanding-risk-assessment-mercury-dental-amalgam/>

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Unit III:

Environmental Health Sciences

INTRODUCTION

Nursing history includes nurses who have identified environmental dimensions that could promote health or be a risk factor in illness and disease development. Florence Nightingale identified the role of hygiene and fresh air in improved patient outcomes. Lillian Wald addressed poor housing, close living situations, and social environments in the health of immigrants. Nurses have continued to use the evidence of environmental exposures to reduce health risks to patients, families, and communities.

In our first edition of this e-textbook in 2016, the Environmental Health Sciences section spanned 25 pages with eight subsections. The first edition included the current knowledge of environmental exposures that influence human health. Now, five years later with the second edition of *Environmental Health in Nursing*, environmental health science and knowledge continues to grow, and nurses have played an important role in generating environmental health science, interpreting the science, and educating the public and other nurses in the application of environmental health science to protect health and reduce exposure risks.

This revised Environmental Health Science section includes 17 new or revised sections written by nurse scientists and environmental health nursing experts. The sections of epidemiology, exposure routes, biomonitoring, toxicology, and epigenetics provide a foundation in understanding the science of environmental health. In this edition, we have added environmental health toxicants of electromagnetic fields, noise, and per- and polyfluoroalkyl substances (PFAS) to the revised content of air quality, water, endocrine disruptors, and lead. The information contained in this section provides the building blocks to identify environmental health vulnerabilities and to develop interventions to reduce the risks. We encourage you to use the materials in this section to expand your own knowledge and include your understanding of environmental health science in your nursing practice.

INTRODUCTION TO EPIDEMIOLOGY AND THE RELATIONSHIP TO ENVIRONMENTAL HEALTH

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Epidemiology is the study of disease distribution and its underlying factors in populations (Celentano & Szklo, 2019), which is an essential discipline for public health and environmental health. Today, epidemiology is used to establish distribution and prevention of disease, determine causal relationships, compare different intervention outcomes, and evaluate and propose primary and secondary prevention programs and public health policies.

Epidemiology and environmental health are related. The basic principle of epidemiology is to clarify the relationship between environmental agents and human health. Epidemiology can help with validating models that are used in predicting hazards and their potential health outcomes. Human acute or chronic health problems arise from the interaction between humans as the host and an agent (e.g., virus) and/or the environment (e.g., lead in contaminated water). However, not everyone is vulnerable to a particular disease, vulnerability is determined by many factors such as genetic background, immunological characteristics, and nutritional status (Gordis, 2013). Some of the most studied environmental exposures are toxic air pollutants such as particulate matter (PM), pesticides such as organophosphates, personal care products such as phthalates and triclosan, plastics such as Bisphenol A (BPA), flame retardants such as Polybrominated Diphenyl Ethers (PBDEs), and water pollutants such as lead and Per- and polyfluoroalkyl substances (PFAS).

Nurses' knowledge for diagnosis, prognosis, and treatment of diseases and even patient education are based on epidemiologic data and heavily rely on population concepts. For instance, encouraging patients to quit smoking or to vaccinate their children are based on previous epidemiologic and population based studies. Furthermore, in everyday practice, nurses use the basic epidemiologic approach, to determine possible etiologies of poor clinical outcomes and to evaluate the existing preventive policies and protocols. For instance, a public health nurse uses the epidemiologic approach when conducting home visits to gather information about possible environmental risks that may lead to children's low IQ in the specific community. Another example is when nurses use the epidemiologic approach to prevent in-hospital elderly fall incidence and its related injuries by studying characteristics of the unit and patients to determine whether there are any relationships between characteristics of the unit or patients with fall incidence.

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CONTAMINATION PATHWAYS

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A contamination pathway describes a mechanism that occurs when a substance contaminates a person from an environmental source (National Research Council Commission on Engineering Technical, 2000). The Agency for Toxic Substances and Disease Registry (ATSDR) identifies the following five elements of a contamination pathway (ATSDR, 2005):

11. **source of contaminant or release**, such as chemical container drums and landfills;
12. **environmental fate and transport** after being released, in other words how contaminants move or degrade through and across different media;
13. **exposure point or specific locations** where people encounter an existing contaminated medium;
14. **exposure route**, which means how people contact contaminants at the exposure point, such as inhalation, ingestion, or dermal contact;
15. **current or future exposed populations** and their characteristics, if any.

In environmental health, the concept of exposure “can be applied to the primary explanatory variable of interest and to other variables that may be associated with the outcome, such as confounders or effect modifiers...” (Velentgas, Dreyer, Nourjah, Smith, & Torchia, 2013, p. 45). The exposure event is characterized by the following factors: substance physicochemical properties and concentration, route of exposure, time/space scale of substance concentration, duration of exposure, time scale of potential health effects, exposure medium, and of course demographic characteristics of the exposed individual, such as age and gender (National Research Council Commission on Engineering Technical, 2000).

Developing a site conceptual model early in the environmental assessment is very helpful in evaluating a contamination pathway and putting together all of the above elements for a better understanding of what is going on in a community (ATSDR, 2005). In constructing a conceptual model, consider including links to an individual or a population group with a series of time-specific activities and with geographic locations. Figure 1 is an example of a site conceptual model in a community that is exposed to a coal ash landfill and a cheese plant. Also, consider completing an exposure evaluation form (Figure 2), which applies to sites that have one or multiple

Figure 1 An example of a contamination pathway conceptual model



contamination sources. Figure 3 is an example of a site with multiple contamination sources.

Nurses can communicate with public health specialists about environmental exposures in their state to familiarize themselves with the common environmental hazards. Also, nurses should work with patients' primary care providers, and the local epidemiologists and public health researchers to optimize patient care and community engagement. For the unknown and questionable exposures and symptoms, nurses are encouraged to search the literature and contact well-known researchers in the field. Also, the Alliance of Nurses for Healthy Environments is a great resource for connecting with nurse specialists in environmental health.

CONTAMINATION SOURCE(S)

A contamination source indicates the location of the contamination; in other words, a contamination pathway starts with a source of contamination. Contamination sources can be from a variety of sites, including drums (or containers), incinerators, landfills (e.g., coal ash landfill), buried waste, impoundments, spills, open burning areas, industry, power plants, lagoons, sewage spray fields, and transportation. It is also necessary to study the location of contamination sources, operating periods, remedial actions (e.g., landfill liners, scrubbers, wastewater treatment system, plans), characteristics, history, and types and amount of substances that are released to the media. Sometimes the details about contamination are not clear and conclusive, which makes it difficult for assessors to

Figure 2. Contamination pathway evaluation form (a modified version from ATSDR, 2005)

Contamination Source 1				
Source	Environmental medium	Exposure point	Exposure route	Potentially exposed population
Drums	air	Ambient air	inhalation	Family members in source proximity
Incinerator	soil	Residential yard	Digestion	Nearby residents
Landfill	drinking water	Surface water	Dermal	City residents
Industry	ground water	On site		State residents
Power plant	Biota	Well water		School children
Lagoon	Physical hazards	Public drinking water		workers
Sewage spray field	Radiological parameters	Indoor air		Minority and low socioeconomic
Transportation		Public water supply		Live stock
Impoundments		Surface and subsurface soil		Birds and fish
Other (Add)		Sediment		
Contamination Source 2				
Source	Environmental medium	Exposure point	Exposure route	Potentially exposed population
Drums	air	Ambient air	inhalation	Family members in source proximity
Incinerator	soil	Residential yard	Digestion	Nearby residents
Landfill	drinking water	Surface water	Dermal	City residents
Industry	ground water	On site		State residents
Power plant	Biota	Well water		School children
Lagoon	Physical hazards	Public drinking water		workers
Sewage spray field	Radiological parameters	Indoor air		Minority and low socioeconomic
Transportation		Public water supply		Live stock
Impoundments		Surface and subsurface soil		Birds and fish
Other (Add)		Sediment		
Contamination Source 3				
Source	Environmental medium	Exposure point	Exposure route	Potentially exposed population
Drums	air	Ambient air	inhalation	Family members in source proximity
Incinerator	soil	Residential yard	Digestion	Nearby residents
Landfill	drinking water	Surface water	Dermal	City residents
Industry	ground water	On site		State residents
Power plant	Biota	Well water		School children
Lagoon	Physical hazards	Public drinking water		workers
Sewage spray field	Radiological parameters	Indoor air		Minority and low socioeconomic
Transportation		Public water supply		Live stock
Impoundments		Surface and subsurface soil		Birds and fish
Other (Add)		Sediment		

Figure 3. Contamination pathway evaluation form: Example of a community with a coal ash landfill, spray field, and cheese plant

Contamination Source 1				
Source	Environmental medium	Exposure point	Exposure route	Potentially exposed population
Drums	air	Ambient air	inhalation	Family members in source proximity
Incinerator	soil	Residential yard	Digestion	Nearby residents
Landfill, Coal Ash Industry	drinking water ground water	Surface water On site	Dermal	City residents State residents
Power plant	Biota	Well water		School children
Lagoon	Physical hazards	Public drinking water		workers
Sewage spray field	Radiological parameters	Indoor air		Minority and low socioeconomic
Transportation		Public water supply		Live stock
		Surface and subsurface soil		Birds and fish
Other (Add)		Sediment		
Contamination Source 2				
Source	Environmental medium	Exposure point	Exposure route	Potentially exposed population
Drums	air	Ambient air	inhalation	Family members in source proximity
Incinerator	soil	Residential yard	Digestion	Nearby residents
Landfill	drinking water	Surface water	Dermal	City residents
Industry	ground water	On site		State residents
Power plant	Biota	Well water		School children
Lagoon	Physical hazards	Public drinking water		workers
Sewage spray field	Radiological parameters	Indoor air		Minority and low socioeconomic
Transportation		Public water supply		Live stock
		Surface and subsurface soil		Birds and fish
Other (Add)		Sediment		
Contamination Source 3				
Source	Environmental medium	Exposure point	Exposure route	Potentially exposed population
Drums	air	Ambient air	inhalation	Family members in source proximity
Incinerator	soil	Residential yard	Digestion	Nearby residents
Landfill	drinking water	Surface water	Dermal	City residents
Industry	ground water	On site		State residents
Power plant	Biota	Well water		School children
Lagoon	Physical hazards	Public drinking water		workers
Sewage spray field	Radiological parameters	Indoor air		Minority and low socioeconomic
Transportation		Public water supply		Live stock
Impoundments		Surface and subsurface soil		Birds and fish
CHEESE PLANT(Add)		Sediment		

take appropriate action (ATSDR, 2005). Identifying contamination sources helps assessors to identify possible hazardous substances, types of media that might be contaminated by these substances, and how they may reach a population. For example, if the source of contamination is a coal ash landfill, reviewing levels of contamination in soil, soil gas, groundwater, and air are necessary to determine if people are being exposed.

For nurses to identify possible contamination sources, it is necessary to collect some background information about the proposed site, e.g. regulatory actions, site operation and history, physical hazards, and demographics. This information can be found using NEPAAssits (<https://nepassisttool.epa.gov/nepassist/entry.html>) and EJScreen (<https://ejscreen.epa.gov/mapper/>) tools and by contacting the state's environmental department (Amiri & Zhao, 2019; Environmental Protection Agency, 2018; EPA, 2018). Reviewing the location of the site and its proximity to residential areas, schools, and places of worship is also necessary. This information can be obtained using Google maps or NEPAAssits and EJScreen tools.

TRANSPORT AND FATE OF CONTAMINANTS

Transport and fate of contaminants indicate how contaminants travel or are transformed in the environment. Contaminants can accumulate in a local area or be transported by cross-media to a different location or another medium. Besides, contaminants can be biologically transformed to a new agent or chemically broken down and deteriorated. Therefore, for a meaningful description of a contaminant, nurses should look at the environment as a series of interacting compartments. Estimating transport and fate of contaminants helps nurses to understand better the contaminants of interest, exposure points, and a population that is exposed to contaminants.

Reviewing possible transport processes and physical, chemical, and biological factors that can affect travel and transformation of contaminants in media is important. Assessors may refer to local topographic characteristics to understand the relative steepness of slopes and elevation of site and rate of soil erosion. Studying soil type also will help identify groundwater recharge, contaminant release, and transport rate. Other factors include the rate of rainwater infiltration, evaporation, and soil erosion that influences the direction of contaminant transport. In addition, climatic and meteorological factors, such as temperature and precipitation, can affect contamination transport and fate; for instance, warmer temperature increases the volatilization of contaminants, and more rain escalates the chance of flooding and groundwater

recharge rate. Furthermore, wind speed and direction influence contaminant transportation (ATSDR, 2005).

POINTS OF EXPOSURE

The point of exposure refers to the points or places in which someone can encounter environmental contaminants. Points of exposures should be identified for each medium. The most common points of exposures are ambient air, a residential yard, surface water, on-site, private well, drinking water, food, indoor air, public water supply, surface and subsurface soil, and sediment (ATSDR, 2005; The Texas Risk Reduction Program (TRRP), 2009). Information about the points of exposure can be obtained by reviewing site information and conducting a public health assessment. Patterns of land use may change over time; therefore, assessment of current, past, and future exposure points are important during the point exposure evaluation. Moreover, it is necessary to collect and compare available environmental contamination records, exposure pathway information, substance-specific information, and health-related data in different periods. To make a proper assessment, the nurse must also do a site visit and interview residents and other stakeholders about their health and environmental concerns.

ENVIRONMENTAL MEDIUM

The media that can be affected by contamination sources are air, soil gas, food chain, groundwater, surface water, surface and subsurface soil, sediment, sludge, leachate, and waste materials. When investigating groundwater, as a medium for possible contamination, assessors should consider investigating the location and possibility of any groundwater or well water contamination, location and depth of potentially contaminated wells, and location of liners or slurry walls for landfills (ATSDR, 2005). In the case of potential drinking water contamination, reviewing the source of drinking water (e.g., utility) and existing reports are helpful. It is necessary to study boundaries and controls such as physical barriers and institutional controls, which are in place by the government, regulatory committee, or industry to prevent contamination of the media; however, be aware that sometimes the boundaries are not effective and can contaminate the media.

The next step is to confirm the possible contaminations by determining the concentration of the contaminants in the media and comparing them with the baseline data and data from other non-contaminated sites, if available. Information on air permits and reports of the amount of substances that are released to the environment are helpful and can be obtained from the NEPAAssist (Amiri & Zhao, 2019; Environmental Protection Agency, 2018). If the adequacy and quality of available data are not acceptable,

then samples of media should be taken and sent to a laboratory for analysis. In some instances, e.g., when it is expected for contaminants to migrate, serial media sampling over time in different locations or depths is required. The goal of exposure assessment is to combine data on the current and past exposures to any contaminants with activities and lifestyle of the individuals. Therefore, environmental contamination data on different media and different times is necessary to identify potential exposure points. Keep in mind that in the case of multiple contaminants, assessment of all contaminants at any given time is impossible; therefore, assessments should be prioritized (ATSDR, 2005).

When media sampling from the source and exposure point is necessary, assessors should consider taking samples from upstream and downstream of the proposed site, and impoundments and drainage ditches in case of surface water and sediment sampling. When soil is the potential contaminated medium, sampling from surface soil (0-12 inches) and subsurface soil (below the surface soil, depending on the depth of surface soil) is required (ATSDR, 2005). The concentration of potential contaminants in the air should be studied on-site (e.g., stack emission, soil gas, buried liners) and off-site (e.g., indoor and outdoor air in residential areas or schools). In addition, home visits might be necessary for learning about potential indoor contaminants (e.g., lead paint, lead in dust, and drinking water). Furthermore, the potential contaminated foods and livestock can be tested for the existence of substances. Finally, physical hazards and radiologic parameters can be identified by inspection of the site for any missing fences, gates, and warning signs close to the sources of hazard, e.g., electric boxes, industrial equipment, polluted impoundment or drainage ditches. Radiologic parameters can be measured using appropriate testing kits (e.g., radon) (ATSDR, 2005). Different techniques are used for the collection of samples from different media, for example, groundwater (EPA: Region 4, 2017); however, discussing techniques is not in the scope of this chapter. Assessors can consult with their region's EPA office or the state's environmental department to learn about the specific techniques.

EXPOSURE ROUTES

The exposure route refers to the way a substance enters the body via environmental media. Environmental pollutants may contaminate humans through multiple routes. The common exposure routes are inhalation of polluted indoor air and outdoor air (e.g., particulate matter, volatile organic compounds, and radon gas), ingestion (e.g., water, food, soil contents, medication), dermal contact (e.g., water, soil, food, other media such as

personal products or contaminated waste), and internal/external exposure to radiation. The external radiation exposure can come from various resources such as sun, x-ray, radiation generators, buildings, or the ground. The internal radiation may happen when the radiation is emitted within the body due to inhalation or ingestion of radioactive materials (e.g., radon, radiopharmaceuticals), radioactive iodine (e.g., in the Chernobyl nuclear accident) and contaminated foods and drinks (ATSDR, 2005; Ministry of the Environment Government of Japan, 2013). The injection is another exposure route, but it is not the case in an environmental exposure event.

Another classification of exposure routes is direct or indirect exposure. A direct exposure route is when someone is exposed to a substance that directly comes from the source, for instance, inhalation of ambient air with a high level of ultrafine particulate matter in coal power plant proximity. However, the indirect route is when a person is exposed to a contaminant from a secondary source, for example when a chemical agent is transferred from air to soil and then deposited onto vegetation and transferred to food (Bachmann, 2006; National Research Council Commission on Engineering Technical, 2000). In the event of acute exposure to a contaminant, inhalation, and to a lesser extent, dermal is the most common exposure route. However, when assessing chronic exposures to a contaminant, persistent and indirect routes must also be taken into account (Bachmann, 2006; National Research Council Commission on Engineering Technical, 2000).

POTENTIAL EXPOSED POPULATIONS

When assessing human exposure, it is useful to focus on contact media, which includes the air surrounding a community; the water and food ingested; the layer of soil, water, surface water or other substances that contact skin surface (National Research Council Commission on Engineering Technical, 2000). Identifying the characteristics and size of the potentially contaminated population is necessary. The demographic information can be obtained using the EJSCREEN tool (EPA, 2018). The conceptual model (Figure 1) helps determine the potential exposed populations. To develop an exposure model, an individual or a population group is linked with a series of time-specific activities and with the geographic locations and macro and microenvironments associated with those activities (National Research Council Commission on Engineering Technical, 2000). For instance, when characterizing exposed populations, the assessors should find answers to the following questions (ATSDR, 2005):

1. Who is exposed? Residential population, worker populations, vulnerable populations (children, elderly, disabled)
2. What is the estimated number of potentially exposed people?
3. What activities are occurring and where? Local fish consumption, locally grown food consumption, groundwater use, well water use, surface water contamination
4. What is the history of exposure (past, current, and future)?
5. How long has the exposure occurred?
16. What are the exposure points? Is there any site accessibility?
17. What is the climate condition?
18. Is there any institutional control?

CONCLUSION

Evaluating source, environmental medium, exposure point, exposure route, and potentially exposed populations are five main elements of contamination pathway. The exposure process can be short term (over hours or days) or long term (over months or years). Reviewing available information on emission factors, transport and transformation processes, exposure scenarios and pathways, and routes of intake or uptake are important components of a contamination pathway. The critical step is combining the collected information. When the quality or quantity of available data is not acceptable, collecting additional information by sampling the media and interviewing the potentially exposed populations is required.

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INTRODUCTION TO TOXICOLOGY IN ENVIRONMENTAL HEALTH NURSING

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Nurses must have a broad understanding of environmental health that relies on knowledge of social, biological, chemical, and physical sciences. A clear understanding of basic toxicology is the foundation for nurses to understand and communicate environmental risk and exposures. According to the National Institute of Environmental Health Sciences (NIEHS, n.d.) of the National Institutes of Health, "toxicology is a field of science that helps us understand the harmful effects that chemicals, substances, or situations, can have on people, animals, and the environment." This includes the source and route of exposure of the chemicals, substances, or situations.

PHARMACOLOGY AND TOXICOLOGY

Many nurses have not studied toxicology and the idea of addressing chemical or other environmental exposures can be overwhelming. However, nurses have the knowledge and skill of monitoring patients when they take medications. How a medication is taken (the route), the amount of medication (the dose), the length of time that a patient takes a medication (the treatment plan), how the medication is absorbed, distributed, metabolized, and excreted (pharmacokinetics) and the patient's response whether it be therapeutic or with side effects are all skills that support nurses to better understand environmental exposures and human health.

There is different terminology for toxicology when compared pharmacology. A chemical substance that can cause an adverse health problem that occurs naturally is called a toxin and one that is made synthetically is called a toxicant (American Academy of Pediatrics, 2019; Miller, 2016). For example, methane (natural gas) is a toxin and human made per- and polyfluoroalkyl substances (PFAS) are toxicants. Unlike the expectation of improving health with medications, in toxicology there is an assumption that substances have the potential to be harmful to humans (Miller, 2016). Therefore, it is important to understand that the investigation of toxicant exposure has a unique difference between toxicology and pharmacology. This makes the study of toxicology and the determination of toxic exposures more challenging than the study of pharmacology.

In the field of pharmacology, drugs have been tested in human populations and are given in prescribed dosages –

We know how much medication and the route that the medication is being administered. When giving medications, for the most part, conditions are controlled; vital signs and therapeutic levels are monitored. Whereas, in the case of a toxicant often we have no control of the route of exposure and we may not have knowledge of the exact amount of exposure (how much was ingested or breathed in). Also, for ethical reasons, toxic chemicals or other toxicants have not been tested on human beings. Therefore, when we examine toxicological data, we frequently rely on animal studies and accidental human exposures where we are approximating the amount of exposure to make an informed decision regarding human health (Richards & Bourgeois, 2013). Consequently, many times we make the best decision we can with the available scientific evidence while recognizing that there may be limitations in the data. For example, in animal studies we are asked to make inferences to humans when the study was conducted on a different species and we may not know threshold level of toxic human exposure. Pharmacology and toxicology share some similar concepts; but toxicology is much more complex and frequently toxicologist must make inferences from the data to determine human toxicity of a particular chemical.

HUMAN RESPONSES TO TOXICANTS

Environmental exposures can occur at every level of human development and can have a single effect or cumulative effects across the lifespan. Health impacts can be mild such as nasal irritation, to more severe such as birth defects, cancer, or death. Exposures to toxicants can influence an entire population, a family, a specific body organ (such as the brain or reproductive organs), the body's cells, or influence genetic response (Richards & Bourgeois, 2013; Miller, 2016). For example, the lead chapter in this section describes the impact of physiological impact of lead within the human body.

Like medications, the toxicant's chemical properties determine how the human body absorbs, distributes, metabolizes, and excretes the chemical. The movement of a toxicant from the environment through the human body is called toxicokinetics (Miller, 2016). It is important to understand this so that one can determine the risk to human health of a specific toxicant. At the end of this chapter there are resources to learn about the toxicological effects of specific toxicants. There are also, specific chapters within this e-textbook regarding toxicants such as lead, PFAS, and radiation.

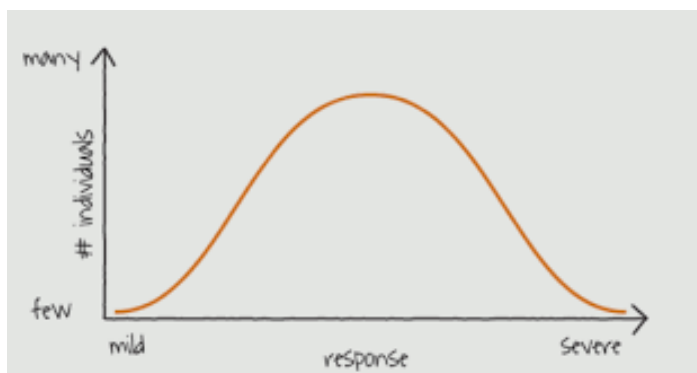
DOSE-RESPONSE

When medications are studied, they are examined to determine the appropriate dose to be administered

without causing untoward and unacceptable effects for the person taking the medication. This is referred to as the dose-response. This is the amount of medication or exposure to an environmental toxicant in which there are effects on the human body (DNA, cells, organs). The threshold response is the point at which there is a response to the lowest dose of exposure. The human response can be immediate, occur over time, be cumulative, or have a latency period as seen with radiation or exposure to asbestos.

The dose-response curve (as seen in Figure 1 below) is used to demonstrate the impact of a toxicant upon the number of people exposed to a toxicant. The impact of a toxicant negatively affects the person is known as toxicity to that substance. This is the standard curve, but depending on the toxicant, the amount or concentration of exposure, the length of exposure, and the route of exposure the curve can look very different. For example, depending on the concentration of carbon monoxide (CO) in an indoor space the response can be from very mild symptoms of head headache for a low concentration, to coma or death from high concentrations of CO with a brief exposure.

Figure 1 Dose-response curve.



(National Institutes of Health, ToxTutor), reproduced as part of the public domain.

According to Richards and Bourgeois (2014) understanding the dose-response relationship can be used to:

- Establish the threshold of the exposure.
- Quantitatively determine the relationship between exposure to a toxicant and the response.
- Provide basic evidence of a causal relationship.
- Compare relative toxicity to other toxicants tested under similar exposure conditions.

TOXICANT CLASSIFICATION

Like medications, toxicants or toxins are classified. There are three general classifications of toxins/toxicants: biological, chemical, and physical. Biological toxins are disease causing pathogens such as viruses, microorganisms, and parasites. This category also includes animals such as toxic shellfish, venomous snakes, and spiders. Toxic plants are also in the biological category (Richards & Bourgeois, 2013).

The chemical category includes solid, liquid, or gas toxicants. These poisons can be found in household items such as personal care products or cleaning agents. Other common examples of chemical toxicants are pesticides, painting products, gasoline, and carbon monoxide (Richards & Bourgeois, 2013).

Physical toxicants are found in the built environment, in nature, and from industry. Physical toxicants are toxicants such as radiation, lead, or asbestos. Radon, a colorless, odorless gas from the breakdown of uranium is a residential risk in some regions of the United States and globally. Radiation risks are also found in our electronics (see chapter Wireless Smog). Health care facilities where radiation is used for therapeutic and diagnostic procedures are another area where there is risk of radiation exposure and toxicity. Lead and asbestos can be found in homes, schools, and workplaces.

NURSE'S ROLE IN TOXICOLOGY

Much like monitoring a patient who is taking a medication, the nurse's environmental health role related to toxicology includes risk prevention and managing a toxic exposure. Regardless of practice setting, nurses are educated and prepared to address health promotion and disease prevention. An important part of promoting health is educating individuals, families, and populations related to potential environmental exposures in their homes, schools, places of employment and worship, and communities. Nurses must be aware of the toxicological risks within their practice setting and monitor for risk, educate those in the setting to reduce risk, and advocate for safe policies and practice. This may also include collaborating with facilities management and purchasing within an organization to ensure proper ventilation and that products are stored safely and marked appropriately. Safety Data Sheets must be available for all chemicals that are used within an organization. If standards are not being met, the nurse's role of advocacy for clients, fellow-employees, and self is important to reduce toxic exposures and health risks. Additionally, nurses must advocate for the least toxic materials and safe chemical

policies. The policy section of this text has examples of nurses' advocacy for policies that protect our health.

If the nurse is caring for an individual, toxic risk reduction and management would follow the nursing process as described below:

- Observe the environment and determine risks and the routes of exposures. When possible, attempt to reduce risk.
- Assess the patient's physical status, health history including exposure history and risk.
- Plan methods to safely remove the patient from the toxicant (some exposures can present risk for the health provider and personal protective equipment may be required). Identify referrals and resources. Educate for prevention of future risk and management of exposure.
- Intervention: If a patient is demonstrating symptoms, refer to primary provider, contact poison control, or if symptoms are severe call 911 for transport to emergency services.
- Evaluate: continue to monitor patient status, effects of interventions, collaboration of health care team, and methods to reduce risk in the future.

Nurses have excellent observation and assessment skills, as well as the scientific knowledge to support patients, families, and communities in addressing environmental exposures. Collaborating with experts in toxicology to address exposures can assure the health of those in the care of the nurse. Please find more detailed information about specific toxicants throughout this e-textbook and from the electronic resources listed below.

ELECTRONIC TOXICOLOGY RESOURCES

- Chemical IDPlus has links to scientific information about specific toxicants. <https://chem.nlm.nih.gov/chemidplus/chemidlite.jsp>
- Consumer Product Safety this website contains information about automobile, lawn, cleaning, and other products that are used in homes and workplace. <https://www.whatsinproducts.com/>
- Haz-map provides information regarding hazardous chemicals and occupational diseases: <https://haz-map.com/>
- Pediatric Environmental Health Specialty Units. Provides education and consultation related to reproductive and children's exposures. Regional

environmental health experts can answer your questions: <https://www.pehsu.net/>

- ToxTutor from the National Library of Medicine. Basic toxicology information for further understanding of the topic: <https://toxxtutor.nlm.nih.gov/01-002.html>

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BIOMONITORING IN ENVIRONMENTAL HEALTH: IMPLICATIONS FOR NURSES

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Biomonitoring is the assessment of individual or population exposure to environmental contaminants, by measuring the concentration of chemicals or their metabolites in human specimens (Association of Public Health Laboratories [APHL], 2013, pg. 1). It is beneficial to measure the contaminants that have been absorbed into the body because those findings reflect the multiple sources and routes of contamination. Therefore biomonitoring, as compared to self-reported history or environmental measures (i.e. air quality), provides nurses with a more comprehensive assessment of overall, cumulative exposure to specific toxins.

Biomonitoring has many applications in the study and practice of environmental health, including (APHL, 2013; Council of State and Territorial Epidemiologists [CSTE], 2012):

- General surveillance of exposures
- Comparison of exposure levels in various populations
- Targeted investigations of specific exposures (see Success Story: New York)
- Rapid response activities during actual or potential threats
- Planning and evaluation of new policies
- Evaluation of policy change or elimination

Most importantly, results from biomonitoring offer a critical link between the presence of contaminants in the environment and observed adverse health effects in humans. Biomonitoring has the potential to become an integral aspect of environmental health nursing. For this reason, nurses with an interest in environmental health must have a basic understanding of biomonitoring concepts. This chapter provides background information on biomonitoring, including common methods, past and current efforts, and existing challenges related to biomonitoring in the United States. Implications for nurses in the areas of practice, education and research are discussed. Finally, success stories, resources and references for further reading are provided.

WHAT DOES BIOMONITORING HAVE TO DO WITH NURSING?

Practicing nurses often unknowingly participate in biomonitoring activities while delivering routine care. For

example, pediatric nurses that conduct lead screenings on their young patients are directly measuring the level of a contaminant (lead) in a human specimen (blood). However, the topic of biomonitoring is rarely introduced in the undergraduate nursing curriculum, leaving many practicing nurses without the necessary background knowledge of basic definitions (Table 1) and methods.

Table 1: Biomonitoring definitions

Absorption	The process by which a toxin enters the body via the skin, gastrointestinal tract, lungs or eyes
Biomarker	The contaminant or its metabolite that is measured during biomonitoring
Body burden	Overall amount of a contaminant in all parts of the body
Distribution	The process by which a toxin moves within the body to various organs
Lipophilic	Describes a compound that dissolves in fat instead of water
Metabolite	Substance produced by the breakdown of a chemical in the body, can be more or less harmful than the parent chemical
Reference range	Lowest and highest values that will be used for comparison with another value, helpful for identifying levels that may be unexpected
Reference value	Single value used for comparison with another value, helpful for identifying levels that may be unexpected
Sensitivity	How low of a level of a contaminant can the biomonitoring test detect?
Specificity	Can the biomonitoring test detect a particular contaminant or just the class of chemical?

Currently, methods for most biomonitoring activities involve the collection of blood and/or urine specimens. However, some chemicals and metabolites quickly exit the circulatory system to be stored in various parts of the body prior to being excreted, making blood and urine testing inaccurate measures of the body burden of many contaminants. Therefore, researchers continue to explore other types of specimens to be used in biomonitoring, including saliva, expired breath, hair, fingernails, teeth, stool,

Table 2: Types of specimens used in biomonitoring

Specimen	Examples of contaminants detected	Advantages	Disadvantages
Adipose Tissue	Dioxin	Can be used for lipophilic contaminants	Invasive
Blood	POPs, lead, mercury (recent exposure only)	Good for contaminants with very long half-lives; in contact with entire body; familiar to people	Invasive
Bone Marrow	Benzene, Lead	Can represent long-term exposures	Invasive
Breast Milk	Persistent bioaccumulative substances (POPs, PCBs, dioxin, perfluorinated compounds, bromated flame retardants)	Noninvasive; can be used for lipophilic contaminants	Limited population
Expired Air	Benzene, VOCs	Noninvasive; can link directly to exposure from air	Difficulty storing and transporting
Fingernails	Trace elements (cobalt, copper, nickel)	Noninvasive; can represent long-term exposure	Easily contaminated

Hair	Trace elements, mercury, organic pollutants	Noninvasive; can represent long-term exposure	Easily contaminated; volume of specimen needed can be difficult to collect
Saliva	Cotinine, organic solvents, some pesticides	Noninvasive	
Stool	Flame retardants	Noninvasive	Unpleasant for people to collect
Teeth	Lead, trace elements	Noninvasive	Difficult to obtain
Urine	Phthalates, arsenic, lead (only reflects recently absorbed lead); non-persistent pesticides, BPA, VOCs, some metals	Noninvasive; good for contaminants that are excreted quickly	Wide variety of excretion rates among individuals

Source: Centers for Disease Control & Prevention, 2016; World Health Organization, 2015.

Notes: POP= persistent organic pollutants; PCB= polychlorinated biphenyl; VOC= volatile organic compounds; BPA=bisphenol A

and breast milk. Table 2 has a list of potential specimens with advantages and disadvantages of each. Although smaller studies have investigated the feasibility of using other types of specimens, to date, large biomonitoring programs still rely on blood and urine.

PAST AND CURRENT BIOMONITORING EFFORTS

Biomonitoring has been used for over 100 years as a tool for assessing toxic exposures. One of the first examples in the 1890s involved testing the blood and urine of factory workers for elevated levels of lead (Sexton, Needham &

Pirkle, 2004). Figure I outlines the history of formal biomonitoring programs in various US agencies (Committee on Human Biomonitoring for Environmental Toxicants, 2006). Of particular interest, [the Nurses' Health Study](#) (NHS) collected toenail, blood and urine samples from tens of thousands of nurses between 1982 and 2012. These specimens have been used to examine exposure to heavy metals and chemicals. To date, the NHS and the National Health and Nutrition Examination Survey (NHANES) remain the only national surveys that include biomonitoring.

The Centers for Disease Prevention and Control's (CDC) National Center for Environmental Health houses the [National Biomonitoring Program](#) (NBP), which reports on NHANES biomonitoring data via the [National Report on Human Exposure to Environmental Chemicals](#). In the National Report, the CDC publishes reference values for certain contaminants based on the NHANES data. These values can be used by researchers and providers to

Success Story: New York

Routine surveillance revealed that immigrants from the Dominican Republic had much higher levels of mercury in their urine specimens than native-born New Yorkers. Public health officials conducted follow-up interviews and discovered that a popular imported personal care product used in the Dominican population contained very high levels of mercury. An educational campaign for store owners and consumers ensued, followed by an eventual embargo of the dangerous product.

Source: CSTE, 2012

determine if the exposure level of an individual or a population is elevated and possibly requires action. The most recently published tables reflect population-level exposure to over 300 toxins. The NBP also works to disseminate best practices and methodology for

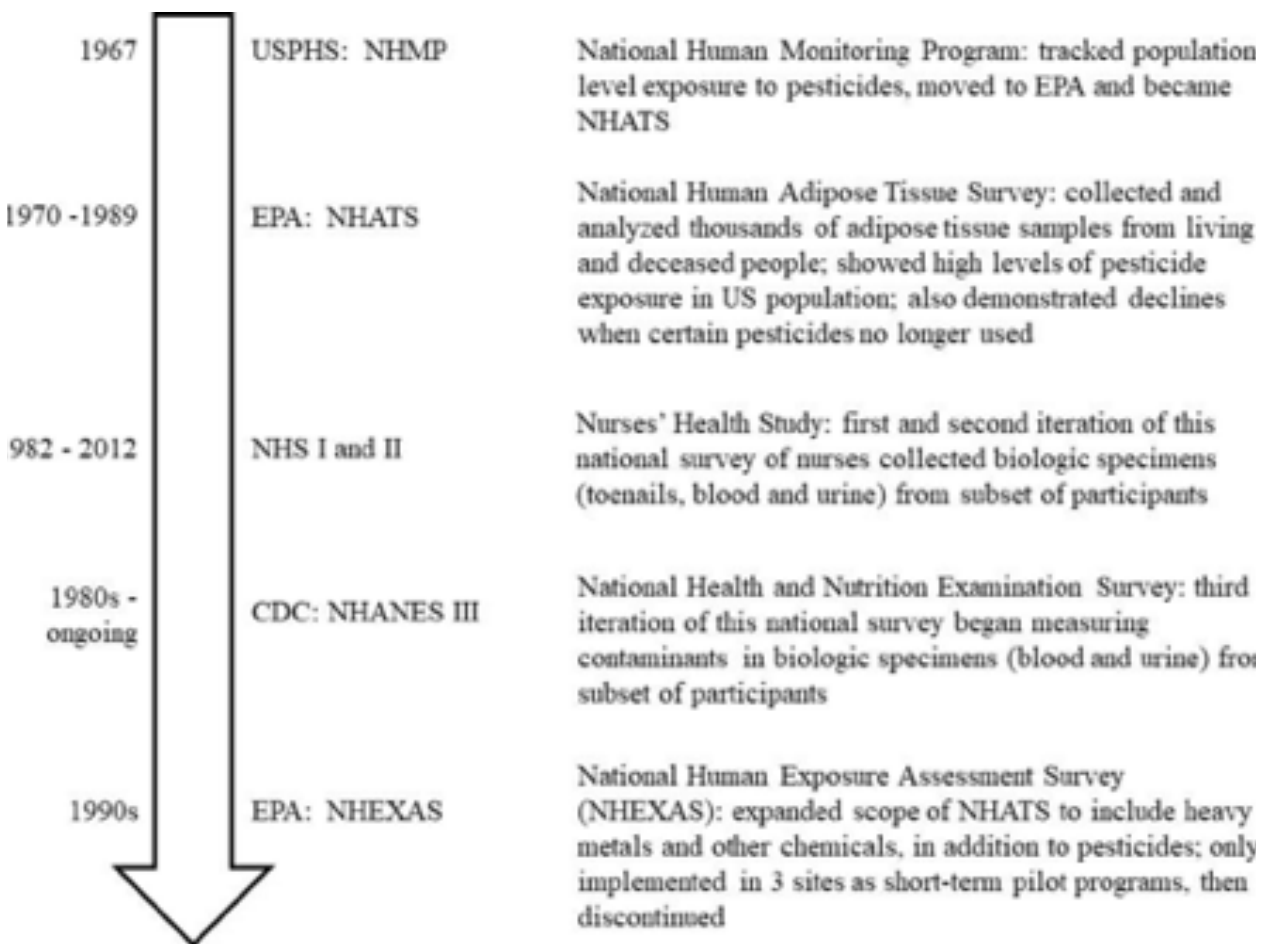


Figure I. Timeline of formal biomonitoring programs in US agencies. USPHS= United States Public Health Service; EPA= Environmental Protection Agency; CDC= Centers for Disease Prevention and Control.

Table 3: Websites and resources on biomonitoring for the practicing nurse

APHL	www.aphl.org/Pages/default.aspx	Provides information and resources on biomonitoring. Note: some areas of the website are for members only.
CDC	www.cdc.gov/biomonitoring/	National Biomonitoring Program
CDC	www.cdc.gov/exposurereport/	National Report on Human Exposure to Environmental Chemicals
CDC	www.cdc.gov/nchs/nhanes/index.htm	NHANES – reports, information and data
COPHES	www.eu-hbm.info/cophes/human-biomonitoring	Consortium to Perform Human Biomonitoring on a European Scale: take a look at what's happening internationally
EPA	www.epa.gov/ace	America's Children and the Environment
EPA	www.epa.gov/expobox	Toolbox for assessing exposures
EPA	https://ephtracking.cdc.gov/showHome	View data in maps, tables and charts, connect to state data
OSHA	www.osha.gov/	Provides information regarding worker protection and employer responsibilities for biomonitoring
PSR	www.psr.org/resources/hazardous-chemicals-in-health.html	Physicians for Social Responsibility's report on Hazardous Chemicals in Health Care

laboratories, and to fund state-level biomonitoring programs (CDC, 2016).

BIOMONITORING IN NURSING PRACTICE

Practicing nurses already routinely participate in biomonitoring activities in acute care, primary care, and in the community setting, but many may be unaware of the implications that exist. For example, nurses may not know that public health labs often perform the analyses on specimens. Public health labs are government laboratories that function as a network at the local, state and federal level. Public health labs serve many purposes in the testing of environmental and human specimens for contaminants, including newborn screening, food safety and emergency response (APHL, n.d.).



A central public health lab is present in each state and territory, and some states have more than one lab. The necessary tests that are involved in biomonitoring can be

Success Story: 4CSBC

The [Four Corners States Biomonitoring Consortium \(4CSBC\)](#), a collaboration between Arizona, Colorado, New Mexico and Utah, helped to address public concern after an accidental mining waste release. The spill impacted a major waterway that flows through all four states and led to increased levels of metals in the water, including lead, mercury, arsenic, and cadmium. As a result, the Consortium increased biomonitoring efforts in the immediate area and assisted in the development of educational materials to provide to affected communities.

Source: Chaudhuri et al., 2017

too complicated, sophisticated or costly for commercial labs, but public health labs work closely with the federal government and the national network of labs to share knowledge, resources and methodology. Every nurse that

participates in biomonitoring should know the [location](#) of their appropriate public health lab.

Nurses that conduct biomonitoring activities as part of practice have critical factors to consider, particularly around planning for the interpretation and communication of findings. Possible questions to contemplate include (CSTE, 2012):

- Will you be testing for a single contaminant or multiple?
- What are the requirements for obtaining, storing and transporting the specimen (consider cost, stability of specimen, timing factors)?
- Is there a reputable lab that can run the analysis?
- How invasive and time-consuming will it be to obtain the specimen?
- How much of the specimen is needed?
- Do reference values exist for the contaminant?
- How long will the analysis take?
- How will you communicate findings to the public?
- How will you follow-up with those who were tested?

Results from biomonitoring tests are often complex and nurses may be responsible for communicating the results to individuals or groups. Interpretation can be complicated by individual variability and a lack of reference values for certain populations. Additionally, most contaminant reference values do not correspond to the presence of disease or symptoms, they strictly serve to allow comparisons among people. Only a small number of contaminants have clinically relevant reference values (CSTE, 2012). Therefore, when communicating results, the nurse must consider the relevance of the information to the health of the individual or population. However, if evidence does exist that links specific levels of a contaminant with adverse health effects, nurses should include information on ways to decrease exposure to and absorption of the contaminant.

BIOMONITORING IN NURSING EDUCATION

Biomonitoring activities are becoming more prevalent, therefore education on biomonitoring principles and practice must be incorporated into nursing education. Introductory content can be introduced in a variety of classes at the undergraduate level, including pediatrics, obstetrics and acute care courses. As diseases linked to environmental exposures are discussed in those classes, a definition of biomonitoring can be presented accompanied by simple examples of current strategies (i.e. lead testing in pediatrics). More extensive coverage can occur in

formal environmental health education that is part of undergraduate or graduate nursing programs. Biomonitoring concepts can be explored within a toxicology course or module. Nursing students can examine emerging trends in biomonitoring, best practice related to methods, and existing or proposed policies. As students transition into the workplace, a basic understanding of biomonitoring will serve to inform nursing care, advance nursing practice, and could improve patient outcomes.

Practicing nurses can take advantage of online training and education. In the past, Coursera has offered a course developed by the Johns Hopkins University called [Chemicals and Health](#) that purports to examine both toxicology and biomonitoring. Additionally, the Environmental Protection Agency (EPA) has online [tutorials](#) on exposure assessment, one of which covers biomonitoring. Please note that this author has neither taken nor reviewed these online offerings. Additional websites and resources for practicing nurses can be found in Table 3. Armed with fundamental knowledge about biomonitoring, nurses will be equipped to more fully protect the health of individuals and populations.

BIOMONITORING IN NURSING RESEARCH

Nurses that conduct environmental health research should consider building biomonitoring activities into the research study design. The linkage of metadata with data from environmental samples and human specimens can be a powerful tool to investigate research questions. Connecting an exposure or a health issue to a particular source remains a major challenge in biomonitoring and environmental health research. Currently, our ability to detect low levels of contaminants far surpasses our ability to link the contaminant with a specific exposure or with a disease (Committee on Human Biomonitoring for Environmental Toxicants, 2006). This is an area of research that needs further exploration.

Success Story: Leaded Gasoline

Prior to the ban of leaded gasoline, mathematical and statistical modeling suggested that removing lead from gasoline would not significantly lower blood levels in people. However, measurements of the actual lead levels in human specimens obtained after unleaded gasoline was introduced demonstrated a much more dramatic decrease than the models predicted. In this case, biomonitoring was a critical tool that aided in the evaluation and validation of a policy change.

Source: CSTE, 2012

Ethical considerations are amplified when including biomonitoring activities in research. Participants must be fully informed of all procedures involved in the collection of specimens. They will also want reassurance that confidentiality will be maintained at all times, and that their specimens will not be used for purposes other than what has been described. Research nurses will need to make decisions about specimen banking if there will be any substance left over after the analyses are completed. Specimen banking typically involves additional costs and may require specific storage conditions, with no guarantee that specimens will remain useful over time. Finally, participants may want to know the results for their individual specimens. Researchers are ethically bound to maximize benefits and minimize harm to participants, but must also consider the reliability and validity of the test and the usefulness of the information to the participant. Although the incorporation of biomonitoring into research studies presents challenges, potential benefits from the findings are important.

Nurses that want to conduct population-level biomonitoring research without collecting their own specimens can leverage existing [NHS](#) and NHANES data to investigate novel research questions. Data and resources may also be available from other large biomonitoring programs or federally-funded studies that have been completed. For example, the Four Corners States Biomonitoring Consortium (see Success Story: 4CSBC) offers information on [lessons learned](#) related to many aspects of the biomonitoring studies conducted, including participant recruitment and reporting results. Finally, nurses can be encouraged that individual biomonitoring studies do help to inform action and policy on a national level, as evidenced by the removal of lead

from gasoline and paint (see Success Story: Leaded Gasoline), and the removal of bisphenol A from many plastic products (APHL, 2015).

CHALLENGES IN BIOMONITORING

Despite decades of collecting NHANES biomonitoring data, limitations in our ability to effectively and efficiently use the data exist. Because of the survey design, NHANES biomonitoring data can only be used for national level estimates; there is no way to use the data to drill down to state or local level estimations (Latshaw et al., 2017). Therefore, a national environmental health surveillance system that provides granular biomonitoring data to states and localities remains unavailable in the United States. Additionally, linkages between large-scale exposure data and data on health outcomes are lacking. For instance, the EPA's report entitled [America's Children and the Environment](#) collates NHANES biomonitoring

data with environmental and health data, but offers no linkage between indicators. As an example, the report details the percentage of children with asthma and the percentage of children with elevated lead levels, but not the combination of asthma and elevated lead levels.

A small number of states have attempted to address these limitations by using NBP funds to increase biomonitoring capacity. Some have even collaborated with neighboring states to leverage regional-level data. Additionally, the CDC developed the [Environmental Public Health Tracking Network](#) (EPHT) to connect population-level biomonitoring data with data from environmental sources and human exposures. These collaborations and efforts aim to provide extensive biomonitoring data at state and local levels, but fall short of delivering a robust monitoring system capable of covering much of the country (Latshaw et al., 2017).

To tackle this problem, the APHL and the CDC recently launched the [National Biomonitoring Network](#) that integrates existing labs and biomonitoring programs into a cohesive, comprehensive network (Latshaw et al., 2017). Once the framework is built, additional partners and stakeholders can be added, with a goal of providing a formal system that can be used for routine surveillance and emergency response (Latshaw et al., 2017). In the meantime some organizations, including the [CSTE](#) and [APHL](#), are providing resources and guidance for thoughtful, effective policy development at local and state levels.

NEXT STEPS

The direct measurement of contaminants in humans is a critical part of advancing the field of environmental health. However, biomonitoring is currently used primarily as a research tool as opposed to an integral component of public health practice. To date, the topic is not included in formal nursing education, and many nurses lack basic biomonitoring knowledge. Additionally, the US lags far behind other countries in developing a large-scale integrated repository for biomonitoring data. Despite these limitations and challenges, opportunities exist for environmental health nurses to be involved in planning, implementing and evaluating biomonitoring programs. Practicing nurses that already participate in biomonitoring activities are well-suited to contribute to policy development and evaluation, as well. Nurses are encouraged to critically appraise findings from biomonitoring studies and to conduct their own biomonitoring research. By incorporating biomonitoring practice, education and research into environmental health nursing, we can begin to bridge the evidence gap between harmful levels of contaminants that we know exist in our

environments and adverse health effects that we see daily in our patients.

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INTRODUCTION TO RISK ASSESSMENT IN ENVIRONMENTAL HEALTH

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WHAT IS RISK?

The Environmental Protection Agency defines risk as “the chance of harmful effects to human health or to ecological systems resulting from exposure to an environmental stressor” (EPA, 2012a).

The EPA defines a stressor as “any physical, chemical, or biological entity that can induce an adverse response. Stressors may adversely affect specific natural resources or entire ecosystems, including plants and animals, as well as the environment with which they interact” (EPA, 2012a).

It is important to keep in mind that risk can be actual (based on empirical data) or perceived (based on cultural and/or personal beliefs). For a noteworthy view on the difference between the two read Perceived vs. Actual Risk (Schneier, 2006).

Remember, risk is also a matter of perception. For example, every time you work with paper, you are at risk of getting a paper cut. One could say that the risk of a paper cut has minimal perceived risks to human health and therefore people continue to work with this material without warning labels.

Changing perception is a matter of gathering relevant and accurate data and balancing this against beliefs and values.

If the negative outcomes of a paper cut were perceived as significant, one could demand that all reams of paper include a warning label informing the end user of the impending dangers. Sound a little extreme? That’s because we don’t perceive paper cuts as a major threat to human health. On the other hand, warning labels are found on cigarette packages, medication bottles, household cleaning agents, plastic bags and thousands of other products that are perceived and proven to negatively impact health.

WHY IS RISK ASSESSMENT IMPORTANT TO NURSES?

Nurses perform risk assessments on a daily basis. For example, an acute care nurse must assess a patient’s risk of developing pressure ulcers in the hospital. Alternatively, a discharge coordinator will assess a client’s risk of falls based on their home environment. In doing so, nurses seek to reduce and prevent harmful effects to human health, including disease, disability, and premature death. One way of achieving this is to limit human exposure to environmental stressors and promote healthy, sustainable

environments. Nurses need to know how to identify environmental hazards and assess human risk related to these hazards. Thus, risk assessments can be done for individuals, families, communities or larger cohorts.

HOW DOES ONE ASSESS A RISK?

The first step in risk assessment is to define a problem. What is the problem, how big is it, how does it impact humans or the environment and which stakeholders are salient enough to help solve the problem? The methodology used in this section combines two excellent risk assessment frameworks:

1. Health Canada’s Decision-Making Framework for Identifying, Assessing and Managing Health Risks (Health Canada, 2000)
2. EPA’s Human Health Risk Assessment (EPA, 2012b).

Problem solvers beware! New risk managers make the mistake of skipping over risk assessment and jumping straight to a solution. Do not make this mistake. The assessment process is what tells you whether or not you even have a risk.

Step One: Identify and Characterize a Problem

For all things risk related, identifying a problem is the starting point. A problem could be a hunch, an observation, or the product of existing information. Below is a list of questions to ask in order to fully understand the problem.

Who is impacted by the problem?

Whenever possible provide a quantitative value.

- Individual/ group
- General population
- Life stages such as children, teenagers, pregnant/nursing women
- Population subgroups - highly susceptible (for example, due to asthma, genetics, etc.) and/or highly exposed (for example, based on geographic area, gender, racial or ethnic group, or economic status) (EPA, 2012b).

Example: “75% of South Asian men and women aged 45 and up, living in Surrey, have diabetes.”

What type of problem/hazard is in question?

- Chemicals (single or multiple/cumulative risk)
- Radiation
- Physical (dust, heat)

- Microbiological or biological
- Nutritional (for example, diet, fitness, or metabolic state)
- Socio-Economic (for example, access to health care) (EPA, 2012b).

Example: “Children aged 0-10 are experiencing increased heat exhaustion due to the recent record breaking temperatures.”

How is the problem reaching humans?

- Point sources (for example, smoke or water discharge from a factory; contamination from a Superfund site)
- Non-point sources (for example, automobile exhaust; agricultural runoff)
- Natural sources (EPA, 2012b).

Example: “There is an increase in reports of asthma attacks downwind of the power plant.”

How does this problem enter the human body?

- Pathways (recognizing that one or more may be involved)
 - Air
 - Surface Water
 - Groundwater
 - Soil
 - Solid Waste
 - Food
 - Non-food consumer products, pharmaceuticals
- Routes (and related human activities that lead to exposure)
 - Ingestion (both food and water)
 - Contact with skin
 - Inhalation
 - Non-dietary ingestion (for example, "hand-to-mouth" behavior)

Example: “Residents of the Kingston neighborhood are complaining of a change in the taste of their water and an increase in unusual skin rashes.”

Lastly, it is important to define whether the problem is acute or chronic; what the severity of the adverse effects

are; what time frame the problem occurs in; and if the risk is only to humans or to other species as well (EPA, 2012c).

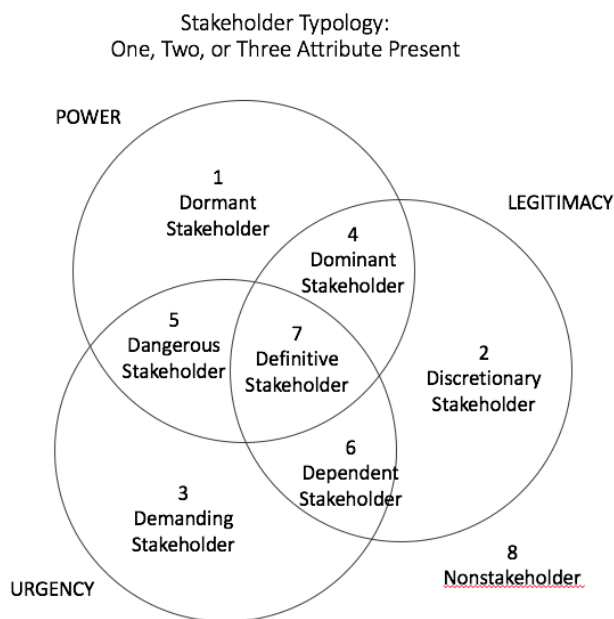
Health Canada (2000) suggests drawing from one or more of the following sources to characterize a risk:

- Toxicology studies (e.g. on laboratory animals, cultured cells, or tissues);
- Epidemiology studies (e.g. of occupationally exposed workers);
- Environmental monitoring (e.g. levels of chemical contaminants in air);
- Biological monitoring (e.g. lead levels in blood);
- Product surveillance (e.g. adverse reactions to specific therapeutic products);
- Disease surveillance (e.g. distribution of cases of a disease over time);
- Investigations of disease outbreaks;
- Targeted risk assessment programs;
- Targeted public health research;
- Information supplied by industry as required by legislation;
- Lack of compliance with legislative requirements;
- Consultation with experts (e.g. advisory committees);
- Literature review;
- Monitoring of the news media;
- Communications from interested and affected parties (e.g. health care professionals, consumers, industry);
- Focus groups
- Examination of public perceptions and concerns.

Step Two: Identify and Characterize the Salient Stakeholders

In this step, identify and characterize the key stakeholders. You will discover that certain stakeholders exhibit power, urgency and/or legitimacy or a combination thereof. Mitchel et al. (1997) categorized stakeholders using these three main attributes as depicted in the Venn diagram below (Figure 1). For more information on how to characterize stakeholders read Mitchel et al. (1997).

Figure I



Step Three: Formulate a Problem Statement

If the nurse has done a good job collecting the data above, then this step will be easy. Take your “hunch” from step one and make it more specific.

For example, the problem, “Sudden Infant Death Syndrome occurs more often in babies than before” can be transformed to a thorough problem statement.

Problem Statement: (data is fictitious) “Sudden Infant Death Syndrome (SIDS) impacts 1 in 10 infants aged 0-5 months old in North America. This number is equitably distributed across socioeconomic status, ethnicity and geographic regions. Sleeping position is a strong precursor of SIDS; infants sleeping prone (face down) have a 30% increased risk of SIDS as compared to infants that sleep face up.”

Resources about Risk Assessment

- [EPA Risk Assessment](#)
- Healthy People 2020. [Environmental Health](#)
- National Research Defense Council. (2012). [Strengthening Toxic Chemical Risk Assessments to Protect Human Health](#)
- World Health Organization. [Children’s Environmental Health: Environmental Risks](#)

CONCLUSION

This section presented the steps of identifying a problem and gathering pertinent information to assess whether or not a problem poses a health risk. In addition to assessing actual risks it is important to identify the perceived risks through your most salient stakeholders. Selected resources about risk assessment are provided. Finally, this is an iterative process which allows one to truly assess, is this problem really putting the target population at risk?

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EPIGENETICS

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The concept of epigenetics has been in existence since the 1940s. First recognized by developmental biologist Conrad Waddington, epigenetics provided a way to describe gene environment interactions (Van Speybroeck, 2002). When defined by its Greek origin, epi translates to on top of, outside of, or around and genetics becomes genesis or origin. Epigenetics itself is a simple term. However, when looking at the overall concept it becomes rather involved. To fully understand the process of epigenetics, some basic genetic concepts and knowledge are needed. This conceptual foundation provides recognition of the complexity associated with epigenetic change. Additionally, this information will assist in appreciation for the role of gene and environment interactions.

“The behavior of a person's genes doesn't just depend on the genes' DNA sequence - it's also affected by so-called epigenetic factors. Changes in these factors can play a critical role in disease” (Simmons, 2008, p.6)

GENETIC UNDERPINNINGS FOR EPIGENETICS

Epigenetics are biochemical alterations that do not affect the sequence of DNA but influence gene expression or the way in which proteins are formed. Although this definition is easily comprehended, it is of the utmost importance to note that these biochemical alterations are not always easily identified nor readily understood. To explain this further, there are some genetic underpinnings that must be reviewed to understand how epigenetics affects health and how it is related to the environment. This includes some basic genetic principles, the genetic code, and the genomic era of healthcare.

Basic Genetic Principles

Deoxyribonucleic acid (DNA) is the blueprint of the cell. “DNA” has become such a common term that it is used to sell televisions, facial cream, and chips. But what does it really mean to say that it is in our DNA? Humans start as a single cell organism when the haploid (23 chromosomes) sperm fertilizes a haploid egg (23 chromosomes) and creates a diploid zygote cell (46 chromosomes) with all of the genetic “blueprint” the human will ever need. Through the process of replications and cell division the single cell becomes a trillion-cell

organism. Cells as they divide through embryonic development contain the same exact DNA sequence. However, cells will become specialized and as a result will perform different functions. This allows the human body to function and is why a cardiac cell can behave differently than a nerve cell.

The Genetic Code

The central dogma of genetics is that DNA provides instructions to make a functional product for the body. This is done by a two-step process. First, DNA synthesizes or transcribes a ribonucleic acid (RNA) copy of its sequence. Second, the RNA leaves the nucleus of the cell and carries this sequence or code of information into the cytoplasm where it is translated into amino acids that produce proteins (National Institute of Health [NIH], 2020a). As such, human bodies function based on enzymatic processes that stem from a DNA sequence converting to an RNA sequence which is then converted to proteins. This is known as gene expression and conveys how the cell gets from a DNA double helix of base sequences containing nucleic acids (adenines (A), thymines (T), cytosines (C), and guanines (G)) and then interprets this “genetic code” to making protein. So, while every cell contains the “genetic code” to behave like every other cell and has the information to make any protein, certain genes are turned on or off by design otherwise known as differentiation. This results in a gene expression that has been modified and therefore, only makes the necessary proteins for their cell specific function.

Genomic Era of Healthcare

The Human Genome Project (1990-2003) sought to identify the genetic code for human species. This task was accomplished through a collaboration of international researchers, permitting the world for the first time ever to see nature’s blueprint (NIH, 2020b). Prior to this endeavor, healthcare focused on gene-disease models. This would be the classic Mendelian Genetics where patterns of inheritance are basic autosomal dominant (AD) and autosomal recessive (AR) disorders. These genetics forms of transmission are well known and understood with use of the traditional Punnett square that determines probability or likelihood of an offspring acquiring a disorder. For people with an AD disorder, only one copy of the variant gene is needed to have the disease process or phenotype. A prime example of an AD inheritance pattern is achondroplasia dwarfism. However, for individuals with AR disorders two copies of a variant gene are required to have the phenotype. For example, cystic fibrosis or sickle cell anemia are common disorders passed through AR inheritance. Both AD and AR

inheritance patterns are clear and predictable. Their associated genes are easily identified because there is a variant in the DNA sequence that differs from people who do not display the phenotype—or atypical congenital/disease process. Simply presence of the gene (genotype), whether one copy or two is required, equals phenotypic expression (disease state).

However, healthcare has evolved, and the genetic knowledge provided through the Human Genome Project has demonstrated that many of the complex disorders common in healthcare today do not follow simple Mendelian genetic inheritance patterns. The role of the environment in combination with genetic vulnerabilities play a role in phenotypic expression of the disorder. A patient may have a genetic vulnerability, but if they were never exposed to environmental triggers that turned that gene on or off, they may never present with the disease phenotype. For example, a patient may have a genetic vulnerability to high cholesterol, but if they were never exposed to a diet that was high in cholesterol, they may never develop the disease process of hyperlipidemia. Or, an environmental exposure may trigger an epigenetic change, creating a disease process that was not originally in the individual's genetic blueprint. Subsequently, it is the environmental exposures that are thought to be the basis of epigenetic change. This is exemplified among identical twins who share the same DNA, yet exhibit different characteristics and have varying disease history making epigenetic changes resultant of dissimilar environments the most likely contributing factor.

EPIGENETICS AND THE ENVIRONMENT

Epigenetics provides a causal link between the environment and chemical changes to DNA that can result in disease. Environmental triggers that can be related to disease processes are numerous and heterogeneous and can occur through a variety of mechanisms such as nutrition, chemical, and physical exposures (Jirtle & Skinner, 2007). Although epigenetic changes can occur throughout the lifespan, the most susceptible period is from prenatal development when rapid cellular growth occurs to two years of age (Braid & Zelac, 2019). In fact, it is during prenatal development that research findings indicate certain threats such as lack of nutrition or exposure to chemicals can lead to the development of disease later in adulthood known as the “fetal basis of adult disease” (Perera & Herbstman, 2011). For example, poor maternal nutrition resulting in low birth weight infants and subsequent rapid postnatal infant growth, can increase risk for adult obesity, hypertension, heart disease, and type 2 diabetes (Alfaradhi & Ozanne, 2011). Additionally, prenatal exposures to arsenic, tobacco

smoke, polycyclic aromatic hydrocarbon air pollutants, phthalates, and bisphenol A have been indicated with a greater risk for cancers, asthma, obesity, type 2 diabetes, low birth weight, and problems with cognitive development or behavioral disorders (Perera & Herbstman, 2011).

There is also evidence to suggest that epigenetic changes may be involved with nonsyndromic birth defects. Many birth defects do not have a single genetic mutation as their cause; rather, it is an unknown interaction of genes, environment, and lifestyle. (Hobbs et al., 2014). For instance, cleft lip and palate are among the most common birth defects in the world. Although genes and inheritance patterns have been identified with its development, many other environmental factors such as smoking, diabetes, and use of anticonvulsants during pregnancy are known to contribute to its occurrence (Center for Disease Control [CDC], 2019).

Moreover, there are many other known postnatal environmental factors resulting in a disease state. Evidence suggests that certain viral exposures may trigger onset of type 1 diabetes (Filippie & von Herrath, 2008). Ionizing radiation has been a known causative agent of leukemia and lymphoma (Leuraud et al., 2015). Furthermore, an association has been identified with night shift work and subsequent development of breast cancer (Szkiela, 2020). These few examples are not exhaustive as there are countless other causal relationships between the environment and disease processes.

EPIGENETICS

Epigenetics is the changes that affect how genes work. Epigenetic changes do not change the DNA sequence or code. These changes are best thought of as a separate cover or the outermost layer from an individual's DNA structure. If this DNA were sequenced, results would indicate that the actual “genetic code” has not been altered. The additional epigenetic alteration on top of the DNA sequence is responsible for changes in actual expression of the “genetic code”. Pathway modification, or a change in the process of transcription and translation, for gene expression may occur as the result of epigenetic enhancers or silencers, that turn on or turn off the ability for DNA to make RNA which in turn alters specific proteins for cell function. Therefore, gene expression is changed even though the gene sequence is unchanged. As previously mentioned, these changes are related to different environmental exposures. And although genes are reset during the process of conception or ovum fertilization, some of the epigenetic changes can still be passed onto offspring. Currently, the three main ways identified for epigenetics to make its mark on DNA are: 1)

histone modification, 2) DNA methylation, and 3) noncoding RNA (Wei et al., 2017).

Histone Modification

Histones are an integral part of DNA structure. The double helix model which to many looks like a spiral staircase is the known structure of DNA. Given the length of the model or staircase, it needs additional packaging to fit within the cell nucleus. Histones are responsible for aiding with this task. Histones are essentially little proteins that allow the DNA to wind up tightly around them forming chromatin and condensing their size to one suited for housing in the nucleus of the cell. As such, they play a significant role in gene regulation by affecting accessibility of the gene for transcription and DNA repair from cell damage. However, histones can be modified through the process of acetylation, phosphorylation, or methylation (Fessele & Wright, 2018). This modification does not affect the sequence of the DNA but creates a chemical tag on the histone that can be detected by other cell proteins to determine if a particular region of the DNA should be recognized or overlooked within that cell (NIH, 2016a). By modifying the histones with acetyl groups (acetylation) or with phosphate groups (phosphorylation) the gene turns transcription on. This is also known as the process of synthesizing RNA to make a protein. Likewise, if you remove methyl groups from histones (demethylation) the gene turns transcription, or the process of synthesizing RNA to make a protein, off (Fessele & Wright, 2018).

DNA Methylation

Perhaps the most well-known mechanism of epigenetic changes is DNA methylation. The DNA methylation mark or alteration occurs when chemical tags, otherwise known as methyl groups, are attached to specific DNA nucleic acid bases. These DNA nucleic acid bases are the steps of the double helix model's spiral staircase. As DNA is transcribed into RNA and RNA translated into a protein the pattern of methylation can alter protein function resulting in different cell behaviors depending on the type of body tissue. Essentially, these methyl groups patterns can interact between other proteins and DNA and affect their communication process. This results in turning genes on or off altering their expression (Fessele & Wright, 2018).

DNA methylation can be a normal process for cells to ensure proper functioning with gene expression. For example, genomic imprinting is a normal biological pattern of DNA methylation based upon maternal and paternal inheritance. Remember offspring receive two copies of every gene. One copy comes from the mother and the

other from the father. For some genes only the copy from the mother is turned on; for others, only the copy of their father is turned on. This pattern of imprinting is determined by methylation (NIH, 2016a).

Unfortunately, abnormal imprinting can occur. Prader-Willi and Angelman syndrome are two notable syndromes related to abnormal imprinting (NIH, 2016a). Prader-Willi syndrome is often noted in infancy due to poor muscle tone, feeding abilities, and growth. Individuals with Prader-Willi are likely to have developmental delays, cognitive disabilities, and behavioral problems. During childhood, they will exhibit excessive hunger resulting in obesity (NIH, 2016b). Angelman syndrome mainly affects the nervous system resulting in a small head size, seizures, developmental impairment, intellectual and speech disabilities, and difficulties with movement or balance. Those affected tend to display excessively happy emotions with frequent laughter, smiling, and hand-flapping motions (NIH, 2015). Although characteristics of these two syndromes are very different, both originate with abnormal imprinting or abnormal methylation on chromosome 15.

In addition to abnormalities with imprinting, humans can accumulate abnormal DNA methylation patterns that can disrupt gene expression associated with other disease processes. These processes include cancer, neurological disorders, autoimmune diseases, neuropsychiatric disorders, and genetic syndromes (Rodenhiser & Mann, 2006). Research indicates that cancer can be a direct cause of methylation turning tumor genes on or off. Neurological disorders may also arise from the aging process and this epigenetic mechanism contributing to development of Alzheimer's disease. In addition, autoimmune diseases such as systemic lupus erythematosus (Patel & Richardson, 2010) and neuropsychiatric disorders such as schizophrenia, mood disorders, and autism have also been associated with DNA methylation. Lastly, some genetic syndromes, such as Rett syndrome which results in a small brain and developmental delays, have been identified as a result of a gene mutation that interacts with the epigenetic pathway through binding of an abnormal protein to methylated DNA (Rodenhiser & Mann, 2006).

Non-coding RNA

RNA plays a significant role in the transcription and translation of DNA to make proteins for cell function. However, modifications can occur to RNA prior to translation and subsequent production of a protein. One key modification is "splicing" where a portion of RNA is not coded for making a protein and therefore, is cut out

of the sequence. The short non-coding RNA (20-25 nucleotide bases) that become spliced out, are called microRNA. MicroRNA can bind to other functioning RNA and DNA sequencing limiting or preventing gene expression. Long non-coding RNA (greater than 25 nucleotide bases) can recruit transcription factors and increase gene expression. They can also condense the chromatin of the chromosomes and decrease access to transcription. This results in decreased gene expression (Fessele & Wright, 2018).

Of the epigenetic mechanisms, non-coding RNA's role in disease processes is the least understood. Nevertheless, research has linked non-coding RNA to several ailments. Among these associated non-coding RNA conditions are prostate cancer, melanoma, colorectal cancer, and leukemia as well as neurodegenerative disorders such as Huntington's disease. Furthermore, there is evidence that Fragile X syndrome which is a known cause of autism may result from non-coding RNA's (Fessele & Wright, 2018).

EPIGENETICS AND CLINICAL APPLICATION

Epigenetic changes occur throughout the human lifespan. For example, research indicates that as individuals age the amount of DNA methylation decreases. Meaning that newborns will have a greater amount of DNA methylation than older adults. Evidence further suggests that epigenetic changes such as DNA methylation can both occur and resolve based on behaviors and environmental changes. Smoking cigarettes, for instance, can impact rates of DNA methylation which resolve with smoking cessation (CDC, 2020). In addition, different nutrients and vitamins, such as tea polyphenols (Hardy & Tollefsbol, 2011) and folic acid (Crider, et al., 2012), have been explored in relation to epigenetic changes associated with cancer prevention. It is important to note that these behavioral and dietary changes are just a few of the many being explored. As for epigenetic testing, clinical screening for illnesses is limited to DNA methylation analysis. This analysis can be performed for diagnosis of some cancers as well as Prader Willi and Angelman Syndromes. While we are gaining knowledge on epigenetics and the intersection with human diseases much of the treatment and testing are still in the research arena.

EPIGENETIC RESEARCH

To better understand the role of epigenetics in the human disease process the National Institute of Health formed the Roadmap Epigenomics Project. The purpose of this project was to provide a resource for epigenomic data which is data on epigenetic changes of all cells. This store of information was then made available to the public for research. Much like the human genome project, this

project used sequencing technologies to map histone modifications, DNA methylation, and small non-coding RNA in stem cells and tissues. The resulting roadmap presents normal tissues and organ systems epigenomes for comparison of epigenomes in human disease processes. By February 2015, over 100 cell and tissue types had been mapped. These data have enabled valuable insights to the genetic information used for the development of different cell types (Roadmap Epigenomics Project, 2010).

CONCLUSION

Epigenetics is a remarkable genetic concept uniting the science between gene-environment interactions. The nature of epigenetic mechanisms covering DNA without altering its structure and sequence, is truly a unique albeit challenging design. With resources such as the Roadmap Epigenomics Project, research progress can be made to grow the current body of epigenetic knowledge. This research will assist in unveiling healthy behaviors and other environmental factors that promote or impede personal wellness. Truly, we are only beginning to understand the full epigenetic impact on disease processes and management.

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AIR QUALITY AND AIR POLLUTION

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INTRODUCTION

Air pollution is the largest environmental risk to human health (World Health Organization, 2016). Globally, outdoor air pollution contributes to an estimated 4.2 million annual deaths and is among the top nine risk factors for lost years of health (Lim et al., 2012; World Health Organization, 2016). High levels of outdoor air pollution have been classified as a human carcinogen, with an estimated 15% of lung cancer deaths attributable to outdoor air pollution (International Agency for Research on Cancer, 2016). Other major health conditions impacted by outdoor air pollution include acute lower respiratory disease, obstructive lung diseases, ischemic heart disease and conductive disorders, and stroke (Lim et al., 2012; World Health Organization, 2016). These are all health conditions commonly seen by nurses in a wide variety of clinical practice settings. The major sources of outdoor air pollution are combustion from energy, industry, transportation, and household energy practices; agricultural practices; waste management, and dust (World Health Organization, 2020a).

Indoor household air pollution is also a major determinant of health, with substantial regional variations in specific exposures and burden of disease. For example, the health effects in regions with high levels of lead from old paint sources in the household dust, compared to global regions where solid fuels are routinely used for cooking, present vastly different exposure types, intensity, duration, and health effects. Household pollution from polluting cooking fuels is estimated to lead to 3.8 million annual deaths, which is a problem that tends to be seen more often in low and middle income countries, compared to in the United States (World Health Organization, 2020a). In the future, the average person's exposure to harmful indoor air pollution may worsen, without intervention, due to the ongoing effects of climate change (Institute of Medicine, 2011). In particular, climate change may lead to more air pollution that penetrates the indoor environment; increased mold, moisture, and flooding conditions; increased risks of thermal (heat and cold) extremes in both the indoor and outdoor environment; more hospitable conditions for rodent or insect disease vectors or infectious agents that intrude into the indoor environment; and increased likelihood the household resident uses mitigation strategies, like

pesticides, that worsen hazardous exposures indoors (Institute of Medicine, 2011).

PEOPLE AT RISK FROM AIR POLLUTION EXPOSURE

Globally, only 1 in 10 people live in an area where the air is clean enough outdoors to meet the World Health Organization's air quality guidelines (World Health Organization, 2020a). In the United States, outdoor air quality has steadily improved for decades. Unfortunately, over 122 million Americans still live in counties that do not meet federal air quality standards (Office of Disease Prevention and Health Promotion, 2014). Black/African American and Latino communities are disproportionately exposed to higher levels of air pollution compared to predominantly Caucasian/White communities (Amiri & Zhao, 2019a, 2019b; Castner, 2020b). The Environmental Protection Agency calls those at high risk for health effects from poor outdoor air quality "sensitive groups." These sensitive groups include individuals with pre-existing heart disease, respiratory disease, diabetes, older adults, children, and people with low income (Environmental Protection Agency, 2017b). Those at highest risk for poor indoor air quality include those from low and middle income countries that cook with solid fuels, homes where cigarette smoking or vaping is allowed indoors, those in poverty or who reside in low income housing in the United States, those who live in homes built before 1978 from before lead paint was banned in the United States, and individuals who live in flood plains or regions with high levels of radon (Castner, Barnett, Moskos, Folz, & Polivka, 2020; Centers for Disease Control and Prevention, 2017; Hahn et al., 2019; World Health Organization, 2020a).

CRITERIA AIR POLLUTANTS

In the United States, the Environmental Protection Agency regulates 187 hazardous air pollutants outdoors. The most common and pervasive harmful outdoor air pollutants are called "criteria" air pollutants (Castner, Gittere, & Seo, 2015; Environmental Protection Agency, 2015). These six criteria air pollutants are particulate matter (PM), ozone (O₃), sulfur oxides, nitrogen oxides, carbon monoxide (CO), and lead (Pb). PM is further defined by size, with mean diameter of less than 10 µg (PM₁₀), less than 2.5 µg (PM_{2.5}), or ultrafine (UFP). The regulatory standards for these pollutants are called the National Ambient Air Quality Standards (NAAQS), based on the Clean Air Act of 1970, which was amended in 1990.

Regulatory science is the technical and scientific foundation for environmental protection policies and standards. There is a difference in the ethical considerations between research studies that test

therapeutic interventions for clinical practice, compared to exposing human participants to harmful pollutants and toxicants in regulatory science. The clinical sciences that inform evidence-based nursing practice are based on a hierarchy of scientific designs from meta-analysis of randomized controlled trials as the highest level to expert consensus. In contrast, regulatory science is generally based on different research evidence evaluations that comprehensively integrate results from a range of epidemiology, exposure and atmospheric science, animal model toxicology, ecological, and controlled human exposure research study designs (Environmental Protection Agency, 2015).

Periodically, the Environmental Protection Agency conducts and extensive literature review and quality appraisal of the research evidence, called an Integrated Science Assessment (ISA) (Environmental Protection Agency, 2015). This culminates in a causality determination. The causality determination for each pollutant-health effect relationship relays the EPA's confidence in the strength, consistency, coherence, and biological plausibility of the research evidence. Table I lists the most recent causality determination by health effect for PM_{2.5}, PM_{2.5-10}, UFP, O₃, SO_x, and NO₂ (Environmental Protection Agency, 2016a, 2017a, 2019, 2020b). CO and Pb have not been evaluated in an ISA since 2010 and 2013, respectively, and are not included in the table (Environmental Protection Agency, 2010, 2013). The evidence from the ISAs causality determination inform policy recommendations, and ultimately the EPA Administrator's decision to set and update the standards on what levels of pollution are considered harmful to public health and the environment. Where is the evidence the strongest? The strongest evidence supports that cardiovascular disease and mortality are caused by both short- and long-term exposure to PM_{2.5}, and respiratory effects are caused by short-term increases in O₃, SO_x, and NO₂. Research evidence also indicates that Pb causes decreased cognitive function and behavioral disorders in children,

reproductive, hematologic, coronary artery disease, and hypertension in adults (Environmental Protection Agency, 2013). While high levels of carbon monoxide are known to cause acute poisoning that can lead to death, the strength of evidence for health effects of outdoor pollution levels of CO is less conclusive. The strongest link between outdoor CO levels and health problems is a 'likely to be causal' relationship between short-term exposure and

Table I: Strength of evidence that the criteria pollutant causes health problem

	PM _{2.5}	PM _{2.5-10}	UFP	Ozone	SO _x	NO ₂
Date of ISA (MM/YY)	12/19	12/19	12/19	04/20	12/17	01/16
Short Term Effects						
Respiratory effects	L	S	S	C	C	C
Cardiovascular effects	C	S	S	S	I	S
Metabolic effects	S	I	I	L		
Total mortality	C	S	S	S	S	S
Nervous system effects	S	I	S	S		
Long Term Effects						
Respiratory effects	L	I	I	L	S	L
Cardiovascular effects	C	S	I	S	I	S
Metabolic effects	S	S	I	S		
Total mortality	C	S	S	S	I	S
Reproductive effects	S	I	I	S	I	S
Nervous system effects	L	S	S	S		
Cancer	L	S	S	I	I	S

C=Causal relationship

L=Likely to be a causal relationship

S=Suggestive of, but not sufficient to infer, a causal relationship

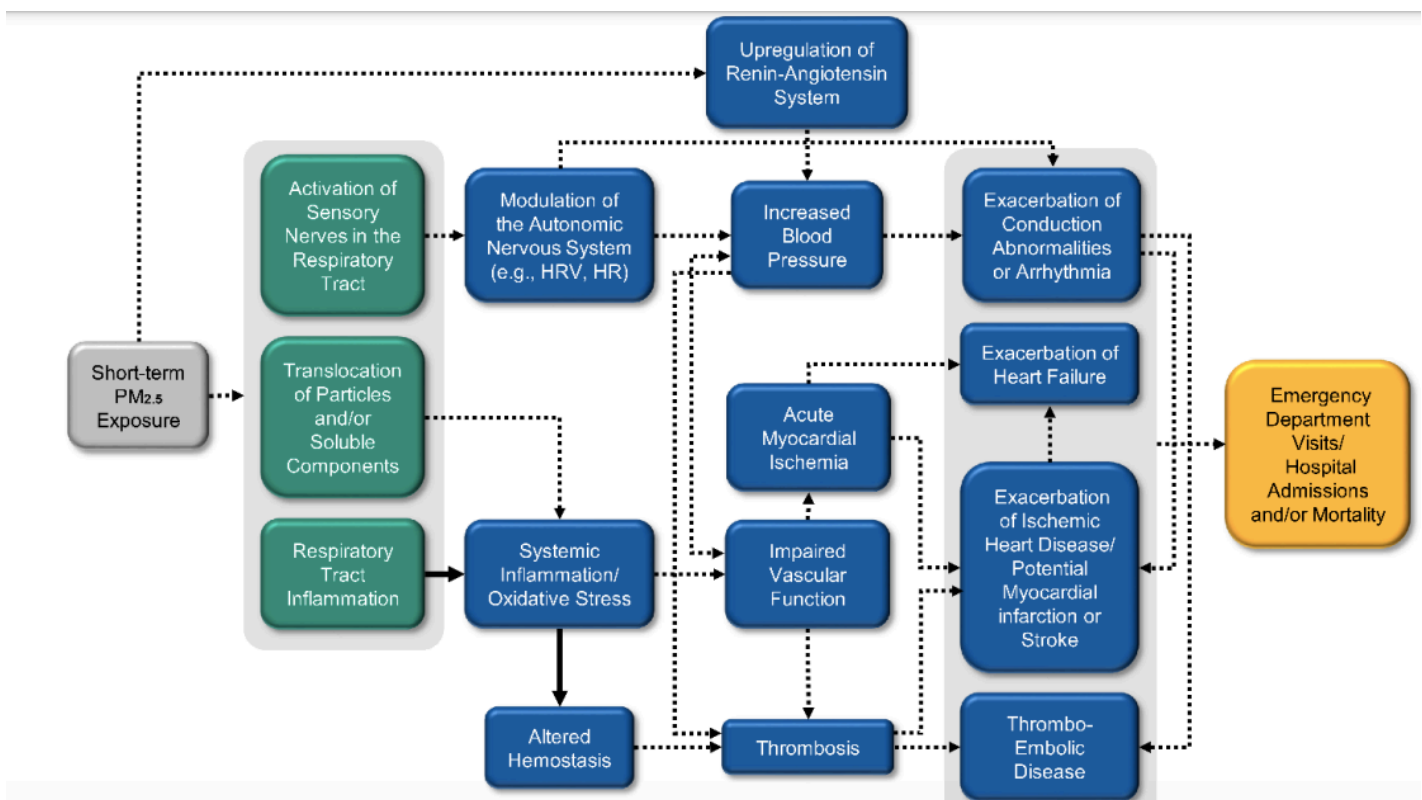
I=Inadequate to infer a causal relationship

cardiovascular disease outcomes (Environmental Protection Agency, 2010).

How does the pollutant cause the health problem? For each relationship in Table 1, the Environmental Protection Agency's ISA summarizes the research evidence on the causal mechanisms, often called the pathophysiology in nursing or the potential biological pathway in regulatory science. The pathways begin with the specific pollutant exposure and initial effect. Generally, the initial effects include inflammation and oxidative stress of barrier tissue in direct contact with the pollutant (mucus membrane and

epithelium of the skin, eyes, nose, throat, and lungs), acid-base changes in barrier tissue fluid, activation of sensory nerves, and direct mechanical irritation (Kousha & Castner, 2016). In some instances, the initial effect is a systemic penetration of soluble or ultrafine particle pollutants from the alveoli of the lungs into the bloodstream, surrounding lung tissue, or lymphatic system. Next, a series of intermediate effects are depicted, such as how the immediate effect is linked to altered homeostasis in the body, temporary increases in blood pressure, blood clot formation, or other evidence of endocrine, immune, and

EXAMPLE PATHOPHYSIOLOGY PATHWAY FOR SHORT-TERM PM_{2.5} EXPOSURE AND CARDIOVASCULAR EFFECTS



Reprint of Figure 6-1 (Environmental Protection Agency, 2019), reproduced as part of the public domain.

Potential biological pathways for cardiovascular effects following short-term exposure to PM_{2.5}.

“HR = heart rate; HRV = heart rate variability; PM_{2.5} = particulate matter with a nominal mean aerodynamic diameter less than or equal to 2.5 μ m.

Note: The boxes above represent the effects for which there is experimental or epidemiologic evidence related to short-term PM_{2.5} exposure, and the arrows indicate a proposed relationship between those effects. Solid arrows denote evidence of essentiality as provided, for example, by an inhibitor of the pathway or a genetic knockout model used in an experimental study involving PM_{2.5} exposure. Shading around multiple boxes is used to denote a grouping of these effects. Arrows may connect individual boxes, groupings of boxes, and individual boxes within groupings of boxes. Progression of effects is generally depicted from left to right and color coded (gray = exposure; green = initial effect; blue = intermediate effect; orange = effect at the population level or a key clinical effect). Here, population-level effects generally reflect results of epidemiologic studies. When there are gaps in the evidence, there are complementary gaps in the figure.”

nervous system responses. The clinical and population effects as endpoints of the pathways are depicted last, generally measured as emergency department visits, hospital admissions, mortality, or long-term disease morbidity diagnosis.

While the Environmental Protection Agency's ISAs provide comprehensive and substantial synthesis of the state of the scientific evidence on criteria air pollutants, they are far from complete to inform the full practice of nursing. For example, pollution from agricultural sources, rural areas, and large-scale fire disasters (often called wildfires regardless of the human or geologic cause) are not adequately represented in the measurement, scientific evaluation, and regulation of air pollutants. In real life, human beings are exposed to a mixture of harmful pollutants, and rarely to a single pollutant alone. Further, symptom and syndromic health effects that may have a substantial impact on an individual patient's quality of life are not conceptually well defined in the review process and final documents. Symptom science and emerging evidence on pollutant exposure impacts on headache, general irritation of the eyes, nose, and throat, chemical or environmental sensitivity, fatigue, depression, abdominal pain, skin and mucus membrane irritation, renal insufficiency, and interaction with allergy and infection require further attention in the regulatory sciences (Castner, Amiri, & Huntington-Moskos, 2020; Castner et al., 2019; Kousha & Castner, 2016; Szyszkowicz, Kousha, & Castner, 2016). Thus, the need for the ongoing leadership, influence, and work of clinical nurses, nurse policymakers and administrators, and nurse scientists in the environmental and regulatory sciences is evident.

INDOOR AIR QUALITY

The qualities of a healthy home, from the physical environment perspective, can be summarized in the following eight ways: 1) dry, 2) clean, 3) safe, 4) well-ventilated, 5) pest free, 6) contaminant free, 7) well-maintained, and 8) energy efficient (Brand, Caine, Rhodes, & Ravenscroft, 2016; Green & Healthy Homes Initiative, 2020). Three major health outcomes in the United States linked to poor indoor air quality include neurological and developmental delays from lead exposure, asthma development and exacerbation from multiple triggers, and lung cancer from radon (Butz et al., 2019; Reddy, Gomez, & Dixon, 2017).

The dust in homes built before 1978 in the United States can contain lead (Pb) from peeling or cracking paint on windows or walls that leach into the dust coating household items (Centers for Disease Control and Prevention, 2020). Children are susceptible to neurological developmental delays from lead poisoning when they

breathe or swallow this dust. Lead exposure can also occur from pipes that carry water to the home, certain homeopathic remedies, or from high risk hobbies or occupations. Nurses often contribute to lead poisoning prevention through home assessment and education, routine screening and case finding, and treatment of acute lead poisoning (Spanier, McLaine, & Gilden, 2019). Nursing educational interventions include sharing information on routine cleaning practices to limit dust contamination, water testing, referral to home maintenance programs for resources for window replacements, and home maintenance education to safely eliminate areas of peeling or cracked paint.

Common home exposures that can cause and exacerbate asthma, and other allergic or chronic respiratory disorders include pets (more specifically, proteins from their dander, saliva, or other fluids), cockroaches, dust mites and other pests, mice or rats, mold, pollen, tobacco smoke exposure, and other chemical irritants (Castner, Barnett, et al., 2020; Institute of Medicine, 2011). The sources for these indoor pollutants can come from cooking (including gas and solid fuel burning), heating, smoking or vaping, any type of combustion (including scented candles), cleaning or pesticide sprays, and off-gassing from new furnishing or construction materials. There are several integrated pest management, home environment modification, and trigger reduction programs and interventions the clinical nurse can learn more about and provide to patients. These programs often focus on (Green & Healthy Homes Initiative, 2020; Reddy et al., 2017):

- Reducing and eliminating cigarette and vape smoke exposure
- Improved ventilation, including use of working bathroom and cooking fan
- Safe cleaning practices, including use of high-efficiency particulate air (HEPA) filter vacuums
- Integrated pest management
- Removing, washing, or covering reservoirs for dust mites and allergens
- Mold and moisture remediation
- Alternating to less polluting heating and cooking sources
- Caretaking practices for pets

Indoor, household radon is a leading risk factor for developing lung cancer (Hahn et al., 2019; Huntington-Moskos, Rayens, Wiggins, & Hahn, 2016). Radon generally enters household air from the soil or rocks that surround

a house's foundations through cracks and gaps. Some regions of the United States have higher levels of radon compared to others, and a map can be found at the Environmental Protection Agency's Radon website (Environmental Protection Agency, 2020c). As inhaled radon decays, it creates a risk for cancer by irradiating surrounding lung tissue (Institute of Medicine, 2011). The human senses cannot detect radon because it is odorless, tasteless, and colorless. The only way to detect radon is through testing. Each state has a radon program to contact for information about obtaining a test kit, and many home improvement stores carry radon testing kit supplies (Environmental Protection Agency, 2020c). In homes where radon levels are high, solutions focus on new or improved ventilation systems.

There are several other important topics and exposures to consider in regards to patients' home indoor air quality, such as asbestos, carbon monoxide, formaldehyde, flood cleanup, volatile organic compounds, semi-volatile organic compounds, and endocrine disrupting chemicals, nurses can find more exposure specific information at the Environmental Protection Agency, World Health Organization, Centers for Disease Control and Prevention, National Institute of Environmental Health Sciences, and Agency for Toxic Substances and Disease Registry websites.

NURSES' ROLE IN REDUCING EXPOSURE TO HARMFUL AIR POLLUTANTS AND HAZARDS

The nurses' role in protecting and promoting health from harmful environmental exposures can occur on the individual, family, organizational, community, regional, state, national, and/or international level (Campbell & Anderko, 2020). Nurses equipped with knowledge about common indoor and outdoor air pollutants are in key positions to apply the nursing process to assess, diagnose, plan, intervene, and evaluate the provided care. In particular, nurses, including advanced practice nurses, are in key positions to educate patients and families on strategies to reduce exposures and risks. Clinical nurses can lead and inform ongoing organizational quality improvement projects or policy by sharing their clinical experiences about the human suffering and health consequences in caring for affected patients, families, and communities (Association, 2007; Castner et al., 2015; Castner & Polivka, 2018; Johnson & Schenk, 2019). At the organizational level, nurses are crucial to implementing assessments, interventions, and programs to improve air quality in schools, clinical practice sites, and other organizational settings (Environmental Protection Agency, 2020a; Johnson & Schenk, 2019). Nurses in formal higher education, leadership or administration, research, and policymaking

roles are tasked with advancing environmental health knowledge, policy, and curricula through the nursing and interdisciplinary lens (Castner, 2020b; Castner, Amiri, et al., 2020; Castner et al., 2019; Dodd-Butera, Beaman, & Brash, 2019; Leffers et al., 2015; McDermott-Levy, Jackman-Murphy, Leffers, & Jordan, 2019).

PATIENT EDUCATION AND SELF-MANAGEMENT

Nursing interventions to reduce the health effects of air pollution include patient education and self-management recommendations that individuals can take to reduce their personal exposures (Castner & Polivka, 2018). While the most effective and impactful interventions take place at the broader public health level aimed at changing public policy and regulation that reduces emissions, these individual interventions are a particularly relevant priority to prevention and chronic disease management among high risk groups (World Health Organization, 2020b). There are several resources for clinical nurses to obtain evidence-based professional development, patient education videos, handouts, and posters about air quality for use in their practice settings. In addition to full reports, the World Health Organization's website on Air Pollution includes links to short videos, fact sheets, and infographics about ambient and household air pollution as a resource for individual clinical nurses to learn more about the topic, as well as to drive quality improvement projects at their clinical site (World Health Organization, 2020a).

Here are several resources to locate evidence-based patient education material ready for use in clinical nursing practice, with internet links that can be accessed from the reference list. The American Thoracic Society's Information Series includes 2-page, ready to use, Patient Education handouts focused on patients with, or at risk for, respiratory disease (American Thoracic Society, 2020). Topics for these patient education handouts include outdoor air pollution (Rice, Balmes, & Malhotra, 2016), indoor air quality problems (Mainardi & Redlich, 2018), mold exposure after water damage (Graham Carlos et al., 2017), work exacerbated asthma (Harber, Redlich, & Henneberger, 2018), military burn pit exposure (Sotolongo et al., 2020), burning indoor fuels (Sood, Kapoor, Doo, & Blount, 2018), among many others. The National Institute of Environmental Health Sciences (NIEHS) also publishes brochures and fact sheets for the layperson audience that the clinical nurse might consider using as patient education handouts (National Institute of Environmental Health Sciences, 2020). These NIEHS brochures tend to be lengthier than the American Thoracic Society's patient education handouts, and include toxin specific content (e.g. arsenic, asbestos, bisphenol A), disease specific topics (e.g. asthma, autism, breast cancer), general topics (e.g.

climate change, air pollutants), and information about ongoing NIEHS supported studies and initiatives. For summaries about specific hazardous pollutants and toxins, the Agency for Toxic Substances and Disease Registry hosts ToxFAQs™ which are written at an appropriate level to be included in patient and public education (Agency for Toxic Substances & Disease Registry, 2014). Last, the Environmental Protection Agency (EPA) provides open access links to posters on the health effects of common air pollutants; fact sheets about air pollution and diseases like stroke, heart disease, and asthma; and health behavior education about how to limit exposure to large scale fire disaster smoke and receiving notifications about air quality alerts (Environmental Protection Agency, 2016b, 2017b). Despite the widespread and open access availability of these patient education tools on air quality and health, little is known from an implementation science perspective about the overall reach, effectiveness, adoption, implementation, or sustainability of these patient education interventions into clinical nursing practice and individual patient care (Castner, 2020a).

Specific areas for the clinical nurse to consider focusing on when providing patient education and self-management coaching include: 1) “Know your Numbers,” 2) avoiding exposure by place and time, 3) air filters, and 4) respirator use. First, the goals of “Know your Numbers” interventions are to improve patient knowledge, skill, and attitudes about air quality alerts or indices with subsequent government-recommended health protective behaviors (World Health Organization, 2020b). Nurses can assist patients on ways to receive and understand air quality index, air quality health index, or air quality alerts through media, emergency management, and personal communication systems. For example, the nurse can assist patients to access, download, and practice using freely available smartphone compatible software applications, such as the Environmental Protection Agency’s AirNow app (available in the Apple App Store or the Google Play Store) in order to receive an email or cell phone alert notifications and follow behavior recommendations when air quality presents a health risk in the patient’s community, while tailoring the education and behavior change recommendation to the patients’ personalized risks and preferences. Research evidence demonstrates the need for additional nursing intervention, as most patients currently do not follow recommended guidance from air quality alerts (D’Antoni, Smith, Auyeung, & Weinman, 2017). There are several additional experimental self-management software apps in various stages of research and development, such as measuring the level of indoor formaldehyde exposure (Castner, Gehrke, Shapiro, & Dannemiller, 2018).

Clinical nurses are in an important position to individualize patient education and self-management coaching to avoid air pollution by specific place and time (World Health Organization, 2020b). It is important to support and encourage outdoor physical activity for overall health and wellbeing. However, it is also important that patients avoid, if possible, major roadways during heavy traffic times or late afternoon on ozone action days. Discussing the specific routes patients may use for outdoor exercise, with considerations for industrial corridors or other pollution sources can aide in reducing the patient’s short- and long-term exposures to pollutants. The overall research evidence on the use of small area or home air filtration on health is mixed, and caution should be followed when recommending any particular filtration device or product to patients. For patients with high risk for allergies, asthma, or other cardio-respiratory diseases, attention to routine home maintenance that includes following manufacturer instructions for the frequency of furnace/air conditioner filter cleaning or change is needed. Additional air purifiers or cleaners, particularly those using High Efficiency Particulate Air (HEPA) filtration systems may be promising to reduce symptoms and exposures, especially in high pollution areas or during high pollution times or disasters. While the priority is to eliminate exposure to second and third hand smoke from cigarette, or other smoking, in the home, air filtration may help mitigate exposures where second or third hand exposures indoor still do occur (Schuurs, Chapron, Guihard, Bouchez, & Darmon, 2019). Last, clinical nurses can provide evidence-based information on face masks and respirators for patients. There is little evidence to support the use of face masks or respirators to reduce exposure to general outdoor air pollution. However, there are specific occupational job exposures, geological disasters (volcanic eruption, desert dust storm), disaster clean up (mold-related water damage in homes), or specific immunocompromised populations (patient with HIV/AIDs at risk for aspergillosis) where face coverings and masks are recommended. In these instances, specialty consults and training for the care of immunocompromised patients, specialty training to provide occupational health nursing or fit testing and occupational wear (Occupational Safety and Health Administration, nd), and Centers for Disease Control and Prevention disaster guidance on respirator use in disasters (Centers for Disease Control and Prevention, 2017, 2018) offer key evidence-based recommendations and material to inform patient education interventions.

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WHERE DOES OUR DRINKING WATER COME FROM?

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Many Americans don't think too much about where drinking water comes from or the infrastructure and processes that enable us to get safe, clean water from our faucets. The United States is fortunate to have one of the most reliable and safest systems for drinking water in the world (United States Environmental Protection Agency [US EPA], 2018). Yet, aging infrastructure, gaps in federal and state law, climate change, land use practices and pollution pose significant threats to drinking water sources.

The majority of Americans get their drinking water from public water utilities that pump and treat groundwater from aquifers and surface water from reservoirs, rivers, lakes and streams, before pumping it to our faucets. There are more than 170,000 public water systems in the United States, both publicly or privately owned, all required to meet federal and state standards for safety (US EPA, 2020h).

Recent crises of public drinking water like in Flint, Michigan, heighten awareness of the critical importance of assuring safe drinking water. As the most trusted profession, it is important for nurses to have an understanding of not only where local water supplies come from but potential sources of risk to drinking water. A very helpful report from ANHE is here: ([United States Environmental Protection Agency, 2018](#))

Protecting drinking water sources, also referred to as source waters, requires a variety of pollution prevention methods including protecting the source itself and assuring the infrastructure and processes to deliver the water are safe. Both are required to protect public health.

PROTECTING WATER SOURCES

- **Protect watershed land:** A watershed encompasses the land that drains rainwater or snow into a water body used for drinking water, agricultural and industrial processes and for plants and wildlife. The land around the water body, including the small streams, helps filter water going into the waterbody. Protecting this land from environmental impacts and pollution protects these vital water sources for millions of Americans.
- **Stormwater runoff:** Stormwater runoff is the rain or snowmelt that flows over land and impervious surfaces, such as paved streets, parking lots, and building rooftops, that does not soak into the ground. The runoff picks up pollutants like trash, chemicals, oils, and dirt/sediment

that can harm our rivers, streams, lakes, and coastal waters. Preventing or minimizing runoff is critical to protecting watersheds. Under federal law, municipal separate storm sewer systems (MS4s), construction activities, and industrial activities may be required to implement stormwater runoff practices (US EPA, 2020c). Despite this, stormwater runoff continues to be a significant source of pollution flowing into waterways (US EPA, 2020e). Protecting land around a drinking water source from stormwater runoff is critical.

- **Agriculture:** Manure and wastewater from farms, particularly large-scale confined animal feeding operations (CAFOs) are often significant sources of nitrogen and phosphorus, organic matter, sediments, pathogens, hormones, and antibiotics to the environment (US EPA, 2020b).
- **Nutrients:** Nutrients, like nitrogen and phosphorus found in fertilizers and in pet and animal waste can be harmful to water bodies. When excessive amounts of nutrients run off into water bodies, they can cause excessive growth of algae and algal blooms which significantly impair water quality. Some algae blooms contain cyanobacteria which can harm the health of humans, pets and other wildlife (Centers for Disease Control and Prevention, n.d.). Excessive nutrients and algae growth can also lead to areas of low or no oxygen, known as dead zones. Severe algal growth blocks light that is needed for aquatic plants. As the plants die and decay, they take up more dissolved oxygen in the water which can kill aquatic life (US NOAA, 2020).
- **Pesticides:** Pesticides are toxic chemicals designed to kill pests. They contain a variety of chemicals, many of which are carcinogenic, neurotoxic and hormone-disruptors. Pesticides are applied to farmlands, gardens and lawns and can make their way into groundwater or surface water systems that feed drinking water supplies. According to the U.S. EPA, the question of whether these contaminants pose a health risk depends on how toxic the pesticides are, how much is in the water, and how much exposure occurs on a daily basis. Numerous other studies show that many of these chemicals are present in umbilical cord blood and have health concerns at low levels (Earth Justice, 2014; Formuzis, 2020).
- **Climate change:** Changing weather patterns and warming temperatures affect drinking water sources in a variety of ways. Frequent, intense storms contribute to erosion and stormwater runoff and potentially more nutrient pollution. Longer periods of warm temperatures and lack of rain impact water supply. Warmer temperatures can lead to algal blooms,

cyanobacteria growth and low levels of dissolved oxygen all of which impair water quality (Union of Concerned Scientists, 2010).

PROTECT AND UPGRADE INFRASTRUCTURE

Aging infrastructure

Much of the water infrastructure in the United States is aging and in need of repair or replacement (Sedlack, 2019). There are approximately one million miles of underground pipes, laid in the early to mid-19th century. These pipes generally have an estimated lifespan of 75-100 years. According to a 2017 report, there are approximately 240,000 leaks from water infrastructure each year, wasting over two trillion gallons of treated drinking water (Infrastructure Report Card, n.d.). Overall, according to the American Society of Civil Engineers Infrastructure 2017 Report card, the U.S. drinking water infrastructure system scored a grade of D and approximately \$105 billion dollars in funding is needed to address the country's aging infrastructure. You can learn more about conditions in your state here: [Water Infrastructure | ASCE's 2017 Infrastructure Report Card](#).

Water utilities are responsible to maintain, monitor, repair and upgrade infrastructure to assure safe drinking water (US EPA, 2020a). They must also comply with the federal Safe Drinking Water Act (SDWA) and regulations to meet drinking water standards. The U.S. Environmental Protection Agency set limits for ninety contaminants in drinking water, under SDWA authority. The Safe Drinking Water Act also enables states to adopt their own drinking water standards that at least meet or are more protective than the EPA (US EPA, 2017).

Lead Service Lines

Congress banned lead pipes in 1986 but the problem of lead service lines is extensive. Lead service lines are the portion of pipe that connects the main water line under the street to the building or home and most are made of lead. Lead can enter drinking water when this portion of the pipe corrodes-usually from acidic water or water with low levels of minerals. Corrosion of lead into drinking water is also impacted by other factors including water temperature and the age and status of the pipes. Sources of lead may also include the solder and fixtures (US EPA, 2020f).

In most communities, the water utility is responsible for the water main and the portion of the lead service line up to the property line. The property owner is responsible for the portion from the property line to the building or home. It is impractical, expensive and unsafe to replace

only a portion of the lead service line as disconnecting the line can cause lead and other contaminants to get into the pipe. The dual responsibility for the lead service line replacement poses many legal challenges as states and municipalities often have different requirements and funding streams for service line replacement. These barriers, along with other challenges, have hindered robust progress in replacing all lead service lines in the U.S. More information on legal aspects of LSL replacement is here: [Legal Factors - LSLR Collaborative \(lslr-collaborative.org\)](#).

Water utilities are required to monitor lead levels in drinking water supplies and submit a Consumer Confidence Report annually by July 1 to all residents. Residents that have small community or private wells should contact their local health department about testing their water.

Nurses know there is no safe level of lead. Lead is a heavy metal that is persistent and bioaccumulative. The federal Safe Drinking Water Act set the maximum contaminant level (MCL) for lead at zero due to serious health impacts including premature birth, lowered IQ, behavioral disorders, hyperactivity, delayed growth and hearing disorders. Fetuses, infants and young children are particularly vulnerable to extremely low levels of lead. Understanding sources of lead in drinking water, local issues and what is being done to address lead exposure is a critical role for nurses.

THE CRISIS IN FLINT: CAN IT HAPPEN AGAIN?

The public health crisis that occurred in Flint Michigan was an enormous tragedy, the result of cost-cutting decisions that exposed approximately 99,000 residents to high levels of lead in their drinking water and caused 12,000 cases of lead poisoning and many others to Legionnaires disease. In 2014, Flint, Michigan officials switched the city's water supply from the Detroit Water and Sewage Department to the Karegnondi Water Authority to save money. In the interim before the connection was built, the city used water from the Flint River. The acidity of the water from the river corroded pipes, leaching lead into the drinking water supplies for Flint residents. Despite complaints from residents about foul smelling, brown water that caused rashes and other health concerns, city officials failed to take rapid action, often denying that there was a problem. In August 2020 after five years of litigation, the state of Michigan and other defendants agreed to pay \$600 million that will go to a victims' compensation fund to support residents. Despite the settlement, more than five years later, not all pipes have been replaced and residents remain fearful that the drinking water is still unsafe (Smith et al., 2019). The magnitude of this tragedy, the slow response and blatant

failures on the part of city and government officials are rooted in systemic racism and caused one of the biggest man-made public health crises in the U.S, highlighting potential gaps in how we assure safe drinking water for all.

WATER PROTECTION LAWS---AND GAPS

Despite strong laws protecting drinking water in the U.S., the tragedy in Flint Michigan pointed to the serious consequences that occur when laws are violated, not enforced or accountability is lacking. The federal Safe Drinking Water Act (SDWA), passed in 1974, protects drinking water sources in the U.S, authorizes the Environmental Protection Agency (EPA) to establish minimum standards to protect tap water and requires all owners or operators of public water systems to comply with these primary (health-related) standards (US EPA, 2020d). The EPA has set health-based standards for ninety contaminants that all public utilities must monitor and comply with. The SDWA also allows states to set their own health protective standards that at a minimum, meet the federal standard or are more health protective.

Although most Americans receive their drinking water from public utilities, there are gaps. EPA estimates that approximately 8,000 schools and child care facilities maintain their own water supply and are regulated under the Safe Drinking Water Act (SDWA).

There are approximately 98,000 public schools and 500,000 child care facilities not regulated under the SDWA. These unregulated schools and child care facilities may or may not be conducting voluntary drinking water quality testing (US EPA, 2019). Prior to the passage of the revised Lead and Copper Rule (December 2020), only twenty-four states and the District of Columbia required testing water in schools (Vock, 2019).

In 2015, the National Resources Defense Council (NRDC) analyzed reports from public water systems regulated under the SDWA. They found “more than 80,000 reported violations of the Safe Drinking Water Act by community water systems. Nearly 77 million people were served by more than 18,000 of these systems with violations in 2015. These violations included exceeding health-based standards, failing to properly test water for contaminants, and failing to report contamination to state authorities or the public. What’s worse, 2015 saw more than 12,000 health-based violations in some 5,000 community water systems serving more than 27 million people” (Fedinick et al., 2017).

The report clearly shows that despite laws, concerns about safe drinking water exist in Flint and across the country.

LEAD AND COPPER RULE

In 1991, the EPA published the Lead and Copper Rule. This regulation requires public water utilities to monitor drinking water at customer taps and implement a treatment technique if levels of lead are above 15ppb or if copper concentrations exceed an action level of 1.3 ppm in more than 10% of customer taps sampled. If either occur, the system must undertake a number of additional actions to control corrosion. If the action level for lead is exceeded, the utility must also inform the public about steps they should take to protect their health and may have to replace lead service lines under their control (US EPA, 2021). The rule was revised in December 2020 and has better protections for children in schools and childcare facilities. The rule includes:

- Using science-based testing protocols to find more sources of lead in drinking water.
- Establishing a trigger level to jumpstart mitigation earlier and in more communities.
- Driving more and complete lead service line replacements.
- For the first time, requiring testing in schools and child care facilities.
- Requiring water systems to identify and make public the locations of lead service lines (US EPA, 2020g).

Unfortunately, while the inventory of lead service lines is helpful, the rule does not require all water utilities to fund and replace this portion of the pipes, leaving residents at risk. The failure will continue to disproportionately affect low-income communities as they cannot bear the burden of paying for partial replacement of these lines. The gap in the revised rule prolongs the potential of lead exposure for all Americans and perpetuates the inequities faced by vulnerable communities. Environmental advocacy organizations will continue to press for fully funded and complete lead service line replacement.

WHAT NURSES CAN DO

As the most trusted profession, nurses can play an important role in educating patients about safe drinking water issues in their community. Nurses can take steps to understand local drinking water sources, any local or state laws regarding testing drinking water in schools, any inventory on lead service lines in the community and drinking water issues raised by local health departments or water utilities. Nurses can also share steps on what individuals can do:

Important Steps Individuals Can Take to Reduce Lead in Drinking Water

- Have your water tested. Contact your water utility to have your water tested and to learn more about the lead levels in your drinking water.
- Learn if you have a lead service line. Contact your water utility or a licensed plumber to determine if the pipe that connects your home to the water main (called a service line) is made from lead.
- Run your water. Before drinking, flush your home's pipes by running the tap, taking a shower, doing laundry, or doing a load of dishes. The amount of time to run the water will depend on whether your home has a lead service line or not, and the length of the lead service line. Residents should contact their water utility for recommendations about flushing times in their community.
- Learn about construction in your neighborhood. Be aware of any construction or maintenance work that could disturb your lead service line. Construction may cause more lead to be released from a lead service line.
- Use cold water. Use only cold water for drinking, cooking and making baby formula. Remember, boiling water does not remove lead from water.
- Clean your aerator. Regularly clean your faucet's screen (also known as an aerator). Sediment, debris, and lead particles can collect in your aerator. If lead particles are caught in the aerator, lead can get into your water.
- Use your filter properly. If you use a filter, make sure you use a filter certified to remove lead. Read the directions to learn how to properly install and use your cartridge and when to replace it. Using the cartridge after it has expired can make it less effective at removing lead. Do not run hot water through the filter. (see more here: [Basic Information about Lead in Drinking Water | Ground Water and Drinking Water | US EPA](#))

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CARCINOGENS AND ENVIRONMENTAL HEALTH

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INTRODUCTION

What are carcinogens?

Carcinogens are commonly known as cancer causing substances. These substances have been shown to cause carcinogenesis or the process whereby normal cells are transformed. Carcinogens are commonly known as cancer causing substances. These substances have been shown to cause carcinogenesis or the process whereby normal cells are transformed into cancer cells. Carcinogens can either be physical, biological or chemical. Physical carcinogens include ultraviolet light and ionizing radiation. A biological example would be the Human Papillomavirus (HPV) which is known to cause cervical cancer in women. Carcinogens can also come from chemicals that we use daily in our personal and professional lives.

Carcinogenesis

In simple terms, carcinogenesis is a complex process that involves gene interaction with a carcinogen through 3 distinct phases of carcinogenesis: initiation, promotion and progression. During initiation there is an irreversible alteration in cellular genes or mutation. In the promotion stage, these abnormal cells self-proliferate and the final stage is progression where the cancer cells transform and grow and can lead to malignant proliferations and further mutations. (Baba & Catoi, 2007). Cancers generally come from genetic, environmental, and lifestyle factors and scientific investigators work to identify how these processes intersect in order to learn more about etiology and more effective treatments. Health professionals and the lay public are well aware of some of the risks from lifestyle such as tobacco use and some workplace exposures such as asbestos and radiation as well as more recent publicity about viral carcinogens such as Human Papilloma Virus (HPV). However, there is mounting concern about the 80,000 chemicals in our environment of which only about 7% have been tested for safety. This chapter looks at those chemicals that are known carcinogens or are considered as potentially hazardous.

WHAT NURSES HAVE LEARNED IN THEIR BASIC EDUCATION

Nurses first learn about carcinogens in their pre-licensure education, particularly in their pathophysiology course. During their medical-surgical courses they are likely to revisit the topic but very briefly as those courses focus upon the care and management of patients with acute and chronic diseases, with limited discussion of prevention. In courses such as community/public health, there is a strong emphasis upon health promotion and disease prevention but extensive content about carcinogens again is limited. Commonly used pathophysiology textbooks are more likely to include information about cancer epidemiology and identify risk factors than other course textbooks. For example, in one popular textbook, there is a chapter on cancer epidemiology with discussion and graphics to guide the learner in understanding epigenetics, DNA methylation, methylation of a gene region and gene transcription, free radical formation and modeling for radiation exposure (Huether & McCance, 2012). Huether & McCance (2012) include a table of environmental and occupational links to cancer citing the category (e.g. aromatic amines, metals, chlorination by-products, environmental tobacco smoke [ETS], natural fibers, pesticides, petrochemicals, radiation, and solvents), carcinogenic agents (e.g. arsenic, lead, benzidine, asbestos, herbicides, polycyclic aromatic hydrocarbons, ionizing radiation, formaldehyde, vinyl chloride and benzene), strong association for cancer (e.g. aromatic amines and bladder cancer; ETS and lung cancer; asbestos and mesothelioma; ionizing radiation and leukemia, brain, thyroid, and sarcoma cancers; benzene and leukemia) as well as suspected link for cancer (2012). If nurses enter the profession with a strong background in carcinogenesis, it should be clear that knowledge of carcinogens must become integral to their nursing practice.

GENE-ENVIRONMENT INTERACTION

In the prior discussion of carcinogenesis, genetic sequences in the cell interface with environmental factors to begin the process of carcinogenesis known as initiation. Epigenetics is that branch of science that examines heritable changes in gene expression or more simply mechanisms that will switch genes. Genes are composed on DNA sequencing but epigenetics is the field that looks at epigenetic processes that influence genetic functioning. In simpler terms, epigenetics looks at gene activity that occurs without changing DNA sequencing. These are generally natural and essential to the function of the organism but can occur improperly resulting in many illnesses and adverse health events. The etiology of cancer is one of the most studied areas of epigenetic research leading to greater knowledge of how epigenetic processes influence cancer. (Weinhold, 2006). (For more information about epigenetics, please see the chapter on epigenetics.)

UPSTREAM APPROACH

Nurses have long understood the importance of an upstream approach to health. Initially introduced into nursing literature in 1990 by Dr. Patricia Butterfield (2018) the roots extend to sociologists Dr. Irving Zola and John McKinley in the late 1970s. The concept is explained by the analogy of a bystander seeing someone being swept downstream in a river and struggling with the current. The bystander quickly jumps into the river and pulls the person to shore only to see a second, then third being swept downstream. He was asked later what was pushing the victims into the river and his response was that he was so busy rescuing victims that he had not had time to look or focus upstream (Butterfield, 2017). This approach has become part of nursing discourse particularly when examining social determinants of health, contextual factors in disease etiology, system level influences on health and illness and environmental health (Butterfield, 2018). For our understanding of carcinogens this approach is very important. Many of the chemicals commonly used in our daily lives are known or suspected carcinogens. Using an upstream approach to safer choices for chemical use in health care settings as well as personal choices can promote health and can likely reduce the prevalence of cancer.

PRECAUTIONARY PRINCIPLE

Related to an upstream approach is the concept of precaution. In 1998, a group of scientists, environmental activists, lawyers and philosophers convened at the Johnson Foundation Wingspread Conference Center in Wisconsin where they developed the Wingspread Statement. The significant result of that statement is the Precautionary Principle that is stated as, “When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof. The process of applying the precautionary principle must be open, informed, and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action.” – Wingspread Statement on the Precautionary Principle, Jan. 1998

NURSING AND THE ENVIRONMENT

The landmark book, *Nursing, Health and the Environment* (Pope, Snyder & Mood, 1995), recommends that environmental health content be integrated into nursing education, practice, research and policy/advocacy. At the time of publication there was reference to human

exposures to toxicants in occupational settings that had high risk for the development of cancers such as liver (vinyl chloride), lung /mesothelioma (asbestos), and blood dyscrasias (benzene). In the intervening 26 years since its publication, the nursing profession has built a stronger body of work in the four key areas outlined by the IOM report. In particular, the work includes the publication of the original e-text, *Environmental Health in Nursing* (2016), manuscripts with recommendations for how to integrate environmental health content into nursing education, webinars with essential content to advance knowledge, journal clubs, publications that highlight nursing research about toxic chemicals (Pak & McCauley, 2007) or make recommendations for practice (Rafferty & Limonik, 2013) or advocacy (Ballard, 2008)

WHY IS THIS IMPORTANT?

The group of diseases known as cancer can result in death if the growth of the abnormal cells is not controlled. Nurses work in many settings where people who have developed cancer are being treated. According to the American Cancer Society, as many as 1 in 3 Americans are likely to develop cancer in their lifetime. Data shows that 7.6 million women and 6.9 million men had a cancer diagnosis during 2014. Cancer costs are high for both individuals and for society as well with estimates of direct medical costs for cancer in the US in 2015 totaling \$80.2 billion (American Cancer Society, 2018). Globally, the numbers of those diagnosed with cancer is higher with people living in low-income countries and people of color in the US more likely to die from the effects of cancer. Efforts to inform health professionals and the public about carcinogens to reduce risk can have benefits to the health of populations as well as reduction in health care expenditures (Department of Health and Human Services, 2016).

HOW IS DETERMINATION MADE TO CLASSIFY AS A CARCINOGEN?

National and international agencies select the chemicals of concern to be studied based upon the likelihood of risk to human health. Scientific research is conducted using laboratory animal studies as well as human epidemiologic studies. Environmental epidemiologic studies include surveillance systems, ecologic studies, cluster studies, case control studies, cohort studies and cross-sectional designs. Comparison of data from a body of research on a particular chemical can lead to conclusive evidence that a substance can be designated as a carcinogen or has a high probability of causing the mutations in DNA that lead to carcinogenesis (National Research Council, 1997).

Three agencies, the International Agency for Research on Cancer (IARC), part of the World Health Organization, the US National Toxicology Program (NTP) and the EPA are the major agencies that make classifications about substances that are then labeled as carcinogens. Each has its own standards and reporting mechanism as identified below:

International Agency for Research on Cancer (IARC)

The IARC has evaluated more than 900 likely carcinogens in order to develop their classifications.

Group 1: Carcinogenic to Humans

Group 2A: Probably Carcinogenic to Humans

Group 2B: Possibly Carcinogenic to Humans

Group 3 Unclassifiable as to Carcinogenicity to Humans

Group 4 Probably NOT Carcinogenic to Humans

National Toxicology Program (NTP)

The second agency, the National Toxicology Program was formed from the National Institutes of Health, the Centers for Disease Control and Prevention, and the Food and Drug Administration. They compile a report on carcinogens with the belief that the identification of carcinogens is a key step in prevention (Department of Health and Human Services, 2016).

Report on Carcinogens, 14th Report

The Report on Carcinogens is designed to be a public health and scientific document, and includes a list of substances that pose a potential hazard. Placement on that list does not mean that the substance will cause cancer in any individual. Cancer etiology is dependent upon many factors such as susceptibility on the part of the individual, the amount of exposure and the duration of the exposure. Classifications of potential carcinogens on the [Report of Carcinogens](#) are:

- “Known to be human carcinogens”: There is sufficient evidence of carcinogenicity from studies in humans, which indicates a causal relationship between exposure to the agent, substance, or mixture, and human cancer.
- “Reasonably anticipated to be human carcinogens”: There is limited evidence of carcinogenicity from studies in humans, which indicates that causal interpretation is credible, but that alternative explanations, such as chance, bias, or confounding factors, could not adequately be excluded, or there is

sufficient evidence of carcinogenicity from studies in experimental animals, which indicates there is an increased incidence of malignant and/or a combination of malignant and benign tumors (1) in multiple species or at multiple tissue sites, or (2) by multiple routes of exposure, or (3) to an unusual degree with regard to incidence, site, or type of tumor, or age at onset, or there is less than sufficient evidence of carcinogenicity in humans or laboratory animals; however, the agent, substance, or mixture belongs to a well defined, structurally related class of substances whose members are listed in a previous Report on Carcinogens as either known to be a human carcinogen or reasonably anticipated to be a human carcinogen, or there is convincing relevant information that the agent acts through mechanisms indicating it would likely cause cancer in humans. From US Department of Health and Human Services, Report of Carcinogens, 14th edition (2016)

Additionally, the EPA maintains the Integrated Risk Information System (IRIS) that is an electronic database containing information on human health effects from substances in the environment. Their rating system is:

- Group A: Carcinogenic to humans
- Group B: Likely to be carcinogenic to humans
- Group C: Suggestive evidence of carcinogenic potential
- Group D: Inadequate information to assess carcinogenic potential
- Group E: Not likely to be carcinogenic to humans

There are other federal agencies, such as the National Cancer Institute, CDC's National Institute for Occupational Safety and Health (NIOSH), and the Food and Drug Administration (FDA) that do not maintain listings but may comment on whether a substance or exposure may cause cancer.

WHAT SHOULD NURSES DO?

According to the ANA Scope and Standards (2015) for nursing practice, nurses must incorporate environmental health knowledge into professional practice. Nurses can learn essential knowledge about environmental health risks not only through formal educational offerings in academic and professional settings but also through independent learning. This e-text is one effective way but there are also webinars, journal articles, and many other resources available. Many of these can be accessed on the Alliance of Nurses for Healthy Environments website. For our focus here on carcinogens and risk reduction we can

examine three ways this is important to nursing practice. First, inclusion of knowledge about carcinogens will improve nurse's ability to conduct nursing health assessments that include hazardous chemical risks and exposures. Second, nurses can use that knowledge gained to educate patients and community members about hazardous chemicals and carcinogens. Increased knowledge about carcinogens can lead to greater engagement for nurses in nursing research and finally, nurses can include an exposure history into nursing assessments. This allows nurses to identify areas for patient or community education. Nurses should educate patients about exposure risks for chemicals in their workplace, schools, or homes. Exposure routes for chemicals into the body include absorption through the skin, ingestion of food and water, injection, and inhalation. A discussion of exposures from chemicals through absorption must include those used in household cleaning, personal care, and cosmetic use. Excellent sources of information for the lay population include the Environmental Working Group's Home Guide, Skin Deep, Healthy Cleaning and Consumer Products databases. Further, the National Library of Medicine offers a Household Products Database that includes sections for inside the home, landscape/yard, home maintenance, personal care, pet care, arts and crafts, auto products, home office, and commercial/institutional products commonly used in homes. The databases examine the products, the manufacturers, the ingredients, and health effects. The user can either search for the products they commonly use or locate those products rated as safest through the chemical testing results. Resources for education about food and water, the most common ingestion routes of exposure, include the Environmental Working Group's Tap Water Database, Shopper's Guide to Pesticides in Produce, and Food Scores. The Environmental Working Group also sponsors a Healthy Living App that can be used on a mobile telephone for use when shopping. Additionally, for specific source and exposure risk to carcinogens see the chapters about air, PFAS, and wireless technology in this e-textbook.

The ANHE site offers a menu of many tools including a Home Environmental Health and Safety Tool. Planned Parenthood offers an Environmental Health Assessment Form, and assessments for pesticides, personal care products, and cleaning products.

Many nurses practice in acute care settings where there is increasing emphasis upon sustainability. These initiatives which have been steadily increasing over the past 20 years include efforts to create healthier environments, eliminate mercury, establish green purchasing policies, reduce energy and water use, reduce and recycle solid waste and

MY PERSONAL ACCOUNT OF CANCER AS A PRACTICING BEDSIDE NURSE

By Liz Clark:

I graduated from nursing school in 1997 and worked at an emergency department. Initially, I had limited exposure and experience with the oncology patients because there were always rooms available on the oncology floor for them to be directly admitted. The ED was just considered "too dirty" of a place for immunocompromised oncology patients. As my career and time progressed, I have found oncology patients sitting in waiting rooms for hours waiting to get a gurney in the emergency department. Now, there are times when there is a whole section with active oncology patients or patients with a history of cancer in the ED. My journey to environmental nursing started when I started to get "burnt out" and realized I suffered from moral distress. To witness the physical decline and pain and emotional upheaval cancer has on a patient and family made me question my role as a nurse. I realized that I needed to get more involved in advocacy, working up stream, and having the moral courage to speak out on behalf of my patients. I needed to become more active in reducing the likelihood of cancer. That meant that I needed to understand the environmental risks of cancer and teach patients ways to avoid those risks and advocate to policies that reduced exposures to carcinogens.

reduce chemical waste by phasing out toxic substances (Practice Greenhealth, 2018). Initiatives are driven by concerns for healthier environments for patients and staff, climate change and the significant contribution made by healthcare facilities to greenhouse gas emissions, and financial incentives to reduce expenditures for waste removal, energy consumption and water use. Many of the toxic substances include carcinogens. Nurses have been leaders as sustainability coordinators for health care facilities as well as participants on Green teams. Dr. Beth Schenk is one of those leaders.

Research

Nurses are actively involved in research that looks at environmental health risks. What is most foremost in the public's view is nurse participation in the Nurses Health Study that began in 1976 and has followed more than 275,000 nurses longitudinally. Key findings have made contributions to scientific knowledge related to lifestyle factors such as cigarette smoking, alcohol use, physical activity and diet, and biomarkers (exposures to heavy metals, cancer risks, role of Vitamin D in disease