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# Evaluation of Occupational Hygiene Measurement Results of Chemical Risks in Hospitals: A Cross-sectional Study

## Hastanelerde Kimyasal Risklerin İş Hijyeni Ölçüm Sonuçlarının Değerlendirilmesi: Kesitsel Bir Çalışma

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## Abstract

**Objective:** According to the characteristics of the tasks in hospitals -cleaning works, laboratory services, polyclinic services- chemicals with high evaporation potential at room temperature and that named volatile organic compounds are used. Healthcare workers are defined as one of the worker groups that are most exposed to chemical risks in the literature. To protect the health of healthcare workers, it is necessary to evaluate the chemical risks in terms of possible negative health and safety effects for health workers and to measure their levels.

**Methods:** In this cross-sectional study, the measurement of chemical risks in hospitals will be discussed over two years of data from an accredited occupational hygiene laboratory to measure chemical risks.

**Results:** To 2.328 occupational hygiene measurements performed in 26 hospitals, 341 (14.6%) were related to chemical risks. Of the chemical risk measurement results, 19 (5.5%) exceeded the permissible limit value. Although different occupational risks were measured in 4 hospitals, chemical risks were not measured.

**Conclusion:** Although the activities and legal legislation offered through risk assessment in our country are sufficient in terms of quality, there are situations that need to be improved in quantity. It has been observed that national standards on the measurement of chemical risks do not adequately define the parameters to be measured, where and how they will be measured.

**Keywords:** Healthcare workers, hospital, chemical risks, occupational hygiene

## Öz

**Amaç:** Hastanelerde yapılan işin özelliklerine göre-temizlik işleri, laboratuvar hizmetleri, poliklinik hizmetleri gibi- birimlerde oda sıcaklığında buharlaşma potansiyeli yüksek olan ve uçucu organik bileşikler adını verdiğimiz kimyasallar kullanılmaktadır. Sağlık çalışanları literatürde kimyasal risklere en yoğun maruz kalan çalışan gruplarından biri olarak tanımlanmaktadır. Sağlık çalışanının sağlığını koruyabilmek için kimyasal risklerin sağlık çalışanları için olası olumsuz sağlık ve güvenlik etkileri açısından değerlendirilmesi ve çalışma ortamlarındaki düzeylerinin ölçülmesi gereklidir.

**Yöntem:** Kesitsel olarak yürütülen bu çalışmada kimyasal riskleri ölçmek üzere akredite bir iş hijyeni laboratuvarın iki yıllık verileri üzerinden hastanelerdeki kimyasal risklerin ölçümü konusu ilgili ulusal mevzuat ile birlikte tartışılacaktır.

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## Öz

**Bulgular:** Yirmi altı hastanede yapılan toplam 2,328 iş hijyeni ölçümünden 341'i (%14,6) kimyasal riskler ile ilgili idi. Kimyasal riskler ölçüm sonuçlarından 19'u (%5,5) izin verilen sınır değeri aşmıştı. Dört hastanede diğer iş hijyeni risklerinin ölçümü yapılsa da kimyasal riskler ölçülmemişti.

**Sonuç:** Ülkemizde risk değerlendirme ile sunulan faaliyetler ve yasal mevzuat nitelik olarak yeterli olsa da nicelik olarak geliştirilmesi gereken durumlar bulunmaktadır. Kimyasal risklerin ölçümü ile ilgili ulusal standartların ölçülecek parametreleri, nerede ve nasıl ölçüleceğini konusunda rehberlere ihtiyaç bulunmaktadır.


**Anahtar Kelimeler:** Sağlık çalışanı, hastane, kimyasal riskler, iş hijyeni

## Introduction

Healthcare workers are exposed to numerous different risks considering the diversity of tasks and chemicals used in hospitals. The National Institute for Occupational Safety and Health in America has indicated that there are 25 different chemical hazards and risks in hospitals[1,2]; disinfectants, sterilizers, anesthesia gasesgasses laboratory work, and cleaning materials are the main sources of chemical risk in the hospital environment. Chemical risks are classified into volatile, semi-volatile, and persistent chemical substances based on their evaporation potentials at room temperature. Volatile organic compounds (VOCs), which continuously evaporate into the ambient air due to their high evaporation level, are usually colorless and odorless. We not only inhale these chemicals present in high concentrations in the ambient air but also absorb them through other routes such as dermal and mucosal pathways[3,4]. Isopropyl alcohol, ethanols used in disinfection and cleaning tasks, fluoranes found in anesthesia gases; (enflurane, isoflurane, desflurane, and sevoflurane), nitric oxide, ether; acetone, glutaraldehyde, formaldehyde, toluene, xylene, and ammonia commonly encountered in pathology laboratories are examples of VOCs[5]. Chemicals have acute or chronic, direct or indirect toxic effects on worker health. Toxicity varies depending on the exposure route, duration and frequency of exposure, dose of the chemical substance exposed and polymorphic features in genes and enzymes playing a role in the toxicokinetics of the toxic substance[6]. Acute effects usually arise due to intense exposures because of spills or scatterings. Respiratory or dermal irritation symptoms that start immediately after the incident are prominent. However, in chronic exposure cases, there is usually low dose and long-term exposure; they can cause toxicities such as liver and kidney damage, permanent damage on the central nervous system, asthma and respiratory diseases, congenital anomalies, and cancer[7-10]. Measuring exposure to chemicals directly or indirectly, risk control studies in the workplace, causality assessments in occupational health relations, and selection of appropriate personal protective equipment for workers are among the most important steps in planning occupational health and safety (OHS) activities[11]. Therefore, it is recommended to measure chemical risks at regular intervals using occupational hygiene methods in both national legislation and international regulations. However, there are vague issues in legal regulations about which risk will be measured where, how much, and how. There are insufficient data regarding the measurement of chemical risks in hospitals in Turkey. This study aimed to obtain data on occupational hygiene measurements and chemical risks in hospitals through occupational hygiene laboratory measurement reports and compile the relevant legal regulations in Turkey.

## Materials and Methods

The study is a cross-sectional type of research. In Turkey, the authority to perform occupational hygiene measurements is given to occupational hygiene laboratories that have received accreditation certificates from Republic of Turkey Turkish Accreditation Agency by the relevant legal regulations. Accordingly, there are 10 occupational hygiene laboratories in the province of İzmir. Three of them currently appear active and have adequate laboratory status (https://www.isgum.gov.tr/labyetki.aspx). The three laboratories were contacted by phone and asked to share their data, but only one laboratory volunteered to share its data. In this study, occupational hygiene measurement result reports carried out in hospitals by a private laboratory, which is an accredited institution, between 2021 and 23 were evaluated. Occupational hygiene measurements were performed by the same experimental staff using the same methods, and the collected samples were measured by the same devices according to the Turkish Standards Instution ISO 16200-1 standard[12]. The regulation of OHS activities related to chemical risks in hospitals, occupational hygiene measurements, and protective measures were searched on the national legislation website https://www.mevzuat.

gov.tr/ with the keywords "chemical risk", "occupational hygiene", "occupational health", "occupational safety", "risk assessment", "measurement of risks", "volatile organic compounds", "carcinogen and mutagen", "hospital", "dental technician", "medical laboratory".

Data collection and data anonymization: The measurement results consist of an introductory part presenting the experimenter who performed the measurement, the date of measurement, the name of the hospital where the measurement was made, the number of workers, and the list of measured parameters, followed by sections where the tables providing risk measurement results are presented and where the measured values are compared with permitted limit values. Identifying data of hospitals were anonymized by the laboratory manager and shared with the responsible researcher.

The study was conducted in compliance with research and publication ethics. The study was approved by the Non-Interventional Ethics Committee of Dokuz Eylül University, İzmir (decision no: 45269, date: 04.09.2021).

### Statistical Analysis

Descriptive findings are given with mean and standard deviation, minimum-maximum values for numerical measurement values, and percentage for categorical values. The analysis was performed using the SPSS 21.0 package program.

## Results

In this study, the occupational hygiene measurement data of an accredited occupational hygiene laboratory for the years 2021-2022 were evaluated. Of the total 108 measurement activities carried out by the laboratory during the specified period, 24% (26) were conducted in hospitals. Accordingly, the average number of workers in 21 hospitals with worker data was 1081.5 and the median number of workers was 490. The least number of workers was found in a dental technician laboratory with 2 workers while the highest number of workers was observed in a secondary level state hospital with 4.500 workers. The average number of all occupational hygiene risk measurements conducted in 26 hospitals was 93.1 parameters, and the median value was 44 parameters. The hospital with the least number of occupational hygiene measurements measured 1 parameter, and the hospital with the most measured 496 parameters. Among these measurements, the average number of VOC measurements was 13.2, median 7, the hospital that did the most had conducted 74 VOC parameter measurements, and the hospital that did the least had not conducted any VOC measurements. Although different occupational hygiene measurements were made in 4 hospitals, no VOC measurements were made. The number of measurements exceeding the permitted limit value among VOC measurements was 19 out of 327 measurements (5.8%). Of the 19 measurements, 10 were measured in the pathology laboratory in the same hospital. Generally, it has been observed that VOCs are most frequently measured in pathology laboratories and dental technician laboratories. It was observed that an OHS professional participated in occupational hygiene measurements in 13 measurements, while they did not participate in the rest. Data regarding the number of workers in hospitals and occupational hygiene measurements are presented in Table 1.

In organizing OHS activities related to chemical risks in hospitals, access to 254 legal regulations was achieved in the search made with the keywords given in the method part of the compilation studies related to occupational hygiene measurements. The 14 regulations related to chemical risks in hospitals are presented in Table 2. Accordingly, it is observed that besides the general OHS legal regulations related to chemical risks in hospitals, regulations related to quality systems in health are quite comprehensive.

## Discussion

In this study, occupational hygiene measurement results performed in 26 different hospitals over two years were evaluated. It was observed that hospitals mainly focused on quantitatively measuring VOCs in their occupational hygiene measurements, however, significant qualitative differences were observed. It is noteworthy that the number of VOC measurement results exceeding the permissible limit value is low in all measurements. In the national legislation, it was seen that the regulations that might be related to the measurement of chemical risks in hospitals were collected under two headings, regulations related to OHS and regulations related to quality in health.

Different results can be encountered in studies regarding the measurement of chemical risks in hospitals. In their study, Bessonneau et al.[13] reported that they measured more than 40 VOCs in 6 different units of a hospital, but almost all were below the permissible limit value. LeBouff et al.[14] stated that they measured 14 different VOCs in 14 health workers in 5 hospitals and that the worker groups had a wide variety of VOC exposures. Therefore, they emphasized the importance

of determining the substances to be measured using a good job analysis[14]. Rautiainen et al.[15] mentioned the importance of planning the measurements according to the worker groups, in addition to technical features such as the size of the room, whether the place of measurement is closer to the ceiling or the floor among the parameters considered while making measurements in 47 hospitals. Both guides and literature discussions show that the planning stage is crucial in VOC measurements. When the measurement results made in 26 different hospitals in this study are evaluated, it is seen that there is no standard regarding the parameters measured. It is not understood for what purpose, in which units, and which parameters are measured in hospitals. It is noteworthy that the risk of VOCs has not been measured in 4 of the 26 hospitals where other occupational risks have been measured. This finding brings to mind the

**Table 1. Characteristics of hospitals where occupational hygiene measurement was performed and parameters measured**

| Hospital | The number of employees | Total OHS parameters measured | The number of VOCs | Measurement locations | The number of VOC measurements exceeding the permitted limit value | Participation of OHS specialists in measurements |
|---|---|---|---|---|---|---|
| H1 | 235 | 1 | 1 | Dental technician lab. | 0 | Yes |
| H2 | 300 | 3 | 3 | Pathology lab | 0 | No |
| H3 | 798 | 138 | 6 | ICU/operating room | 0 | Yes |
| H4 | 870 | 36 | 7 | General | 0 | No |
| H5 | Data not available | 19 | 8 | General | 0 | No |
| H6 | 847 | 496 | 28 | General | 0 | No |
| H7 | 300 | 108 | 7 | General | 0 | No |
| H8 | Data not available | 143 | 8 | Central lab/operating room | 0 | No |
| H9 | 3150 | 357 | 56 | General | 10 | No |
| H10 | 200 | 111 | 7 | General | 0 | No |
| H11 | Data not available | 28 | 2 | Pathology lab | 0 | No |
| H12 | 1322 | 235 | 65 | General | 4 | Yes |
| H13 | 1650 | 90 | 6 | General | 3 | Yes |
| H14 | Data not available | 97 | 74 | General | 0 | Yes |
| H15 | 194 | 26 | 7 | Operating room/ sterilization unit | 0 | No |
| H16 | 430 | 44 | 7 | Data not available | 0 | Yes |
| H17 | 1650 | 100 | 22 | General | 2 | Yes |
| H18 | 2 | 2 | 1 | Pathology lab | 0 | Yes |
| H19 | Data not available | 11 | 11 | General | 0 | Yes |
| H20 | 4500 | 36 | 1 | Dental technician lab. | 0 | Yes |
| H21 | 4500 | 14 | 0 | General | 0 | Yes |
| H22 | 300 | 46 | 1 | General | 0 | Yes |
| H23 | 490 | 28 | 13 | General | 0 | Yes |
| H24 | 700 | 16 | 0 | General | 0 | Yes |
| H25 | 25 | 143 | 0 | General | 0 | No |
| H26 | 250 | 14 | 0 | General | 0 | No |

"Total OHS Parameters Measured" refers to the total number of occupational hygiene parameters measured, ICU: Intensive care unit, OHS: Occupational health and safety, VOCs: Volatile organic compounds

**Table 2. Regulations in national legislation related to chemical risks in hospitals**

| Regulation name | A year of acceptance | Section/s related to chemical risks |
|---|---|---|
| Law no. 6331 on occupational health and safety | 2012 | Concepts of hazard and risk, employer duties and responsibilities in risk identification and control activities |
| Regulation on duties, authorities and responsibilities of workplace physicians | 2013 | Activities to guide the employer in health surveillance of employes and surveillance of the working environment within the scope of OHS services |
| Regulation on duties, authorities and responsibilities of occupational safety experts | 2012 | Guidance to the employer in risk assessment, risk control activities, planning occupational hygiene measurements, and controlling applications |
| Occupational health and safety services regulation | 2012 | In the activity areas of the OHSBs, provided that they obtain approval from the general directorate, OHSBs can keep the necessary equipment for all kinds of measurements and analyzes related to occupational health and safety at the address where the OHSB operates, limited to the employes and the workplace where they provide service, and can employ the relevant personnel |
| Regulation on occupational health and safety services to be conducted by the employer or employer representative at workplaces | 2015 | Measurements to be made in the workplace according to the provisions in the law and sub-regulations are carried out by laboratories authorized by the ministry |
| Regulation on health and safety measures in work with chemical substances | 2013 | The employer is obliged to determine whether there is a dangerous chemical substance in the workplace and to make a risk assessment to determine the adverse effects on the health and safety of the workers in case of a dangerous chemical substance. The employer ensures that measurements and analyzes of chemical substances that may pose a risk to employeshealth are made regularly. These measurements are repeated when there is any change in conditions that could affect employesexposure to chemical substances. Measurement results are evaluated considering the occupational exposure limit values specified in the annexes of this regulation |
| Regulation on the procedures and principles of occupational health and safety training for employees | 2013 | Chemical risks and health effects in training subjects |
| Regulation on occupational health and safety risk assessment | 2012 | Multiple articles - it is recommended to read in detail |
| Dental prosthetics laboratories regulation | 2005 | Laboratory types and mandatory tools and equipment<br>Vacuum dust collector workbench, mask, and obligation to provide occupational safety gloves that can prevent chemical exposure |
| Regulation on improving and evaluating quality in health<br>2023 quality evaluations in health standards (general hospital)<br>Measurements of formalin and xylene in pathology units and comparison with the permitted limit value in ministry of health circular | 2015 | Employee safety score and management of chemical, biological, radiological, and nuclear (CBRN) hazards<br>measurement of formalin and xylene in pathology units and comparison with the permissible limit value<br>Ventilation should be available in pathology units for volatile chemicals |
| regulation on health and safety measures in work with carcinogenic or mutagenic substances | 2013 | Risk assessment, measurement of chemicals and risk control studies, occupational exposure limit values in Annex-2 of the regulation |
| Regulation on occupational hygiene measurement, test and analyses | 2023 | Multiple articles - it is recommended to read in detail |
| Medical waste control regulation | 2017 | Pathological waste treated with any chemical, volatile and semi-volatile organic substances, mainly chemical substances, genotoxic/cytotoxic agents, radiological waste and pressurized containers cannot be found among the waste to be sterilized |
| Regulation on private health institutions providing oral and dental health services | 2022 | The measures specified in the relevant legislation are taken for the provision and protection of patient and employe safety in health institutions |

Repealed regulations are excluded. OHS: Occupational health and safety

question of whether it was thought that there was no VOC risk in that hospital when planning. It was observed that the number of parameters measured in hospitals measuring VOCs is very variable. In the hospital that made the least measurements, only one (excluding the number of hospitals not making any measurements) in the hospital that made the most measurements, 74 VOC measurements were made. Accordingly, there are differences in VOC measurement planning in certain units common in hospitals -central laboratory, operating room, pathology- units. In the study by Ndlele and Naidoo[16] on cleaning workers in hospitals, it has been defined that there are many chemical risks for cleaning jobs only. In this study, it was seen that no special evaluation was made for cleaning workers in the measurements made in hospitals[16]. Considering that the number of measurements exceeding the permissible limit value is 19 (5.8%) and 10 of the 19 measurements were measured in the pathology laboratory of the same hospital, it is striking that only 10 measurement results are high. If it is assumed that this could be due to the lack of sufficient regulations regarding the planning and execution of measurements, possible errors related to measurement and analysis, it is thought that national legal regulations and inspections on the subject are insufficient. However, studies with larger data are needed.

In Table 2, it is seen that the regulations collected in two separate headings are general OSH regulations and regulations related to quality in health in the compilation made specifically for chemical risks in hospitals. It is seen that the legislation talks about the subject with general definitions of its activities in the field of OSH. It is striking that the regulations related to quality in health define the parameters to be measured for pathology laboratories in detail along with measurement periods. This explains the result that the unit with the most measurements in the results of the study was the pathology laboratory. However, in Turkey, the delay in the implementation of law no. 6331 on OHS, which is the main regulation regarding OSH, for hospitals is at the forefront of the problems in the implementation of the legislation in the field. According to the Business Inspection Board activity report, a total of 8.592 inspections consisting of 148 scheduled and 8.444 unscheduled inspections from the perspective of the conduct of work in 2022 and a total of 17,842 inspections consisting of 15,761 scheduled and 2.081 unscheduled inspections in terms of OSH in 2022 have been conducted. No inspection activity in hospitals was encountered in the details of the report. A similar result was reached in the reports of the previous year[17]. The positive results of regulations such as the applications of health quality systems, guidance, application, and inspection activities are obvious. Although the awareness about OSH and health issues of healthcare workers has increased with Coronavirus, it is thought that the lack of sufficient activity in the inspection leg, postponement of regulations, etc. hinder the development of occupational hygiene activities in hospitals[18-20].

### Study Limitations

In this study study's reliance on evaluations based on a single data set constitutes a significant limitation. However, it should not be forgotten that voluntary assessments are inevitable due to the lack of the publication of measurement data on the subject by a national authority.

## Conclusion

In conclusion, hospitals are distinctive workplaces in terms of the chemical risks they harbor. However, there is a need first to ensure the implementation of existing legal regulations on the subject and then to provide guidance to the field with new regulations. The preparation of guideline documents and the conduct of constructive inspections are important for the standardization of occupational hygiene activities. Regulations related to quality in healthcare, which are effectively implemented and audited in the field and which guide the field, are considered to be good examples of practice.

### Ethics

**Ethics Committee Approval:** The study was approved by the Non-Interventional Ethics Committee of Dokuz Eylül University, İzmir (decision no: 45269, date: 04.09.2021).

**Informed Consent:** Not applicable.

### Footnotes

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### Authorship Contributions

Concept: A.C.B., B.M., E.B., Design: A.C.B., Data Collection or Processing: A.C.B., B.M., E.B., Analysis or Interpretation: A.C.B., B.M., E.B., Literature Search: A.C.B., B.M., E.B., Writing: A.C.B., B.M., E.B.

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