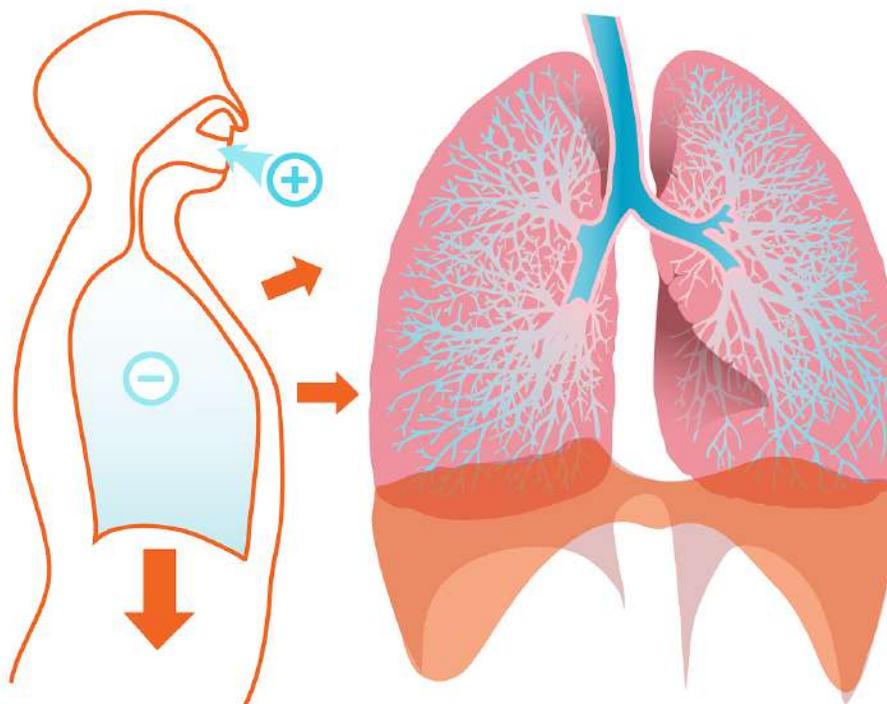


Management and Treatment of Smoke Inhalation



Inhalation

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Introduction

Inhalation injuries can be devastating to an individual's health. They can lead to inflammation, respiratory tract damage, lung damage, toxicity, and death. Thus, inhalation injuries must be effectively managed and treated by health care professionals. The question is, how can health care professionals effectively manage and treat inhalation injuries? This course will answer that very question, while providing health care professionals with recommendations to optimize patient care.

Section 1: Inhalation Injuries

A wildfire rages across the countryside. It is not long before the negative effects of the wildfire are felt by a small community situated in the path of the wildfire's destruction. Eventually, as the wildfire spreads, private property is damaged, air quality is diminished, and residents of the community begin to stream into the local hospital because they are suffering from inhalation injuries. The question is, how can health care professionals effectively manage and treat inhalation injuries? The straightforward answer to the aforementioned question is to incorporate the three essential elements of inhalation injury management/treatment into patient care. With that in mind, this section of the course will review the first essential element of inhalation injury management/treatment, which is to possess insight into inhalation injuries and how they may affect potential patients. The information found within this section was derived from materials provided by the Centers for Disease Control and Prevention (CDC) unless, otherwise, specified (Centers for Disease Control and Prevention [CDC], 2020).

What is an inhalation injury?

An inhalation injury may refer to any damage to the respiratory tract or lungs caused by the inhalation of heat, smoke, and/or chemical irritants.

Health care professionals should note that an inhalation injury may result from the inhalation of toxic substances, house fires, and/or national disasters such as wildfires (note: the term wildfire may refer to a large, uncontrolled fire that spreads over areas such as forests, grasslands, and brushlands). Health care professionals should also note that inhalation injuries related to wildfires may be especially dangerous to individuals because wildfire smoke is, typically, a mixture of environmental pollutants such as: particulate matter, carbon dioxide, carbon monoxide, hydrocarbons, and nitrogen oxides.

What are the signs/symptoms of inhalation injuries?

The signs/symptoms of inhalation injuries may include the following:

- Coughing
- Wheezing
- Trouble breathing
- Shortness of breath
- Chest pain
- Chest tightness
- A scratchy throat
- Irritated sinuses
- Headaches
- Lightheadedness
- Stinging eyes
- A runny nose

What are the different types of inhalation injuries?

The different types of inhalation injuries include: upper airway inhalation injuries, lower airway/tracheobronchial system inhalation injuries, lung parenchyma inhalation injuries, and systemic toxicity (Jones et al). Specific information regarding the aforementioned types of inhalation injuries may be found below.

- **Upper airway inhalation injuries** - the upper airway may refer to the area above the vocal cords. Upper airway inhalation injuries are typically caused by thermal injury and/or chemical irritation (Jones et al). An upper airway inhalation injury may lead to erythema, ulcerations, and/or edema.
- **Lower airway/tracheobronchial system inhalation injuries** - the tracheobronchial system may refer to the system composed of the trachea, bronchi, and bronchioles, which allows air into the lungs. Lower airway/tracheobronchial system inhalation injuries are typically caused by chemicals in smoke (Jones et al).

Lower airway/tracheobronchial system inhalation injuries may result in coughing, wheezing, breathing difficulty, and erythema.

- **Lung parenchyma inhalation injuries** - the lung parenchyma may refer to the area of the lung involved in gas transfer. Lung parenchyma inhalation injuries are typically caused by smoke (Jones et al). Lung parenchyma inhalation injuries may result in atelectasis (note: the term atelectasis may refer to a complete or partial collapse of the lung/lung area).
- **Systemic toxicity** - systemic toxicity may refer to the results of a toxin that affects the entire body and/or multiple organs (Jones et al). Systemic toxicity, when related to inhalation injuries, is typically caused by the inhalation of chemicals as well as cytotoxic liquids, mists, fumes, and gases (Jones et al). Systemic toxicity may result in organ failure and, ultimately, death.

How are inhalation injuries diagnosed?

Inhalation injuries are typically diagnosed by a physician using diagnostic tools such as the following: carboxyhemoglobin measurements, chest computed tomography (CT), fiberoptic bronchoscopy (FOB), radionuclide scans, and pulmonary function testing (Jones et al). Health care professionals should note the following: a FOB may refer to a diagnostic technique used to examine the air passages of the lungs via a fiberoptic bronchoscope; the results of a FOB may be used to grade the severity of an inhalation injury (Jones et al). Health care professionals should also note the following: one of the most widely used approach for grading the severity of an inhalation injury is the Abbreviated Injury Score (AIS); the AIS assigns a severity score from 0 (no injury) to 4 (massive injury) based on the findings of the initial FOB examination (Jones et al).

What are the complications typically associated with inhalation injuries?

As previously alluded to, inhalation injuries are associated with the following complications: respiratory tract damage, lung damage, toxicity, and death. In addition to the aforementioned complications, inhalation injuries may also be associated with pneumonia and acute respiratory distress syndrome.

What are the specific patient populations that may be more susceptible to the complications associated with inhalation injuries?

Inhalation injuries pose significant danger to all patient populations - however, specific patient populations may be more susceptible to the complications associated with

inhalation injuries. Information on the specific patient populations that may be more susceptible to the complications associated with inhalation injuries can be found below.

- **Older adults** - one of the first patient populations that may come to mind when considering the complications associated with inhalation injuries is the older adult population (note: the term older adult may refer to an individual 65 years or older). Older adults are more susceptible to the danger of inhalation injuries due to a variety of different factors such as pre-existing diseases, decreased immune systems, and decreased lung function. Health care professionals should note that older adults suffering from inhalation injuries may require emergency health care and/or hospital admission.
- **Pregnant women** - pregnant women may also come to mind when considering the complications associated with inhalation injuries. Pregnant women are also more susceptible to the dangers of inhalation injuries. One of the main reasons why pregnant women are more susceptible to the dangers of inhalation injuries is due to the physiological changes (e.g., increased breathing rates) that occur in a woman during pregnancy. Essentially, the physiological changes associated with pregnancy may make a pregnant woman more vulnerable to the effects of the many irritants (e.g., smoke) that cause inhalation injuries. Health care professionals should note that the irritants that cause inhalation injuries may also affect the fetus, and lead to complications such as low birth rates.
- **Children** - children are also more susceptible to the complications associated with inhalation injuries because their lungs are still developing, and thus, may be extremely vulnerable to the effects of the many irritants (e.g., smoke) that cause inhalation injuries. Health care professionals should note that inhalation injuries in children may lead to decreased lung function.
- **Individuals suffering from asthma** - individuals suffering from asthma may be more susceptible to the complications associated with inhalation injuries. Asthma may refer to a respiratory condition that causes difficulty in breathing. Those individuals suffering from asthma may be more susceptible to the dangers of inhalation injuries because their compromised respiratory health may result in a life threatening respiratory response when exposed to the many irritants (e.g., smoke) that cause inhalation injuries. Health care professionals should note that an individual suffering from asthma and inhalation injuries may require emergency health care.

- **Individuals suffering from chronic obstructive pulmonary disease (COPD)** - along with asthma, individuals suffering from COPD may be more susceptible to the complications associated with inhalation injuries. COPD may refer to a chronic inflammatory lung disease that causes obstructed airflow. Much like with asthma, an individual suffering from COPD may be more susceptible to the dangers of inhalation injuries because their compromised respiratory health may result in a life threatening respiratory response when exposed to the many irritants (e.g., smoke) that cause inhalation injuries. Health care professionals should note that an individual suffering from COPD and inhalation injuries may require emergency health care.
- **Individuals suffering from cardiovascular disease** - finally, those individuals suffering from cardiovascular disease may be more susceptible to the complications associated with inhalation injuries. Cardiovascular disease may refer to a group of heart conditions that involve narrowed or blocked blood vessels, which may lead to chest pain, a heart attack, or stroke. Individuals suffering from cardiovascular disease may be more susceptible to the complications associated with inhalation injuries because their compromised health status may result in a severe cardiovascular event when exposed to the many irritants (e.g., smoke) that cause inhalation injuries. Health care professionals should note that an individual suffering from cardiovascular disease and inhalation injuries may require emergency health care and/or hospital admission.

How may individuals suffering from inhalation injuries present?

Individuals suffering from inhalation injuries may appear in a variety of different states. They may be coughing, wheezing, and/or having trouble breathing. Also, individuals suffering from inhalation injuries may display body language indicating breathing difficulties (e.g., moving slowly, slouching, and gasping for air). Additionally, they may appear lightheaded or on the verge of losing consciousness. Furthermore, individuals suffering from inhalation injuries may appear like they have been in or near a fire (e.g., an individual may have burns on his or her body).

In addition to their appearance, individuals suffering from inhalation injuries may use certain types of wording to describe or articulate their state. Examples of wording that may be used by individuals potentially suffering from inhalation injuries to describe or articulate their state may include:

- I cannot breath.

- I inhaled smoke and cannot breath.
- I was in a fire and cannot breath.
- I was near a wildfire and cannot breath.
- I am having trouble breathing.
- I cannot stop coughing.
- I cannot stop wheezing.
- I have chest pain.
- My chest feels tight.
- I feel lightheaded.
- I have a headache.
- My throat hurts.
- My sinuses are irritated.
- My nose is running.

Health care professionals should note the following: when attempting to distinguish specific wording regarding inhalation injuries, health care professionals should keep in mind that they may hear or encounter many different versions or variations of the previously highlighted language; individuals may use different versions or variations of the previously highlighted language while trying to breathe, breathing heavy, and/or while coughing or wheezing.

What should health care professionals consider while working to identify and/or care for patients suffering from inhalation injuries?

Burn injuries

An individual suffering from an inhalation injury may have been involved in a fire, and thus, may also be suffering from burn injuries on his or her body. Health care professionals should work to identify burn injuries on those patients suffering from inhalation injuries, when applicable. Health care professionals should note the following types of burn injuries: first-degree burns, second-degree burns, and third-degree burns.

Specific information regarding the aforementioned types of burn injuries may be found below.

- **First-degree burns** - first-degree burns involve the top layer of skin. A sunburn is a typical example of a first-degree burn. Signs of a first-degree burn may include the following: redness, pain, and mild swelling.
- **Second-degree burns** - second-degree burns involve the first two layers of skin. Examples of second-degree burns may include a brief exposure to heat and/or scalding with hot water. Signs of a second-degree burn may include the following: a deep reddening of the skin, pain, blisters, a glossy appearance from leaking fluid, and possible loss of skin.
- **Third-degree burns** - third-degree burns penetrate the entire thickness of the skin and permanently destroy tissue. Third-degree burns may result from exposure to fire. Signs of a third-degree burn may include the following: loss of skin layers, dry skin, leathery skin, as well as white, black, or brown skin. Health care professionals should note that third-degree burns may be painless due to the destruction of nerve endings.

Carbon monoxide poisoning

Health care professionals should consider carbon monoxide poisoning while working to identify and/or care for patients suffering from inhalation injuries, especially those inhalation injuries related to fire. Carbon monoxide is an odorless, colorless, poisonous gas that can cause sudden illness and death if present in a sufficient concentration. The signs and symptoms of carbon monoxide poisoning may include: headache, dizziness, weakness, nausea, vomiting, chest pain, and altered mental status. The symptoms of severe carbon monoxide poisoning may include: malaise, shortness of breath, headache, nausea, chest pain, irritability, ataxia, altered mental status, loss of consciousness, and coma. Health care professionals should note that carbon monoxide poisoning may lead to systemic toxicity and death.

Hydrogen cyanide poisoning

Health care professionals should also consider hydrogen cyanide poisoning while working to identify and/or care for patients suffering from inhalation injuries, especially those inhalation injuries related to fire. Hydrogen cyanide is the gaseous form of cyanide, which is a colorless gas with the odor similar to that of bitter almonds. The signs and symptoms of hydrogen cyanide poisoning may include a decreased level of

consciousness and cardiac arrest. Health care professionals should note that hydrogen cyanide poisoning may lead to systemic toxicity and death.

Pneumonia

As previously mentioned, inhalation injuries may be associated with pneumonia. Pneumonia may refer to an infection that can lead to lung inflammation. Signs/symptoms of pneumonia may include the following: cough with phlegm or pus, wheezing, difficulty breathing, fever, chills, fatigue, loss of appetite, and malaise. Health care professionals should monitor inhalation injury patients for the aforementioned signs/symptoms.

Acute respiratory distress syndrome

In addition to pneumonia, inhalation injuries are associated with acute respiratory distress syndrome. Acute respiratory distress syndrome may refer to a syndrome characterized by an acute injury that often involves fluid accumulation in the lungs, which deprives organs of oxygen. Signs/symptoms of acute respiratory distress syndrome may include: fatigue, fever, blue tone to the skin or lips, dyspnea, and respiratory distress. Health care professionals should monitor inhalation injury patients for the aforementioned signs/symptoms. Health care professionals should note that acute respiratory distress syndrome may develop within days of the initial inhalation injury.

Post-traumatic stress disorder (PTSD)

PTSD may not be one of the first things that comes to mind when considering inhalation injuries - however, those suffering from inhalation injuries, especially if they resulted from a traumatic event such as a house fire or raging wildfire, may eventually suffer from PTSD. PTSD may refer to a mental health disorder characterized by persistent mental and emotional stress/symptoms occurring as a result of an injury or severe psychological/terrifying event that creates distress or functional impairment (National Institute of Mental Health, 2020). Health care professionals should note the following symptoms of PTSD: upsetting memories, nightmares, flashbacks, emotional distress after exposure to traumatic reminders, physical reactivity after exposure to traumatic reminders, negative affect, decreased interest in activities, feeling isolated, difficulty experiencing positive affect, irritability, aggression, risky or destructive behavior, hypervigilance, heightened startled reaction, difficulty concentrating, difficulty sleeping, depersonalization, and derealization (note: depersonalization may refer to an experience of being an outside

observer of or detached from oneself; derealization may refer to an experience of distance or distortion) (National Institute of Mental Health, 2020).

Depression and anxiety

lastly, along with PTSD, health care professionals should also consider depression and/or anxiety. Due to the potential traumatic nature of inhalation injuries, patients suffering from inhalation injuries may develop a form of depression and/or anxiety. A depressive disorder may refer to a mood disorder characterized by a persistent depressed mood and/or anhedonia, which ultimately causes significant interference in daily life (note: the term anhedonia may refer to a loss of interest in previously enjoyable activities) (National Institute of Mental Health, 2020). An anxiety disorder may refer to a mental health disorder characterized by prolonged periods of persistent, excessive worry about a number of events or activities, which cause clinically significant distress or impairment in social, occupational, or other important areas of functioning (note: in regards to an anxiety disorder, excessive worry may refer to worrying when there is no specific reason/threat present or in a manner that is disproportionate to the actual risk of an event, activity, and/or situation) (National Institute of Mental Health, 2020). Health care professionals should note the following symptoms of a depression disorder: depressed mood, anhedonia, appetite changes, weight changes, sleep difficulties, psychomotor agitation or retardation, fatigue or loss of energy, diminished ability to think or concentrate, feelings of worthlessness or excessive guilt, and suicidality (National Institute of Mental Health, 2020). Health care professionals should also note the following symptoms of an anxiety disorder: excessive anxiety, excessive worry, restlessness, persistent feelings of being keyed up or on edge, easily fatigued, difficulty concentrating, mind feeling blank at times (i.e., mind going blank), irritability, and muscle tension (National Institute of Mental Health, 2020). Furthermore, health care professionals should note that patients suffering from depression and/or anxiety may experience suicidal ideation. Suicidal ideation may refer to thoughts of suicide and/or thoughts of planning suicide (National Institute of Mental Health, 2020). Health care professionals should make efforts to identify the potential for suicide and prevent patient suicide, when applicable.

Section 1: Summary

An inhalation injury may refer to any damage to the respiratory tract or lungs caused by the inhalation of heat, smoke, and/or chemical irritants. The signs/symptoms of inhalation injuries may include the following: coughing, wheezing, trouble breathing, shortness of breath, chest pain, chest tightness, a scratchy throat, irritated sinuses,

headaches, lightheadedness, stinging eyes, and a runny nose. The different types of inhalation injuries include: upper airway inhalation injuries, tracheobronchial system inhalation injuries, lung parenchyma inhalation injuries, and systemic toxicity (Jones et al). Inhalation injuries are associated with the following complications: respiratory tract damage, lung damage, toxicity, and death. The specific patient populations that may be more susceptible to the complications associated with inhalation injuries include: older adults, pregnant women, children, individuals suffering from asthma, individuals suffering from COPD, and individuals suffering from cardiovascular disease. Health care professionals should consider the following while working to identify and/or care for patients suffering from inhalation injuries: burn injuries, carbon monoxide poisoning, hydrogen cyanide poisoning, pneumonia, acute respiratory distress syndrome, PTSD, depression, and anxiety. Finally, health care professionals should note that the first essential element of inhalation injury management/treatment is to possess insight into inhalation injuries and how they may affect potential patients.

Section 1: Key Concepts

- The first essential element of inhalation injury management/treatment is to possess insight into inhalation injuries and how they may affect potential patients.
- An inhalation injury may result from house fires or natural disasters such as wildfires; inhalation injuries related to wildfires may be especially dangerous to individuals because wildfire smoke is, typically, a mixture of environmental pollutants such as: particulate matter, carbon dioxide, carbon monoxide, hydrocarbons, and nitrogen oxides.
- The signs/symptoms of inhalation injuries may include the following: coughing, wheezing, trouble breathing, shortness of breath, chest pain, chest tightness, a scratchy throat, irritated sinuses, headaches, lightheadedness, stinging eyes, and a runny nose.
- The different types of inhalation injuries include: upper airway inhalation injuries, tracheobronchial system inhalation injuries, lung parenchyma inhalation injuries, and systemic toxicity (Jones et al).
- Inhalation injuries are typically diagnosed by a physician using diagnostic tools such as carboxyhemoglobin measurements, chest computed tomography (CT), fiberoptic bronchoscopy (FOB), radionuclide scan, and pulmonary function testing (Jones et al).

- Inhalation injuries are associated with the following complications: respiratory tract damage, lung damage, toxicity, and death.
- The specific patient populations that may be more susceptible to the complications associated with inhalation injuries include: older adults, pregnant women, children, individuals suffering from asthma, individuals suffering from COPD, and individuals suffering from cardiovascular disease.
- Individuals suffering from inhalation injuries may appear in a variety of different states.
- Health care professionals should consider the following while working to identify and/or care for patients suffering from inhalation injuries: burn injuries, carbon monoxide poisoning, hydrogen cyanide poisoning, pneumonia, acute respiratory distress syndrome, PTSD, depression, and anxiety.

Section 1: Key Terms

Inhalation injury - any damage to the respiratory tract or lungs caused by the inhalation of heat, smoke, and/or chemical irritants

Wildfire - a large, uncontrolled fire that spreads over areas such as forests, grasslands, and brushlands

Upper airway - the area above the vocal cords

Tracheobronchial system - the system composed of the trachea, bronchi, and bronchioles, which allows air into the lungs

Lung parenchyma - the area of the lung involved in gas transfer

Atelectasis - a complete or partial collapse of the lung/lung area

Systemic toxicity - the results of a toxin that affects the entire body and/or multiple organs (Jones et al)

Fiberoptic bronchoscopy (FOB) - a diagnostic technique used to examine the air passages of the lungs via a fiberoptic bronchoscope (Jones et al)

Older adult - an individual 65 years or older

Asthma - a respiratory condition that causes difficulty in breathing

Chronic obstructive pulmonary disease (COPD) - a chronic inflammatory lung disease that causes obstructed airflow

Cardiovascular disease - a group of heart conditions that involve narrowed or blocked blood vessels, which may lead to chest pain, a heart attack, or stroke

Carbon monoxide - an odorless, colorless, poisonous gas that can cause sudden illness and death if present in sufficient concentration

Hydrogen cyanide - the gaseous form of cyanide

Pneumonia - an infection that can lead to lung inflammation

Acute respiratory distress syndrome - a syndrome characterized by an acute injury that often involves fluid accumulation in the lungs, which deprives organs of oxygen

Post-traumatic stress disorder (PTSD) - a mental health disorder characterized by persistent mental and emotional stress/symptoms occurring as a result of an injury or severe psychological/terrifying event that creates distress or functional impairment (National Institute of Mental Health, 2020)

Depersonalization - an experience of being an outside observer of or detached from oneself (National Institute of Mental Health, 2020)

Derealization - an experience of distance or distortion (National Institute of Mental Health, 2020)

Depressive disorder - a mood disorder characterized by a persistent depressed mood and/or anhedonia, which ultimately causes significant interference in daily life (National Institute of Mental Health, 2020)

Anhedonia - a loss of interest in previously enjoyable activities (National Institute of Mental Health, 2020)

Anxiety disorder - a mental health disorder characterized by prolonged periods of persistent, excessive worry about a number of events or activities, which cause clinically significant distress or impairment in social, occupational, or other important areas of functioning (National Institute of Mental Health, 2020)

Excessive worry (*in the context of an anxiety disorder*) - worrying when there is no specific reason/threat present or in a manner that is disproportionate to the actual risk of an event, activity, and/or situation (National Institute of Mental Health, 2020)

Suicidal ideation - thoughts of suicide and/or thoughts of planning suicide (National Institute of Mental Health, 2020)

Section 1: Personal Reflection Question

How may inhalation injuries affect potential patients?

Section 2: Inhalation Injury Treatment Options

The second essential element of inhalation injury management/treatment is to select appropriate treatment options for patients in need. This section of the course will review specific treatment options for inhalation injuries. The information found within this section was derived from materials provided by the National Heart, Lung, and Blood Institute unless, otherwise, specified (National Heart, Lung, and Blood Institute, 2020).

Intubation and Tracheostomy

It is paramount that an inhalation injury patient's airway is clear/not obstructed. With that in mind, inhalation injury patients may require intubation. The term intubation may refer to the process of inserting an endotracheal tube into the airway in order to facilitate sufficient breathing. Health care professionals should note the following: health care professionals should be aware of and adhere to their specific health care organizations' policies and procedures and/or treatment protocols regarding intubation.

Some inhalation injury patients may require a tracheostomy. The term tracheostomy may refer to the process of creating an opening through the neck into the trachea, where a tracheostomy tube may be placed, to facilitate sufficient breathing. Health care professionals should note the following: health care professionals should be aware of and adhere to their specific health care organizations' policies and procedures and/or treatment protocols regarding tracheostomy.

Oxygen Therapy

Inhalation injury patients may require oxygen therapy. Oxygen therapy may refer to a treatment option characterized by the use of oxygen to facilitate sufficient breathing. Specific information regarding oxygen therapy may be found below.

- Oxygen therapy may also be referred to as supplemental oxygen.
- Oxygen therapy is typically delivered via tanks, tubs, masks, and oxygen concentrators.

- Oxygen may pose a fire risk. Health care professionals should adhere to their specific health care organizations' policies and procedure regarding the use of oxygen and oxygen therapy to prevent fires from occurring.
- Oxygen therapy may be associated with the following effects: bloody nose, tiredness, and headaches.
- Hyperbaric oxygen therapy is a form of oxygen therapy. Hyperbaric oxygen therapy may refer to a treatment option characterized by the use of pure oxygen.
- Patients may receive hyperbaric oxygen therapy via tubes or in pressurized rooms.
- Hyperbaric oxygen therapy may be associated with the following effects: lung damage, fluid buildup in the middle ear, sinus damage, changes in vision, and oxygen poisoning. Oxygen poisoning, otherwise referred to as oxygen toxicity, may refer to a condition resulting from breathing in high partial pressures of oxygen for extended periods of time. Signs/symptoms of oxygen poisoning may include the following: visual abnormalities, hearing abnormalities, unusual fatigue, muscular twitching, anxiety, confusion, and a loss of coordination. Health care professionals should note that oxygen poisoning may be managed by reducing exposure to increased oxygen levels.

Fluid Resuscitation

Patients suffering from inhalation injuries, especially if they are associated with burn injuries, may require fluids.

Fluid resuscitation may refer to the act or practice of replacing bodily fluids. Health care professionals should note the following: when providing patients with fluids, close monitoring of fluid balance is required to help avoid any fluid-related complications; health care professionals should monitor patients' urine output; an adult patient's hourly urine output should be maintained at, approximately, 0.5 mL/kg/hr.

Mechanical Ventilator

Some patients suffering from inhalation injuries may require a mechanical ventilator. Specific information regarding mechanical ventilators may be found below.

- A mechanical ventilator may refer to a device or machine that provides artificial ventilation for an individual that cannot breathe on his or her own; a device or machine that moves gas in and out of the human body.

- A mechanical ventilator can move oxygen into the body and carbon dioxide out of the body; a mechanical ventilator can preserve a stable airway and prevent injury from aspiration.
- A mechanical ventilator may be used until a patient can effectively breathe on his or her own.
- The use of a mechanical ventilator may lead to patient infection. Health care professionals can prevent mechanical ventilator-related infections by various means including suctioning (note: suctioning may refer to the process of clearing material (e.g., mucus) from a patient's breathing tube/air way).

Mucolytic Agents

Airway cleaning can be vital to the management/treatment of patients with inhalation injuries. Mucolytic agents, such as acetylcysteine solution, may be used to clear inhalation injury patients' airways. Specific information regarding acetylcysteine solution may be found below. The information found below was derived from materials provided by the United States Food and Drug Administration (FDA) (United States Food and Drug Administration [FDA], 2020).

Acetylcysteine Solution

Medication notes - acetylcysteine solution is a mucolytic agent for inhalation or oral administration. Potential side effect of acetylcysteine solution include the following: nausea, vomiting, fever, rhinorrhea, drowsiness, chest tightness, and bronchoconstriction.

Safety notes - contraindications associated with acetylcysteine solution include hypersensitivity to acetylcysteine. Warnings and precautions associated with acetylcysteine solution include the following: administration of acetylcysteine may produce an odor; continued nebulization of acetylcysteine solution with a dry gas may result in an increased concentration of the drug in the nebulizer; extreme concentration may impede nebulization and efficient delivery of the drug; dilution of the nebulizing solution with appropriate amounts of Sterile Water for Injection may be required.

Considerations for special patient populations - acetylcysteine solution falls into Pregnancy Category B.

Bronchodilators

Inhalation injury patients suffering from wheezing or bronchospasms may require bronchodilators. Bronchodilators may refer to medications that relax muscles in the lungs and widen airways to facilitate breathing. Specific information regarding bronchodilators may be found below. The information found below was derived from materials provided by the FDA (FDA, 2020).

Albuterol

Medication notes - albuterol is a beta₂-adrenergic agonist indicated for treatment or prevention of bronchospasm in patients 4 years of age and older. A typical dose of albuterol for the treatment or prevention of bronchospasm in adults and children 4 years of age and older is 2 inhalations every 4 - 6 hours. Potential side effect of albuterol include the following: headache, tachycardia, pain, dizziness, and rhinitis.

Safety notes - contraindications associated with albuterol include hypersensitivity to albuterol. Warnings and precautions associated with albuterol include the following: life-threatening paradoxical bronchospasm may occur; cardiovascular effects may occur; use with caution in patients sensitive to sympathomimetic drugs and patients with cardiovascular or convulsive disorders; hypokalemia and changes in blood glucose may occur; excessive use may be fatal.

Considerations for special patient populations - albuterol is not indicated for patients under 4 years of age.

Levalbuterol

Medication notes - levalbuterol is a beta₂-adrenergic agonist indicated for the treatment or prevention of bronchospasm in patients 4 years of age and older with reversible obstructive airway disease. A typical dose of levalbuterol for adults and children 4 years of age and older is 1 - 2 inhalations repeated every 4 - 6 hours. Potential side effect of levalbuterol include the following: bronchitis, dizziness, pain, rhinitis, and vomiting.

Safety notes - contraindications associated with levalbuterol include hypersensitivity to levalbuterol. Warnings and precautions associated with levalbuterol include the following: life-threatening paradoxical bronchospasm may occur; cardiovascular effects may occur; use with caution in patients with underlying cardiovascular disorders; hypokalemia and changes in blood glucose may occur; excessive use may be fatal.

Considerations for special patient populations - levalbuterol is not indicated for patients under 4 years of age.

Epinephrine Inhalation

Medication notes - epinephrine inhalation is a bronchodilator indicated for the temporary relief of shortness of breath, wheezing, and chest tightness. Potential side effects of epinephrine for inhalation include the following: headache, dizziness, tremor, nausea, and vomiting.

Safety notes - contraindications associated with epinephrine inhalation include hypersensitivity to epinephrine; concurrent use with monoamine oxidase inhibitors; use of monoamine oxidase inhibitors within 14 days. Warnings and precautions associated with epinephrine inhalation include the following: may increase blood pressure; may increase risk of heart attack; may increase risk of stroke.

Considerations for special patient populations - epinephrine inhalation is indicated for adults and children 12 years or older.

Burn Injury Therapy

As previously mentioned, some patients suffering from inhalation injuries may also suffer from burn injuries. Health care professionals should work to manage and treat burn injuries, when applicable. Burn injury treatment can depend on the type of burn sustained by a patient. Burn injury treatment options may be found below. The information found below was derived from materials provided by the CDC (CDC, 2020).

- **First-degree burns** - first-degree burns involve the top layer of skin. Treatment for first-degree burns typically involves the application of a cool compress, cool water immersion, and/or burn injury cleaning, when applicable. Health care professionals should note that first-degree burns may be covered with a sterile, non-adhesive bandage, when applicable.
- **Second-degree burns** - second-degree burns involve the first two layers of skin. Treatment for second-degree burns typically involves the application of a cool compress, cool water immersion, and burn injury cleaning, when applicable. Health care professionals should note the following: second-degree burns may be covered with a sterile, non-adhesive bandage; patients with second-degree burns should be evaluated for shock.

- **Third-degree burns** - third-degree burns penetrate the entire thickness of the skin and permanently destroy tissue. Treatment for third-degree burns typically involves covering the burn with sterile gauze, antibiotic therapy to prevent/treat infections, and/or skin grafting procedures, when applicable. Health care professionals should note that patients with third-degree burns should be evaluated for shock.

Pneumonia Therapy

Patients suffering from inhalation injuries may develop pneumonia. Specific antibiotics may be used to treat patients suffering from pneumonia. Information regarding the types of antibiotics that may be used to treat the different types of pneumonia (e.g., hospital-acquired pneumonia; ventilator-associated pneumonia) can be found below. The information found below was derived from materials provided by the FDA (FDA, 2020).

Piperacillin and Tazobactam (Zosyn)

Medication notes - Zosyn is a combination penicillin-class antibacterial and β -lactamase inhibitor indicated for the treatment of infections (e.g., pneumonia). A typical dose of Zosyn for the treatment of pneumonia is 4.5 g IV every 6 hours (note: to reduce the development of drug-resistant bacteria and maintain the effectiveness of Zosyn and other antibacterial drugs, Zosyn should be used only to treat or prevent infections that are proven or strongly suspected to be caused by bacteria). Potential side effects of Zosyn include the following: diarrhea, constipation, nausea, headache, and insomnia.

Safety notes - contraindications associated with Zosyn include a history of allergic reactions to any of the penicillins, cephalosporins, or β -lactamase inhibitors. Warnings and precautions associated with Zosyn include: serious hypersensitivity reactions are possible; discontinue Zosyn if a reaction occurs; Zosyn may cause severe cutaneous adverse reactions, such as Stevens-Johnson syndrome; discontinue Zosyn if patients experience a progressive rash; bleeding, leukopenia, and neutropenia are possible; nephrotoxicity in critically ill patients has been observed; *Clostridium difficile*-associated diarrhea may occur; evaluate patient if diarrhea occurs.

Considerations for special patient populations - dosage in patients with renal impairment should be reduced to the degree of actual patient renal function impairment.

Cefepime

Medication notes - cefepime is a broad spectrum, cephalosporin antibiotic (note: other cephalosporins may be used to treat pneumonia). Cefepime is indicated for the treatment of moderate to severe pneumonia, as well as other infections. The typical adult dose of cefepime for the treatment of pneumonia is 1 - 2 grams IV every 12 hours. Potential side effects of cefepime include the following: stomach cramps, diarrhea, fever, and chills.

Safety notes - contraindications associated with cefepime include a history of hypersensitivity reactions to cefepime or the cephalosporin class of antibiotics; penicillins or other beta-lactam antibiotics. Warnings and precautions associated with cefepime include: before therapy with cefepime is instituted, careful inquiry should be made to determine whether a patient has experienced previous immediate hypersensitivity reactions to cefepime, cephalosporins, penicillins, or other drugs; exercise caution if this product is to be given to penicillin-sensitive patients because cross-hypersensitivity among beta-lactam antibiotics has been clearly documented and may occur in up to 10% of patients with a history of penicillin allergy; if an allergic reaction to cefepime occurs, discontinue the drug; cefepime should be prescribed with caution in individuals with a history of gastrointestinal disease, particularly colitis; *Clostridium difficile*-associated diarrhea may occur.

Considerations for special patient populations - in patients with creatinine clearance less than or equal to 60 mL/min, the dose of cefepime should be adjusted to compensate for the slower rate of renal elimination.

Meropenem

Medication notes - meropenem is a penem antibacterial that may be used for the treatment of pneumonia (note: other penem antibiotics may be used to treat pneumonia). A typical adult dose of meropenem that may be used to treat pneumonia is 1 gram IV every 8 hours. Potential side effects of meropenem include the following: headache, nausea, vomiting, constipation, diarrhea, anemia, and rash.

Safety notes - contraindications associated with meropenem include a known hypersensitivity to meropenem or anaphylactic reactions to β -lactams. Warnings and precautions associated with meropenem include: serious and occasionally fatal hypersensitivity (anaphylactic) reactions have been reported in patients receiving β -lactams; seizures and other adverse CNS experiences have been reported during treatment; co-administration of meropenem with valproic acid or divalproex sodium

reduces the serum concentration of valproic acid potentially increasing the risk of breakthrough seizures; *Clostridium difficile*-associated diarrhea may occur.

Considerations for special patient populations - dose adjustment is necessary, if a patient's creatinine clearance is 50 mL/min or less.

Levofloxacin

Medication notes - levofloxacin is a fluoroquinolone antibacterial indicated in adults (\geq 18 years of age) with infections caused by designated, susceptible bacteria (e.g., pneumonia). A typical dose of levofloxacin for the treatment of pneumonia is 750 mg daily. Potential side effects of levofloxacin include the following: nausea, headache, dizziness, diarrhea, and constipation.

Safety notes - contraindications associated with levofloxacin include a known hypersensitivity to levofloxacin or other quinolones. Warnings associated with levofloxacin include the following: fluoroquinolones, including levofloxacin, are associated with an increased risk of tendinitis and tendon rupture in all ages; the risk is further increased in older patients usually over 60 years of age, in patients taking corticosteroid drugs, and in patients with kidney, heart or lung transplants. Additional warnings and precautions associated with levofloxacin include: anaphylactic reactions and allergic skin reactions, serious, occasionally fatal, may occur after first dose; hematologic (including agranulocytosis, thrombocytopenia), and renal toxicities may occur after multiple doses; hepatotoxicity has been reported; discontinue immediately if signs and symptoms of hepatitis occur; central nervous system effects, including convulsions, anxiety, confusion, depression, and insomnia may occur after the first dose; use with caution in patients with known or suspected disorders that may predispose them to seizures or lower the seizure threshold; *Clostridium difficile*-associated colitis may occur; evaluate patient if diarrhea occurs; prolongation of the QT interval and isolated cases of torsade de pointes have been reported; avoid use in patients with known prolongation, those with hypokalemia, and with other drugs that prolong the QT interval.

Considerations for special patient populations - severe hepatotoxicity has been reported in older adult patients.

Ciprofloxacin

Medication notes - ciprofloxacin is a fluoroquinolone antibacterial indicated for infections caused by designated, susceptible bacteria. A typical dose of ciprofloxacin for

the treatment of pneumonia is 400 mg every 8 hours. Potential side effects of ciprofloxacin include the following: nausea, vomiting, diarrhea, abnormal liver function tests, and rash.

Safety notes - contraindications associated with ciprofloxacin include a known hypersensitivity to ciprofloxacin or other quinolones; concomitant administration with tizanidine. Warnings associated with levofloxacin include the following: fluoroquinolones, including ciprofloxacin, are associated with an increased risk of tendinitis and tendon rupture in all ages; fluoroquinolones, including ciprofloxacin, may exacerbate muscle weakness in patients with myasthenia gravis; avoid ciprofloxacin in patients with a known history of myasthenia gravis. Additional warnings and precautions associated with ciprofloxacin include: serious and sometimes fatal reactions (e.g., anaphylactic reactions) may occur after the first or subsequent doses of ciprofloxacin; discontinue ciprofloxacin at the first sign of skin rash, jaundice or any sign of hypersensitivity; discontinue immediately if signs and symptoms of hepatitis occur; *Clostridium difficile*-associated colitis may occur; evaluate patient if diarrhea occurs; prolongation of the QT interval and isolated cases of torsade de pointes have been reported; avoid use in patients with known prolongation, those with hypokalemia, and with other drugs that prolong the QT interval.

Considerations for special patient populations - dose modification is recommended for patients with renal dysfunction.

Vancomycin

Medication notes - vancomycin is an antibacterial indicated for adult and pediatric patients (note: vancomycin should be used only to treat or prevent infections that are proven or strongly suspected to be caused by susceptible bacteria). A typical adult dose of vancomycin is 15 mg/kg IV every 8 - 12 hours (note: a vancomycin loading dose may be required). Potential side effects of vancomycin include the following: "red man" syndrome, acute kidney injury, hearing loss, and neutropenia.

Safety notes - contraindications associated with vancomycin include hypersensitivity to vancomycin. Warnings and precautions associated with vancomycin include: infusion reactions are possible; administer vancomycin in a diluted solution over a period of 60 minutes or greater and also prior to intravenous anesthetic agents; systemic vancomycin exposure may result in acute kidney injury (AKI) including acute renal failure, mainly due to interstitial nephritis or less commonly acute tubular necrosis; monitor serum vancomycin concentrations and renal function; ototoxicity has occurred in patients

receiving vancomycin; monitor patients for signs and symptoms of ototoxicity during therapy; *Clostridium difficile*-associated diarrhea is possible; evaluate patients for diarrhea; periodically monitor leukocyte count; to reduce the risk of local irritation and phlebitis administer vancomycin by a secure intravenous route of administration; prescribing vancomycin for injection in the absence of a proven or strongly suspected bacterial infection is unlikely to provide benefit to the patient and increases the risk of the development of drug resistant bacteria.

Considerations for special patient populations - vancomycin for injection is known to be substantially excreted by the kidney, and the risk of adverse reactions to this drug may be greater in patients with impaired renal function.

Acute Respiratory Distress Syndrome Therapy

In addition to pneumonia, inhalation injury patients may develop acute respiratory distress syndrome (note: acute respiratory distress syndrome may refer to a syndrome characterized by an acute injury that often involves fluid accumulation in the lungs, which deprives organs of oxygen). Acute respiratory distress syndrome therapy may include: oxygen therapy, fluid management, corticosteroids, and diuretics.

Section 2: Summary

The second essential element of inhalation injury management/treatment is to select appropriate treatment options for patients in need. Inhalation injury-related treatment options may include the following: intubation and tracheostomy, oxygen therapy, fluid resuscitation, the use of a mechanical ventilator, mucolytic agents, bronchodilators, burn injury therapy, pneumonia therapy, and acute respiratory distress syndrome therapy. When selecting inhalation injury-related treatment options, health care professionals should be aware of and follow their health care organizations' policies and procedures/ treatment protocols to ensure the administration of safe and effective health care.

Section 2: Key Concepts

- The second essential element of inhalation injury management/treatment is to select appropriate treatment options for patients in need.
- Inhalation injury-related treatment options may include the following: intubation and tracheostomy, oxygen therapy, fluid resuscitation, the use of a mechanical ventilator, mucolytic agents, bronchodilators, burn injury therapy, pneumonia therapy, and acute respiratory distress syndrome therapy.

Section 2: Key Terms

Intubation - the process of inserting an endotracheal tube into the airway in order to facilitate sufficient breathing

Tracheostomy - the process of creating an opening through the neck into the trachea, where a tracheostomy tube may be placed, to facilitate sufficient breathing

Oxygen therapy - a treatment option characterized by the use of oxygen to facilitate sufficient breathing

Hyperbaric oxygen therapy - a treatment option characterized by the use of pure oxygen

Oxygen poisoning (*otherwise referred to as oxygen toxicity*) - a condition resulting from breathing in high partial pressures of oxygen for extended periods of time

Fluid resuscitation - the act or practice of replacing bodily fluids

Mechanical ventilator - a device or machine that provides artificial ventilation for an individual that cannot breathe on his or her own; a device or machine that moves gas in and out of the human body

Suctioning - the process of clearing material (e.g., mucus) from a patient's breathing tube/air way

Bronchodilators - medications that relax muscles in the lungs and widen airways to facilitate breathing (FDA, 2020)

Section 2: Personal Reflection Question

How can health care professionals select appropriate treatment options for patients suffering from inhalation injuries?

Section 3: Inhalation Injury Recommendations

The third and final essential element of inhalation injury management/treatment is to follow related recommendations. This section of the course will review inhalation injury recommendations. The information found within this section of the course was derived from materials provided by the CDC unless, otherwise, specified (CDC, 2020).

Inhalation Injury Recommendations

- **Remove patients from the source of their inhalation injuries** - first and foremost, health care professionals should remove patients from the source of their inhalation injuries (e.g., fire; area affected by a wildfire). This recommendation may seem obvious - however, it is worth noting because it is absolutely vital to the care of inhalation injury patients. Health care professionals should note that this recommendation may be most relevant in emergency situations (e.g., a fire in a health care facility; excessive smoke in a health care facility).
- **Ensure that an inhalation injury patient's airway is clear** - as previously mentioned, it is paramount that an inhalation injury patient's airway is clear/not obstructed. Health care professionals should observe patients' airways when administering care. Health care professionals should note that this recommendation may provide the foundation for inhalation injury treatment.
- **Obtain information regarding a patient's Abbreviated Injury Score (AIS)** - an AIS may be used to assign a severity score, from 0 (no injury) to 4 (massive injury), to a patient's inhalation injury (Jones et al). Health care professionals should note that an AIS is a key element of inhalation injury care (i.e., a patient's inhalation injury treatment or care may be based on his or her AIS).
- **Observe/monitor patients** - as previously alluded to, patient observation can be essential to inhalation injury treatment. Health care professionals should observe patients' signs and symptoms, as well as monitor patients' therapy. Health care professionals should note the following: health care professionals should effectively document any relevant patient observations/information.
- **Complete effective health care documentation** - health care documentation may refer to a digital or an analog record detailing the administration of health care to patients. If completed effectively, health care documentation can be used in daily practice by health care professionals to communicate vital patient information to other health care professionals in order to facilitate positive health care outcomes and to decrease the potential for negative health care outcomes, such as adverse events and patient mortalities. Effective health care documentation may be used as a method to review patient cases and to ensure all aspects of an individual patient's health care are noted and evaluated to maximize therapeutic outcomes.

In order for health care documentation to be considered effective, it must function as a viable form of communication, as well as a means to establish a detailed

record of health care administration. There are many different forms of health care documentation - however, if health care professionals include specific characteristics in their documentation, they can ensure their documentation will be effective.

The first characteristics of effective documentation are objectivity and accuracy. Health care documentation should include objective information free of subjective judgment, bias, or opinion. Health care documentation should also be accurate - meaning it should include information which can be measured or verified by another individual.

Additional characteristics of effective health care documentation include clarity and completeness. Clarity, as it relates to health care documentation, may refer to a quality which enables multiple health care professionals to obtain meaning from recorded data and/or information relating to health care. Completeness, as it relates to health care documentation, may refer to a state where all of the necessary components and/or parts are present. Only when clarity and completeness are achieved can health care documentation be considered effective.

Finally, the information found within health care documentation should be readily accessible and available to all those who require it. Thus, health care professionals must include accurate times and dates of health care administration when completing their health care documentation to further its effectiveness. Health care professionals should note that completing effective health care documentation can help health care professionals foster effective communication and ensure patients receive the care they require.

- **Practice effective hand hygiene** - health care-associated infections are a patient safety issue affecting all types of health care organizations and patient populations. With that said, evidence suggests that inhalation injury patients may be more susceptible to health care-associated infections when compared to other patient populations. Thus, health care professionals should work to prevent health care-associated infections when administering health care or engaging with inhalation injury patients. One of the most important and effective ways to address health care-associated infections is by practicing effective hand hygiene. Hand hygiene may refer to the process of cleaning hands in order to prevent contamination and/or infections (CDC, 2018). Hand hygiene is most effective when dirt, soil, microorganisms, and other contaminants are removed from the hands.

Health care professionals should complete effective hand hygiene when evaluating, assessing, and engaging with inhalation injury patients. Specific information regarding effective hand hygiene may be found below. The information found below was derived from materials provided by the CDC (CDC, 2018).

- Health care professionals may use a variety of different products to carry out effective hand hygiene. The following products are typically available to health care professionals and may be used to carry out effective hand hygiene: detergents, plain soap, antimicrobial (medicated) soap, antiseptic agents, and alcohol-based handrubs.
- The major indications for hand hygiene can be broken down into the following five key moments:
 1. Before patient contact
 2. Before an aseptic procedure or task
 3. After a body fluid exposure risk occurs
 4. After touching a patient
 5. After contact with a patient's surroundings
- Health care professionals should wash their hands with soap and water when they are visibly dirty or visibly soiled with blood or other body fluids or after using the toilet.
- Health care professionals should use an alcohol-based handrub when their hands are not visibly soiled to reduce bacterial counts.
- Don personal protective equipment (PPE), when appropriate - another way health care professionals can help limit health care-associated infections is by donning personal protective equipment (PPE), when appropriate (e.g., when cleaning an open wound; when trying to prevent the airborne transmission of an infectious agent). PPE may refer to equipment designed to protect, shield, and minimize exposure to hazards that may cause serious injury, illness, and/or disease (CDC, 2018). Essentially, donning PPE can prevent the spread of infectious materials and agents to patients. PPE can include a variety of different types of equipment such as: masks, face shields, respirators, and gloves. Specific information regarding the

aforementioned PPE may be found below. The information found below was derived from materials provided by the CDC (CDC, 2018).

Mask

Background information - the mask is one of the most recognizable pieces of PPE. The purpose of a mask is to protect a health care professional's face from potentially infectious materials.

Donning PPE - when putting on a mask, a health care professional should make sure the mask completely covers his or her mouth and nose. A health care professional should also ensure the mask fits snugly to the face and below the chin. Often masks can be secured to the head and neck via separate ties.

Removing PPE - to effectively remove a mask, a health care professional should untie the bottom ties, if applicable, followed by the upper ties. The mask should then be pulled off and discarded in the appropriate waste container. A health care professional should not touch a contaminated mask. Health care professionals should wash their hands or use an alcohol-based hand sanitizer after removing all PPE.

Face Shields

Background information - a face shield is another recognizable piece of PPE. The purpose of a face shield is to protect the eyes, nose, and mouth from potentially infectious materials.

Donning PPE - when putting on a face shield, health care professionals should make sure the face shield covers the forehead, extends below the chin, and wraps around the side of the face.

Removing PPE - to effectively remove a face shield, a health care professional should take off the face shield from the back by lifting the face shield's band and pulling it forward. If the face shield is not reusable, it should be placed in the appropriate waste container. A health care professional should not touch a contaminated face shield. Health care professionals should wash their hands or use an alcohol-based hand sanitizer after removing all PPE.

Respirator

Background information - the purpose of a respirator is to protect a health care professional from hazardous and/or infectious aerosols. There are many types of respirators available to health care professionals including: particulate respirators, half-face elastomeric respirators, full-face elastomeric respirators, and powered air purifying respirators (note: one of the most common types of respirators used by health care professionals is the particulate respirator). When selecting a specific type of respirator, health care professionals should consider the type of exposure risk associated with patient care. A "fit test" may be required to determine the appropriate size respirator needed for each individual health care professional. Health care professionals may also require training regarding how and when to use a respirator.

Donning PPE - when putting on a respirator, a health care professional should make sure the respirator completely covers his or her mouth and nose. Health care professionals should also ensure the respirator fits snug to the face and below the chin. Additionally, a health care professional should be sure the respirator is properly sealed.

Removing PPE - to effectively remove a respirator, a health care professional should untie the bottom ties, if applicable, followed by the upper ties. The respirator should then be pulled off and discarded in the appropriate waste container. A health care professional should not touch a contaminated respirator. Health care professionals should wash their hands or use an alcohol-based hand sanitizer after removing all PPE.

Gloves

Background information - gloves are often the most common piece of PPE used by health care professionals. The two main reasons why health care professionals should wear gloves include the following - to reduce the risk of contamination of health care professionals' hands with blood and/or other body fluids and to reduce the risk of germ dissemination to the environment and/or transmission from a health care professional to a patient and vice versa, as well as from one patient to another. When wearing gloves, health care professionals should avoid touch contamination. Touch contamination may refer to touching one's self and/or other surfaces such as tables, light switches, and doors while wearing gloves. Touch contamination may lead to contamination and/or the passing of potentially infectious materials. Health care professionals should also remember to change

their gloves as they administer health care to different patients (i.e., a new patient means a new pair of gloves).

Donning PPE - when putting on a pair of gloves, a health care professional should make sure the gloves extend to cover the wrists of isolation gowns, when applicable. Gloves are often the last piece of PPE donned when putting on required PPE. When donning gloves, health care professionals should adhere to the following steps:

1. Engage in effective hand hygiene. Health care professionals should note the following: when an indication for hand hygiene precedes contact that also requires glove usage, hand rubbing with an alcohol-based handrub or hand washing with soap and water should be performed before donning gloves.
2. Take out a glove from its original box. Health care professionals should be sure to touch only a restricted surface of a glove corresponding to the wrist (i.e., at the top edge of the cuff).
3. Don the first glove.
4. Take the second glove with the bare hand, from its original box. Health care professionals should be sure to touch only a restricted surface of a glove corresponding to the wrist (i.e., at the top edge of the cuff).
5. Don the second glove. Health care professionals should note the following: to avoid touching the skin of the forearm with the gloved hand, turn the external surface of the glove to be donned on the folded fingers of the gloved hand.
6. Avoid touch contamination. Health care professionals should note the following: once both hands are gloved, hands should not touch anything else that is not defined by indications and conditions for gloved use.

Removing PPE - to effectively remove a pair of gloves, a health care professional should use one gloved hand to grasp the palm area of the other gloved hand. Once the health care professional has a firm grip on the palm of one gloved hand, the health care professional should then peel off the first glove. After removing the first glove, the health care professional should then hold that glove in one hand. Using his or her fingers, the health care professional should slide the fingers off his or her ungloved hand under the remaining glove at the wrist and peel off

the second glove right over the first glove. Both gloves should then be placed in the appropriate waste container.

If health care professionals are wearing a gown with gloves, they may also remove their gloves when they are removing their gowns. To do so, health care professionals should peel off each glove as they roll or fold their gowns before disposal. Both the gloves and the gown should then be discarded in the appropriate waste container. When removing a pair of gloves with a gown, health care professionals should ensure they do not touch the gloves or the gown with their bare hands. Health care professionals should wash their hands or use an alcohol-based hand sanitizer after removing all PPE.

- **Apply fall precautions** - due to the potential symptoms of an inhalation injury (e.g., lightheadedness), inhalation injury patients may be susceptible to falls. Thus, health care professionals should apply fall precautions to inhalation injury patients. Health care professionals should note that fall precautions constitute the basics of patient safety and should be applied in all health care facilities to all patients. Specific fall precautions may be found below.

Fall Precautions

- Familiarize the patient with his or her environment
- Have the patient demonstrate call light use
- Maintain the call light within patient reach
- Keep a patient's personal possessions within safe reach of the patient
- Have sturdy handrails in patient bathrooms, rooms, and hallways
- Place the patient's bed in a low position when a patient is resting in bed; raise the patient's bed to a comfortable height when the patient is transferring out of bed
- Keep patient bed brakes locked
- Keep wheelchair wheel locks in the locked position when stationary
- Keep non slip, comfortable, well-fitting footwear on the patient
- Use night lights or supplemental lighting

- Keep floor surfaces clean and dry
 - Clean up all spills promptly
 - Keep patient care areas uncluttered
 - Follow safe patient handling practices
- **Conduct medication reconciliations** - when a patient suffering from an inhalation injury is admitted into a health care facility, health care professionals should conduct a medication reconciliation. A medication reconciliation may refer to a process of comparing the medications an individual is taking (or should be taking) with newly ordered medications (Joint Commission, 2020). Health care professionals should note the following information regarding medication reconciliations: medication reconciliations are intended to identify and resolve medication discrepancies; medication reconciliations should address medication duplications, omissions, and interactions, and the need to continue current medications; the type of information health care professionals should use to reconcile medications include (among others) medication name, dose, frequency, route, and purpose; health care professionals should identify the information that needs to be collected in order to reconcile current and newly ordered medications and to safely prescribe medications in the future (Joint Commission, 2020).
 - **Identify patients that have special needs and/or requirements** - some inhalation injury patients (e.g., older adults) may have special needs and/or requirements. Health care professionals should work to identify such patients to ensure they meet the needs and requirements of each individual patient. Health care professionals should note the following: specific patient populations may be more susceptible to the complications associated with inhalation injuries (e.g., older adults, pregnant women, children, individuals suffering from asthma, individuals suffering from COPD, and individuals suffering from cardiovascular disease); patients that may be more susceptible to the complications associated with inhalation injuries may have special needs and/or requirements.
 - **Ensure inhalation injury patients are adequately hydrated** - adequate hydration may be an essential aspect of inhalation injury patient care, especially if the patient is also suffering from burn injuries. Thus, health care professionals should ensure patients are adequately hydrated. Health care professionals should note the following signs of dehydration: very dry skin, rapid heartbeat, rapid breathing, confusion, and dark urine output.

- **Ensure inhalation injury patients receive adequate nutrition** - in addition to adequate hydration, it is important inhalation injury patients are well nourished when receiving health care. Thus, health care professionals should ensure patients receive adequate nutrition. Health care professionals should note the following symptoms of malnutrition: fatigue, dizziness, and weight loss.
- **Possess insight into vital health care equipment** - the term health care equipment may refer to equipment used for the purposes of health care diagnosis, treatment, and/or therapy. Health care professionals should ensure they are adequately trained on how to use any such health care equipment necessary for the care of inhalation injury patients (e.g., oxygen therapy devices). If a health care professional is not sure how to effectively use any piece of health care equipment, he or she should seek training and education pertaining to the health care equipment in question. Health care professionals should note the following: health care professionals should ensure health care equipment is adequately sterilized, when applicable.
- **Follow relevant health care organizations' policies and procedures/treatment protocols** - health care organizations may have specific policies and procedures/treatment protocols regarding the management/treatment of inhalation injury patients. Health care professionals should be aware of and follow any health care organization policies and procedures/treatment protocols related to the management/treatment of inhalation injury patients. Health care professionals should note the following: if a health care organization does not have specific inhalation injury policies and procedures/treatment protocols, health care professionals should consider developing such policies and procedures/treatment protocols.
- **Educate patients on how to reduce wildfire smoke exposure** - as previously mentioned, wildfires can lead to inhalation injuries. Inhalation injuries related to wildfires may be especially dangerous to individuals because wildfire smoke is, typically, a mixture of environmental pollutants such as: particulate matter, carbon dioxide, carbon monoxide, hydrocarbons, and nitrogen oxides. Thus, health care professionals should work to educate patients on how to reduce wildfire smoke exposure. Specific recommendations related to reducing wildfire smoke exposure may be found below. Health care professionals should note that the following recommendations may be used to prevent inhalation injuries from occurring and/or further inhalation injuries:

- Stay inside - during a wildfire, individuals should stay inside, with the doors and windows closed, to prevent/reduce exposure to wildfire smoke. If individuals are not able to stay in their homes due to the path of a wildfire, individuals should seek shelter in other safe and secure locations as soon as possible.
- Create an evacuation plan - individuals should create evacuation plans in case they are forced to leave their homes during a wildfire. Evacuation plans should include the following key elements: safe means of transportation, safe routes of travel away from wildfire smoke, and safe and secure shelter locations.
- Utilize a portable air cleaner - during a wildfire, individuals should consider using a portable air cleaner to reduce any wildfire-related smoke and/or pollution that may enter their home.
- Create a "safe zone" or "clean room" within the home - to prevent exposure to wildfire smoke, individuals should consider creating a "safe zone" or "clean room" within their home, especially if they live in or near areas typically impacted by wildfires. To create an effective "safe zone" or "clean room" individuals should select a room or area within their homes, with few windows/no windows, that can be sealed off from the outside. Once in the "safe zone" or "clean room," individuals should not repeatedly break the seal of the "safe zone" or "clean room" during times when wildfire smoke exposure may be possible.
- Store food in the home during times of potential wildfire smoke exposure - to limit the amount of times an individual has to leave his or her home during times of potential wildfire smoke exposure, food should be stored in the home. Individuals should be advised to store enough food to last, at least, five to seven days.
- Store medications and other necessary products in the home during times of potential wildfire smoke exposure - along with food, individuals should store medications and other necessary products in the home during times of potential wildfire smoke exposure to prevent/reduce wildfire smoke exposure.
- Avoid the use of bandanas - a simple, common bandana is typically not effective when used to prevent/reduce wildfire smoke exposure.

- Use a N95 respirator - a N95 respirator may refer to a particulate-filtering, face piece respirator that filters at least 95% of airborne particles. N95 respirators are typically effective when used to prevent/reduce wildfire smoke exposure (note: a N95 respirator should fit firmly against the face in a manner that does not leave any open gaps between the skin and the N95 respirator seal). Individuals should be advised to use N95 respirators to prevent/reduce wildfire smoke exposure and to store N95 respirators within their home, especially if they live in or near areas typically impacted by wildfires.
- Listen to news reports, public service announcements, and health advisories - news reports, public service announcements, and health advisories can provide vital information that may be used to prevent/reduce wildfire smoke exposure.
- **Provide patients with information regarding air quality** - finally, health care professionals should provide patients with information regarding air quality. Air quality may refer to a measurement of how clean or polluted the air may be at any given time. Air quality information is typically provided via an air quality index. An air quality index provides colors and numerical values that correspond with specific indications/descriptions of air quality (e.g., a green color indication associated with a numerical value between 0 - 50 indicates that air quality is satisfactory, and air pollution poses little or no risk; a maroon color indication associated with a numerical value of 301 and higher indicates a health warning of emergency conditions where everyone is more likely to be affected). Health care professionals should note that individuals may obtain information regarding air quality and air quality forecasts via AirNow (note: AirNow is a U.S. government provided air quality resource).

Section 3: Summary

The third and final essential element of inhalation injury management/treatment is to follow related recommendations. Inhalation injury recommendations include the following: remove patients from the source of their inhalation injuries, ensure that an inhalation injury patient's airway is clear, obtain information regarding a patient's Abbreviated Injury Score (AIS), observe/monitor patients, complete effective health care documentation, practice effective hand hygiene, don personal protective equipment (PPE) (when appropriate), apply fall precautions, identify patients that have special needs and/or requirements, ensure inhalation injury patients are adequately hydrated,

ensure inhalation injury patients receive adequate nutrition, possess insight into vital health care equipment, follow relevant health care organizations' policies and procedures/treatment protocols, educate patients on how to reduce wildfire smoke exposure, and provide patients with information regarding air quality.

Section 3: Key Concepts

- The third essential element of inhalation injury management/treatment is to follow related recommendations.

Section 3: Key Terms

Health care documentation - a digital or an analog record detailing the administration of health care to patients

Clarity (*as it relates to health care documentation*) - a quality which enables multiple health care professionals to obtain meaning from recorded data and/or information relating to health care

Completeness (*as it relates to health care documentation*) - a state where all of the necessary components and/or parts are present

Hand hygiene - the process of cleaning hands in order to prevent contamination and/or infections (CDC, 2018)

Personal protective equipment (PPE) - equipment designed to protect, shield, and minimize exposure to hazards that may cause serious injury, illness, and/or disease (CDC, 2018)

Touch contamination - touching one's self and/or other surfaces such as tables, light switches, and doors while wearing gloves (CDC, 2018)

Medication reconciliation - a process of comparing the medications an individual is taking (or should be taking) with newly ordered medications (Joint Commission, 2020)

Health care equipment - equipment used for the purposes of health care diagnosis, treatment, and/or therapy

N95 respirator - a particulate-filtering, face piece respirator that filters at least 95% of airborne particles

Air quality - a measurement of how clean or polluted the air may be at any given time

Air quality index - an index that provides colors and numerical values that correspond with specific indications/descriptions of air quality

Section 3: Personal Reflection Question

How can health care professionals use the above recommendations to effectively manage/treat patients suffering from inhalation injuries?

Case Study: Inhalation Injuries

A case study is presented below to review the concepts found in this course. A case study review will follow the case study. The case study review includes the types of questions health care professionals should ask themselves when considering the management/treatment of inhalation injuries. Additionally, reflection questions will be posed, within the case study review, to encourage further internal debate and consideration regarding the presented case study and inhalation injuries. The information found within the case study and case study review was derived from materials provided by the CDC unless, otherwise, specified (CDC, 2020).

Case Study

A 28-year-old male patient is admitted into a health care facility. Upon admission, the patient is coughing, wheezing, and appears to be experiencing shortness of breath. Upon questioning, the patient reports that he is feeling lightheaded and that his "throat hurts." Upon further questioning, the patient reveals that he was camping near an area impacted by wildfire smoke before coming to the health care facility. Additionally, the patient reports he was initially unaware of the wildfire's proximity to his camp site, and that he wore a bandana to protect himself from wildfire smoke once it entered his camp site. The patient also reports that he has asthma and uses an albuterol inhaler as needed. Before the patient answers any more questions, he asks a health care professional if he is suffering from an inhalation injury.

Case Study Review

What patient details may be relevant to the potential presence of an inhalation injury?

The following patient details may be relevant to the potential presence of an inhalation injury: upon admission the patient is coughing, wheezing, and appears to be experiencing shortness of breath; the patient reports that he is feeling lightheaded and that his "throat hurts;" the patient was camping near an area impacted by wildfire

smoke before coming to the health care facility; the patient reports he was initially unaware of the wildfire's proximity to his camp site; the patient wore a bandana to protect himself from wildfire smoke once it entered his camp site; the patient reports that he has asthma; the patient reports that he uses an albuterol inhaler as needed.

Are there any other patient details that may be relevant to the potential presence of an inhalation injury; if so, what are they?

How are each of the aforementioned patient details relevant to the potential presence of an inhalation injury?

Each of the previously highlighted patient details may be relevant to the potential presence of an inhalation injury. The potential relevance of each patient detail may be found below.

Upon admission the patient is coughing, wheezing, and appears to be experiencing shortness of breath - the previous details are relevant because they may represent signs/symptoms of an inhalation injury. Health care professionals should note the following signs/symptoms of an inhalation injury: coughing, wheezing, trouble breathing, shortness of breath, chest pain, chest tightness, a scratchy throat, irritated sinuses, headaches, lightheadedness, stinging eyes, and a runny nose.

The patient reports that he is feeling lightheaded and that his "throat hurts" - the previous details are relevant because they may represent additional signs/symptoms of an inhalation injury.

The patient was camping near an area impacted by wildfire smoke before coming to the health care facility - the previous patient detail may be relevant because it provides context for the patient's potential inhalation injuries. The previous patient detail also provides insight into why the patient may be suffering from an inhalation injury.

The patient reports he was initially unaware of the wildfire's proximity to his camp site - the previous patient detail may be relevant because it provides additional context for the patient's potential inhalation injuries. Health care professionals should note the following: health care professionals should educate and counsel patients on how to reduce wildfire smoke exposure. Health care professionals should also note the following related recommendations: stay inside - during a wildfire, individuals should stay inside, with the doors and windows closed, to prevent/reduce exposure to wildfire smoke; listen to news reports, public service announcements, and health advisories -

news reports, public service announcements, and health advisories can provide vital information that may be used to prevent/reduce wildfire smoke exposure.

The patient wore a bandana to protect himself from wildfire smoke once it entered his camp site - the previous patient detail may be relevant because it provides context for the patient's potential inhalation injuries. The previous patient detail also provides additional insight into why the patient may be suffering from an inhalation injury. Health care professionals should note the following: a simple, common bandana is typically not effective when used to prevent/reduce wildfire smoke exposure; N95 respirators are typically effective when used to prevent/reduce wildfire smoke exposure (note: a N95 respirator should fit firmly against the face in a manner that does not leave any open gaps between the skin and the N95 respirator seal); individuals should be advised to use N95 respirators to prevent/reduce wildfire smoke exposure and to store N95 respirators within their home, especially if they live in or near areas typically impacted by wildfires.

The patient reports that he has asthma - the aforementioned patient detail may be relevant because individuals suffering from asthma may be more susceptible to the complications associated with inhalation injuries. Health care professionals should note the following complications associated with inhalation injuries: respiratory tract damage, lung damage, toxicity, and death.

The patient reports that he uses an albuterol inhaler as needed - the aforementioned patient detail is relevant because the patient reports that he uses a medication that may be essential to the effective management/treatment of potential inhalation injuries. Health care professionals should note the following: health care professionals should conduct medication reconciliations when individuals are admitted into a health care facility to determine their current medications. Health care professionals should also note the following information regarding medication reconciliations: medication reconciliations are intended to identify and resolve medication discrepancies; medication reconciliations should address medication duplications, omissions, and interactions, and the need to continue current medications; the type of information health care professionals should use to reconcile medications include (among others) medication name, dose, frequency, route, and purpose; health care professionals should identify the information that needs to be collected in order to reconcile current and newly ordered medications and to safely prescribe medications in the future (Joint Commission, 2020).

What other ways, if any, are the previous patient details relevant to the potential presence of an inhalation injury?

Is the patient highlighted in the case study suffering from an inhalation injury?

Based on the information presented in the case study, it does appear the patient is suffering from an inhalation injury.

How can health care professionals potentially gather additional information to help confirm the possible presence of an inhalation injury?

How can health care professionals effectively manage/treat the patient's inhalation injury?

Health care professionals can effectively manage/treat the patient's inhalation injury by incorporating the following three essential elements of inhalation injury management/treatment into the patient's care: possess insight into inhalation injuries and how they may affect potential patients; select appropriate treatment options for patients in need; follow inhalation injury recommendations.

How can insight into inhalation injuries, selecting appropriate treatment options, and inhalation injury recommendations optimize patient care?

Conclusion

Inhalation injuries can be devastating to an individual's health. They can lead to inflammation, respiratory tract damage, lung damage, toxicity, and death. Thus, inhalation injuries must be effectively managed and treated by health care professionals. Health care professionals can effectively manage/treat patients suffering from inhalation injuries by incorporating the following three essential elements of inhalation injury management/treatment into patient care: possess insight into inhalation injuries and how they may affect potential patients; select appropriate treatment options for patients in need; follow inhalation injury recommendations.

References

Centers for Disease Control and Prevention. (2020, August 3). Protect Yourself from Wildfire Smoke. <https://www.cdc.gov/nceh/features/wildfires/index.html>

Centers for Disease Control and Prevention. (2018, June 18). Standard precautions. <https://www.cdc.gov/oralhealth/infectioncontrol/summary-infection-prevention-practices/standard-precautions.html>

Joint Commission. (2020). Hospital: 2020 national patient safety goals. www.jointcommission.org/standards/national-patient-safety-goals/hospital-2020-national-patient-safety-goals/

Jones, S.W., Williams, F. N., Cairns, B. A., & Cartotto, R. (2017). Inhalation injury: Pathophysiology, diagnosis, and treatment. *Clin Plast Surg*, 44(3), 505–511. 10.1016/j.cps.2017.02.009

National Heart, Lung, and Blood Institute. (2020). Health topics. <https://www.nhlbi.nih.gov/health-topics>

National Institute of Mental Health. (2020). Health topics. <https://www.nimh.nih.gov/health/topics/index.shtml>

United States Food and Drug Administration. (2020). Find information about a drug. <https://www.fda.gov/drugs/drug-information-consumers/find-information-about-drug>



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