



## Theoretical Determinants of Laboratory Spill Prevention: an Overview

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### ABSTRACT

Laboratory spills are a significant concern in healthcare settings, posing risks to personnel, patients, and the environment. This review explores the theoretical determinants of laboratory spill prevention, focusing on the Health Belief Model (HBM) and Socioecological Model (SEM). The HBM highlights the importance of perceived susceptibility, severity, benefits, and barriers in influencing laboratory workers' behavior. The SEM emphasizes the interplay between intrapersonal, interpersonal, institutional, community, and public factors in shaping laboratory workers' adherence to spill prevention guidelines. Understanding these theoretical frameworks can inform strategies to promote safe laboratory practices, including education, provision of personal protective equipment, and institutional support. Effective laboratory spill prevention requires a multifaceted approach that addresses the complex factors influencing laboratory workers' behavior.

## **INTRODUCTION**

Laboratory spills are a significant concern in healthcare settings, posing risks to personnel, patients, and the environment. The handling of hazardous chemicals and materials in laboratories requires strict safety protocols to prevent accidents and minimize harm. Laboratory spills can occur due to various factors, including human error, equipment failure, or inadequate safety measures. Understanding the causes and consequences of laboratory spills is crucial for developing effective prevention strategies. This review explores the theoretical determinants of laboratory spill prevention, highlighting the importance of education, personal protective equipment, and institutional support in promoting safe laboratory practices.

## **LABORATORY SPILLS**

A spill is an amount of liquid or chemical that is accidentally poured in the laboratory or other areas. Laboratory spill involved an accidental pouring of chemicals in the laboratory. Spills can be minor or major ones. The minor spill refers to any spill that is small, can be easily cleared by laboratory personnel (worker), and is limited to an area, and cause minimal hazard (if there is any). Major spill involves an easy spared to another area of the environment. Major spill has the following features:

- It is in large quantity
- It is Highly hazardous
- It cause widespread contamination
- It poses significant risk
- May need the attention of regulatory bodies or other agencies such as fire services
- Laboratory workers are supposed to be evacuated
- Immediate action is needed

However, minor spill may have the following features:

- It is in small quantity of the spilled chemical
- Low risk of hazard is a typical feature
- It can be easily contained (Santra, 2017).

## **Properties of chemicals of spill**

Chemicals in the laboratory stay as solid or liquid or gas. Solid chemicals possess definite volume and shape, liquid chemical has certain volume but no shape. On the other hand, gas chemical has no shape or volume, rather occupy the container. Some solid chemicals upon gaining required kinetic energy turn to liquid, while traverse directly to form gases in a process dubbed as sublimation. Some chemicals (liquids) molecules obtain kinetic energy (become excited) and break away or evaporate. Movement of chemical spills from region of higher concentration to the region of lower concentration is termed as diffusion. Diffusion encourages spilling and distribution of chemicals, and occurs in liquids, gases, and solids as well (Santra, 2017). Some hazardous chemicals that may spill in the laboratory due to carelessness are enumerated in Table 1.

**Table 1: Some hazardous chemicals that may spill in the laboratory due to carelessness**

S/N	General nature of chemical	Description
1	Reactive chemicals	They potentially easily react with others, and mostly vigorously. The reaction may be accompanied by light, fire, heat, and toxic chemicals release. Oxidizers react and supply oxygen to fire, example nitrate salts. Water reactive chemicals react vigorously with water, for example, lithium, potassium, and sodium. Peroxides have peroxides in their typical names. Pyrophonic chemicals have the potential of igniting through contact with air for instance, alkyl lithium, yellow or white phosphorus.
2	Shock sensitive explosives	They are chemicals that explode spontaneously due to shock such as being dropped, struck, heated, agitated, and vibrated. For instance, carbides, selenium, mercury, nitrate, bromate, chlorate, lead tetrachloride, ammonia, and many more
3	Flammable chemicals	They are combustible as a result of fast evaporation. They easily cause fire, for instance, acetone, ethanol, ethyl ether, hexane, benzene, toluene, carbon disulfide, ethyl acetate, xylene, etc.
4	Corrosive chemicals	Easily cause damage to tissue, for example, chromic acid, sodium hydroxide, sulfuric acid, potassium hydroxide, etc.
5	Irritants	Cause irritation , for instance, halogens, phosgene, alkaline dusts, ammonia, hydrogen chloride, etc

6	Hepatotoxic	Damages the liver for example carbon tetrachloride, nitrosamines, etc
7	Nephrotoxic	Damages the kidney, for example, uranium, halogenated compounds
8	Neurotoxic	Damages the nervous system for example, manganese, thallium, carbon disulfide, tetraethyl lead, methyl mercury, etc

Source: Santra (2017)

### Responses to chemical spill

When chemical spill, basically the following major actions are to be taken include, leaving and demarcating or controlling the affected area, helping the injured (if there is any), making preliminary check or investigation, cleaning the spill, and preventing the occurrence (Salgar et al., 2023). If the spill had contacted eyes, it should be washed immediately and properly, and medical attention sought without reluctance. Ingestion of spilled chemicals needs the victim to seek for medical attention as well.

### Personnel safety outfits and spill prevention

Personnel safety outfits include protective goggles, laboratory coat, and good gloves (Salgar et al., 2023). Therewith, strategies to reduce or prevent spill are enumerated as follows:

- Ensuring that laboratory users utilized personal protective measures including safety goggles, laboratory coat, gloves, and proper garment. The basic safety rules such as no food or drink, hygiene, staying focused, understanding safety of equipment, proper labeling of chemicals, should be imbibed.
- Ensuring that the laboratory is neat and organized
- Conducting procedures purely according to manual
- Always closing reagent chemicals except when pouring out chemicals during use
- Using laboratory containment in the course of transferring chemicals (Kambade et al., 2023; Salgar et al., 2023).
- Maintaining standard operation procedures (Salgar et al., 2023).
- Capacity building of laboratory workers (Salgar et al., 2023).
- Ensuring access to clean and sufficient water supply in the laboratory (Sarkingobir, 2025a).

### Theoretical determinants of laboratory spill prevention

Theory refers to ideas intended to describe or explain facts or events. Theories help us to comprehend laboratory spill. Here prevention of laboratory spill could be understood using two public health or human behavior theirs, namely, health belief model and socioecological model.

### Health Belief Model (HBM)

Accordingly, the Health Belief Model (HBM) is among the pioneer theories being utilized in understanding human behavior in health sciences and

quasi. Health Belief Model (HBM) has major components that are explained in Table 2. However, the best way to incite laboratory workers and related officers to follow laboratory spill prevention tips is to give them two things, namely education or awareness, and enough and sufficient laboratory hardware and equipment.

**Table 2: Health Belief Model (HBM) major components**

S/N	Component	Description of application in laboratory spill prevention
1	Perceived susceptibility	Perceived susceptibility refers to the belief of the laboratory worker or relations that he/she may be inflicted by laboratory hazards
2	Perceived severity	Perceived severity refers to the belief of the laboratory worker that they may affect him/her severely. Workers or administrators who agree that laboratory spill or hazards may likely affect them seriously are more likely to heed to laboratory spill prevention tips during the management of any laboratory dealings
3	Perceived benefits	Perceived benefits refer to the value of following prevention guidelines. Workers who believed that following laboratory guidelines help sufficiently in preventing laboratory spill and hazards are more likely to heed to prevention.
4	Perceived barriers	Perceived barriers refer to the obstacles that may prevent the workers from following laboratory guidelines, for instance lack of safety protection equipment.

Source: Sarkingobir (2025b)

**Socioecological Model (SEM)**

Socioecological Model (SEM) requires that for a laboratory worker to follow spill prevention tips, there must be interaction of two general aspects, the self and the environment. The specific components of SEM applied to understanding laboratory spill prevention are explained in Table 3.

**Table 3: SEM and its major components**

S/N	Component	Description as applied to laboratory spill
1	Intrapersonal factors	These factors consist of personal knowledge, belief, and self-concept. This is in-line with the level of education of the worker or administrator. Therefore, people who are more educated such as laboratory scientists, fellow of medical laboratory science, PhD holders, professors in the field or relations are well-trained, and passed through various professional development training act positively to abide by laboratory spill prevention tips.
2	Interpersonal factors	This refers to the peers that are within the laboratory workers. Working along with professional colleagues encourage the worker to abide by professional ethics
3	Institutional factors	The institutional factors include the bodies or institutions such as hospital or colleges administrators that are mandated by the law to provide sufficient and efficient laboratory equipment and personal protective equipment utilized in laboratory spill prevention
4	Community factors	These refer to the professional bodies that regulate or monitor the training of laboratory workers. They are responsible by the law to help in providing guidance and license for training of laboratory workers, and assist them with seminars, conferences, workshops or relations. They are also deemed to advocate for the rights of laboratory workers and excite governments to equip laboratories properly.
5	Public factors	Public factors refer to the government responsible for building and equipping laboratories. They are also responsible for rewarding, employing, and punishing laboratory workers according to law.

Source: Adapted from Barth et al. (2021) and Sarkingobir (2025b)

## **CONCLUSION**

In conclusion, laboratory spill prevention is a critical aspect of laboratory safety that requires a comprehensive approach. By understanding the theoretical determinants of laboratory spill prevention, including the Health Belief Model and Socioecological Model, laboratory workers and administrators can develop effective strategies to promote safe laboratory practices. Education, provision of personal protective equipment, and institutional support are essential components of a successful laboratory spill prevention program. By working together, we can reduce the risks associated with laboratory spills and create a safer environment for laboratory workers, patients, and the community

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