Chemicals and Materials

How Workplace Chemicals Enter the Body

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How can chemicals enter my body?

In order for a chemical to harm a person's health, it must first come into contact with or enter the body, and it must have some biological effect on the body. There are four major routes by which a chemical may enter the body:

- Inhalation (breathing)
- Skin (or eye) contact
- Swallowing (ingestion or eating)
- Injection (skin penetration)

Breathing in contaminated air is the most common way that workplace chemicals enter the body. Some chemicals, when contacted, can pass through the skin into the bloodstream. The eyes may also be a route of entry. Usually, however, only very small quantities of chemicals in the workplace enter the body through the eyes. Workplace chemicals may be swallowed unintentionally if contaminated hands are not washed before the worker touches food or cigarettes, or if the items are contaminated directly. For this reason, workers should not drink, eat, or smoke in areas where they may be exposed to chemicals.

Regardless of the way the chemical gets into the body, once it is in the body, it is distributed in the body by the bloodstream. In this way, the chemical may harm organs which are far away from the original point of entry as well as where they entered the body.

What happens to contaminated air when I breathe it in?

Contaminated air in the workplace can be inhaled. Air is drawn through the mouth and nose, and then into the lungs. An average person will breathe in and out about 12 times a minute. Each of the 12 breaths brings in about 500 mL of air, corresponding to 6 litres of air per minute, together with any contaminants that the air contains.

People involved in hard physical work will breathe harder and take in more than 6 litres a minute. Over an 8-hour working day, more than 2,800 litres of air will be breathed in and out of the lungs. In conditions of hard physical work, up to 10,000 litres may be exchanged. Air breathed in through the nose is filtered by the nasal hairs so that large, solid particles in the atmosphere are prevented from going any further. Inside the nose there are small bones and cartilage that cause the inhaled air to swirl around. This swirling air can cause some large contaminating particles to be deposited in the nose and trapped by the moisture of the mucus lining.

Air coming in from the nose and the mouth reaches the back of the throat and enters an area known as the pharynx. The pharynx, which is the entrance to the airways, divides into two tubes, one called the esophagus, which carries food to the stomach, and one called the trachea, which leads down toward the lungs. Contaminated air passes into the trachea which itself divides into two large tubes, each called a bronchus. Each bronchus enters a lung. Once inside its lung, each bronchus starts to branch. The tubes of the bronchus get thinner and thinner as they spread, similar to branches of a tree. Eventually, the tiniest tubes, which are called bronchioles, end in thin-walled air sacs. Each of these sacs is called an alveolus. Collectively, they are called alveoli and there are many thousands of these alveoli in each lung. The walls of the alveoli are very thin and are richly supplied with tiny blood vessels (capillaries).

See How Do Particulates Enter the Respiratory System? for a diagram and more details.

Oxygen in the inhaled breath crosses the alveolar walls to enter the blood. Once oxygen has become attached to the blood inside the veins, it is then distributed throughout the body. Chemical vapours, gases, and mists which reach the alveoli in the lungs can also pass into the blood and be distributed around the body.

Sometimes, the concentration of chemicals reaching the alveolar air sacs is lower than in the workplace air. This difference in concentration occurs because the airways contain a lining of sticky, thick fluid called mucus. Tiny hairs, known as cilia, on the inside of the tubes constantly carry this mucus upwards toward the back of the throat. In some instances, a portion of the gases, vapours and mists may be dissolved in this mucus before they reach the alveolar sacs.

Solid, visible particles (found in dusts, fumes, and smoke) that have escaped the filtering mechanisms of the nose may also be trapped by the mucus. The mucus is propelled by the tiny cilia hairs until it reaches the back of the throat where it is either expelled through the mouth or swallowed and passed to the stomach. If it passes into the stomach, the chemical will enter the body in the same way as contaminated food or drink. This route of exposure is dealt with in more detail in the section below on swallowing (ingestion).

Much smaller particles (so small that they cannot be seen by the eye) may not be stopped by the mucus in the trachea and bronchiole tubes. They travel through the various branches of the airways and eventually reach the alveoli. Solid particles which cannot pass through the thin wall of the air sacs may lodge and stay where they are. Some may dissolve, and others may be attacked and destroyed by the scavenger cells of the body's defence system. Others may prove too big or too insoluble to be disposed of in this way and simply stay in the air sacs. Some of these particles, if they are present only in small quantities, do no apparent harm. Other types of dusts may damage the surrounding alveolar walls. The damage may be permanent and may cause scars, which eventually interfere with the lung's ability to pass oxygen into the bloodstream.

Some acids, bases, or organic chemicals, when inhaled in sizable amounts, can cause serious and irreparable "burn" damage to the mouth, nose, trachea, bronchi and lungs.

How are chemicals inhaled?

Gases and Vapours

Workplace chemicals can enter the air in a number of different ways. Simple evaporation is probably the most common way. Organic solvents, such as toluene, methyl ethyl ketone (MEK), or alcohols, generally evaporate more rapidly than water, acids, or bases, although this situation is not always the case. Evaporation produces vapours. Vapours are formed from products that exist as solids or liquids under normal temperature and pressure conditions. Products that do not exist as solids or liquids at normal temperatures and pressures are called gases. Gases, as well as vapours, can contaminate the workplace air.

Mists

In some instances, an industrial process might produce tiny liquid droplets that are able to float in the air. These droplets are called mists. Mists are formed by gases that condense into small liquid droplets in the air. Alternatively, mists may form by breaking up, splashing, or atomizing a liquid. Examples include acid mists from electroplating, oil mists from cutting and grinding, or paint spray mists from painting operations.

Dusts, fumes and smoke

Other workplace processes can generate tiny solid particles which are light enough to float in the air, and these particles are referred to as dusts, fumes and smoke. Dusts are solid particles often generated by some mechanical or abrasive activity. They are usually heavy enough to settle slowly to the ground. Fumes are very tiny solid particles which can remain airborne, and are formed when a heated metal has evaporated in the air and then condensed back to a solid form. Fumes can occur in welding operations. Smoke is carbon or soot from burning. Smoke particles can settle or remain airborne depending on their size.

How can a chemical enter my body through the skin?

The skin is the second most common route by which occupational chemicals enter the body. Chemicals which pass through the skin are nearly always in liquid form. Solid chemicals and gases or vapours do not generally pass through the skin unless they are first dissolved in moisture on the skin's surface.

The skin consists essentially of two layers, a thin, outermost layer called the epidermis and a much thicker underlayer called the dermis. The epidermis consists of several layers of flat, rather tightly-packed cells which form a barrier against infections, water, and some chemicals. This barrier is the external part of the epidermis. It is called the keratin layer, and is largely responsible for resisting water entry into the body. It can also resist weak acids but is much less effective against organic and some inorganic chemicals. The keratin layer contains fat and fat- like substances which readily absorb chemicals which are solvents for fat, oil, and grease.

Organic and alkaline chemicals can soften the keratin cells in the skin and pass-through this layer to the dermis, where they are able to enter the bloodstream. Areas of the body such as the forearms, which may be particularly hairy, are most easily penetrated by chemicals since they can enter down the small duct containing the hair shaft. Chemicals can also enter through cuts, punctures or scrapes of the skin since these are breaks in the protective layer. Contact with some chemicals such as detergents or organic solvents can cause skin dryness and cracking. There can also be hives, ulcerations or skin flaking. All these conditions weaken the protective layer of the skin and may allow chemicals to enter the body.

Chemicals can vary enormously in the degree to which they penetrate the skin. Some solvents may soften the keratin layer but are not believed to penetrate much further unless there is prolonged skin contact. Other chemicals can readily pass through the epidermis and subsequently enter the bloodstream. Some chemicals are so corrosive they burn holes in the skin, allowing entry for infection or other chemicals.

How can chemicals enter my body through my eye(s)?

Although eye splashes or eye contamination by workplace chemicals is fairly common, chemicals usually do not enter the body this way. Small amounts of chemicals may enter by dissolving in the liquid surrounding the eyes, and larger, but probably not significant amounts, may enter the eyes if they are splashed with chemicals.

The eyes are richly supplied with blood vessels and many chemicals can penetrate the outer tissues and pass into the veins. The eye may or may not be damaged during this process, depending on the corrosive nature of the chemical and its ability to penetrate the outer tissues.

How are chemicals swallowed (ingested)?

Chemicals can enter the stomach either by swallowing contaminated mucus which has been expelled from the lungs, or by eating and drinking contaminated food. Food and drink are most frequently contaminated by contact with unwashed hands, gloves or clothing, or by being left exposed in the workplace. Nail-biting and smoking can also contribute to exposure.

Once inside the mouth, chemicals pass down the esophagus and then into the stomach. Some chemicals, such as alcohols, may pass across the stomach wall and enter the bloodstream here, but most chemicals move from the stomach into a long, twisting tube known as the small intestine. The inside of the small intestine has many hundreds of tiny finger-like projections called villi. The villi have very thin walls and are filled with tiny blood vessels. This formation allows some ingested chemicals to pass from the small intestine across the walls of the villi and enter the veins. The chemical is then carried around the body by the bloodstream.

Some chemicals, which are not soluble or whose basic units (molecules) are too big to pass across the villi walls, will stay in the gut and pass out of the body in the feces without being absorbed into the bloodstream to any extent.

Some acids, bases and organics may cause severe "burn" damage to the digestive system if swallowed in high concentrations.

What happens when the skin is penetrated?

Injection is the fourth way chemicals may enter the body. While uncommon in most workplaces, it can occur when a sharp object (e.g., needle) punctures the skin and injects a chemical (or virus) directly into the bloodstream.

In some instances, chemicals may enter the body by unintentional injection through the skin. This situation may occur in hospital settings (e.g., needlestick injuries) or in industrial hole-punching or injection processes. Once in the bloodstream, these chemicals can be transported to any site or organ of the body where they may exert their effects.

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