*Iran J Public Health, Vol. 49, No.12, Dec 2020, pp.2287-2294*

**Review Article**

# The Safety of Schools Based on Heavy Metal Concentrations in Classrooms' Dust: A Systematic Review and Meta-Analysis

***Mozhgan MOGHTADERI [1], *Saeed HOSSEINI TESHNIZI [2], Tahereh MOGHTADERI [3], Mohammad Ali ASHRAF [4], Habibollah FARAJI [5]***

1. *Allergy Center of Aliasghar Hospital, Neonatal Research Center, Shiraz University of Medical Sciences, Shiraz, Iran*
2. *Clinical Research Development Center of Children Hospital, Hormozgan University of Medical Sciences, Bandar Abbas, Iran*
3. *Department of Soil Sciences, Science and Research Branch, Islamic Azad University, Tehran, Iran*
4. *Student Committee of Research Center, Shiraz University of Medical Sciences, Shiraz, Iran*
5. *Molecular Medicine Research Center, Hormozgan Health Institute, Hormozgan University of Medical Sciences, Bandar Abbas, Iran*

***Corresponding Author:** Email: Saeed.teshnizi@gmail.com

**(Received 14 Apr 2020; accepted 08 Jun 2020)**

**Abstract**

**Background:** Classroom is where children spend much of their time in; this study aimed to identify the concentration of heavy metals in the classroom dust based on the results of various studies in the world using the published data up to years 2018.

**Methods:** Fifteen studies were selected for the study according to the inclusion and exclusion criteria. The mean concentration of 11 heavy metals including arsenic, barium, cadmium, cobalt, chromium, copper, iron, lead, manganese, nickel, and zinc was extracted.

**Results:** The highest mean concentration of heavy metal (mg/kg) in classroom dust was related to iron (3904.7, 95%CI: 3657.1-8154.3), zinc (429.9, 95%CI: 182.8-677.1) and barium (419.2, 95%CI: 274.7-253.7), respectively. Subgroup analysis showed the maximum concentration (mg/kg) of iron in Iran (16945.5), zinc in Hong Kong (2293.5), barium in China (979.8), manganese in Iran (288.9), lead in Iran (258.8), chromium in Ghana (381.3), copper in Hong Kong (274.4), nickel in Iran (50.1), cobalt in China(43.4), arsenic in China(13.7) and cadmium in Hong Kong(8.7).

**Conclusion:** Even safe and healthy classrooms can threaten children's health by heavy metals. These metals are important since they are naturally found throughout the earth's crust, accumulate in the food chain and contaminate drinking water as well as alloys in school equipment.

**Keywords:** Heavy metals; Dust; Schools

## Introduction

"The children of today are the adults of tomorrow"; this message emphasizes the fact that governments should prepare a safe and healthy school setting for children. School environment is where children spend a lot of their time; therefore, it is one of the key settings for promoting children's health (1,2).

Heavy metals (HM) are naturally the elements found throughout the earth's crust; most environmental contamination results from industrial sources such as metal processing in refineries, coal burning in power plants, petroleum combustion, nuclear power stations and plastics, textiles, microelectronics and paper processing plants. A variety of

HM from vehicles and automobile exhaust has been found to contaminate the environment, too (3-5). The very small amount of some HMs is essential for health, while if its concentration exceeds a certain threshold in the body, it can threaten health (6-8). School is an environment where children might be exposed to these HMs through inhalation of dust, direct ingestion of contaminated soils or contaminated food stuff and dermal contact with polluted school supplies (9,10).

This systematic review and meta-analysis was designed to determine HM concentration in schools using the published data up to years 2018.

## Methods

This systematic review and meta-analysis was conducted following the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines (PRISMA).

### *Search Strategy*

An electronic search was done on scientific literature published in the database PubMed/Medline (NLM), Scopus, Science Direct and Google Scholar for articles published in English up to 2018. The search was performed using the following English words "heavy metal" AND "classroom" AND "dust" AND "school" AND "heavy metal concentrations".

### *Data extraction*

Two researchers (MM and TM) individually reviewed the data extracted from the included studies by two reviewers using a standardized electronic form in Microsoft Excel. The following data were extracted from all the included studies: 1) Study characteristics: the first author's name, year of publishing of the study, location where the study was performed, type of school and number of sample; 2) Outcome measures: mean and standard deviation (SD) for concentration of 11 heavy metals. Any discrepancy was resolved by consensus between the two reviewers.

### *Inclusion and exclusion criteria*

Studies were included in this meta-analysis if the following criteria were met: the study was conducted in classrooms of nursery, elementary and high schools; it measured the level of HM in the dust; it reported descriptive statistics of measurement of at least one HM; the measurement unit of HM was mg/kg or μg/gr. Studies were excluded if: 1) the study was duplicate reports, a review article, letters or conference abstracts; 2) the article reported the concentration of airborne HM not in the dust; 3) the study reported the HM concentration in indoor environment other than classrooms such as home, garden, playground; or 4) the article had identified HM in outdoor environment such as street.

### *Quality of studies*

To assess the quality of each included study in meta-analysis, we used the 22-item STROBE checklist (https://www.strobe-statement.org/). We categorized all the studies in three categories obtained based on total score of checklists: >80% of the total score of checklists yes= High; 60%-80% of total score yes= Medium; and <60% yes= Low.

### *Data analysis*

The mean of concentrations for eleven HM was considered as the outcome of this meta-analysis. The Cohen's d effect size (ES) was calculated, using mean divided by standard error of mean ($SE=SD/\sqrt{n}$). To evaluate the heterogeneity among the studies, the Q test ($P<0.1$) and $I^2>50\%$ were used. If heterogeneity was found, a random effect model (Der Simonian-Laird method) was applied to compute the pooled effect size. The mean of HM concentration with 95% CIs was used in the calculation for achieving the appropriate summary statistics. Sensitivity analysis was conducted to assess the influence of each study on the pooled estimate. Subgroup meta-analysis and meta-regression were applied to assess the sources of heterogeneity. The potential publication bias was assessed using Eagger's test. All statistical analyses were done using the Stata software, v.14 (Stata Corp LP, College Station, Texas, USA).

## Results

### *Study characteristics*

Overall, 149 studies were identified and subjected to initial screening. After removing the duplicates and reviewing the titles or abstracts, 105 studies were deemed ineligible. Among the 105 studies for full-text review, 71 were further excluded for the following reasons: no relevance, review and conference abstract. Finally, 15 studies with data for HM level in the dust of classrooms was included in our meta-analysis (Fig.1).

The studies on the concentrations of HM in classroom dust from different countries are shown in Table 1 (2, 11-24).

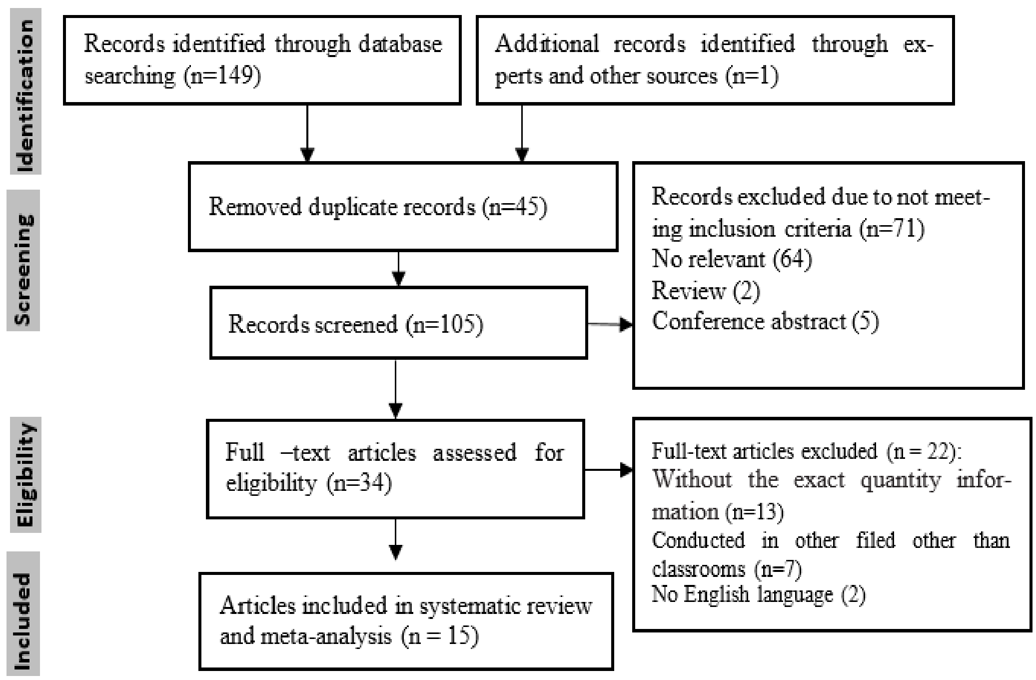


**Fig. 1:** PRISMA flowchart describing the process of the selected study

Except for one study (11), the other 14 cross-sectional studies were published from 2007 to 2018. The majority of studies (73.3%) were conducted in Asia, 3 (20%) studies in Africa, and one (6.7%) in North America (Mexico). The nursery setting was considered for assessing HM itself in 46.7% of studies, while two studies had described the concentration of HM in three levels of education including nursery, primary, and high school (Table 1). The total dust samples of HM were 486 (ranging from 3 to 101 in each school) for 15 studies.

The influence of each study on the pooled concentration of HM was assessed by mean and sensitivity analysis. The results of I-square index and Q test showed a high heterogeneity among the mean of the concentrations of HM for 11 metals (I^2> 50%, $P$<0. 1). There was no evidence of potential publication bias among the mean of the concentrations of metals except for lead, chromium and arsenic (Table 2).

The concentration of heavy metals in the dust of schools: A random-effect model was used to obtain the pooled mean of HM concentration (Table 2). The highest concentration of HM (mg/kg) in classroom dusts was related to iron (3904.7, 95%CI: 3657.1-8154.3), zinc (429.9, 95%CI: 182.8-677.1), and barium (419.2, 95%CI: 274.7-253.7), respectively.

**Table 1:** Characteristics and statistics of concentration of heavy metals in the included studies

| *Reference* | *Country, city* | *Place* | *School type* | *Arsenic* | *Barium* | *Cadmium* | | | *Cobalt* | | | *Nickel* | *Zinc* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | **Chromium** | **Copper** | **Iron** | **Lead** | **Manganese** | | |
| (11) | Hong Kong | 1 | NR | NR | 8.48±20.62 | NR | NR | 247.38±212.47 | NR | 199.96±144.89 | 224.28±132.73 | NR | 2293.56±1075.26 |
| (12) | Mexico, Hermosillo | 1 | NR | 56.59 | 4.24 | 2.21 | 11.15 | 26.34 | NR | 36.15 | NR | 4.7 | 387.98 |
| (13) | Malaysia, Dungun | 1 | NR | NR | 1.5 | NR | NR | 13 | NR | 47 | 121 | NR | 41 |
| (14) | Malaysia, Serdang | 1,2,3 | NR | NR | 5.94 | NR | NR | 212.9 | 3624.1 | 390.1 | NR | 47.9 | 709.7 |
| (15) | Malaysia, Shah Alam | 1 | NR | 30.9±18.91 | NR | NR | 16.88±3.61 | 30.19±6.25 | 4225.33±2282.01 | 31.24±17.49 | NR | 9±3.24 | 148.71±44.19 |
| (16) | Nigeria, Lagos | 2 | NR | NR | 0.09±0.12 | NR | 10.53±5.08 | NR | NR | 23.89±16.38 | not found | NR | NR |
| (17) | China, Xi'an | 1 | 14.5±6.6 | 978.5±270.1 | NR | 43.3±15.1 | 159.7±109.0 | 74.2±24.0 | NR | 176.2±94.8 | 565.4±97.7 | 36.2±11.9 | 462.6±289.9 |
| (18) | China, Xi'an | 1,2 | 13.2±6.3 | 980.1±511.6 | NR | 43.4±15.5 | 149.2±92.8 | 70.8±26.3 | NR | 180.9±162.4 | 558.3±92.4 | 34.6±9.9 | 461.5±300.6 |
| (19) | Malaysia, Bandar Baru Bangi and Kajang | 1 | NR | NR | 0.23±0.10 | NR | 11.9±6.8 | NR | 4801±1873 | 253.5±83.2 | NR | NR | 144.9±73.4 |
| (20) | Malaysia, Serdang | 2 | NR | NR | 1.89 ± 0.76 | NR | NR | 53.27 ± 31.67 | NR | 89.05 ± 85.71 | NR | NR | NR |
| (21) | China, Beijing | 1,2,3 | NR | NR | 0.2± 0.07 | NR | 63.6± 9.19 | 27.96±4.97 | NR | 48.63±21.74 | NR | 24.76± 2.43 | 107.28±31.32 |
| (22) | Ghana, Kumasi | 1 | NR | NR | NR | 0.576±3.714 | 381.302±280.682 | NR | NR | 4.816±9.219 | NR | NR | NR |
| (23) | Nigeria, Ogun | 2,3 | 2.04 ± 1.07 | 59.9 ± 46.4 | 855 ± 1898 | 21.9 ± 78.4 | 41.8 ± 25.4 | 40.9 ± 63.5 | 13.7 ± 9.16 | 27.6 ± 28.5 | 254 ± 161 | 12.7 ± 13.6 | 121 ± 129 |
| (24) | South Africa,Pretoria | 3 | 1.59 | NR | 0.7 | 5.95 | 49.6 | 32.6 | NR | 50.9 | 169.4 | 21.2 | 186.1 |
| (2) | Iran, Shiraz | 2,3 | 2.77±1.74 | NR | 1.03±2.33 | 6.36±2.96 | 172.8±122.1 | 40±22.4 | 16945.5±8691.1 | 258.8±268.2 | 288.9±156.1 | 50.1±22.5 | 258.8±210.6 |

NR=no reported; 1= Nursery; 2= Primary School; 3= High school

**Table 2:** The pooled mean of concentrations of the heavy metals (mg/kg) with 95% CI in the classroom dust of different countries

| *Heavy metals* | *Number of studies* | *Heterogeneity* $I^2$ (%) | *P* | *Model* | *Mean of concentration (mg/dL) (95%CI)* | *Egger's test* Bias | *P* |
|---|---|---|---|---|---|---|---|
| Iron | 5 | 38.1 | 0.16 | Fixed | 3904.7 (3657.1-8154.3) | 0.86 | 0.45 |
| Zinc | 11 | 93.1 | <0.001 | Random | 429.9 (182.8-677.1) | 0.84 | 0.20 |
| Barium | 5 | 98.0 | <0.001 | Random | 419.2 (274.7-253.7) | 26.93 | 0.16 |
| Manganese | 6 | 79.6 | 0.002 | Random | 335.3 (186.0-84.7) | 1.73 | 0.21 |
| Lead | 15 | 91.4 | <0.001 | Random | 121.3 (90.8-151.8) | 2.49 | 0.03 |
| Chromium | 11 | 93.7 | <0.001 | Random | 91.5 (75.1-107.9) | 2.51 | 0.04 |
| Copper | 10 | 29.2 | 0.36 | Fixed | 81.1 (47.3-114.9) | 0.12 | 0.98 |
| Nickel | 9 | 43.7 | 0.171 | Fixed | 26.6 (16.2 -36.6) | 0.99 | 0.37 |
| Cobalt | 7 | 76.6 | 0.004 | Random | 17.7 (8.0-27.3) | 1.89 | 0.18 |
| Arsenic | 5 | 91.2 | <0.001 | Random | 6.6 (4.1-9.2) | 3.91 | 0.03 |
| Cadmium | 8 | 94.3 | <0.001 | Random | 2.7 (2.4-3.0) | 1.87 | 0.10 |

Subgroup analysis showed the highest school concentration (mg/kg) of iron in Iran (16945.5), zinc in Hong Kong (2293.5), barium in China (979.8), manganese in Iran (288.9), lead in Iran (258.8), chromium in Ghana (381.3), copper in Hong Kong (274.4), nickel in Iran (50.1), cobalt in China (43.4), arsenic in China (13.7), and cadmium in Hong Kong (8.7) (Table 3).

**Table 3:** The mean (95% CI) of the concentration of heavy metals mg/kg in classroom dust samples in various countries

| *Heavy metal (mg/kg)* | *Hong Kong* | *Malaysia* | *China* | *Iran* | *South Africa* | *Nigeria* | *Mexico* | *Ghana* |
|---|---|---|---|---|---|---|---|---|
| Arsenic | NR | NR | 13.7 (12.4-14.9) | 2.8 (2.2-3.4) | 1.6 (1.4-1.4) | 2.0 (1.6-2.2) | NR | NR |
| Barium | NR | 30.9 (20.8- 40.9) | 979.8 (962.6-997.0) | NR | NR | 59.9 (57.8- 61.9) | 56.6 (52.2-61.0) | NR |
| Cadmium | 8.5 (7.7- 9.2) | 2.7 (1.8- 7.2) | 0.2 (0.2-0.2) | 1.0 (0.9-1.2) | 0.7 (0.5- 0.9) | 4.31 (3.9-12.6) | 4.2 (4.0-4.4) | NR |
| Cobalt | NR | NR | 43.4 (40.9-45.8) | 6.4 (6.2-6.5) | 5.9 (5.8-6.1) | 21.9 (19.2-24.6) | 2.2 (2.1-2.4) | 0.576 (1.1-2.2) |
| Chromium | NR | 14.4 (9.5-19.3) | 123.2 (52.4-194.1) | NR | 49.6 (32.4-6.8) | 26.2 (4.5-56.8) | 11.2 (10.9-11.5) | 381.3 (258.3-504.3) |
| Copper | 247.4 (239.5-255.2) | 77.4 (46.1- 200.9) | 57.6 (22.9-92.2) | 40.0 (32.2- 47.8) | NR | 40.9 (24.4-57.3) | 26.3 (22.6-30.0) | NR |
| Iron | NR | 4027.8 (3213.4-4842.1) | NR | 16945.5 ( - ) | NR | 13.7 (11.3- 16.1) | NR | NR |
| Lead | 99.1 (194.6- 205.3) | 162.4 (28.2-353.0) | 135.2 (34.4-236.1) | 258.8 (242.4-275.2) | 50.9 (49.8-52.0) | 25.7 (22.1-29.4) | 36.2 (35.2- 37.1) | 4.8 (3.9-5.7) |
| Manganese | 224.3 (219.4-229.2) | 121.0 (112.3-129.7) | 561.6 (554.7-568.5) | 288.9 (279.3-298.4) | NR | 254.0 (248.5-259.5) | NR | NR |
| Nickel | NR | 28.5 (9.7-66.6) | 31.8 (23.7-39.8) | 50.1 (42.3- 57.8) | 21.2 (20.4-21.9) | 12.7 (9.2-16.2) | 4.7 (4.0-5.4) | NR |
| Zinc | 2293.5 (2004.0-2582.9) | 261.2 (192.3-714.7) | 342.2 (59.5-624.9) | 258.8 (185.8-331.8) | 186.1 171.5-200.7) | 121.0 (87.5-154.4) | 387.9 (325.1 450.9) | NR |

NR=no reported

## Discussion

There has been a public health concern for increasing environmental contamination by HM in recent years. This systematic review and meta-analysis represented the concentration of HM in the dust of classrooms in selected nursery, elementary and high schools in various countries. The pooled mean concentration of HM in classrooms showed the highest level for Fe, Zn, Ba, Mn and Pb respectively, while the least concentration was related to Cd and As.

The frequency of concentration of HM in classrooms varies depending on the location. In Malaysia, the mean values of the HM was Fe> Zn> Pb> Cu> Ba> Ni> Cr> Cd in the classrooms, respectively. The highest concentration was reported for Fe (4225.3 mg/kg) and Zn (148.7 mg/kg) concentration, Tahir et al. for Mn (121 mg/kg), and Yap et al. for Pb (390.1 mg/kg) in Malaysian schools (13-15). The concentration of HM in Chinese classrooms showed the highest amount for Ba (979.8 mg/kg) followed by Mn (561.6 mg/kg), Zn (34.2 mg/kg), Cr (163.2 mg/kg), and pb (102.6 mg/kg) in Xi'an (17,18). Two studies were conducted in Nigeria; a low amount of Cd was showed and no detectable Mn in Lagos, while Olujimi et al. reported the high level of Cd (855 mg/kg) and Mn (254 mg/kg) in Ogun classrooms (16,23).

In the study of Hong Kong, the concentration of Zn and Cu was high in classrooms; contaminants from high auto-vehicles were blown into the schools through opened windows (11). The study conducted in Iran was limited to Shiraz that is the 5th largest city in Iran; the concentration of HM in classrooms were Fe 1694.5 mg/kg, Mn 288.8 mg/kg, Pb and Zn each 258.8 mg/kg in decreasing order; moreover, Pb concentrations in schools' dust were reported to be in the range of

9- 971 mg/kg, even more than high traffic area (2). In African reports, Cr concentration (381.3 mg/kg) was the highest HM in Ghana and Zn (186.1 mg/kg) as well as Mn (169.4 mg/kg) in classrooms of Pretoria (22,23). In Hermosillo city, which has a large industrial and agricultural activity is located in northwestern Mexico, the mean concentration of Zn was 387.9 mg/kg followed by Ba 58.5 mg/kg, and the level of Cd was higher than the average values in street dust of other big industrial cities (12).

Major HM is found throughout the earth's crust, but its amount varies greatly over the earth's surface. The concentration of iron, lead, nickel and manganese was high in classroom dusts in Iran (2). Fe is one of the abundant HM in the environment and can be transmitted to schools by airflow stream and wind. Lead in classroom dust can originate from outdoor particles or indoor from building materials, cleaning and hygienic products, computers, and printers. Nickel is used in many specific and recognizable industrial and consumer products; however, mobile phone has been a potential source of nickel in schools in recent years (25,26). Drinking water is strongly suggested as a source of manganese in schools; moreover, a cross-sectional study found that exposure to manganese in groundwater is associated with intellectual impairment in school-age children (27).

In school dust of Hong Kong, the concentration of zinc, copper and cadmium was high. The sources of zinc and copper in schools can be some foodstuff and food importers; however, the drinking water contains certain amounts of Zn and copper which may be higher when it is stored in metal tanks. Cadmium is a stabilizer for polyvinyl chloride in toys and electronic compounds in schools, and also food intake is the main route of this HM in students (25,26).

The samples of dust from Chinese schools showed that concentration of barium, cobalt and arsenic was high. Barium is used in the manufacture of soap and plastic in school environment; furthermore, drinking water and food appear to be the prevalent route of exposure to barium compounds in students. Cobalt is not released extensively in the environment and the world's major producer of cobalt is China; also, it is used in the manufacture of alloys and magnet (28,29). The effects of drinking arsenic-contaminated water on children's health were reported in Bangladeshi schools (30).

In Ghana, children are exposed to high levels of chromium. Since schools appear to be near the shops, the dust in the classrooms and playground is greatly polluted with emissions of chromium from the activities of these shops (22).

This study revealed a significant bias for lead, chromium and arsenic, it can be related to publication bias. There are many factors involved in the publication bias including; the role the author, journal editor, and reviewer in selecting studies with significant results for publication (31).

There has been no report of HM concentration in many countries in the world and no enough data on some HM such as Hg in schools. HM from airborne sources is generally released as particulates in atmosphere, so we cannot consider data on airborne dust in schools.

## Conclusion

This study is the first systematic review and meta-analysis on heavy metal concentrations in classrooms' dust. The mean concentration of HM was Fe > Zn > Ba > Mn > Pb > Cr > Cu> Ni> Co> As > Cd in the classrooms, respectively. Locating schools in low traffic areas, regular cleaning, improved ventilation of classrooms, renovation of old schools and attention to food chain are recommended to simultaneously address the inseparable goals of health for students.

## Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

## Acknowledgements

The study was funded and supported by Shiraz University of Medical Sciences, Shiraz, Iran (Grant Number 16027 and the ethics code: IR.SUMS.RED.1397.166). The authors would like to thank Shiraz University of Medical Sciences, Shiraz, Iran and Center for Development of Clinical Research of Nemazee Hospital and Dr. Nasrin Shokrpour for editorial assistance.

## Conflict of interest

The authors declare that there is no conflict of interests.

## References

1. Geller RJ, Rubin IL, Nodvin JT, et al (2007). Safe and healthy school environments. *Pediatr Clin North Am, 54*(2):351-73.
2. Moghtaderi M, Ashraf MA, Moghtaderi T, et al (2020). Heavy metal concentration in classroom dust samples and its relationship with childhood asthma: a study from Islamic Republic of Iran. *East Mediterr Health J,* 26(5):594-601.
3. United States of Environmental Protection Agency (2011). Integrated risk information system. Washington, DC: US EPA. Available from: https://www.epa.gov/iris
4. Li Z, Ma Z; van der Kuijp TJ, et al (2014). A review of soil heavy metal pollution from mines in China: pollution and health risk assessment. *Sci Total Environ,* 15;468-469:843-53.
5. Minguillón MC, Rivas I, Moreno T, et al (2015). Road traffic and sandy playground influence on ambient pollutants in schools. *Atmospheric Environ,* 94-102.
6. Järup L (2003). Hazards of heavy metal contamination. *Br Med Bull,* 68(1):167-82.
7. Moghtaderi T, Shakeri A, Mahmoodi Sh (2018). Heavy metals contamination and human health risk assessment in soils of an industrial area, Bandar Abbas - South Central Iran. *Human and Ecological Risk Assessment,* 24(4): 1058-1073.
8. Singh R, Gautam N, Mishra A, et al (2011). Heavy metals and living systems: An overview. *Indian J Pharmacol,* 43(3):246-53.
9. Zeng X, Xu X, Boezen HM, et al (2016). Children with health impairments by heavy metals in an e-waste recycling area. *Chemosphere,* 148:408-15.
10. Tan SY, Praveena SM, Abidin EZ, et al (2018). Heavy metal quantification of classroom dust in school environment and its impacts on children health from Rawang (Malaysia). *Environ Sci Pollut Res Int,* 25(34):34623-34635.
11. Tong TY, Lam KC (2000). Home sweet home? A case study of household dust contamination in Hong Kong. *Sci Total Environ,* 256(2-3):115-23.
12. Meza-Figueroa D, De La O M, De La Parra ML (2007). Heavy metal distribution in dust from elementary schools in Hermosillo, Sonora, México. *Atmospheric Environ,* 41(2):276-288.
13. Tahir N, Poh SC, Jaafar M (2007). Determination of heavy metals content in soils and indoor dusts from nurseries in Dungun, Terengganu. *Malaysian J Anal Sci,* 11:280–286.
14. Yap CK, Krishnan T, Chew W (2011). Heavy metal concentration in ceiling fans dusts sampled at schools around Serdang area. *Sains Malaysiana,* 40(6):569-575.
15. Darus FM, Nasir RA, Sumari SM, et al (2012). Heavy metals composition of indoor dust in nursery schools building. *Procedia - Social and Behavioral Sciences,* 38:169–175.
16. Popoola OE, Bamgbose O, Okonkwo OJ, et al (2012). Heavy metals content in classroom dust of some public primary schools in metropolitan Lagos, *Nigeria. Res J Environ Earth Sci,* 4(4):460-465.
17. Lu XW, Zhang XL, Li LY, et al (2014). Assessment of metals pollution and health risk in dust from nursery schools in Xi;an, China. *Environ Res,* 128:27–34.
18. Chen H, Lu X, Chang Y, et al (2014). Heavy metal contamination in dust from kindergartens and elementary schools in Xi'an, China. *Environ Earth Sci,* 71:2701–9.
19. Latif MT, Saw MY, Saad A, et al (2014). Composition of heavy metals in indoor dust and their possible exposure: a case study of preschool children in Malaysia. *Air Qual Atmos Health,* 7:181–193.

20. Praveena SM, Abdul Mutalib NS, Aris AZ (2015). Determination of heavy metals in indoor dust from primary school (Sri Serdang, Malaysia): Estimation of the health risks. *Environ Forensics,* 16:257–263.
21. Li R, Cai G, Wang j, et al (2014). Contents and chemical forms of heavy metals in school and roadside top soils and road-surface dust of Beijing. *J Soil Sediment,* 14(11):1806-1817.
22. Nkansah MA, Fianko JR, Mensah S, et al (2015). Determination of heavy metals in dust from selected nursery and kindergarten classrooms within the Kumasi metropolis of Ghana. *Cogent Chemistry,* 1(1): 1-9.
23. Olujimi O, Steiner O, Goessler W (2015). Pollution indexing and health risk assessments of trace elements in indoor dusts from classrooms, living rooms and offices in Ogun State, Nigeria. *J Afr Earth Sci,* 101:396–404.
24. Olowoyo O, Mugivhisa LL, Magoloi ZG (2016). Composition of Trace Metals in Dust Samples Collected from Selected High Schools in Pretoria, South Africa. *Applied and Environmental Soil Science,* 16: 1-9.
25. Wuana RA., Okieimen FE (2011). Heavy metals in contaminated soils: a review of sources, chemistry, risks and best available strategies for remediation. *ISRN Ecology,* 1-20.
26. Schreinemachers DM, Ghio AJ (2016). Effects of environmental pollutants on cellular iron homeostasis and ultimate links to human disease. *Environ Health Insights,* 10:35-43.
27. Bouchard MF, Sauvé S, Barbeau B, et al (2011). Intellectual impairment in school-age children exposed to manganese from drinking water. *Environ Health Perspect*, 119(1):138–43.
28. Pi X, Jin L, Li Z, et al (2019). Association between concentrations of barium and aluminum in placental tissues and risk for orofacial clefts. *Sci Total Environ,* 20:652:406-412.
29. Aquino M, Mucci T, Chong M, et al (2013). Mobile Phones: Potential Sources of Nickel and Cobalt Exposure for Metal Allergic Patients. *Pediatr Allergy Immunol Pulmonol,* 26(4):181-186.
30. Murray MP, Sharmin R (2015). Groundwater arsenic and education attainment in Bangladesh. *J Health Popul Nutr,* 33:20.
31. Thornton A, Lee P (2000). Publication bias in meta-analysis: its causes and consequences. *J Clin Epidemiol,* 53(2): 207-16.