

**Tran Uyen & Thao Vu**

**CHEMICAL SUBSTANCES AND THEIR SIDE EFFECTS ON  
NURSES' HEALTH**

**A Literature Review**

**Thesis**

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## ABSTRACT

<b>Centria University of Applied Sciences</b>	<b>Date</b> December 2020	<b>Authors</b> Tran Uyen & Thao Vu
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<b>Name of thesis</b> CHEMICAL SUBSTANCES AND THEIR SIDE EFFECTS ON NURSES' HEALTH: A literature review		
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<b>Supervisor</b> Timo Kinnunen		
<p>The thesis purpose was to observe the dangers of hazardous chemical substances and how to manage problems in the health care setting. The aim of the thesis was to address the side effects of chemical substances on nurses' health, and how to prevent those side effects in hospitals.</p> <p>The study was done by using the literature review. Strict inclusion and exclusion criteria were utilized to ensure the quality of data. A content analysis was performed, and data has been collected and analyzed from relevant sources based on their particular issues, area of research, or theory. By using systematic literature review method, the collected data was analyzed. The data was collected by using Centria's databases, such as CINAHL (EBSCO), Science Direct, PubMed and SAGE journals. 23 articles were used in the literature review by applying inclusive and exclusive criteria. The authors chose articles which were published no more than ten years ago to update latest information.</p> <p>The results of the study are divided into two parts which are the impacts of chemical substances and the management of how to avoid chemical hazards in the working environment. Chemical exposure affects every aspect of nurse's health. For example, respirational failure, biological change, reproductive health, allergic reaction, and neurological damage are the main side effects of chemical hazards. The core findings of the research include the prevention of chemical exposure in the hospital. For example, personal protective equipment (PPE) should be applied in a working environment.</p> <p>The conclusion of this study highlights the importance of management and the need to understand profoundly negative effects of chemical substances.</p>		
<b>Key words</b> Chemical hazards, chemical substances, disinfectants, hazardous drugs, literature-review, nurse's work in hospital, prevention, radiological procedure, safety issues.		

## CONCEPT DEFINITIONS

ASHP	American Society of Health- System Pharmacists
COPD	Chronic Obstructive Pulmonary Disease
FPE	Facial Protective Equipment
HDs	Hazardous Drugs
LMICs	Low- and Middle-Income Countries
MRI	Magnetic Resonance Imaging
NIOSH	National Institute of Occupational Safety and Health
ONS	Oncology Nursing Society
OSHA	Occupation Safety and Health Administration
PPE	Personal Protective Equipment
UAS	University of Applied Sciences
WHO	World Health Organization

**ABSTRACT**  
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## 1 INTRODUCTION

Chemical substances, in essence, are any material that have a definite chemical composition. Chemical substances are seen as a significant function in the life on earth because of their beneficial economy. (Apatsidou, Konstantopoulou, Foufa, Tsarouhas, Papalexis, Rezaee, Spandidos, Lourtas & Tsitsimpikou 2018.)

In recent decades, chemical substances have emerged as significant substance health care environment. It, without doubt, is applied in pharmaceutical progress, cleaning products, food processing. Because of this convenience, a growing trend of using these substances has received a great deal of public attention. Chemical substances play an important role in nursing job. There are a great number of reasons why chemical substances have capabilities in any industrial field. (Apatsidou et al. 2018.)

It is obvious that hospital is such a place where unexpected health hazards rapidly become a familiar term to any nurse. There is no doubt that it obviously happens because of chemical substances. They are ubiquitous in the hospital environment. Furthermore, health care sector is the largest user of chemical substances. Many chemicals are used by the health sector for specific purposes such as treating patients, disinfection and sterilization. Yet, an increasing number of using these kinds of agents in hospitals is a growing risk for nurses being in exposure to plenty of elements that would do harm to one's health. (Gorman, Dropkin, Kamen, Nimbalkar, Zuckerman, Lowe, Szeinuk, Milek, Piligian & Freud 2013, 6-7.)

It is important for nurses to know how risky it might be when being regularly exposed to hazardous chemicals. Although there are clear instructions, explained in a way that could be understood by common sense, nurses should still protect themselves because the risk of the substances can lead to serious consequences. Nurses may be considered vulnerable because they could be more at risk from chemical substances than any other group. As the ones who directly deal with chemicals every day, nurses have a high risk of developing related diseases. (Manyele, Anicet, Chibunda, Mkungu, Kayenze, Katorogo, Dauda, Chuwa, Mollel, Hokororo, Muyombe & Kajwangya 2012.)

Chemical substances are illustrated like cleaning material, specialized medication and medical waste. Most of them are absorbed through breathing, touching, and/or through the eyes. Long-term working nurses are more likely to be exposed to health hazards. The amount of chemical substances that enter

the body will be stated in person's health condition. Headaches, nausea, vomiting, rashes, allergic reactions are the first symptoms to be noticed when being in contact with toxic substances for a long time or without any protection. Chronic illnesses may occur as asthma, dermatitis, nerve damage or cancer. In addition, the chemical agents can affect straightforwardly the nervous system and the nervous system is the most damaging effect of chemical substances. (Manyele et al. 2012.)

Managers of the workplace should be responsible for administering safety instructions and reducing the risk of being exposed to hazardous chemicals. Short courses and educational plans should be provided to nurses in order to renew their knowledge about managing chemical substances. The health of the nurse is as important as the safety of the patient. As nurses take care of the patients, their well-being should as well be taken care of. The responsibilities belong to supervisors, nurses, and staffs. A guideline should be published to help nurses to identify safer alternatives. (Safe Work Australia 2012.)

The purpose of this thesis is to study the danger of chemical substances in hospital and how to manage with them. Authors chose this topic because it approaches to nursing and the health of nurses. The goal is to figure out the effects of chemical substances and to find the ways how to manage the use of a chemical substances in order to reduce its harmful consequences on nurses' health. By using chemical substances in the health care environment, a portion of harmful meaning will decrease dramatically. At the same time, the authors want to conduct the study as clearly as possible in order to publish available sources.

## 2 NURSES WORKING AND REGULATION USING IN THE HOSPITAL

### 2.1 Nurses Working in The Hospital

According to the Act on Health Care Professionals, the registered nurse is fully educated with a certificate. That is why their wellbeing are important and they need to be protected. Without them, the stable condition of the patient will be absented. They act as the connector between doctors and patients. And under the working conditions, the high risk of dealing with chemical substances are even more. The health of nurses is a consideration in the workplace because their elated to health, social wellbeing, and quality of working lives. (Walton, Eisenberg & Friese 2017.)

According to Ensio, Lammintakanen, Härkönen & Kinnunen 2019), nurses command trust and respect, and are the most trustworthy professionals, whom patients and their families have ever known. In the health care environment, nurses must be ready to complete a comprehensive physical and mental assessment. Although working conditions vary with the place of employment, nearly all nursing jobs involve close contact with people. Good health and emotional stability are valuable assets. Nurses must be careful workers who take their responsibilities seriously. They must follow rigid guidelines to ensure the health and safety of themselves and their patients. In Finland, there is a great range of demand that nurses in general practice have to adopt, they are decision-making process, critical thinking, both strong mental and physical. (Ensio, Lammintakanen, Härkönrn & Kinnunen 2019.)

By repairing the medicines, even handling vaccine, nurse takes risk from those actions. Thus, nurses must be aware of any dangerous substances surrounding them daily, especially chemical agents in general, and hazardous drugs (HDs) in particular. These should, where possible, be highly taken into account under legislation. Legislation, where necessary, for identifying risks associated with hazardous substances. Nurses have to aware of how to handle chemical substances in a safe manner.

Nevertheless, nurses face several workplace hazards, such as exposure to blood-borne pathogens, both mental and physical injuries, hand washing dermatitis, cold and flu. However, chemical hazards are one of the most dangerous hazards. Because of their science-based practice, nurses understand the connection between the environment, human health, and disease. Workplace exposures handling dozens of chemicals, drugs, and cleaning agents also make nurses increasingly vulnerable to incurring health risks associated with long-term exposure to these chemical agents. Nurse practitioners must exercise vigilant

readiness to care for them as victims of chemical injuries. It is obvious to see that chemical substances commonly as cleaning agents, or even medicine. This means that available legislation from workplace will significantly improve the safety when dealing with chemicals regularly.

## **2.2 Typical Regulations Used in Hospitals for Nurses**

Because of the danger of chemical agents, the workplace's staff publish the risk management for nurses to follow; therefore, they gradually know how to protect themselves. The risk management follow four steps: hazard identification, risk assessment, risk control and monitoring, and review. Firstly, the hazard identification is the step from which the nurses can know about the hazards in the workplace. Secondly, the risk assessment is the step from which the hazard is considered for higher risk of health. Thirdly, the risk control is the step from which the hazard is under controlled and decreased in some way. Finally, the step is illustrated to the finish paper and how the paper can work smoothly in the workplace. The nurse should consider where and how the chemical substances are contained. The nurse should be reminded to look if there are any specific warnings in the ward. (Pagura 2016.)

By focusing on restricting the chemical hazards in particularly, the nurses always take into consideration the chemical hazards. When the nurses deal with the chemical hazards, they should use gloves even mask to restrict the risk. Besides, the nurses must remember if they put the chemical waste in the right place or not. It is important to remind each other. For example, the nurse should follow the waste storage with different colors of plastic bags. (Ali, Wang & Chaudhry 2017.). In addition, laboratories waste is dangerous waste because it is contaminated. Laboratories wastes also use the same method as above. For example, the blood after lab goes directly into a sanitary sewage and urine/stool goes through sewage system also (Askarian, Motazedian, Palenik 2011).

According to the Ministry of Social Affairs and Health, Finland (2020), nurses always have to follow the safety instructions provided by the employer. Many hazardous chemicals are used in healthcare settings, for a variety of reasons: to treat patients in medications and anesthetic agents; to clean, disinfect, and sterilize surfaces and supplies, for example cleansers and/or disinfectants. It is important that the drugs used to treat patients can have unintended consequences for workers, especially who are exposed to them when they prepare and administer solutions or are exposed to the off gassing of anesthesia and aerosolized breathing treatments. Indeed, pharmaceuticals can be a hazard to the community when they are improperly disposed of. (Ministry of Social Affairs and Health 2020, 10.).



Particularly, in the past several years, the control of chemical hazards in hospitals must be based on principles of good occupational health practice. The very first step of hazard control is the equipment needed, nurses should always wear gloves that are protective against the hazardous drug they are using. Gloves are required during handling of HDs e.g., drug preparation, initial administration, changing of IV bags, and discontinuation of chemotherapy and other HDs. If there is a potential for leaking or splashing, such as during compounding and administration, double gloves are required. Nurses must wash their hands before donning and after removing gloves. Gloves or clothing that become contaminated must be changed as soon as possible. Employees must be trained proper methods to remove contaminated gloves and gowns. (Ministry of Social Affairs and Health 2020, 10-11.).

### 3 DEFINITION OF CHEMICAL SUBSTANCES USED IN HOSPITALS

According to the Swedish Chemicals Agency, chemical substances are solids, liquids or gases form of characteristic compositions and chemical elements. They could be in any form of matter as long as the chemical bonds remain unchanged. (KEMI, Swedish Chemicals Agency 2019.) Chemical substances play huge part in daily life. Every year, about 1,000 new chemicals are being utilized, more than 100,000 substances are used globally, and many of these, if not being handled carefully, may do harm human health or the environment. There have been several national and international schemes founded and established in the last 50 years. During the Rio Earth summit in 1992, the globally harmonized technique for the categorization and characterization of chemicals was selected and approved to prevent confusion for users.

Chemicals that are considered hazardous are mixtures, groups, or procedures of hereditary properties of the substance that having ability to admit the harmful effects to living organisms or the environment. Those that may lead to short- or long-term damage to people's health related to dangerous chemicals could be divided into two categories of hazards: health hazards and physicochemical hazards. The latter consists of flammable, destructive, explosive, chemically reactive and oxidizing chemicals that would do harm to people and/or damage to valuable possessions and belonging due to elemental physical endangerment by inappropriate use or handling of the consumer. Chemicals causing health hazards - adverse effects can be acute or chronic injury/illness, including nausea or vomiting, headaches, skin disintegration (acute); asthma, dermatitis, impairment of the nerves or even cancer (chronic) - normally be exposed through direct skin contact, inhalation or ingestion. There are many chemicals that carry both types of risk. (Safe Work Australia, 2012.).

Many hazardous chemicals are used in the hospital, cleaning agents, for instance, during the cleaning activities in hospital. These substances do not include sterilize and disinfect surgical and/or medical instruments. The more frequent contact with chemical substances, higher the risk of injuries. Cleaners, staff and especially nurses are the groups which are affected by chemical substances. The health is affected negatively, for example, the eyes. (Gorman et al. 2013.).

Hygiene is a matter of life and health, especially within the hospital environment. It is definitely important in the hospital and nothing can be left to change. All professional members assure the highest standards of safety and cleanliness. Proper cleaning, disinfection and sterilization of tools and equipment

are important in limiting the transmission of microorganisms from reused equipment. The level of disinfection depends on the risk of infection when the device is reused. As a result, the importance of using some kinds of chemical agents are compulsory measures.

### 3.1 Disinfection

Disinfection is commonly used in hospital. In general, disinfection is the process of cleaning, especially with a chemical, in order to reduce or even destroy bacteria. Disinfection is the term for destruction of microorganism, except bacterial spores, and on inanimate objects, for example, medical devices such as endoscopes. (Government of South Australia 2017.)

In addition, there are three common types of disinfectants in hospital, which are low level of disinfectants, medium level of disinfectants, high level of disinfectants. Firstly, low-level disinfection is totally used for noncritical patient care surfaces such as bedrails, over the bed table, and equipment that directly touch intact skin. Low level of disinfectants is Ammonium compound grade 4, Phenol, Hydrogen peroxide 3%, those disinfectants have a key role in keeping the surfaces are imperceptibly contaminated or soiled. Commonly, herpes simplex, varicella-zoster virus, rubella virus, influenza virus, B and C hepatitis virus would be sensitive to those low-level of disinfectants; therefore, chance for transmitting of those diseases would be limited. (Government of South Australia 2017.)

Secondly, medium level of disinfectants are alcohols, Chlorines, Iodophors. According to effect on forms of microbes, medium level partly helps with destroying; however, it is not resistant to bacterial spores so far. Intermediate disinfectants have a capability of killing mycobacterium tuberculosis var.bovis. In particular, this bacterium is very resistant to chemical killing and is a hallmark microbe for disinfectants, much like bacterial spores are for sterilant. Similarly, intermediate ones are water-based phenolics, alcohol-based phenolics, iodophors, sodium hypochlorite and other chlorine compounds, and alcohol-based quaternary ammonium compounds. These disinfections are used in dentistry as surface disinfectants. (Rutala & Weber 2019, 3-9.)

Last but not least, high-level of disinfection contains Gluta-aldehydes, Peracetic acid, hydrogen peroxide 6%, Formaldehydes (use limited). According to Rutala & Weber (2019, 3-9), a high-level disinfectant is a chemical solution that can kill low level of bacterial spores at the contact time recommended for disinfection on the production label (usually 45-90 minutes for example). Nevertheless, with an extended

contact time (10 hours, for example), the high-level disinfectant becomes a liquid sterilant able to kill high levels of bacterial spores. Specially, those high-level agents are commonly to be used as immersion products and medical devices, but not for surface disinfection (such as laboratory benches or floors). This procedure kills vegetative microorganism and inactivates viruses.

All in all, disinfection maintains the safety during medical care treatment in hospital, and it certainly contributes to reduce the percentage of infection. Yet, those disinfectants should be used under tight and clear instruction.

### **3.2 Specialized Hazardous Drugs**

Medicine is obvious to discover; yet it seems notably clear. As a result, there are four outstanding systems of organizing those groups basing on their purposes. Medicines, obviously, arrange by their therapeutic use, it means that the types of condition they are treating. Besides that, they also could be arranged by their mechanism of action, meaning the specific biochemical reaction that occurs when taking a medicine. Medicines, in another way, could be classified by their mode of action, meaning the specific way in which the body responds to medicines. Cleverly utilizing chemical structures of medicines, people could eventually put medicines into the final group. With a systematic structure above, people, somehow, could easily got idea of medicines. Medicine, in general, has a superb strong relationship with medical care treatment, which plays a huge role in health care system. (World Health Organization 2020.)

According to Alberta Health Services & Covenant Health (2019,1), by going into hospitals, nurses allow plenty of injuries, health risks and illnesses simultaneously affects their health. Among those hospital hazards, hazardous medication can be seen as a outstanding example. In general, hazardous chemicals can be defined based on Occupation Safety and Health Administration (OSHA's) conception. It can be seen as antivirals, hormone therapy or those used for cancer treatment. They lead to health failure, such as acute or chronic health effects. Moreover, a drug will become hazardous drug if it displays one or more following characteristics, based on American Society of Health System Pharmacists (ASHPs): genotoxicity, carcinogenicity, teratogenicity or fertility impairment, or even serious organ failures. On the one hand, the National Institute of Occupational Safety and Health (NIOSH) divided drugs into HDs if they satisfy one or more following six characteristics: carcinogenicity, teratogenicity, other development toxicity, reproductive toxicity, organ toxicity at low dose. Additionally, it leads to worse outcome

than others because of the direct contact to preparing or administering by health care worker, especially nurses. (Alberta Health Services & Covenant Health 2019, 1.)

Also, the study by Alberta Health Services & Covenant Health (2019, 11), divided hazardous medication into 3 groups, namely known hazard medication, potential hazard medication and reproductive hazard medication, which respectively means antineoplastic medication, non-antineoplastic medication, and non-antineoplastic medication. (Alberta Health Services & Covenant Health 2019, 11.)

Similarly, cancer medication is a crucial element of health risk. Fundamentally, cancer is the common name for a set of related diseases. In any cancer case, there is always the appearance of abnormal cells, which are basically cells of the body; nevertheless, they have a tend to divide, multiply out of control (WHO 2018, 14). It means that those abnormal cells eventually invade surrounding tissues and possibly metastases transfer from one part of the body to another via blood vessels. The method is applied to treat cancer is chemotherapy. It can be understood as a drug treatment, which uses power chemicals to kill fast-growing cells in the body. The latest research of Alberta Health Services & Covenant Health (2019, 11) showed that nurses have a higher risk to diminished health by manual dealing such as formulating the doses or even supervision during the giving time. Moreover, by accidentally touching patient-related objects or medical instruments is an example for the way how nurses could face to unsafe medicine. (Alberta Health Services & Covenant Health 2019, 11.)

### **3.3 Radiological Procedure**

Radiology is used in numerous purposes such as diagnosis tool in the health care setting. Radiology is a medical tool which utilizes imaging to diagnose and treat diseases seen within the body. Accordingly, radiologists use a variety of imaging techniques such as X-ray, ultrasound, computed tomography (CT), nuclear medicine including positron emission tomography (PET), and magnetic resonance imaging (MRI) to diagnose and/or treat disease. According to Mohanty, Kabi & Mohanty (2019, 2568-2572), this radiation of ionizing from all radiologist actions are negatively affected and harmful the health care staff. Nevertheless, those techniques which do not use ionizing radiation such as ultrasound and MRI have minor power; thus, it has not many dangers compared to others. (Mohanty, Kabi & Mohanty 2019, 2568-2572.)

#### **4 PURPOSE, AIM AND RESEARCH QUESTIONS**

The thesis purpose was to identify the risks of using chemical substances in hospitals and recommend useful guidance to deal with this matter. The aim of thesis was to the prevention of chemical hazard in hospitals. By safe using chemical substances, a portion of negative effects will decrease dramatically. At the same time, the authors want to conduct the study as clear as possible.

##### **THE RESEARCH QUESTIONS**

1. How can nurses be affected by chemical substances in hospital?
2. How the chemical substances can be prevented in a hospital?

## 5 METHODOLOGY

This thesis was written and summarized by using the literature review technique. All the data was collected and analyzed from different scientific resources.

### 5.1 Literature Review

The literature review uses the summary and evaluation tool. This method is a synthesis of information relevant to the researchers' work and the background as well. Through this method, the researchers clarify understanding of the field then explain the rationale for research. In addition, the key concepts and unique ideas are defined as clear as possible. The literature review is an interesting method which help the researchers to summarize a large amount of information into one paper without misunderstanding about the main topic. (Levy & Ellis 2006.)

The authors have conducted this thesis mostly by the traditional literature review and systematic literature review method. Writing a literature review means gathering information and data from articles, reports, journals, and other scientific resources, then with personal evaluation, all materials and databases will be analyzed and refined in order to generate new perspective or distinctive aspect that makes a diverse contribution to the topic (Shreshtha 2016, 11; Winchester & Salji 2016).

It is a critical method to summarize and combine all evidence-based data collected from reliable sources and the writer's own appraisal. According to Jill K Jesson, Lydia Matheson and Fiona M Lacey in one study in 2012, there are two main forms of literature review: traditional literature review and systematic literature review. Six subcategories were given as examples of the traditional way to approach: critical, conceptual – known as synthesis of theoretical knowledge, state-of-the-art – which is the advanced or the most recent study, expert – or an acknowledged authority and scoping – which establishes a picture for future examination, they could all be inclusive and perceptive. The systematic review was updated with the gold standard, in which addresses more of a precise analytic question by associating and combining conclusions of several clinical experiments and trials, often carried out by a group of people rather than one single person. (Winchester & Salji 2016; Jesson et al. 2012.) The traditional way of literature review aims to be contemplative and deliberate, however, it may generate a one-sided review even with many ways of approach. Nevertheless, systematic literature review is a convenient tool to help notice

the gap between researchers' knowledge as well as judgement towards the topic, also helps explain the study to the audience in a more professional way with hypothesis and standardize method by illustrating its target and straightforward to the point (Jesson et al. 2012, 14-15).

The meta-analyses and systematic literature reviews are known to be the main element of evidence-based healthcare. Meta-analysis is described as a statistical technique that compares various results of accumulated research. It has been known to be effective in the history of medical and pharmaceutical studies, as the field is broad with an immense amount of knowledge needed to be processed. (Jesson et al. 2012.) The authors have used both the systematic and the traditional way of literature review method to conduct this thesis. Besides the traditional way of literature review, the systematic review is a specific kind of literature review that helps the writer to have more convenience during the research process. It is: "*A review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyze data from the studies that are included in the review*" (Cochrane Collaboration, 2014).

In order to develop an idea for any controversy and questions of the subject, conducting a systematic literature review is fundamental to fortify what has already been consulted and researched about the subject, as well as being able to identify any lack of insight, and to what degree the thesis could provide and contribute to further comprehension. This is how the researchers could extend the theory and hypotheses parts, also to form the analysis questions. (Winchester & Salji 2016.)

After the research has been written, it is, likewise, important making a literature review to assess and evaluate all databases, also decide whether they were appropriate or related to the topic. Considering writing the thesis without a particular framework, the entire information collected could be pointless. A literature review helps the researcher to learn from other studies that contribute or justify each other along with every various outcome, with the result that the study can be distributed to the topic of the study. Dissemination of the findings of the research will use materials and data collected from a literature review, either by advertising, publication in a peer-reviewed article or by oral presentation, therefore contributes comparison ideas as well as reference points of the latest information, also guides the author to define and deliver research that has promising meaning to the related study field. (Winchester & Salji 2016.)



## 5.2 Data Collection

The literature review uses scientific journals and articles as the resources. This thesis uses the sources collected directly from reliable databases that are: CINAHL (EBSCO), Science Direct, PubMed and SAGE journals.

### 5.2.1 Initial search result and inclusion/exclusion criteria

Researchers are required to gather information that is relevant to the study or evidence to strengthen a hypothesis in order to perform a literature review. The first step is to identify all keywords to the purpose of the subject.

Database	Search terms	Search Limitations	Database Search Results	Selected articles by title or subjects	Selected articles based on the abstract	Selected articles	Duplicate articles	Total chosen articles
<b>Cinahl</b>	effects OR impacts OR consequences AND chemical substances OR chemical agents OR chemical hazards OR chemical substances exposure AND nurses OR nur* AND safety in nursing AND in hospital AND disinfectants AND hazardous drugs	- In full text - Published between 2010 and 2020 - English language - Peer reviewed - PDF full text	136	25	8	2	0	6

	AND radio- logical pro- cedure							
	chemical hazards AND nur* AND occu- pational hazards in nursing OR occupational health AND prevention AND in hospital AND nurs- ing	- In full text - Published between 2010 and 2020 - English language - Sub- ject/Major heading: nursing staff, hos- pital	58	7	4	4		
<b>Science Direct</b>	effects AND chemical OR chemi- cal hazards AND nurses AND safety in nursing AND in hospital AND disin- fectants AND haz- ardous drugs AND radio- logical pro- cedure	- Published between 2010 and 2020 - PDF ac- cess - Title in- cluding “nurse”	153	22	9	4	1	6
	prevention AND chem- ical hazards AND occu- pational safety AND disinfectants AND haz- ardous drugs AND radia- tion safety AND in hospital AND nurse	- Published between 2010 and 2020 - PDF ac- cess	29	9	4	3		
<b>Pubmed</b>	effects OR impacts	- Published between	31	15	11	8	5	8

	AND chemical substances OR chemical hazards AND nurses AND occupational health hazards AND in hospital	2010 and 2020 - Full text access						
	chemical substances OR chemical hazards AND occupational health AND prevention AND in hospital AND nurses	- Published between 2010 and 2020	16	8	5	5		
<b>SAGE journals</b>	effects AND chemical substances exposure AND occupational health hazards AND nurses AND in hospital	- Published between 2010 and 2020 - Open access content only	30	8	6	3	3	3
	chemical substances AND chemical hazards AND occupational health AND prevention AND in hospital AND nurses	- Published between 2010 and 2020 - Open access content only	28	5	3	3		
<b>Total Articles</b>								<b>23</b>

Table 1. Initial search results for databases

There were 136 results with the following keywords found from Cinahl for question 1: “effects OR impacts OR consequences AND chemical substances OR chemical agents OR chemical hazards OR

chemical substances exposure AND nurses OR nur\* AND safety in nursing AND in hospital AND disinfectants AND hazardous drugs AND radiological procedure”, of which 2 articles were chosen for this literature review. As for question 2, there were 165 results found with these search terms: “chemical hazards AND nur\* AND occupational hazards in nursing OR occupational health AND prevention AND in hospital AND nursing”, of which 4 articles were chosen for this literature review. There were no duplicate articles for the two questions, so the total of 6 articles were selected from Cinahl.

There were 153 results with the following keywords found from ScienceDirect for question 1: “effects AND chemical OR chemical hazards AND nurses AND safety in nursing AND in hospital AND disinfectants AND hazardous drugs AND radiological procedure”, of which 3 articles were chosen for this literature review. As for question 2, there were 29 results found with these search terms: “prevention AND chemical hazards AND occupational safety AND disinfectants AND hazardous drugs AND radiation safety AND in hospital AND nurse”, of which 3 articles were chosen for this literature review. There was 1 duplicate article of the two questions, so the total of 5 articles were selected from ScienceDirect.

There were 31 results with the following keywords found from PubMed for question 1: “effects OR impacts AND chemical substances OR chemical hazards AND nurses AND occupational health hazards AND in hospital”, of which 8 articles were chosen for this literature review. As for question 2, there were 16 results found with these search terms: “chemical substances OR chemical hazards AND occupational health AND prevention AND in hospital AND nurses”, of which 5 articles were chosen for this literature review. There were 5 duplicates article of the two questions, so the total of 8 articles were selected from PubMed.

There were 30 results with the following keywords found from SAGE Journals for question 1: “effects AND chemical substances exposure AND occupational health hazards AND nurses AND in hospital”, of which 3 articles were chosen for this literature review. As for question 2, there were 28 results found with these search terms: “chemical substances AND chemical hazards AND occupational health AND prevention AND in hospital AND nurses”, of which 3 articles were chosen for this literature review. All 3 articles of the two questions were duplicated, so the total of 3 articles were selected from SAGE Journals.

<b>Inclusion criteria</b>	<b>Exclusion criteria</b>
Articles that were in English	Articles that were in other languages
Articles that were published between 2010 and 2020	Articles that were published before 2010
Articles that were free of charge	Articles that required payments
Articles that were relevant to the study	Articles that were relevant to the study but lack in nursing perspective
Articles that were in full text	Articles that were not available in full text
Articles from advanced sources	Articles from databases that were not academic

Table 2. Inclusion and exclusion criteria

Inclusion and exclusion criteria (Table 2) were used to limit the research to more relevant articles that are useful. All articles and journals reviewed were from scientific resources, they are in English language, the publication time was from 2010 to 2020, all articles were in full PDF and free of charge, and the subject of these articles were related to this literature review.

### 5.3 Data Analysis

Literature review is done by combining evidence, analyzing the results of related studies, examining in contrast the consequences of each research, summarizing information from scientific materials and writing answer for the thesis question (Aveyard 2010).

Winchester C. and Salji M. have made a great example of how to conduct a literature review in 2016, they suggested that in order to compose an instructive and informative writing, having a concise introduction, a combination of paragraphs with an adequate amount of data, then summarized by a conclusion that connects the main points together. A summary table, including the title of the study, authors' names, publication date, prime keywords, are also a beneficial feature that assist the audience to have a better understanding about the research. (Winchester & Salji 2016.)

## 6 RESULTS

This chapter presents the findings from content analysis of the 23 articles, and the research questions are answered and explained in this chapter. The data was collected carefully, and a summary was done with the analysis of scientific articles. The authors have extracted research answers by thorough reading of the included data.

### 6.1 Effects of chemical substances on nurses in hospital

Chemical plays a huge role in life nowadays. There is an increasing number in the use of chemical substances in daily lives because of their convenience. Chemistry can be used in many workplaces, especially in hospital environments. The healthcare field has developed through the years and it is an admirable accomplishment that has been achieved by modern technology. However, it has also made the field more dangerous with several types of health risks. Occupational health hazards for healthcare workers, particularly nurses, are specified as physical, chemical, biological, radiation, reproductive health, stress, and psychiatric disorders. (Azizoğlu, Köse & Gül 2019; Mohanty, Kabi & Mohanty 2019, 2568-2572.)

Chemical substances appear in various forms; hence, healthcare workers are more likely to be subjected to danger. Both disinfectants and HDs can be absorbed through the skin, and the drugs likewise can be spilled to contaminate, make it dangerous not only for the person who handled them but also for others. (Gurusamy, Best, Tanguay, Lennan, Korva, Bussières & Cochrane Work Group, 2018.) The Centers for Disease (CDC) has published an article about chemical hazards in 2020, which summarizes almost all information on any possible exposure caused by chemical substances and provides appropriate recommendations to each element.

Almost all workplace risk issues reported by nurses were related to their personal condition such as age, sex, educational level, workload, working hours, working style, health condition and safety training status (Azizoğlu et al. 2019), the effect of chemical hazards on nurses somewhat remains.

In essence, some jobs will have more health risks than others. For example, a nurse working in a hospital appears to be more likely to be exposed by health hazards than a lawyer working in the office. Effects of chemical substances can be acute or chronic, depending on the concentration and duration of exposure. Chemicals also cause different reactions due to different types and ways of contact. All in all, health care workers are being exposed to occupational health hazards.

### *Airways effects*

Nursing plays an important role in healthcare systems around the world. Nurses in surgical units, for instance, are in an environment with certain risks, especially because of the possibility of exposure to various chemical, biological, or physical hazards. Health care facilities are daily facing the healthcare-associated infections that may be transferred between patients and healthcare workers. The most effective and economical way to reduce hospital environment contamination is by using disinfectants. However, several studies showed that disinfectants contain many chemicals that provoke health effects for cleaning workers, healthcare staff, and nurses. (Casey, Hawley, Edwards, Cox-Ganser & Cummings, 2017.)

Throughout the hospital area, nurses are using cleaning chemicals for sanitizing and safety purposes. Inhalation and skin exposure are two main ways of getting exposed to cleaning agents. Most nurses are careful while using disinfectants, because even when carefully using the chemical substances, there is still a possibility of inhaling them. According to LeBouf, Virji, Saito, Henneberfer, Simcox and Stefaniak in the study in 2015, one of the groups that is affected by the volatile organic compounds found in cleaning agents and disinfectants is nursing, including practical nurses and nursing assistants. The authors pointed out that sanitizing and sterilizing commodities contain convoluted mixture of irritants and sensitizers, for example, bleach, ammonia and quaternary ammonium compounds, ethanolamine. All these substances were indicated to be the cause of asthma or work-provoked asthma and respiratory problems. (LeBouf, Virji, Saito, Henneberfer, Simcox & Stefaniak, 2015.) Apart from cleaning products, hand disinfectant is the most basic but fundamental in healthcare settings. However, many studies have pointed out that a certain number of elements among these disinfecting products may lead to or aggravate acute respiratory syndrome, due to their stimulating ingredients.

According to the study in 2017 by Casey, Hawley, Edwards, Cox-Ganser and Cummings, they had collected air specimens inside the hospital areas and found: hydrogen peroxide, peracetic acid, and acetic

acid, which are the compounds in disinfectants. As a result, health effects associated with acute respiratory syndrome such as shortness of breath or dyspnea, wheezing and coughing were noticed. Participants also experienced asthma-like symptoms such as the chest tightness feeling, wheezing or whistling in the chest or asthma attacks. Some symptoms are reported to be reduced if employees are not at work, on holiday or on their days off. It is certain that the healthcare workers and nurses are inhaling and absorbing air that is tainted with hazardous chemicals on a daily basis in hospital settings. (Casey et al. 2017.)

Chronic obstructive pulmonary diseases (COPD) are also the results of disinfectants. As reported in the article by Dumas, Varraso, Boggs, Quinot, Zock, Henneberger, Speizer, Moual, and Camargo in 2019, seven most used disinfectants and cleaning products (formaldehyde, glutaraldehyde, hypochlorite bleach, hydrogen peroxide, alcohol, quaternary ammonium compounds, and enzymatic cleaners) have been described as the risk factors for developing COPD or contributing to the burden of the disease. Along with COPD, many respiratory health hazards were indicated, such as emphysema or chronic bronchitis, and especially asthma. Diminishment of accelerated lung function was likewise mentioned in some studies from Europe. (Dumas, Varraso, Boggs, Quinot, Zock, Henneberger, Speizer, Moual, & Camargo, 2019.) Moreover, pneumonitis, hypersensitivity and asthma are outcome if the exposure happens for a long period, with persistent contact (Mohanty, Kabi & Mohanty 2019, 2568-2572.) Glutaraldehyde has also been associated with asthma (Henn, Boiano, & Steege, 2016).

### *Reproductive health effects*

Most of the reproductive health effects reported cases were caused by HDs. In the module by Boiano, Steege and Sweeney in 2014, nearly all respondents were nurses. Cytotoxic, oncology drugs and chemotherapy, also known as antineoplastic drugs, are especially utilized for cancer patients and some non-cancer condition treatments (e.g. arthritis, multiple sclerosis). Most drugs classified as hazardous are the ones that are used to treat cancer patients, along with human immunodeficiency virus (HIV) therapies and other antiviral agents. They are confirmed, and some are believed to cause human carcinogens where there are no secure ways of exposure exists. The noxious level of these drugs is well recorded. The most common antineoplastic drugs administered regularly are carboplatin, cyclophosphamide, and paclitaxel. (Boiano, Steege, & Sweeney, 2014.)

HDs are those that can potentially cause developmental or reproductive toxicity, other organ-system damage, or cancer in animals or human beings. Nurses must be careful while taking care of drugs that



are considered hazardous. Therefore, nurses should learn the prevention and protection precautions to protect themselves and others properly. Because side effects may occur within years after the exposure, awareness of HDs' handling, and practical skills are crucial from the very beginning of the nursing professional careers.

The reasons for exposure risks are immense, some examples can be listed: failing to wear non-absorbent gowns or chemotherapy gloves, spilling or leaking the drug while administrating, accidentally taking tainted clothing home, or even lack of hazard training knowledge. Despite the longstanding availability of safe handling guidance, recommended practices are not always followed, underscoring the importance of training and education for employers and workers. They can result in miscarriage, low birthrate, prematurity, brain defects, cancer and other outcomes. (Kyung 2017.)

Furthermore, reproductive research on female workers exposed to these medications has demonstrated miscarriage, birth defects, infertility, abnormal blood count and other negative pregnancy consequences. Exposure during maternity can cause congenital abnormalities, miscarriages, stillbirths, and low birth-weight. There have been reports on developed occurrence of genotoxicity biomarkers, including chromosomal aberrations and in health care workers who deal with chemotherapeutic drugs. Oncology nurses exposed to chemotherapy medications have a higher risk of leukemia and other cancers. (Boiano et al. 2014; Gurusamy et al. 2018.)

Organ-radioactive, carcinogenic, mutagenic or reproductively radioactive substances have been identified as HDs adverse health effects by the National Institute for Occupational Safety and Health. Another study summarized that drugs used for cancer chemotherapy, antiviral drugs, hormones, bio-engineered drugs may cause carcinogenicity, teratogenicity, developmental toxicity, reproductive toxicity, organ toxicity at low doses or genotoxicity. The handling of such medications is, therefore, associated with the risk of occupational exposure. Only small doses of these medications present a risk to the health of the person administering them, if the safety guidelines and instructions for administering them are followed inaccurately. The instructions refer to the growing number of oral antineoplastic drugs where the toxicity can be absorbed through the skin. There are also HDs which are administered intravenously by infusions, so nurses inhaling them is another risk. (Gurusamy et al. 2018.)

There is one individual finding about the risk of spontaneous abortion and its relation to occupational exposures among nurses. Researchers gathered self-reported results from female nurses in the United States, which considered all occupational exposure factors: disinfectants, HDs and X-rays. However,

they concluded that antineoplastic drugs are the causes to spontaneous abortion, and due to the lack in information, the risk of occupational exposure during pregnancy is not strongly confirmed. (Lawson, Rocheleau, Whelan, Lividoti Hibert, Grajewski, Spiegelman & Rich-Edwards 2015.)

Additionally, exposure to radiation is believed to be one other reason to provoke reproductive health hazards in the workplace. It is a growing problem about safety issues which may include reproductive wellbeing, for instance, menstruation, ovulation, fertility condition, and impacts on the fetus. Regular contact with radiation can lead to reproductive health problems such as miscarriage, infertility, menstruation and ovulation issue, and birth defects. Potential health effects also include developmental disorders in children. The causes of reproductive hazards in radiation procedures noted are lead (chemical), radiation (physical) and viruses (biological). (Mohanty, Kabi & Mohanty 2019.).

### *Allergic reactions*

As mentioned, many high-level disinfectants do not only cause asthma but also dermatitis and skin problems. There are some high-level disinfectants used in healthcare settings such as glutaraldehyde, ortho-phthalaldehyde, peracetic acid, hydrogen peroxide, hypochlorous acid/hypochlorite, ethylene oxide, and formaldehyde. These elements cause provocation to the skin, causing redness, skin fracture, cracking, swelling, itchiness, tingling or burning sensation, especially with hand sanitizer, where it is constantly used directly to bare skin. . They as well generate mucous membranes difficulties like nasal irritation, wheezing, cough, sore throat, and discomfort to the eye (Mohanty, Kabi & Mohanty 2019, 2568-2572). In addition, glutaraldehyde has specifically been associated with dermatitis, which is occupational health hazard. (Henn et al. 2016.)

Chemicals in cleaning and disinfecting goods, for example, are quaternary ammonium compounds, ethanolamines, chlorhexidine, glutaraldehyde, ortho-phthalaldehyde, hexachlorophene, chloramine-T. Eye irritation is the most common reaction listed from these chemicals. Multiple health consequences induced including chronic cough, sore throat and other allergic responses were indicated as the acute outcome of occupational health effects generated by HDs. (Boiano et al. 2014; Gurusamy et al. 2018.)

### *Biologic effects*

Apart from the reproductive health effects, these HDs are also seriously damage the human biological health due to their toxicity level. Oncology nurses are the ones with escalated risks having leukemia, non-Hodgkin lymphoma or other types of cancer such as bladder or liver cancer due to the frequent exposure to cancer-treating drugs. (Boiano, Steege, & Sweeney 2014; Gurusamy et al. 2018.)

Genetic changes could be as well the consequences of HDs. The health care workers who handle chemotherapeutic drugs have even experienced an elevated level of biotoxicity and genotoxicity, including chromosomal damage and aberrations. (Boiano, Steege, & Sweeney 2014; Gurusamy et al. 2018.). The cytotoxic elements damage DNA or inhibit cell division, therefore prevent the routine of cell replication (Gurusamy, Best, Tanguay, Lennan, Korva, Bussi eres & Cochrane Work Group, 2018). The handling of these medications is dangerous because it can cause end-organ damage including hair loss, liver damage, abdominal pain and organ toxicity from low to high doses.

### *Neurological symptoms*

Daily exposure to chemicals and ototoxic agents can lead to acute and chronic neurological symptoms. Inhaling disinfectants and cleaning agents for a long period of time may lead to neurological impairment. HDs, on the other hand, could also cause light-headedness and dizziness subsequent to acute or chronic prolonged exposure (Boiano, Steege, & Sweeney 2014; Gurusamy et al. 2018). Neurologic symptoms and headaches were reported by 32% of the respondents in the study by Casey in 2018 (Casey et al. 2018).

In the article written by Cannizzaro, Cannizzaro, Plescia, Martines, Soleo, Pira and Coco in 2014, the authors had summarized from several previous studies that there is a connection between ototoxic chemicals and permanent hearing damage. Tinnitus and cochlear damage may be the easiest symptoms to appear. It can also be portended by vestibular damage, following with neurological symptoms as headaches, vomiting, vertigo, and ataxia or nystagmus. The authors pointed out that hearing damage develops after exposure, for a prolonged long time, to moderately high doses of HDs, and gradually from high densities to lower frequencies. These acoustic damages are impaired ability to distinguish sound, balance disorders, or sensorineural hearing loss. (Cannizzaro, Cannizzaro, Plescia, Martines, Soleo, Pira, & Coco 2014.)

## 6.2 Preventing exposure to chemical substances in hospital

Nurses experience different occupational risks, so it is important for them to know how to protect themselves from workplace risks. The knowledge about the subject which is frequently renewed and provided to nursing staff and nursing students, and according to one study from the University of Athens (2013), chemical occupational hazards is the second most investigated of all preventive measures. Nevertheless, nurses tend to have inaccurate knowledge and low conformity to a great deal of problems relating to occupational hazards. (Copanitsanou & Sourtzi 2013.) If the risk is identified, nurses can be provided healthier working settings by taking mandatory precautions. Therefore, recognizing and evaluating the situation would not only help the nurses adapt to the professional competences but also maintain their own well-beings.

Chemical agents contain a variety of aspects and numerous types in health service. For example, many strong chemicals are used for treating purposes like medication and anesthetic agents; or for sanitizing purposes. Besides the benefits and application of it, hazardous is still the first consideration, because all chemicals are hazardous, even small doses of chemical can have a damaging impact on health. (Manyele et al. 2012.) Chemicals are divided into many types, however, their effects can be positive or negative. Occupational exposures can occur due to lack of knowledge about the impairment that chemical substances cause of the employees. (Kyung 2017.)

The efficiency of disinfectants and HDs is undeniable, but when these turns into a health risk, safety guidance about how to handle them that was published available for workers by professional practice associations and federal departments. As a way of determining the degree which primary preventive can practices, the National Institute for Safety and Health created a web survey to generalize the application of *The hierarchy of controls*, including engineering, administrative and workplace controls, and personal protective equipment (PPE). (Boiano et al. 2014; Gurusamy et al. 2018.)

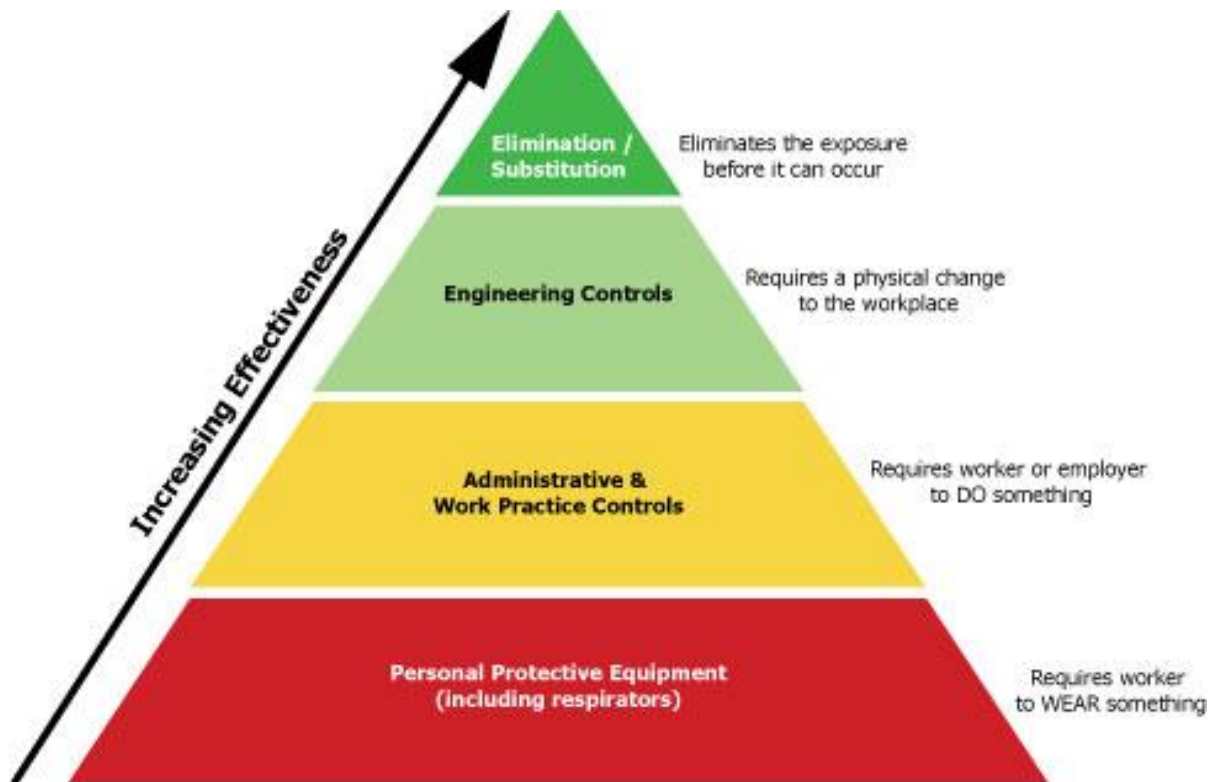


Table 3. Hierarchy of controls (OSHA 2020)

According to OSHA, the hierarchy of controls is used as a way of evaluating how practicable and efficient controls can be enforced (OSHA, 2020). In this sector, highlight points are shown as valuable instructions; hence, nurses could securely enhance their awareness to avoid being exposed to chemical hazards with a proactively controls behavior.

#### *Using the Personal Protective Equipment (PPE)*

According to NIOSH in 2020, PPE is a leading source of protection for emergency and recovery workers. Exposure could be unexpectedly faced with many ways, so the PPE secures workers, from physical, chemical and biological hazards. There are four main types of protective equipment: eye protection, respirators, protective clothing (skin protection) and hearing equipment, matching four routes of exposure: contact through mucous membranes, inhalation, dermal contact or ingestion. (Centers for Disease, Control and Prevention, 2020.).

Eye injuries can occur by a variety of means. Many eyes damages occur as solid particles like metal slivers, wood chips, sand or asphalt chips fall into the eyes. Tiny particles in smokes and bigger particles

like broken glass can cause eyes injury caused by particulate matter. Blunt force may occur to the eye when undue force contacts the eye. Chemical burns, infectious agents, and kinetic agents also lead to workplace eye damage from consequences such as welding torches and ultraviolet (UV) light. Although the eye protection needed varies according to profession, the safety given can be standardized. Security glasses provide protection from exterior hazards and can provide side protection by a wrap-around or side shield configuration. There are a few commonly used protectors: eye protection, goggles, face shields and full-face piece respirators. Face shields offer extra protection and are worn over normal eyewear, as well as shielding against impact, chemical and blood hazards. Full-face piece respirators are known to be the best type of eye protection when respiratory safety is also required, but they may be less efficient against possible eye hazards. (Rozenbojm, Nichol, Spielmann & Holness 2015; Hanvold, Kines, Nykänen, Thomée, Holte, Vuori, Wærsted & Veiersted 2019.)

Respirators serve as users from breathing pollutants in the air and thus maintain one's respiratory tract health. There are two types of respirators that are significant. One type of respirator operates to eliminate the air breathing of patient contaminants and gasses or airborne particles. The filtration can be either passive or active. Examples of this type of respirator are the gas masks and particulate respirators such as N95 masks. A second form of respirator protects consumers by providing another source of clear, respirable air. This form involves airline respirators and self-contained breathing apparatus. Surgical masks are considered as PPE, but are not qualified to be respirators, because they are unable to inhibit the movement of submicron particles and often have unregulated air flow at the edges of the masks. (Nichol, McGeer, Bigelow, O'Brien-Pallas, Scott & Holness 2013; Rozenbojm et al. 2015.)

Occupational skin health effects such as contact dermatitis, skin cancers and other skin injuries and diseases are the second most prevalent form of occupational disease and can be extremely severe. Skin hazards which cause skin disease in the workplace can be divided into four categories. Chemical agents can encounter the skin through direct contact with polluted surfaces, aerosol deposition, immersion or splashing. By extended exposure, physical agents such as high temperatures and ultraviolet or solar radiation may cause damage to the skin. Mechanical trauma takes place in the form of friction, strain, abrasion, laceration and bruising. Any type of PPE which performs as a barrier between the skin and the exposure agent can be considered as skin protection. Gloves are an important component in providing skin protection, while a lot of work is performed with the hands. The latex gloves, cut-resistant gloves, and heat-resistant gloves are some examples of gloves widely used as PPE. Any other item of clothing or protection worn for a purpose other than gloves serves to protect the skin. For instance, lab coats are worn to protect against accidental chemical splashes. Face masks help to protect one's skin from possible

dangers of damage, toxic splashes, or even contagious material. (Nichol et al. 2013; Rozenbojm et al. 2015; Hanvold et al. 2019.)

Earplugs and earmuffs are primary examples for PPE hearing equipment. Employers should offer hearing security to staff who are routinely subject to noise levels above the NIOSH guideline, because they are a low-cost solution. A specific attenuation level can be assessed objective by a fit-testing method for hearing safety. The efficacy of hearing aid varies with the instruction given on its use. (Centers for Disease, Control and Prevention, 2020.).

### *Administrative and work practice controls*

The health care provided by nurses who work in a healthy environment would be more efficient and of better quality, which would result in better economic and social outcomes for individuals and communities (Azizoğlu et al. 2019). Monitoring exposure to the workplace with medical surveillance and policies is the first thing to consider. Although nurses are well trained and all familiar with handling chemical substances, underestimating the consequences and lacking knowledge are sometimes the reasons for occupational hazards. Most of the time exposure happens due to a lack of knowledge and carelessness handle of workers. According to Boiano et al in 2014, the exceeding answer for failing to use protective gowns and gloves was “skin exposure was minimal” (Boiano et al. 2014). A survey conducted by NIOSH in 2011 demonstrated typical examples of actions that intensify the chance of getting exposed to risky situations being the failure to put on nonabsorbent gown (42%), leakage of cytotoxic drugs or dribble while handling (12%), accidentally taking contaminated clothing home (12%), failing to use chemotherapy gloves (12%), using intravenous tubing for antineoplastic infusion (12%), or absence of knowledge and training about hazard recognition (6%). Subsequently, skin contact during administration was reported. Therefore, education and understanding of employment practices and national guidance for the proper handling of chemical substances are recommended. (Boiano et al. 2014.)

All work practices were analyzed to assess the degree to which the precautionary guidelines were applied to reduce exposures. Prevalence distributions of feedbacks rely mainly on the proportion of respondents who do not completely adhere to suggested practices. Monitoring exposure to a workplace with medical surveillance and policies is reliability method to help health care staff physically and an effective mechanism to decrease frequency of exposure. Thus, to provide guidelines cover methods for safe handling HDs should be a prior necessity for administrative and work practice controls. All needed information

has to be provided to employers by the manager of each organization so that all staff could know what to do and what to avoid. Healthcare equipment also need to provide health surveillance programs at workplaces, as well as appropriate procurement of health facility materials in the manufacturer's guidance for spilled products, along with information about the safe handling of spillages or contamination. In essence, controlling exposure at its source is the main goal to maintain workplace safety. (Boiano et al. 2014; Gurusamy et al. 2018.)

Most of the respondents in Boiano's survey mentioned having had the training, as far as continuing education courses were offered by the Oncology Nursing Society (ONS) on the proper handling of chemotherapy medications are concerned. It was completed by the largest percentage of nurses who responded. The nurses did as well report to be familiar with the ONS guidelines. Nonetheless, some said that it was more than a year ago, others indicated that their employer either did not have policies to handle secure administration. In spite of the vast number of easily accessed safety guidelines, the suggested methods are not always practiced, emphasizing the value of preparation and education for health care workers. In order to improve nurses' knowledge about the situation and recommend them to follow safety guidelines, there are several programs of specialized training to raise awareness about the safe handling of HDs provided by leading health organizations such as NIOSH, ONS, ASHP, and OSHA. The guidelines cover methods and safe handling HDs — from shipping and receiving, transport and distribution, compounding, administration, and waste disposal. There is also education on identification of occupational risks, the use of tools, facilities and the PPE. (Boiano et al. 2014; McDiarmid 2014.)

There have been plenty of suggested approaches by Gurusamy and other authors to reduce the chance of getting exposed to dangerous drugs, and the most well-known way is the use of safe products, including implementation of safe procedures; providing safe waste disposal for chemical products; acquisition of medications and materials with safe spill protocols; and last but not least, regular equipment maintenance to avoid technology errors (Gurusamy et al. 2018). There are also work practices controls like hazard barrier or containment and separating hospital areas. It was listed a statistic table of precautionary work practices made up of using a plastic-backed absorbent pad under injection site, storing packaged antineoplastic medications in a restricted storage that only give the necessary time for staff before giving them to patients, washing hands before and after using gloves, instantly disposing contaminated gloves, and the use of PPE. (Boiano et al. 2014.) Both studies pointed out the use of biological safety cabinets to safeguard chemicals, needle sticks, and sharp equipment containers. One separate study proposed to use specialized glove boxes, isolating healthcare facility areas and equipment, using exhaust hoods to



provide local ventilation when compound and mix drugs, and storing flammable chemicals separately from ignition chemicals. However, engineering controls are the important access to work practices.

### *Engineering controls*

The basic approach of protecting staff is to control the exposure to environmental contaminants and hazardous compounds. A closed-system drug-transfer device is an instrument that physically prevents the transfer of environmental pollutants to the loop and the escape from the system of the device of dangerous substances or vapors. Examples of closed-system drug-transfer systems include PhaSeal cell, ChemoClave system, Equashield system, and Chemo Protection system. These systems provide a form of entry to intravenous infusion e.g. a spike intended to avoid leakage and spills and a leak-proof link that helps to move medications without leakage or spills. However, certain devices used in compounding dangerous drugs are not completely called closed-system drug-transfer devices, since they are not equipped or have not been proven to absorb aerosols such as hydrophobic-air-venting filters or chemotherapy transfer or reconstitution spikes. Closed-system drug-transfer systems operate by seeking to provide a leak-proof link that avoids leaks and spills. These can minimize surface pollution and ambient pollution with drug aerosol and thereby reduce workplace exposure to infusions of dangerous drugs, these may also result in less exposure-related adverse effects. In addition, the devices often aim to avoid microbiological degradation of the drug, eventually allowing the re-use of vials and reducing costs. (Gurusamy et al. 2018; Boiano et al. 2014.)

Other support equipment and devices were listed in the study by Boiano in 2014, engineering controls consist of closed-system devices, needleless systems, the use of luer-lock fittings on all needleless devices, syringes, injections, infusion tubes and pumps. The luer-lock fittings and the needleless systems were reported to be the two commonly utilized by nurses. The authors of the research as well mentioned the centralization of priming of intravenous tubing or intravenous tubing primed with antineoplastic drug the “tubing priming practices” so the chemotherapy drugs that were intravenously administered could successfully done without any mistakes. (Boiano et al. 2014.) In addition, Gurusamy and others applied the robotic drug preparation and the use of biological safety cabinets with laminar airflow for drug preparation could also be operated in healthcare facilities. They even mentioned about the safety programs with X-ray machines that shorten exposure time, as well as extend the distance to X-ray machines and the amount of shielding to nurses. (Gurusamy et al. 2018.)

## 7 ETHICAL CONSIDERATION AND RELIABILITY

All databases and references were collected by using systematic literature review method, they directly were gotten from reliable sources as the website of World Health Organization, Ministry of Social Affairs and Health in Finland and from the Centria UAS E-library: SAGE journals, CINAHL (EBSCO), ScienceDirect and PubMed.

Ethical consideration in this thesis follows Centria UAS Guide for thesis and academic writing. The authors have strictly maintained the code of ethics throughout the thesis, as it was the vital part of this study. The validity and reliability of this research has been maintained according to the primary source of the evidence-based articles. Moreover, the reliability of this research project was most recent and up-to-date data. The chosen articles for findings were limited the date of publication to at least the last ten years. The school's library database was collected while searching for the journals. All assessments and opinions of the authors are authentic and genuine, personal bias was completely avoided.

The result of this study should be usable and suitable for Finnish hospital environment. All the databases and references are reliable and accurate from scientific sources, books, and articles. (Wanjugu 2014.) Throughout the research, authors remarked all the references and avoided replicating others' works. Furthermore, own opinions and views just apply in the discussion and conclusion part. Reliability ensures the quality of a research, it means that research tools, data collection and content analysis contribute to the coherence of the study.

The general research ethics is a vital consideration in every aspect of research. The research is done responsibly the one that demonstrates honesty and integrity while collecting data, as well as showing respect for previous studies. (Houser.2012.)

The quality of the collected data was discussed with the instructor. Every source was assessed critically in order to confirm its quality and avoid the use of duplicates. Moreover, to be considered as a high ethical research, all phases of study - from the protocol design stage to the research findings - follow strictly the reality. Additionally, research ethics should obey standards, which are namely preventing plagiarism, managing data, not breaching research ethics and also respecting for participants. As a result, the research ensures high quality, high reliability at the same time.

## 8 DISCUSSION AND CONCLUSION

### 8.1 Discussion

In this chapter, authors analyzed and briefly explained findings in order to draw a complete picture to deeply understand the research questions. The purpose of this thesis was to find out the adverse impact of chemical materials on the health of nurses. The aim was to present managements to prevent and minimize chemical exposure.

The research methodology used was a literature method. By summarizing 23 scientific articles, the authors figured out the concept of harmful influence of chemical substances to nurses and its importance to avoid those problems by applying managements such as engineering controls and personal protective equipment. Every day, nurses confront low-level but repeated exposure to hazardous materials from disinfectants, drugs, and cleaning chemicals. It is toxic materials that accrue to health risks.

The deductive content analysis was certainly a relevant choice for this research. For the most part, the process of producing results was unproblematic. However, a few traits did not go correctly on the track. It was due to the misunderstanding of content analysis's principle. Despite the deficiencies, the content analysis presented coherent results.

The results indicate that nurses are affected by chemical substances. It is seen in all areas of nursing, but it is most prevalent in the hospital environment. Nurses need to be aware of the impact of chemical substances because in poor health, nurses may not be able to provide safe and appropriate care. It is critical that nurses are aware of signs of chemical substances' and know how to prevent chemical exposure by following the guide from organization. The results might be considered answering the research questions comprehensively.

According to our research results, nurses who were exposed to chemical substances, had a higher rate to health collapse. Nurses ingest, touch or breath any number of these potentially harmful substances as they care for patients, as a result, they face potential health problems as a result. Respirational failure, biological change, reproductive health, allergic reaction, and neurological damage were five elements which demonstrate side effects of chemical substances. The sign of those impacted simply identify through a follow-up process. As a nurse, this is a point where symptoms are presented; however, it is also a bright side that nurse can control early and lower the signs.

Additionally, there are some possible symptoms that easily to find out. Shortness of breath, coughing, asthma, and chronic bronchitis are examples for acute respiratory syndrome and respiratory tract disease. Moreover, a hazardous substance can be splashed onto the skin or eyes and inhaled which leads to allergic reaction, dermatitis, and skin problems. It causes dry sin, redness, eye irritation and runny nose. There is considerable cause for concern that substances commonly used in hospital can cause occupational exposure during pregnancy and long-term health effects such as stillbirth, impacts on the fetus, menstruation and ovulation issue, infertility and decrease fertility.

Furthermore, the toxic effects of a chemical may be affecting a target organ, liver, or bladder for examples. Additionally, it primarily causes tumors in the liver and kidneys, which lead to cancer. In addition to the effects, neurological damage is the last one which was obtained in this thesis. There are some significant symptoms that demonstrate the neurological signs, they gradually develop from light to heavy symptoms. Hazardous chemicals can cause headedness, dizziness, nausea and vomiting in the beginning, after that they may lead to central nervous system impairment. Furthermore, authors' findings also presented the hearing damage during the process.

With the analysis, research results also provided a showing on how to minimize the potential illnesses related to chemical substances. In order to reduce the hazards, an engineering, administrative and work practice control, and personal protective equipment were applied during the work time. As a nurse, the importance of ensure as far as practicable, the safe use, handling, storing and transporting of substances should be considered. Besides that, administrators should educate nurses about the potentially harmful chemicals that are typically used in the health care settings including available safer protect and support efforts to ensures that nurses have full access to information and the right to know about the potentially hazardous chemicals. Furthermore, hospitals can apply some PPE during the working time.

For authors' research questions, authors got answer after summarizing 23 articles. Authors learnt how to identify the symptoms related to chemical exposure. Authors got a prevention to minimize the adverse impact of hazardous chemicals.

In authors' opinion, authors think that there is nothing as essential as nurse. As stated at the beginning, a nurse is responsible for the treatment, safety and recovery of acutely or chronically ill patients, health maintenance of the healthy. Nurses may also be involved in medical care and develop a plan of care, they sometimes work with team members. No other health care professional has such a broad and far-reaching role compared to nurses. Therefore, the health of nurses is not only the important to nurses

themselves but also for quality of care. It means that health breakdown makes the negative consequences in the health care setting.

One of the reasons affecting the choice of this topic was the consideration on the importance of nurses during the practices of authors. Authors were aware of that this topic was barely mentioned in other researches although authors both commit the importance of nurse in health care setting. Chemical substances are common materials in hospitals and appear on every corner; however, the side effects are not noticed carefully. Yet, after doing the research, we are aware of the danger of hazardous chemicals and got knowledge how to deal with those side effects.

There were plenty of difficulties during the process, especially in understanding content analysis. Additionally, there was not enough material related to this study in Finland specifically and in the European region in general, those that were relevant within the area mostly required a proper understanding of the Finnish or the countries own languages, made it particularly challenging for authors as international students to have a legitimate way to approach with a different method All articles, research papers, texts and databases were accessed digitally. For future research, Finnish articles should be mentioned in order to get as a example.

From these findings, it can be assumed that, chemical substances affect every aspect of nurses' health, such as airway, biological, reproductive, and neurological effect, and allergic reaction; therefore, it is a barrier that hinders nurses' work. It is proved that the following signs or symptoms are caused by chemical substances such as eye watering, nausea and vomiting. Furthermore, our results pointed out how organizations can control and prevent the hazardous chemicals.

## 8.2 Conclusions

Generally, the study as a whole has provided a foundation for anyone who wanted to understand the essence of chemical substance. There would be some minor errors and limitation in the work such as lacking Finnish sources, being not perfectly written presentation. Yet, this study might be a good starting point for further study.

According to the findings of this study, nurses are surrounded by a chemical substance. Chemical exposure contributes to missing work, injuries, reduced productivity. It is obvious that organizations can have a significant impact on making better attitude towards chemical exposure. Employers should implement strategies to promote safety and provide assistance.

Addressing chemical exposure in the work setting has many significant preventative potentials. The first step that nurses should be aware of impact of chemical substances. From that, nurses are able to recognize the signs or symptoms of chemical exposures. It is critical that nurse should not ignore light signs of chemical exposure.

As mentioned, the nurse's work is to provide safe care and nurses are often the first individuals to be affected by toxic substances. Due to chemical exposure, the quality of nursing care is definitely not stable. As a result, the prevention from chemical exposure is essential for improving the the quality of care.

Administrators control is a key in prevention further chemical hazards. It is not complicated to deepen both nurses' awareness and knowledge. Detection of chemical hazards is most effective when multiple types of identification are use. A combination of education, information, personal protection should be used. A thorough understanding of the side effects of chemical substances on nurses' health helps nurses to choose the most effective prevention strategies.

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## APPENDIX 1

Table of 23 Articles for Question 1 & 2

Author(s)	Articles' names	Journal & Year of publication	Research type	Findings
ASGE Technology Committee, Pedrosa, M., Farraye, F. A., Shergill, A. K., Banerjee, S., Desilets, D., Diehl, D. L., Kaul, V., Kwon, R. S., Mamula, P., Rodriguez, S. A., Varadarajulu, S., Song, L-M. & Tierney, W. M.	Minimizing occupational hazards in endoscopy: personal protective equipment, radiation safety, and ergonomics	ScienceDirect. Gastrointestinal Endoscopy, Volume 72, Issue 2, pages 227-253, August 2010	Technology status evaluation report	During Gastrointestinal (GI) endoscopy, personnel performing or present, and individuals handling endoscopic equipment are exposed to plenty of potential hazards. These include exposures to body fluid and chemical substances, exposure to laser and radiation, and injuries to the musculoskeletal. Protection for endoscopic personnel exposed to these hazards can best be achieved through consistent application of safety practices, including personal protective equipment and radiation safety.
Balthazar, M., Andrade, M., Ferreira de Souza, D., Cavagna, V. & Valente, G.	Occupational Risk Management in hospital services: A reflective analysis	Cinahl. Journal of Nursing UFPE On Line. Revista de Enfermagem UFPE. Volume 11, Issue 9, September 2017	A descriptive study, based on review of the literature	Through a reflective analysis, this article reflects on the job-related health risks and how to implement safety management in hospital settings. However, the tenancy of hazards and damages requires an extension of studies in this reality, taking into account their severity despite many attempts made by healthcare staff. Nurses' work needs to be humanized and appreciated in order to achieve positive results in patient care, but this calls for attention from the hospital managers, education providing scientific and technological associate with health specialists.
Boiano, J. M., Steege, A. L. & Sweeney, M. H.	Adherence to Safe Handling Guidelines by Health Care Workers Who Administer Antineoplastic Drugs	PubMed. US National Library of Medicine. HHS Public Access. J Occup Environ Hyg,	Survey methodology	Antineoplastic drugs, as known as chemotherapy, cytotoxic, and oncology drugs, have been reported poisonous, that is why safety handling is an essential difficulty concerning workers' health related diseases. The study indicates that advised handling

		Volume 11, Issue 11, pages 728-740, 2015		and controlling methods are not always accomplished even though there is precise safety guidance.
Cannizzaro, E., Cannizzaro, C., Plescia, F., Martines, F., Soleo, L., Pira, E. & Coco, D. L.	Exposure to ototoxic agents and hearing loss: A review of current knowledge	Cinahl. informa healthcare. Hearing, Balance & Communication. Taylor & Francis Ltd, 2014	Review article	Several experimental and clinical studies have shown that a variety of ototoxic agents can cause sensorineural hearing loss. Since noise exposure and many drugs or chemical compounds frequently share the same ototoxic mechanisms, this may explain why hearing loss can be potentiated by combined exposure to these agents. However, a great variability in the individual's response to a given xenobiotic exists and depends on a complex interplay between endogenous and exogenous factors.
Casey, M. L., Hawley, B., Edwards, N., Cox-Ganser, J. M. & Cummings K. J.	Health problems and disinfectant product exposure among staff at a large multi-specialty hospital	PubMed. US National Library of Medicine. HHS Public Access. Am J Infect Control, Volume 45, Issue 10, pages 1133-1138, October 2018	An interviewer-administered questionnaire on work and health characteristics was completed. Prevalence ratios were calculated using Poisson regression, and standardized morbidity ratios were calculated using nationally representative data.	Hospital staff expressed health concerns after a surface disinfectant product containing hydrogen peroxide, peracetic acid, and acetic acid. Product users reported higher prevalence of work-related wheeze and watery eyes than non-users. Workers in the department with the highest air measurements had significantly higher prevalence of watery eyes than those in departments with lower air measurements, and they also had a >3-fold excess of current asthma compared with the U.S. population.
Dumas, O., Varraso, R., Boggs, K. M., Quinot, C., Zock, J-P., Henneberger, P.	Association of Occupational Exposure to Disinfectants With Incidence of Chronic Ob-	PubMed. US National Library of Medicine. JAMA Network Open. Volume 2,	Incident physician-diagnosed Chronic Obstructive Pulmonary Disease	In a study of 73,262 U.S. female nurses participating in the Nurses' Health Study II, occupational exposure to cleaning chemicals and disinfectants was significantly associated with increased risk of developing

K., Speizer, F. E., Moual, N. L. & Caramargo, C. A. Jr	structive Pulmonary Disease Among US Female Nurses	Issue 10, October 2019	evaluated by questionnaire.	chronic obstructive pulmonary disease independent of asthma and smoking by 25% to 38%.
Dubray, Q., Diallo, T., Andre, E., Fauqueur, A-S., Poil, S., Thromas, N., Secretan, P-H., Cisternino, S. & Schlatter, J.	Occupational risks evaluation in a centralized antineoplastic agent preparation unit	SAGE journals. SAGE Open Medicine, Volume 7: 1-7, July 2019	Global risk analysis was the essence of the study accepted by a working group comprised of experts.	The global occupational risk evaluation administered to the pivotal unit of preparations for antineoplastic agents is part of a compulsory access needed for employees under European legislation. This study analyzed the risky situations associated with the workforce activity and then enabled a formal occupational prevention plan to be drawn up. Results showed that 33 hazardous cases were spotted. All cases were believed to be controlled when the peril reduction idea was engaged. Corrective actions resulted in the reorganization of human resources, update protection protocols and optimize ergonomic working tools. Annually, staff-specific medical surveillance and regular surface contamination tests were scheduled, basic and steady training has also been updated, particular to product and waste hazards.
Eyi, S. & Eyi, I.	Nursing Students' Occupational Health and Safety Problems in Surgical Clinical Practice	SAGE journals. SAGE Open, 2020	A survey design: descriptive design using self-administered questionnaire	In Turkey, student nurses are exposed to workplace health and safety (OHS) hazards. This study demonstrates OHS-related influences and training of nursing students in association with the risk evaluation process from an academic perspective. The study signified level of awareness about OHS were low to nearly all students, they had trouble providing personal protective equipment (PPE), were verbally assaulted, experienced anxiety and irritation. They also came across risky circumstances involving clinical treatment, preparation of drugs, latter vital signs, general care, afterwards suffered from back pain, headache, increased tendency to sleep, tiredness, and forearm, wrist, hand, and finger injuries, and due to the contact with antiseptic

				and latex, irritation of the skin and burning eyes , nose and throat allergy symptoms have been noticed.
Gurusamy, K. S., Best, L. M-J., Tanguay, C., Lennan, E., Korva, M., Bussières, J-F. & Cochrane Work Group	Closed-system drug-transfer devices plus safe handling alone for reducing exposure to intravenous drugs in healthcare staff	PubMed. US National Library of Medicine. Cochrane Library. Cochrane Databases of Systematic Reviews, March 2018	A systematic Review	The study was about the comparison between closed-system drug-transfer devices combining with safe handling and only safe handling itself.
Hanvold, T. N., Kines, P., Nykänen, M., Thomée, S., Holte, K. A., Vuori, J., Wærsted, M & Veiersted, K. B.	Occupational Safety and Health Among Young Workers in the Nordic Countries: A Systematic Literature Review	ScienceDirect. Safety and Health at Work. Volume 10, Issue 1, pages 3-20, March 2019	A Systematic Literature Review	The purpose of this review was to identify risk factors for occupational accidents and illnesses among young workers in the Nordic countries and to acquire knowledge about specific vulnerable groups within the young work force that may require special attention. Results show that exposures to chemical substances regularly would possibly be causing skin reactions such as hand eczema. The use of Personal Protective Equipment (PPE) is highly utilized because it, when properly managed, can protect healthcare staff from noxious occupational hazards.
Henn, S. A., Boiano, J. M. & Steege, A. L.	Precautionary Practices of Healthcare Workers Who Disinfect Medical and Dental Devices Using High-Level Disinfectants	PubMed. US National Library of Medicine. HHS Public Access. Infect Control Hosp Epidemiol, Volume 36, Issue 2, pages 180-185, February 2015	Descriptive analyses including simple frequencies and prevalence	Throughout the healthcare industry, high-level disinfectants are used to chemically disinfect medical and dental instruments to monitor and prevent health-related infections within patients. There is a chance of exposure to these chemicals, some of which are respiratory and skin irritants and sensitizers, by staff who use them on a daily basis.
Huei, L. C., Ya-Wen, L., Ming, Y. C., Chen, H. L., Yi, W. J. & Hung, L. M.	Occupational health and safety hazards faced by healthcare professionals in	SAGE journals. SAGE Open Medicine, Volume 8: 1-12, March 2020	A systematic review	Numerous occupational risks and health issues such as physical, biological and chemical hazards would be likely to do harm to healthcare workers working in hospitals and other accommodations more than

	Taiwan: A systematic review of risk factors and control strategies			workers from other operations in Taiwan. The intention of this systematic review is to analyze existing research literature on this situation in order to educate policymakers and specialists about the danger of exposure and to include evidence-based advice about how to minimize or mitigate these risks.
Jiang, Z., Wang, J., Gou, X., Feng, L., Yu, M., Zhou, J., Ye, Y., Mei, L., Ju, L., Yu, D., Lu, C., Yu, W. & Lou, J.	Menstrual disorders and occupational exposures among female nurses: A nationwide cross-sectional study	ScienceDirect. International Journal of Nursing Studies, pages 49-55, April 2019	Standardize questionnaire was administer face-to-face with all participants, then determined sample size using the simple random sampling method equation	This national cross-sectional study indicated a critical association between menstrual disorders and occupational hazards in the female nurses' group in China. Approximately 40% of Chinese female nurses have experienced menstrual disorders while at work, compared to non-infirmiry workers, and more than female nurses in the United States and Canada. Anti-cancer drug exposure is one of the triggers for menstrual disorders.
Lawson, C. C., Rocheleau, C. M., Whelan, E. A., Lividoti Hibert, E. N., Grajewski, B., Spiegelman, D. & Richardson, J. W.	Occupational exposures among nurses and risk of spontaneous abortion	ScienceDirect. American Journal of Obstetrics & Gynecology, April 2012	Supplemental questionnaire survey was sent through email to over 100,000 nurses across the U.S. and the content analysis was done using logistic regression	The pregnancy result and workplace exposures were obtained from 8461 participants. 7482 of these were ideal for logistic regression analysis. Exposure to sterilizing agents was linked with a 2-fold rise in incidence of late spontaneous abortion, but not with early spontaneous abortion. This study suggests that some common occupational exposures to nurses are related to risks of spontaneous abortion.
LeBouf, R. F., Virji, M. A., Saito, R., Henneberger, P. K., Simcox, N. & Stefaniak, A. B.	Exposure to volatile organic compounds in healthcare settings	PubMed. US National Library of Medicine. HHS Public Access. J Occup Environ Hyg, Volume 71,	Qualitative content analysis research	Depending on the activities and materials or products used during operations, healthcare staff are exposed to a wide range of chemicals. Therefore, volatile organic compound profiles are used to control the exposures estimated for epidemiological and industrial hygiene studies.

		Issue 9, pages 642-650, July 2014		
McDiarmid, M.	Hazards of the Health Care Sector: Looking Beyond Infectious Disease	ScienceDirect. Annals of Global Health, Volume 80, Issue 4, pages 315-319, July-August 2014	A research article	Explore the conventional hierarchy of threat management systems in resource-intensive health care settings' appropriateness in high-resource settings and low- and middle-income countries (LMICs) by stating that the hazard management hierarchy was used to minimize risks as an example of biological and environmental threats. The result indicated that health care staff are regularly at risk of harm from proximity to agents in this special and dynamic environment in both well-resource settings and in LMICs.
Mohanty, A., Kabi, A. & Mohanty, A. P.	Health problems in healthcare workers: A review	PubMed. US National Library of Medicine. HHS Public Access. J Family Med Prim Care, Volume 8, Issue 8, pages 2568-2572, August 2019	A review study	Due to peculiar causes such as deficiency in personnel, high clientele expectation, long working hours and great amount of workload, and occupational hazards, healthcare workers are under much pressure and being affected by escalating morbidity rate compared to general population. Even though they are all well informed and familiar with the circumstance, advancing self-care, educating and advocating the measures of occupational wellbeing are always in need at administrative and institutional level.
Nichol, K., McGeer, A., Bigelow, P, O'Brien-Pallas, L., Scott, J. & Holness, L.	Behind the mask: Determinants of nurse's adherence to facial protective equipment	Cinahl. American Journal of Infection Control. Volume 41, Issue 1, pages 8-13, January 2013	2-phased study. Phase 2: observational study	Nurses are at high risk for occupational transmission of communicable respiratory disease as the predominant occupation in the health sector, and as the health worker with the most patient interaction. A significant technique for avoiding occupational transmission is the use of facial protective equipment). While increasing knowledge should enhance competence, strategies to improve adherence to recommended use of FPE in a busy and complex healthcare setting should focus on equipment ready availability, training and fit testing, worker health and



				safety organizational support, and good communications practices.
Polovich, M. & Gieseker, K. E.	Occupational Hazardous Drug Exposure Among Non-Oncology Nurses	Cinahl. MEDSURG Nursing, Jan-netti Publications, Inc., Volume 20, Issue 2, March-April 2011	Advance Practice re-view	Oncology wards are not the only units having hazardous drugs (HD). Nowadays, the use of antineoplastic substances has developed, occupational exposure of nurses is elevated more than ever. As reported by the Bureau of Labor Statistics, over 2 million nurses are potentially exposed to HD, almost every day. HD exposure can occur in the operating room, in obstetrics, in rheumatology, neurology, or in units of treatment. Until nurses regain the capacity for exposure, safe handling precautions are unlikely to be enforced. Until precautions for safe handling of HD are universal, similar to those used for blood and body fluid exposure, nurses are at risk of adverse health effects related to HD exposure.
Rioufol, C., Ranchon, F., Schwiertz, V., Vantard, N., Joue, E., Gourc, C., Gauthier, N., Guedat, M. G., Salles, G., Souquet, P-J., Favier, B., Gilles, L., Freyer, G., You, B., Trillet-Le-noir, V. & Guitton, J.	Administration of Anticancer Drugs: Exposure in Hospital Nurses	ScienceDirect. Clinical Therapeutics, Volume 36, Number 3, March 2014	Prospective study	This study assesses this occupational exposure during the intravenous line-purging procedure at the patient's bedside before administration in oncology departments. Nurses are subjected to cytotoxic agents during hospital care. The intravenous line scrub accompanying the application of antineoplastic infusion bag is a possible cause of infection of nurses. Contaminations appear to be invisible but frequent.

<p>Rozenbojm, M. D., Nichol, K., Spielmann, S. &amp; Holness, L.</p>	<p>Hospital unit safety climate: Relationship with nurses' adherence to recommended use of facial protective equipment</p>	<p>Cinahl. American Journal of Infection Control. Volume 43, Issue 2, pages 115-120, February 2015</p>	<p>2-phased study. Phase 1: Data analysis from a cross-sectional survey</p>	<p>In spite of the existence of formal guidelines for the acute healthcare sector, it remains suboptimal for nurses to adhere to the recommended use of facial protective equipment (FPE) to prevent occupational transmission of communicable respiratory disease. The research conducted a data analysis and findings showed that significant variances in unit adherence and 5 of the six dimensions of unit-level climate protection, and a hierarchical model suggested that tenure and unit-level communication were associated significantly with increased adherence to the FPE. Strategies to improve communication on safety at the unit-level should help improve adherence to the FPE.</p>
<p>Salim, N. A. S. &amp; Mrayvan, M. T.</p>	<p>CHEMOTHERAPY SPILLS MANAGEMENT POLICY</p>	<p>Cinahl. Middle East Journal of Nursing Volume 8 Issue 4, November 2014 Middle East Journal of Nursing, July 2012, Volume 6 Issue 4</p>		<p>Chemotherapy chemicals are believed to be life savors considering they are able to increase surviving chance for cancer patients. However, they are as well labelled hazardous by the reaction between these chemicals and cell reproduction process. They are also generally designated for the neoplastic disorders' treatments. So, it is vital for both healthcare staff and patients to know the danger and possibility of health hazards these agents may cause and what to do when it happens.</p>
<p>Shakik, S., Arrandale, V., Holness, D. L., MacLeod, J. S., Mcleod, C. B., Peter, A. &amp; Demers, P. A.</p>	<p>Dermatitis Among Workers in Ontario: Results From the Occupational Disease Surveillance System</p>	<p>PubMed. US National Library of Medicine. Occupational and Environmental Medicine, Volume 76, Issue 9, pages 625-631, July 2019</p>	<p>A case was defined during a 12-month period within 3 years of cohort entry.</p>	<p>The Occupational Disease Surveillance System was used to investigate preventable dermatitis risk factors among workers in Ontario as it is the most common occupational skin disease. Higher risks were expected in certain groups, including food preparation, furniture and equipment industries, and chemicals and associated materials manufacturing occupations. Lower risks were noticed among nurses, as well as professions exposed to latex and indoor cleaning products.</p>

**APPENDIX 2***Content analysis for effects of chemical substances on nurses in hospital*

<b>Raw data</b>	<b>Subcategories</b>	<b>Main categories</b>
Shortness of breath Coughing Wheezing Chest tightness Whistling in the chest Asthma attacks Accelerated lung function decline Escalation of severe acute respiratory syndrome or influenza A Dyspnea	Acute respiratory syndrome	Airway effects
Chronic obstructive pulmonary disease Asthma Hypersensitivity Emphysema Chronic bronchitis Pneumonitis	Respiratory tract diseases	
Impacts on the fetus Developmental disorders in children: learning disabilities in offspring, birth defects Ectopic pregnancy Premature delivery Low birthweight Miscarriage, stillbirth Spontaneous abortion Abnormal blood count	Occupational exposure during pregnancy	Reproductive health effects
Menstruation issue Ovulation issue Prolonged time to conception Biological damage Fertility condition: infertility and decrease fertility Genotoxicity biomarkers Carcinogenicity Teratogenicity Reproductive toxicity Developmental toxicity Congenital abnormalities Produce physiological and DNA-damaging effects	Long-term health effects	
Sore throat Nasal sores Runny nose Eye irritation	Mucous membrane effects	Allergic reactions

Watery eyes Rhinitis		
Dry skin Itching Burning sensation Redness Skin swelling Cracking	Dermatitis and skin problems	
Leukemia Non-Hodgkin lymphoma Bladder cancer Liver cancer	Malignancies	Biologic effects
Increase in chromosomal damage and aberrations DNA/RNA damage	Genetic changes	
Abdominal pain Hair loss Liver damage Organ toxicity at low doses	End-organ damage	
Lightheadedness Dizziness Vestibular damage Vertigo Headaches Nausea Vomiting Ataxia Nystagmus Central nervous system impairment	Acute and chronic neurological symptoms	Neurological symptoms
Permanent threshold shifts in auditory perception Sensorineural hearing loss Impaired ability to distinguish sound Balance disorders Impaired ability to discriminate sounds Tinnitus and cochlear damage	Hearing damage	

### APPENDIX 3

#### *Content analysis for prevention of chemical hazards in hospital*

<b>Raw data</b>	<b>Subcategories</b>	<b>Main categories</b>
Security glasses provide side protection by a wrap-around or side shield configuration, eye protection, goggles, face shields, full-facepiece respirators	Eye protection	Using Personal Protective Equipment
Using protective covers: nonabsorbent gown, lab coats, shoe and head cover Using specialized gloves: chemotherapy gloves, latex gloves, cut-resistant gloves, chainsaw gloves, heat-resistant gloves	Protective clothing/gowns	
Using surgical masks, gas masks, N95 masks Apply Facial Protective Equipment (FPE)	Respirators	
Ear plugs Earmuffs	Hearing protection	
The guidelines cover methods and safe handling hazardous drugs Procurement appropriate health facility materials in the manufacturer's guidance for spilled products Providing information of safety handling with spillages or contamination Providing health surveillance programs Controlling exposure at source	Monitoring exposure at workplace with medical surveillance and policies	Administrative and work practice controls
Implementation of safety procedures for the processing Providing safety waste disposal for chemical products Acquisition of medications and materials with safe spill protocols Regular equipment maintenance to avoid technology errors	Using safety products to avoid exposure	
Using biological safety cabinets to safeguard chemicals Using needle sticks and sharp equipment containers Using specialized glove boxes	Hazard barrier or containment	
Isolating healthcare facility areas and equipment Using exhaust hoods to provide local ventilation when compound and mix drugs Storing flammable chemicals separately from ignition chemicals	Separating hospital areas	

<p>Specialized training programs and awareness education for safe handling of HDs</p> <p>Providing employee safety guidelines</p> <p>Educating health staff on the nature of occupational risks</p> <p>Education on the use of tools, facilities and Personal Protective Equipment</p>	<p>Education to improve nurses' knowledge and follow safety guidelines</p>	
<p>PhaSeal system</p> <p>ChemoClave system</p> <p>Equashied system</p> <p>Chemo Safety system</p>	<p>Closed-system transfer devices</p>	<p>Engineering controls</p>
<p>Using luer-lock fittings</p> <p>Using needleless systems</p> <p>Centralization of priming of intravenous tubing</p> <p>Intravenous tubing primed with antineoplastic drug by nurses or by pharmacies</p> <p>Robotic drug preparation using biological safety cabinets with laminar airflow for drug preparation</p>	<p>Support equipment and devices</p>	
<p>Reducing exposure time</p> <p>Increasing the distance to x-ray machines</p> <p>Increase the amount of shielding</p>	<p>Safety programs with X-ray machines</p>	