Original Article

Occupational Health Risk Assessment of Benzene, Toluene, and Xylene in Shanghai*

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Abstract

Objective This study was designed to conduct a retrospective and systematic occupational health risk assessment (OHRA) of enterprises that used benzene, toluene, and xylene (BTX) in Shanghai, China.

Methods All data for the study were obtained from 1,705 occupational health examination and evaluation reports from 2013 to 2017, and a semiquantitative model following Chinese OHRA guidelines (GBZ/T 298-2017) was applied for the assessment.

Results The selected enterprises using BTX were mainly involved in manufacturing of products. Using the exposure level method, health risk levels associated with exposure to BTX were classified as medium, negligible, or low. However, the risk levels associated with benzene and toluene were significantly different according to job types, with gluers and inkers exhibiting greater health risks. For the same job type, the health risk levels assessed using the comprehensive index method were higher than those using the exposure level method.

Conclusion Our OHRA reveals that workers who are exposed to BTX still face excessive health risk. Additionally, the risk level varied depending on job categories and exposure to specific chemicals. Therefore, additional control measures recommended by OHRA guidelines are essential to reduce worker exposure levels.

Key words: Benzene; Toluene; Xylene; Occupational health risk assessment; Exposure level method; Comprehensive index method

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INTRODUCTION

Benzene, toluene, and xylene (BTX) are commonly used raw materials and organic solvents in industries worldwide. Benzene has been identified as a carcinogen by the International Agency for Research on Cancer (IARC)[1]. According to numerous studies, in addition to leukemia, benzene causes cardiovascular and nervous system diseases[2-4]. Toluene and xylene are

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less toxic than benzene but can cause chronic neurological symptoms[5,6] and menstrual disorders in women[7,8]. Since the promulgation of the Chinese Law on the Prevention and Control of Occupational Diseases (2002), the labor conditions with regard to protection against occupational exposure have markedly improved, and concentrations of BTX in the production environment have been effectively reduced. However, there is no safe level of exposure to benzene, as the results of a growing number of investigations indicate that exposure to benzene at concentrations < 3.25 mg/m^3 still causes hematotoxicity[9,10]. Furthermore, the adverse effects of benzene at low levels are not limited to blood diseases and include cancers, teratogenesis, and neurological symptoms[11]. Additionally, it is difficult to eradicate benzene in some types of manufacturing environments. Therefore, low-level and long-term benzene exposure has recently become a hot topic[12].

It can be assumed that exposure to a mixture of BTX would have a higher toxicity than the sum of the toxicities of the individual components. However, such an assumption needs to be carefully evaluated. To protect the health of occupational workers, the occupational exposure limits (OELs) for benzene were established and are enforced in most countries worldwide. The latest OEL of benzene from the US Occupational Safety and Health Administration is 1 ppm (3.25 mg/m^3), and the permissible concentration-time weighted averages (PC-TWAs) of BTX are 6 mg/m^3, 50 mg/m^3, and 50 mg/m^3, respectively, in China[13]. In addition, occupational health risk assessment (OHRA) models, such as the Environmental Protection Agency (EPA), Australian, Romanian, and Singaporean models, have been substantially improved and are widely used. EPA models have been conducive to identifying occupational hazards and critical control points since they were introduced in the nuclear industry field in China[14]. The Singaporean model has a dominant position because of its advantages when conducting a semiquantitative OHRA, which is mainly used to assess chemical exposures[15] and to help prioritize risk control strategies. For better evaluation of potential health risks caused by BTX, the semiquantitative OHRA models, recommend by Occupational Health Risk Assessment of Chemicals in the Workplace (GBZ/T 298-2017), were applied to evaluate the risk assessment of BTX in China. Compared to the qualitative assessment, the semiquantitative assessment is more objective and comparable by making full use of monitoring data. Furthermore, the semiquantitative OHRA models also have been improved with the aim of supporting health administrative departments or enterprises to qualify health risk at the workplace or enterprise level and for developing better disease prevention strategies.

Our study was conducted based on the Chinese guidelines (GBZ/T 298-2017) to assess health risk from exposure to BTX in Shanghai, China. The assessment was based on data from 1705 occupational health examination and evaluation reports. This investigation was designed to address the following aims: a) to introduce the Chinese methods of a semiquantitative OHRA model and b) to provide insights into the BTX exposure situation in Shanghai, China.

MATERIALS AND METHODS

Sources of Enterprise Data

The occupational health examination and evaluation reports from 2013 to 2017, belonging to BTX enterprises in Shanghai, China, were kindly provided by the Shanghai Administration of Work Safety. All the reports came from independent and qualified testing agencies that were certified by the Shanghai Administration of Work Safety. These reports included the following three detailed parts as inclusion criteria: general information, the use of raw or auxiliary BTX material, and the occupational health protection conditions and facilities. Furthermore, the scales and classifications of the enterprises were conducted with reference to the Industrial Classification for National Economic Activities (GB/T 4754-2017)[16]. Additionally, the job types were divided into painter, inker, gluer, others, and unknown, according to the production process or the use of raw and auxiliary materials. For the 'others' group, information on the BTX exposure associated with the production process included details on the detected concentrations. For workers in the unknown group, no detailed information on raw and auxiliary material or production processes were available to confirm the job; only the detected concentrations and the occupational health protective conditions and facilities were obtained.

BTX Detection

The concentrations of airborne BTX were obtained from the reports. In cases in which the concentrations of BTX were below the limit of detection, the square root of the limit of detection was used as the BTX concentration[17]. Additionally, the sampling procedure in all eligible reports followed the Specifications of Air Sampling for Hazardous Substances Monitoring in the Workplace (GBZ 159-2014)[18], and the detection processes were performed in accordance with the Determination of Aromatic Hydrocarbons in the Air of the Workplace (GBZ/T 160.42-2007)[19].

OHRA

Because of the lack of health data among workers in the EPA model, our study performed the OHRA using a semiquantitative model, as recommended by the Chinese OHRA guidelines (GBZ/T 298-2017), which were mainly improved based on the Singaporean model (available from: https://www.wshc.sg/files/wshc/upload/cms/file/2014/A%20Semiquantitative%20Method%20to%20Assess%20Occupational%20Exposure%20to%20Harmful%20Che.pdf), as described below.

The OHRA according to the Chinese guidelines was performed with the following four core OHRA steps: hazard identification, hazard characterization, exposure assessment, and risk characterization. First, to identify the hazards, all the occupational health examination and evaluation reports were reviewed to confirm that at least one of the components of BTX was used in enterprises. For hazard characterization, the hazard rating (HR) was confirmed based on the effects of chemicals on health and according to the classification of the American Conference of Governmental Industrial Hygienists and the IARC using the HR table (Supplementary Table S1, available in www.besjournal.com). Alternatively, the HR can be obtained based on the acute toxicity of the chemicals according to the lethal dose (LD_{50}) and lethal concentration (LC_{50}) (Supplementary Table S2, available in www.besjournal.com). Ultimately, the HR was determined using the higher value. In this study, the HRs for BTX were confirmed by referring to the oral LD_{50} and LC_{50} values from the material safety data sheet (MSDS).

The semiquantitative Chinese OHRA guidelines involved three independent processes: the exposure level, exposure index, and comprehensive index methods for exposure assessment. Data for the exposure level method were based on the available air monitoring results, and data for the exposure index method were based on the unavailable air monitoring results; these were adapted from the Singaporean model[20]. The comprehensive index method was an innovative approach which that integrated the first two methods with all the information on the routes, frequency, and duration of exposure provided by the Chinese Health Commission. In this study, the exposure assessment was performed with the exposure level method using the available air monitoring results and the comprehensive index method using the air monitoring results and exposure factors.

For the exposure level method, BTX exposure (E, mg/m^3) was calculated using Equation (1) for estimates, and the exposure rating (ER) was determined according to the ratio equal to the maximum value of the exposure concentration of BTX (E) divided by the corresponding OELs (TWAs) and ER (Supplementary Table S3, available in www.besjournal.com).

BTX exposure (E, mg/m^3) was calculated using the following Equation (1) for estimation:

$$E = \frac{F \times D \times M}{W} \tag{1}$$

where F is the weekly exposure frequency (d/w), D is the average exposure time per day (h/d), M is the detected concentration (mg/m^3), and W is the average weekly working time (h/w, set 40 h/w).

In particular, the correction coefficient f was employed to adjust the OELs of BTX for weekly work periods that exceeded 40 h, in which the adjusted OELs were the products of f and OELs. f was calculated from Equation (2), and the ER was confirmed with the BTX exposure and adjusted OELs.

$$f = \frac{40}{H} \times \frac{(168 - H)}{128} \tag{2}$$

where H is the weekly exposure time (h).

For the comprehensive index method, the ER was determined according to the comprehensive and various exposure indices (EIs) (Supplementary Table S4, available in www.besjournal.com), which not only contain the ratio of estimating exposure concentrations to the adjusted OEL (TWA) but also mainly include the vapor pressure, hazard control measures, usage of BTX per week, and duration of work per week. The ER was calculated using Equation (3):

$$ER = [EI_1 \times EI_2 \cdots \times EI_n]^{1/n} \tag{3}$$

where EI represents exposure indices, and n is the number of exposure factors.

Finally, the risk value for each enterprise using BTX was calculated using Equation (4):

$$R = (HR \times ER)^{1/2} \quad (4)$$

The risk characterization of each enterprise was confirmed according to the risk (R) table using the rounded risk value (Supplementary Table S5, available in www.besjournal.com).

Statistical Analysis

Fisher's exact Chi-square test was used to analyze the qualified rates of years and job types, and the Pearson Chi-square test was used to compare the exposure level method and comprehensive index method or to compare the BTX exposure levels. The Kruskal-Wallis test was used to compare rank distributions among multiple groups. A P value < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS 20.0 software for Windows (IBM, Armonk, NY, USA).

RESULTS

General Information Pertaining to Enterprises using BTX

From our investigation, 1,705 reports of enterprises using BTX were available from 2013 to 2017, and the largest number was 366 in 2017. As shown in Table 1, these were mainly small and medium enterprises, which were involved in manufacturing, furniture, metal, and printing products. Most of these enterprises used toluene and xylene more than benzene.

The Exposure of Enterprises using BTX

Compared with the Chinese OELs, the total qualification rates of short-term exposure limits (STEL) and TWA were 99.9% and 99.6, 99.7% and 99.7%, and 99.6% and 99.8% for benzene, toluene, and xylene, respectively. The qualification rates were not significantly different for the benzene STEL, benzene TWA, toluene STEL, toluene TWA, and xylene STEL between years using the Chinese OELs, although a significant difference was observed for the xylene TWA (P < 0.05), for which the lowest qualification rates were in 2013 (Figure 1A). Based on our classification of job types into painters, inkers, gluers, others, and unknown, according to their production process or raw materials to standardize the job types, no significant differences in the benzene STEL, benzene TWA, toluene TWA, and xylene STEL were observed between job types, although significant differences were observed for the toluene STEL (P < 0.05), in which the inkers had the lowest qualification compared to gluers or others, and for the xylene TWA between painters

Table 1. General information pertaining to enterprises using BTX in Shanghai

Items	2013 (*n* = 345)	2014 (*n* = 336)	2015 (*n* = 327)	2016 (*n* = 331)	2017 (*n* = 366)
Enterprise Scale					
Small	112	105	116	89	105
Medium	51	61	39	53	70
Large	11	10	16	16	25
Unknown[a]	171	160	156	173	166
Industry Category					
Furniture-making	150	126	144	132	143
Metal Products	87	71	69	80	86
Printing Industry	19	19	20	27	31
Other	78	84	79	76	95
Unknown[a]	11	36	15	16	11
BTX					
Benzene	255	258	247	233	249
Toluene	271	272	265	239	270
Xylene	279	281	272	252	284

Note. *n* means the number of BTX enterprises. [a]Unknown group means no detailed record was available in the reports.

and gluers, in which the painters had the lowest qualification compared to the gluers or unknown ($P < 0.05$) (Figure 1B).

OHRA Results

Semiquantitative OHRAs were performed using the exposure level and the comprehensive index methods. The hazard ratings for benzene, toluene, and xylene corresponded to 5, 2, and 3 based on the oral LD_{50} and LC_{50} values from the MSDS, respectively. According to the exposure level method and the centralized tendency of the health risk distribution, the health risks due to exposure to benzene, toluene, and xylene were mainly low, negligible, and low, respectively (Table 2). Interestingly, significant differences in health risks from exposure to benzene and toluene were observed after stratification based on job type ($P < 0.001$); however, no significant difference was observed in health risks due to exposure to xylene after stratification based on job type ($P = 0.623$, Supplementary Table S6, available in www. besjournal.com). The difference in the mean rank between benzene and toluene was the largest, indicating that the health risk due to exposure to benzene was significantly greater than the risks due to exposure to toluene and xylene ($P < 0.001$, Supplementary Table S7, available in www. besjournal.com). After comparing the health risks according to job types, gluers and inkers had significantly higher levels of health risks than individuals with other jobs ($P < 0.01$) (Figure 2).

Using the comprehensive index method, the levels of health risk due to exposure to benzene were at the medium level, and the health risks due to exposure to toluene and xylene were mainly at the low levels. The BTX ER not only included the exposure level but was also comprehensively determined by other factors—vapor pressure, engineering ventilation, personal protective equipment, daily use of the material, and daily exposure time. As shown in Figure 3, the problems existing in some enterprises were the limited ventilation, limited use of personal protective equipment, and daily use of large amounts of raw materials. All health risks in these enterprises stratified by job type are shown in Table 2. Meanwhile, regarding the two methods used for the analyses, our study clearly shows that the health risks assessed using the comprehensive index method were significantly higher than the risks assessed using the exposure level method ($P < 0.001$) (Table 2).

DISCUSSION

In our study, the Chinese semiquantitative OHRA method was applied to evaluate the health risk levels of enterprises using BTX. According to the detection of BTX in the workplaces, the qualification rates were close to 100% after stratification by year and by job type. Thus, an evaluation of the potential adverse health effects on workers that focuses only on the OEL would be insufficient[21]. Moreover, the main limitations of the OEL were the lack of qualitative and quantitative risk characterizations and failure to provide effective control measures.

This study involved the application of the Chinese OHRA guidelines. In China, the current approaches for a semiquantitative OHRA, the exposure level method, and the exposure index method have been modified according to the

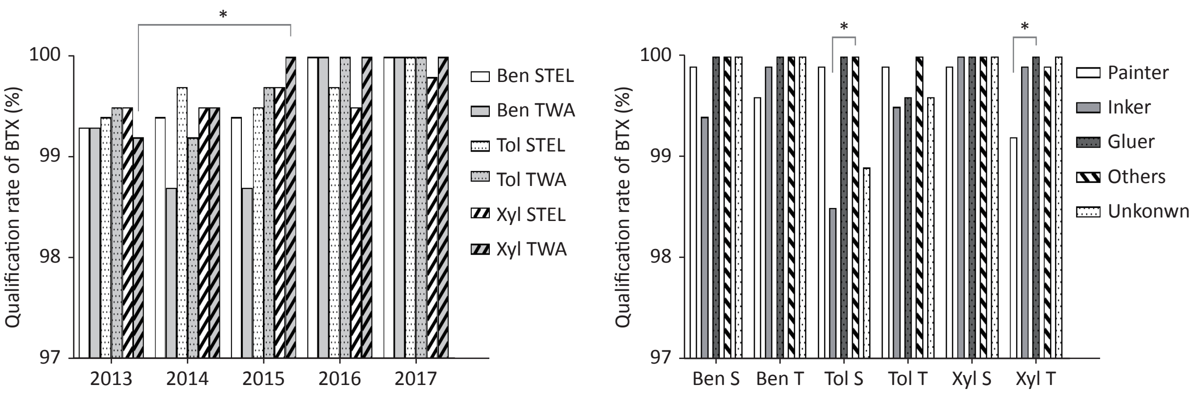

Figure 1. Qualification rates of enterprises using BTX by year or by job type. Ben, Tol and Xyl are the abbreviations for benzene, toluene and xylene, respectively. S and T represent the STEL and TWA, respectively. *Indicates $P < 0.05$.

Singaporean model, for which the exposure level method is widely used and preferred when only the monitoring data for the chemical concentrations are available. However, when the monitoring results are not available, the vapor pressure, hazard control measure, amount of chemical used, and duration of work per week are utilized as the exposure index to determine the ER. In the Chinese OHRA guidelines, the use of the comprehensive index method was proposed, which combined both the exposure level and exposure index methods. Indeed, Chinese researchers postulated that the exposure level method had the characteristics of a simple structure and easy operation; however, it considered only the E/OEL ratios. In contrast, the comprehensive index method not only considers the exposure level but

Table 2. Comparison of health risks in enterprises using BTX assessed by the exposure level method and the comprehensive index method stratified by job type

Items	Health risk[c]	Painter		Inker		Gluer		Others		Unknown	
		EL	CI	EL	CI	EL	CI	EL	CI	EL	CI
Benzene[a,b]	Low	131	8	20	3	12	2	8	0	13	1
	Medium	102	174	22	26	13	19	10	13	15	21
	High	18	69	1	13	4	9	0	5	2	8
	Very High	0	0	0	1	1	0	0	0	0	0
Toluene[a,b]	Negligible	183	5	32	0	20	1	10	0	20	0
	Low	94	251	13	41	7	24	7	17	13	32
	Medium	5	26	0	4	2	4	0	0	0	1
Xylene[b]	Low	267	163	46	27	28	17	18	11	33	24
	Medium	33	109	9	19	4	13	2	7	2	9
	High	10	38	1	10	1	3	1	3	0	2

Note. EL represents the exposure level method, and CI represents the comprehensive index method. [a]Statistically significant differences appeared in the distribution of health risk between benzene and toluene on different job types (P < 0.001). [b]Significant differences were determined for the comparison between the exposure level method and the comprehensive index method among different job types for benzene and toluene (P < 0.001). [c]The health risk of each enterprise was determined by the matrix graph of the risk index. The range of risk levels was 1 to 5, where 1 means negligible, and 5 means very high.

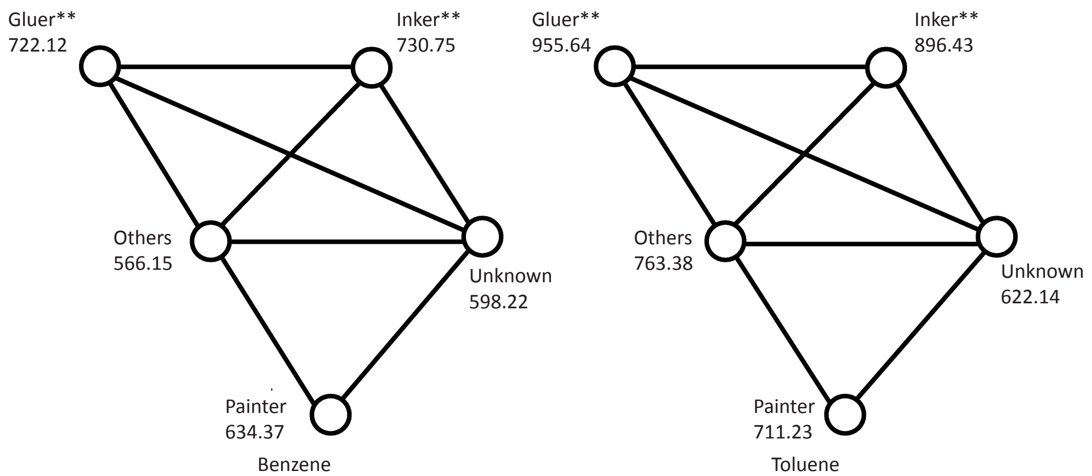

Figure 2. Gluers and inkers have relatively greater health risks. Comparisons of health risks due to exposure to benzene and toluene were performed between all pairs of job types. The mean rank for each job type is labeled. **Means P < 0.01.

also evaluates the vapor pressure, engineering protection measures, daily use of raw material, and daily exposure, making the results more convincing. Numerous studies in China have applied the Chinese OHRA model in various chemical industries since the guidelines were issued in China, and previous studies did not observe differences between the exposure level and the comprehensive index methods. However, after using the two semiquantitative methods, a significantly greater health risk was identified using the comprehensive index method than the exposure level method. The more reliable comprehensive index method should be adopted and encouraged because the greater health risk identified compels the enterprise to take more rigorous exposure control measures. Additionally, our study identified the following problems using the comprehensive index method: inadequate engineering ventilation, reduced use of personal protective equipment, extensive use of raw and auxiliary materials, and long daily average exposure times. Our study took advantage of the extensive information from the reports that made the comprehensive index method more practical than the other method. However, neither of these two methods considered the physical examination data of workers. For instance, if workers had concurrent health problems, their occupational health risks would be substantially increased. Therefore, we recommend that the available health monitoring data should also be considered as an important factor for optimizing the comprehensive index method.

Based on our two methods of evaluation, benzene showed a higher level of health risk than either toluene or xylene, mainly because benzene was associated with the highest HR when evaluating the hazard characteristic, indicating that the health risk level was related to the HR. As mentioned above, no significant difference was observed in the health risk due to exposure to BTX when the data were stratified by year using the exposure level method, consistent with the results of the qualification rates[22]. However, the health risks due to exposure to benzene and toluene were significantly different among different job types.

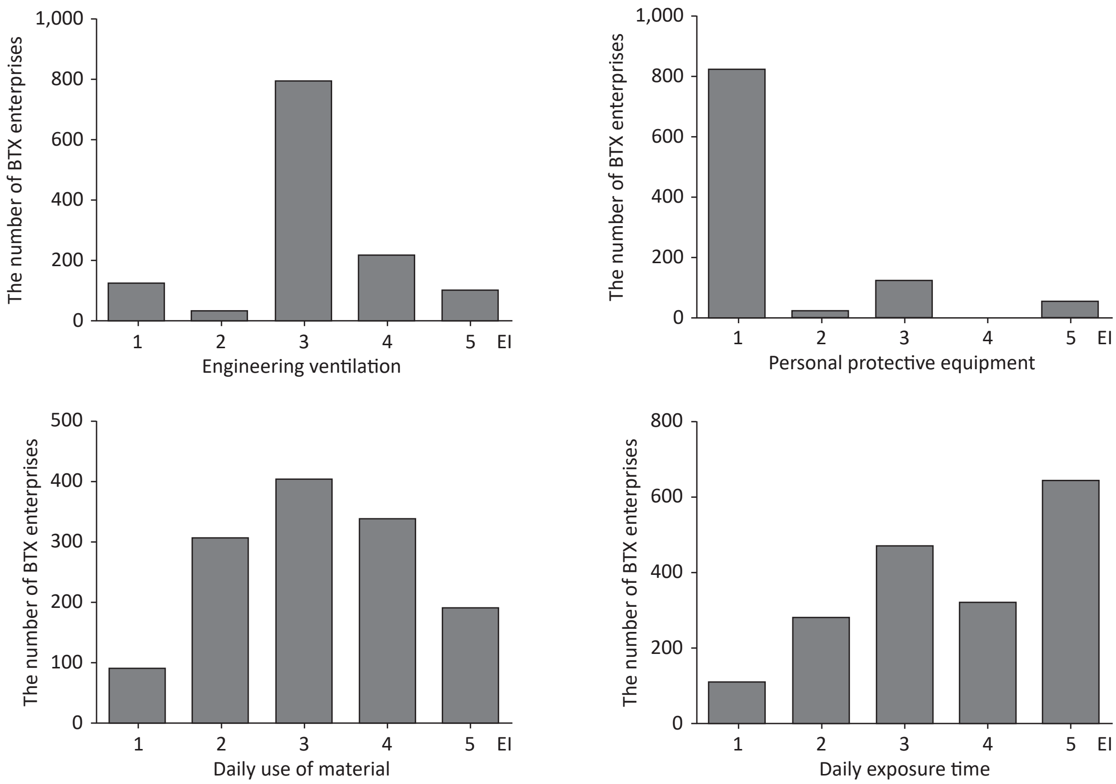

Figure 3. Exposure factors used in the comprehensive index method. All these graphs were generated based on the occupational health examination and evaluation reports. The grades of exposure indexes were adjusted according to the Guidelines for Occupational Health Risk Assessment of Chemicals in the Workplace, where 1 means extremely low exposure, and 5 means extremely high exposure.

Further analyses revealed greater health risks for gluers and inkers than individuals with other jobs, whereas the health risks of painters were classified in the medium category; this might be related to the strict regulation and the use of low-benzene or benzene-free paints. Therefore, gluers and inkers should receive more attention.

This study has several strengths and limitations that are worth mentioning. Although different methods have been used to assess occupational health risks by using precise toxicological data and the health data of workers, the collection of these data is either difficult or extremely expensive[23,24]. In contrast, our study was cost effective and novel because it used the highly relevant occupational health examination and evaluation reports from the government administration that provide an overall profile of the city with regard to BTX exposure. Moreover, this approach is helpful for health departments and enterprised to enhance their managements of occupational health risks on a large scale. Nevertheless, this study has some limitations. First, not all adverse factors were considered because of the constraints of the data. In practice, other chemicals, in addition to BTX, might harm human health. Moreover, data on the accurate use of raw and auxiliary materials by workers with each job type were not available. Therefore, the estimated use of BTX based on the total amount of raw and auxiliary materials might have resulted in an overestimation of the health risks associated with exposure to BTX. Although both the exposure level and comprehensive index methods from the Chinese OHRA guidelines represent a comprehensive and universal tool for health departments or enterprises to qualify workplace- and enterprise-level risk assessments, further studies are needed to compare multiple models, such as the classical Singaporean and Romanian models, in key industries with BTX exposure risks.

In conclusion, an OHRA of enterprises in Shanghai that used BTX from 2013 to 2017 was conducted. The health risk due to exposure to benzene was greater than the health risks due to exposure to toluene and xylene. Gluers and inkers exposed to BTX had further increased levels of occupational health risks. The health risk assessed using the comprehensive index method was higher than that determined using the exposure level method. More effective control measures disclosed by OHRA guidelines are essential to reduce workers' exposure levels. In view of the feasibility, we recommend that health departments or enterprises conduct self-OHRA using the comprehensive index method.

CONFLICTS OF INTEREST

The authors report no conflict of interest.

AUTHOR CONTRIBUTIONS

XZL conceived and designed the study. MCH, JXD, LYX, WTS, and SY completed the data collection. WTS, SB, and SQH analyzed the data and wrote the paper with important intellectual input from XZL and WWA. XZL also provided supervision. All authors approved the final manuscript.

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Supplementary Table S1. HR rating according to toxic or adverse effects of chemicals

Hazard rating	Description of effects/Hazard category
1	No known adverse health effectACGIH A5 carcinogensIARC G4Not classified as toxic or harmful
2	Reversible effects to the skin, eyes or mucous membranes, not sever enough to cause serious health impairmentACGIH A4 carcinogensIARC G3Skin sensitizer and skin irritants
3	Possible human or animal carcinogens or mutagens, but for which data is inadequateACGIH A3 carcinogensIARC Group 2BCorrosive (pH 3 to 5 or 9 to 11), respiratory sensitizers, harmful chemicals
4	Probable human carcinogens or mutagens based on animal studiesACGIH A2 carcinogensIARC Group 2AVery corrosive (pH 0 to 2 or 11.5 to 14)Toxic chemicals
5	Known human carcinogens, mutagens or teratogensACGIH A1 carcinogensIARC Group 1Very toxic chemicals

Note. ACGIH: American Conference of Governmental Industrial Hygienists; IARC: International Agency for Research on Cancer.

Supplementary Table S2. HR rating by acute toxicity

Hazard rating	LD_{50} absorbed orally in rat mg/Kg body weight	LD_{50} dermal absorption in rat or rabbit mg/Kg body weight	LC_{50} absorbed by inhalation in rat, mg/liter per 4h gases and vapors	LC_{50} absorbed by inhalation in rat, mg/liter per 4h aerosols and particulates
2	> 2,000	> 2,000	> 20	> 5
3	> 200 to > 2,000	> 400 to ≤ 2,000	> 2.0 to ≤ 20	> 1 to ≤ 5
4	> 25 to ≤ 200	> 50 to ≤ 400	> 0.5 to ≤ 2.0	> 0.25 to ≤ 1
5	≤ 25	≤ 50	≤ 0.5	≤ 0.25

Supplementary Table S3. Exposure rating (ER) table

Exposure/OEL	Exposure rating (ER)
< 0.1	1
0.1 to < 0.5	2
0.5 to < 1.0	3
1.0 to < 2.0	4
≥ 2.0	5

Note. OEL: occupational exposure limit.

Supplementary Table S4. Exposure factors and index

Exposure Index Exposure factor	1	2	3	4	5
Vapor pressure or particle size	< 13.3 Pa Coarse, bulk or wet material	< 13.3 Pa–133 Pa Coarse and dry material	133 Pa–1,330 Pa Dry and small particle size > 100 µm	1,330 Pa–13,300 Pa Dry and fine material 10 to 100 µm	> 13,300 Pa Dry and fine powered material < 10 µm
E/OEL	< 0.1	0.1 to 0.5	> 0.5 to 1	> 1 to 2	≥ 2
Hazard control measure	Adequate control with regular maintenance	Adequate control with irregular maintenance	Adequate control without maintenance; moderately dusty	Inadequate control; dusty	No control at all, very dusty
Amount used per week	Almost negligible amount used (< 1 Kg or L)	Little amount used (1 to 10 Kg or L)	Medium amount used, workers are trained on handling the chemical (10 to 100 Kg or L)	Large amount used, workers are trained on handling the chemical (100 to 1,000 Kg or L)	Large amount used, workers are trained on handling the chemical (> 1,000 Kg or L)
Duration of work per week	< 8 h	8 to 16 h	16 to 24 h	24 to 32 h	32 to 40 h

Supplementary Table S5. Risk rating table

Risk rating	Ranking
1	Negligible
2	Low
3	Medium
4	High
5	Very High

Supplementary Table S6. Health risks of different job types assessed with the exposure level method

Items	Risk level	Painter	Inker	Gluer	Others	Unknown	*P*
Benzene	2	131	20	12	8	13	0.000
	3	102	22	13	10	15	
	4	18	1	4	0	2	
	5	0	0	1	0	0	
Toluene	1	183	32	20	10	20	0.000
	2	94	13	7	7	13	
	3	5	0	2	0	0	
Xylene	2	267	46	28	18	33	0.623
	3	33	9	4	2	2	
	4	10	1	1	1	0	

Supplementary Table S7. Comparisons between benzene, toluene and xylene with regard to health risk assessed with the exposure level method

Group	Test statistic	*P*
Ben-Tol	1417.532	0.000
Ben-Xyl	647.701	0.000
Tol-Xyl	−1293.441	0.000

Note. Ben, Tol and Xyl are the abbreviations for benzene, toluene and xylene, respectively.