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Exploring Factors Influencing on Occupational Respiratory Exposure to Chemical Airborne Pollutants at Workplace: A Qualitative Study

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ABSTRACT

Allocating the best control for occupational exposures to the airborne contaminants can be accomplished by fully identifying all of the determinants of human exposures. Therefore, achieving a reasonable understanding about these determinants and their control methods remains a high priority for occupational hygienists. The aim of the present study was to explore the factors influencing respiratory exposure of workers to chemicals at workplaces. In this qualitative study 41 experts approved our request to participate in the study but data saturation achieved by 27 interviews. Interviewees were occupational hygienists working in the universities and industries in Iran. Data were collected via semi-constructed interview between May to September 2018. The inductive content analysis method was done manually. The identified factors were categorized into groups based on their similar characteristics. Seven main categories (themes) and 56 subcategories (sub-themes) were identified as determinants of respiratory exposure to chemicals at workplaces, including workplace specific factors (9), source emission properties (3), process characteristics (10), contaminants properties (6), personal related factors (5), engineering control measures (8) and organizational & administrative controls (15). Our results revealed that there are many factors (56 factors) influencing exposure of workers to airborne chemicals. Thus, any preventive program for exposure management should thoroughly take into account such factors.

Keywords: occupational exposure, determinants, Iran, qualitative study

INTRODUCTION

The alarm for being at risk of potential adverse effects related to the chemicals is parallel with extending in chemicals usage without addressing exposure controls[1]. It is estimated that approximately 275000 deaths related to the exposure to hazardous chemical substances annually occurred in the world. Therefore, the International Labor Organization (ILO) suggested that improving safety in developing countries should be established on improving safety and health practice in all industrial sectors. To do this, having a chemical exposure management program remains as an obligation[2].

The intent of such a program is to identify all potential exposure to chemical substances[1,3-6] and to make an attempt for addressing the reasonable and executive measures for their controls[7,8]. As a matter of fact, perso

nal exposure to chemicals has a complicated and multi-dimensional nature which is strongly affected by a number of factors with various degree of importance[9,10]. Significant variability has shown within and between worker exposures and therefore defined “action level” concept of an occupational exposure limit[9,11,12], but not identifying sources of exposure and causes of exposure variability clearly. On the other hand, only using air sampling to determine the exposure levels requires complicated standard procedures and instructions, also is cost-consuming and accompanied with systematic and accidental errors[13-17]. Also, the main sources of exposure are not recognized easily. Some factors may be identified visually, although others may be latent and are usually difficult or even impossible to identify and they can cause uncertainty in exposure assessment[18]. This is while some of the employers spend a great deal of financial resources for chemical management programs without profoundly considering these factors and hence, they may become discouraged or even confused once encountered the unexpected results. Therefore, greater emphasis must be laid on resolving such problems[19,20,21]. Access to most of the creative aspects of science is achieved with the deep reviews of the content of the issues and answer to them[22,23]. Considering the issues more deeply, one can conclude that latent factors have critical roles than the apparent ones and must try to more focus them[24]. To overcome this problem, knowledge of related experts should be improved regarding the latent and apparent factors and the ways they have an effect on personal exposure[25,26]. On the other hand, exposures can be determined by a variety of models. Exposure models along with a good conceptual model constructed with the latent and apparent determinants of exposure will be very effective to elaborate deterministic exposure models for all stages of risk management[3,27,28,29]. Having a comprehensive knowledge about the variables that affect the exposure, can consider the direction and future research needs to determine & confirm amount of their impact on exposure[30].

However, the first step is exploring these factors through available resources with the goals of coming up with the related factors and also improving the effectiveness of chemical management programs [29]. In order to achieve this objective, we need to acquire sufficient data gathered from related resources and industries. Using in-depth experience of expert professionals associated with occupational hygiene and exposure science is a valuable option to achieve this goal [31]. Tielemans mentioned that the state of knowledge on exposure determinants requires further development. It can be completed by expert elicitation procedure [32]. Also, qualitative research by identifying all the latent and effective factors can be the basis for the systematic reviews [33]. Thus, the aim of the present study was to explore the factors influencing respiratory exposure of workers with chemicals at workplaces.

METHODOLOGY

Study design: Qualitative research methodology was used by the purposive semi-structured expert interview to achieve the more effective desired data and findings [34-37]. The study was carried out between May and September 2018 to explore the factors influencing the respiratory exposure to chemicals in Iran. The qualitative study can facilitate the emerging of latent factors as well as exploring and describing phenomena, recognizing potentially major variables or concepts, identifying patterns and relations, and creating coherent group of general assumptions (theories) and hypotheses [38, 39] which are invisible with limitations in our current knowledge.

Participants: In order to determine the occupational chemical exposures, we need to gain insight into all phenomena in causing and changing the exposure levels. Also, for defining the exposure determinants a holistic evaluation and effective common words, terminology & expressions between all experts are required.

A non-probability and purposive sampling technique, also known as judgmental or selective sampling, was employed to recruit the subjects. This will lead one to purposefully choose the relevant individuals for the study [40, 41]. Therefore, the selection of interviewees was based on purposive sampling.

As chemical exposure at workplace is regarded as a multi-dimensional topic and a complex issue, we attempted to involve experts with multiple expertise in academic and industrial contexts. Four types of expertise related to the industrial context were mechanical engineering, chemical engineering, production manager, occupational hygiene professionals.

Inclusion & exclusion criteria: An initial list of professionals was obtained after communicating with several industrial and academic centers. To choose the eligible experts, a set of inclusion criteria was especially defined for industrial professionals (having the membership experience in risk assessment teams and being involved at least three times in proposing and implementation of control measures , having at least five-year of job tenure relevant to the study area, having at least five-year experience on inspecting and risk control in industrial units, and willingness to be involved in the interview) and academic experts (with the same selection criteria as the industrial professionals but with the difference that they were required to have an academic position in this area, have experience of teaching a relevant course, and have published papers or relevant work related to the chemical exposure management). The characteristics of interviewees are presented in Table (1).

About 30 to 50 interviews is suggested to interview at qualitative research[42,43,44] but saturation of data is end of interviews[37,40]. After considering the inclusion criteria, 41 experts agreed to participate in the study at the predefined location but the interviews continued until it reached saturation (n=27). The details of the study along with time and location of interviews were then announced to the selected experts. They were also assured that their demographic characteristics will be kept confidential in the published reports.

Data gathering: A semi-structured interview was employed to explore the in-depth experience of experts about factors influencing respiratory exposure to chemicals at the workplace. All interviews were conducted by a member of the research team which had proper knowledge and skills in interviewing as well as practical experiences in conducting and managing a number of interview sessions. Demographic details of the participants were obtained prior to the study.

An interview guide was used in order to better orchestrate the interviews, nonetheless in many cases, the questions were based on the condition of mutual conversation the between the interviewer and the experts during the interview. Also, with increased insight to the answers, more questions were added to the questions guide accordingly.

The main subjective and purpose of this study was explained to the experts before the questioning process began. It was clearly stated and emphasized that purpose of the exposure is the airborne chemical contaminants concentration at entrance to the respiratory system. Questions addressed both general and detailed points. Welcome to our study. Please explain your experiences & knowledge in a free manner in the following areas. The final interview guide encompassed the following questions (table 2).

The complementary questions were also asked based on the expert responses to each question. All interviewees were encouraged to provide more description about their own experiences[37,40]. Each interview lasted between 45 to 60 minutes. Having the interviews recorded by a voice recorder, the transcript of each one was prepared and later confirmed by the

Interviewee[37,45,46]. Data gathering was continued until saturation of data were obtained. Saturation of data is a point where new data, idea or content do not emerge any more[37,40].. It occurred after conducting and analyzing 24 interview sessions, although, with more carefully designed process, interview sessions were conducted for 27 participants.

Data analysis: An inductive content-analysis procedure was employed for data analysis. The inductive approach is more preferred when similar studies for classifying the results do not exist[46,47].

A practical definition for the content analysis is "a systematic coding and categorizing approach used for exploring large amounts of textual information to unobtrusively determine trends and patterns of words used, their frequency, their relationships, and the structures and discourses of communication" [46]. In order to improve the quality of data analysis, like other qualitative methods, we endeavor gathering and analyzing data are conducted concurrently[48]. Therefore, the interviews were recorded by a voice recorder, were transcribed verbatim on paper on the same day and their interpretations were used as the input for the research.

Inductive content analysis process was fulfilled through four stages manually:

1- The preparation phase: This phase required the transcripts to be read several times in order to extract and obtain the sense of the whole, the whole interview to be considered as unit analysis, and the analysis to be fulfilled on both manifest contents also latent content.
2- The organizing phase which had sub steps: 2-1 defining meaning units by segmenting the text as words, sentences or paragraphs containing aspects related to each other through their content and context, 2-2- condensing meaning units: a process of shortening while still preserving the core, 2-3 considering content area such as the parts of the condensed meaning units based on theoretical assumptions from the literature or parts of the condensed meaning units that refer to a specific topic, 2-4 labelling and coding: labelling of a meaning unit as a code, in order to review and contemplate over the data in an exploration and different way.
3- Abstracting and categorization: distribution of improved codes on a higher logical and varying level, that includes: 3-1 creating sub-categories & categories according to phenomena discovered in the codes, 3-2 Comparing various codes based on differences and similarities, 3-3 sorting into sub-categories & categories (grouping codes), 3-4 reviewing, evaluating, discussing result by two researchers and revising them, 3-5 formulating categories into a theme.
4- The reporting phase: It contains the analysis process described in the previous section, the chart and the table given at diagram for conceptual system (categories and themes) and description of themes separately[37,46,4749,50].

Trustworthiness: Based on the nature of interviews, there is some degree of interpretation in content analysis process and there is mutual relationship between the researcher and the participants, which requires understanding and co-operation between them. Therefore, trustworthiness of findings in qualitative content analysis should be provided[37,46,47].

Trustworthiness refers to the reliability and validity of qualitative data using four criteria: credibility, conformability, dependability, and transferability[37,46,47]. Credibility was achieved by involving participants with relevant experience and various job contexts. Conformability and the process of analysis was evaluated and established by external peer check (by qualified individuals from the fields of occupational hygiene, health education, and occupational epidemiology). The accuracy of the results from interviews such as codes, themes, and indices were also approved by a few of participants. To achieve the levels of dependability, we gave the same chance to all the participants disregarding their characteristics. Also, duration of the analysis process decreased in so far as possible. Transferability; The transcribed interviews and Interpretations (raw data) analyzed was approved using inductive content analysis approach[47].

Table 1- Interviewees characteristics

Code	Age (yr)	sex	Experience (yr)	Education	Division	Job Title
1	47	male	14	Master's	Industry	production manager
2	35	male	7	Master's	Industry	production manager
3	52	male	13	Master's	Industry	production manager
4	41	male	11	Bachelor's	Industry	production manager
5	42	female	9	Bachelor's	Industry	production manager
6	39	male	7	Master's	Industry	chemical engineer
7	37	male	6	Master's	Industry	mechanical engineer
8	46	male	5	Master's	Industry	chemical engineer
9	39	male	8	Master's	Industry	mechanical engineer
10	44	male	13	Master's	Industry	chemical engineer
11	39	male	7	Bachelor's	Industry	mechanical engineer
12	43	male	14	Bachelor's	Industry	chemical engineer
13	44	female	17	Master's	Industry	occupational health
14	43	male	16	Master's	Industry	occupational health
15	39	male	13	Master's	health network	occupational health
16	38	male	14	Bachelor's	health network	occupational health
17	39	female	12	Bachelor's	health network	occupational health
18	41	female	17	PhD	University	University lecturer
19	49	female	22	PhD	University	University lecturer
20	41	male	21	PhD	University	University lecturer
21	37	male	9	PhD	University	University lecturer
22	42	male	12	PhD	University	University lecturer
23	39	male	9	PhD	University	University lecturer

Code	Age (yr)	sex	Experience (yr)	Education	Division	Job Title
24	45	male	17	PhD	University	University lecturer
25	43	male	11	PhD	University	University lecturer
26	42	male	13	Master's	University	University lecturer
27	41	female	9	Master's	University	University lecturer

Table 2- Questions of the interview guide

1	What experiences, reactions and perceptions do you have about controlling and reducing chemical exposures at workplaces?
2	Do you remember the real cases in which chemical exposures occurred?
3	What causes for such exposures were then identified?
4	In which ways the chemical exposure to airborne contaminants takes place in the workplace?
5	What are the factors influencing personal exposure to airborne chemicals at the workplace?
6	What are the factors that increase the risk of exposure to chemicals at the workplace?
7	What are the actions or strategies that can reduce or control the risk of exposure to chemical airborne?
8	How can we achieve effective control to exposures?
9	Controlling which of the factors can further facilitate the mitigation of personal exposure?
10	Why are the problems related to control of some of the factors not resolved yet?
11	Which factors are difficult to control?

RESULTS

The interviewees from two divisions of industry and university were divided into five groups; include university lecturers (10), experts and professionals of occupational health (5), production managers (5), chemical and mechanical engineers (7) among whom there were 21 men (77.8 percent) and 6 women (22.2 percent). Regarding the level of education, there were 6 participants with a bachelor's degree, 13 with a master's degree, and 8 Ph.D. holders. The average age of the participants was 42 years and the average work experience related to occupational safety and health was 12.1 years

During the interview content analysis process, seven main categories/themes and 56 subcategories/subthemes were emerged from the data. The seven main categories included the workhouse specific factors (9), the source emission properties (3), the process characteristics (10), the contaminants properties (6), the personal factor (5), the engineering control measures (8) and the organizational & administrative control (15). Table 3 shows these themes and sub-themes.

The identified factors influencing chemical airborne exposure:

Workhouse specific factors: Participants declared that some of the workhouse related factors play remarkable roles in respiratory exposure to chemicals. These characteristics are often constant or have minimal changes and most of them originate from considerations required to be taken into account in the design phases. For example, a workhouse located in the proximity of a contaminating plant, endanger the workers by exposing them to unwanted chemicals. The shape, geometry and type of buildings can facilitate or upset the removing or precipitating chemicals. Physical space and proximity of workstation to each other can exacerbate the mixed exposure with chemicals. Moreover, the type of materials used in construction of buildings can bring remaining chemicals into the workplace and lead to the secondary exposure to chemicals. The climate of the area (such as temperature, humidity, pressure, wind direction and so forth) can considerably affect the pollution release and further inadvertent exposure. Risk of exposure to chemicals will be minimized once we consider these parameters in the designing stage including site selection, selecting the construction material, the design of workplace and so forth. In other words, it is necessary to consider the vulnerability of a plant against these factors at the design stages.

"After conducting personal air sampling, we found that some workers were exposed to the chemicals that were not typically present as raw material, intermediate and final products in our plant. After investigation, we found that a plant at our upstream vented the chemicals without any alarm. Afterward, this was repeated for several times. "- An occupational hygienist

"In order to minimize the worker's exposure, a local exhaust ventilation was designed by a team. After a while, the system failed to work properly. We identified that sticky dust from an adjacent workstation had entered the duct and its precipitation led to obstruction of the duct. Due to weakness in design of workhouse, any changes into the workstations were impossible". – A university lecturer

Source emission properties: Several participants have pointed out that emission source characteristics is a very important factor in interacting with the worker exposure. Contaminants are produced in the source (such as equipment, process, etc.) and then emitted into the workplace air. Workers may be exposed to the contaminants when they are present in their workstation, during maintenance and repairing the equipment, secondary exposure and so on. The most important characteristics of each source interacting with human exposure include the far field or near field sources, emission time pattern and frequency, and other source specifications (distribution, shape, size, number).

"In a shoe-making company, operator of leather cutting had complained about annoying odor of the chemicals, although solvents were not being used for this operation. After our comprehensive investigation, we found that glue odor far from his workstation is transferred by ventilation system. Results of air sampling confirmed that concentration of some contaminants were higher than threshold limit value." - occupational health managers

"In an industry, three similar production lines were located in an old salon which led to the worker's exposure in entire salon. After constructing a new salon, three lines were located with appropriate distance from one another hence prohibiting pollution emission". - production manager

Process characteristics: Most of the participants stated that process characteristics have a great impact in

emission of contamination and worker's exposure. To make a product, there is need to the special process which having own characteristics. There are many characteristics affecting worker's exposure including the phase of lifecycle of process, level of automation, type of manufacturing process, the life time of equipment, process and so on, characteristics of machine or operation, main cause of emission, process operational parameters and process and job content. These can affect the workers individually or in combination with each other. The most important sub-them in this category includes process lifecycle phase, level of automation, type of manufacturing process, age of equipment, facility or process, machine, operation and process characteristics, process technology, process operational parameters adjustments, main origin or main cause of emission, and process & job content.

"In a transportation of bulk material by conveyor equipped with local exhaust ventilation, we increased the conveyor's speed to gain more production capacity. The ventilation performance measurement showed that its efficiency decreased significantly and it became out of service." - Mechanical engineer

"In a mixed combination storage, mixed operation was done through aeration mixed instead of mechanical mixed operation. This led to exposure reduction, decrease in the numbers of required repairmen and prevention of failure in mixer electromotor."- Chemical engineers

Contaminant's properties: All individuals declared that the Physico-Chemical and contaminant properties are among the most important factors affecting worker's exposure. Each chemical substance has unique inherent properties determining the type of its emission behavior and then human exposure. These can be named as volatility, vapor pressure at process temperature, vaporization, material quantity. The most important sub-them in this category included the role of substances, amount of pollution or substances, impurity and concentration percent, substance health specifications and substance emission potential.

"Results of personal sampling measurements showed that the workers of the cement mills section have lower exposure to chemical dusts than those working in the loading cement station. This is attributable to the state of cement powder in loading station considering granule state of cement at mill section." - University lecturer

"In a forging process, liquid graphite is used for cooling the molds which looks dark pitch black. Welding was also performed simultaneously. The workers pay more attention to precautionary actions (due to the fact that liquid graphite appears black and dirty) during working with liquid graphite, although it can make lower health problems than welding fumes". - occupational health managers

Worker Personal factor: According to most of the participants' opinions, a worker personal factor has great impact on the worker's exposure. There are many personal characteristics affecting human behavior at a workplace which can contribute to the worker exposure. The proper level of worker's attitudes and beliefs can have beneficial effects in reducing self-exposure originated from knowledge, training and learning from the previous similar exposure events. Workers with a higher level of knowledge, exhibit a more proper behavior regarding self-protection, peer-protection, consideration of health and safety regulations during own work, and reduction of their exposure. It is possible to modify the worker's behavior, then reducing their risky behaviors to reduce their personal exposure. The most important sub-themes in this category included personal abilities and characteristics, work departments and job classification, workers demographic factors, organizational cohesion, and human factor status.

"In a factory, the proper respiratory personal protection was provided for all workers, although the rate of occupational asthma had an increasing trend during the past years. Our investigation showed that workers did not know how to use respirators. A training program aimed to change the workers behavior resulted in significant decrease of the asthma rate over the years." - occupational health managers

"In a factory, rate of occupational disease was suddenly increased among workers with high educational level and more years of job tenure. We found that that they did not report the problems in the workplace because they wanted to boast about their own strength for the newly hired workers." - University lecturer

Engineering control measure: Approximately, all of the participants declared that engineering control measures are among the most effective parameters to reduce the worker's exposure. The most effective way for exposure control will be obtained once engineering control measures (such as local exhaust ventilation system) are integrated with production processes during early design phases. It is then when they operate properly with a well-maintained system. It should be mentioned that engineering controls allocated the high amount of financial resource for exposure control.

"In a workshop, most of the workers complained about pollutant exhausted from gasoline forklifts. The forklift with electrical power source was the best alternative, although it may have lower levels of performance than other forklifts. Replacement of gasoline forklift with a liquid gas forklift resulted in satisfactory result." - the production managers

*"In a conveyor, the spill of powder occurred in the spots with partial enclosure. The full enclosure helped us to have proper performance in dust collection and also in the performance of local exhaust ventilation performance.***"** - mechanical engineers

Organizational & Administrative control: Organizational and administrative control refer to the control other than engineering controls. It can include standard operational procedures, inspection plans, training etc. These are not the best options to prevent worker exposure but they required to bring together with engineering controls to obtain the satisfactory results. This covers 15 sub-theme including work duration & exposure patterns, cleaning characteristics, proactive maintenance measures and good housekeeping.

"During an overhaul, several exposures to chemicals (such as benzene) occurred. At the next time, we preventive them via perform by expert and qualified workers which led to the decrease in the chemical spillage considering to the work procedures." -occupational health managers

"A great project to implement a local exhaust ventilation was done for a plastic fibers production line. At first, it was working properly and after two months, their performance in collecting the fibers was remarkably decreased. After establishment of a regular maintenance cleaning and services, its performance was increased near to the design criteria". - the production managers

Table 3-Identified exposure factors including themes and sub-themes

themes	sub-themes	themes	sub-themes
workhouse specific factors	workhouse environment type	worker Personal factor	Personal abilities and characteristics
	workhouse building type		work departments & Job classification
	workhouse physical space Size		workers demographic factors
	Workhouse geometrical figures		Organizational cohesion
	building construction characteristics		human factor status
	the possibility & limitation of implementing of control system (based on building construction properties)	Engineering control measures	Partial or complete engineering substitution
	industry & neighbour pollution index		Isolation
	position & distance toward main neighbor		segregation
	Geographic climate type (environmental climate)		Mechanical Dilution Ventilation
Process characteristics	process lifecycle phase		natural ventilation
	Level of automation		Active process control system
	Type of Manufacturing Process		Suppression techniques
	age of equipment, facility or process		Mechanical local exhaust ventilation
	machine, operation & process characteristics		
	process technology	Organizational & Administrative properties & control	Governance requirements
	process operational parameters adjustments		Administrative segregation
	Type of Process failure (main origin or main cause of emission)		Quality assurance & documentation
	job title & type of activity		work duration & exposure patterns
	Process & job content complexity		Cleaning method & characteristics
contaminant properties	Physico-Chemical properties		method Substitution
	Amount of pollution or substances		proactive maintenance measures
	Substance Impurity & concentration percent		operational preventive maintenance
	substance Health specifications		Safe maintenance Turnover condition
	role of substances		good housekeeping
	substance emission potential		PPE
Source emission properties	Far field or near field sources		Training
	emission Time pattern & frequency		Notification procedure
	other Source specifications (distribution, shape, size, number)		Organizational & strategic management
			Organization demographics factors

DISCUSSION

This study aimed to explore the factors affecting occupational exposure to chemical airborne pollution. A set of 56 factors were identified with the potential effect on source pollution emission and personal exposure which were included into seven categories. Our findings from the semi-constructed interview revealed that physicochemical and contaminants properties, engineering control measure and process characteristics have a great impact on source emission control. Additionally, organizational and administrative controls and personal factors had greatly influenced the contaminant emission and personal exposure. Some of the participants believed that workhouse specific factors, and source emission properties are also important factors which should be addressed. Our findings are in line with the *Tielemans et al. (2008)* study with a difference that their suggested categories can be included into three categories of our study (Physico-chemical and contaminating properties, Engineering control measure & Process characteristics) [51]. For example, PPE is classified as one of the fifteen factors under the organizational and administrative control category. Personal behavior, as a personal factor, was a sub category of human factor status.

Organizational factors identified as one of the latent factors on human chemical exposure which do not seem to be an evidently effective direct factor. *Arif et al. (2008)* also reported that organizational factors (management, communication with other organizational personnel and equipment problems), training, frequent violation of organization policy, the quality of equipment and clothing provided, poorly fitting protective clothing, and lack of awareness regarding some topic (such as best practice & PPE, knowledge about jobs & job and skill competence) are contributing to risk of exposure to chemical substances at workplace [52]. The obtained code at the present study is the same as *Arif et al. (2008)* study, although most of the identified factors by them were located into the organizational and administrative control and personal factor. It can be related to a difference between the type of employed methodologies, the content of investigated tasks, their participants and the study scope.

The other researchers also reported some of the factors based on their methodologies. For example, the study of *Dunham et al. (2001)* employed some of the

important factors for risk assessment, including frequency of use, time of use, closed versus open system (part of process mode in our study), PPE used, quantity used, current measures to control exposure, number of employees exposed, percentage of chemical in mixture, lowest regulatory limit and health code (the type of health effects) [53]. It should be mentioned that our study is somewhat different from that of *Dunham et al.* in the study scope and objectives. The aim of the present study was to identify influencing factors on respiratory exposure with chemical substances which was differed to the aforementioned study.

The obtained codes in the present study were somewhat same as *Fransman et al (2011)* study, although they didn't consider the role of individual and organizational characteristics and quality of any control measures in their model [9]. The category of process and substances properties in our study was similar to exposure with different process and materials in *Fransman et al.* study's. they referred to the more need for a review of the exposure modifying factors, especially the behavior and characteristics of the worker. That's one of the outputs of codes in this study, which bring to of individual factors theme.

As an important principle, establishing a comprehensive qualitative process for worker's exposure assessment depends on the set some rational criteria for comparison the exposure parameters. It should be remembering that researchers concerned about the generality and applicability of their models in most of the workplaces. On the one hand, neglecting some critical factors may lead to the hiding latent parameters and subsequently, it leads to the reducing validity of the proposed model. On the other hand, the excessive number of parameters can also lead to the user confusing and thus reduce the applicability of model [54]. Our study attempts to provide sufficient data aiding the users to select the most applicable factors for exposure assessment based on the characteristics of own workplace. Our findings are in line with the most studies previously performed by the other researchers [55]. We also introduce the novel categories in our analysis. It should be remembering that our study can be a good representative of the current conditions of worker exposure to chemical substances existing in developing countries.

CONCLUSION

This qualitative study tries to shed some lights on the factors influencing the respiratory exposure of workers with chemical substances. We identified 56 factors locating in seven categories. These findings can steer the attempts toward considering more factors in the design of healthier workplaces, better control of hazardous chemical substances, make more efficient decisions to allocate the financial resource for exposure control, training the workers and so on.

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