Research article

# A pediatric health risk assessment of children's toys imported from China into Nigeria

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A B S T R A C T

Trade liberalization led to the flooding of the Nigerian markets with "made in China'' children's toys. Information about metal contamination in toys is vital to ensure the safety of children's product. This is a pediatric health risk assessment of three toxic metals (Pb, Cd and As) in children toys purchased from Nigerian market. Thirty cheap "made in China'' toys were purchased from stores in Port Harcourt, Nigeria. Three toxic metals (Pb, Cd and As) in the thirty toys samples were determined by absorption spectrophotometry. Pb, Cd and As were present in all the toys at levels below the limits set by EU. The oral and dermal exposure risk assessment showed no significant non-carcinogenic and carcinogen health risks of public health concern. Some "made in China'' toys imported into Nigeria may not add to the body burden of these metals in children.

## 1. Introduction

Trace metals have been detected in toys and baby products (Levin et al., 2008). Lead and cadmium are used as stabilizers in certain plastics, paint color enhancers, or anti-corrosion agents in children's toys (Kumar and Pastore, 2007; Greenway and Gerstenberger, 2010; Al-Qutob et al., 2014). The restrictions on the use of lead has justified substitution with cadmium since it also prevents formation of hydrochloric which can degrade the polymer (Kumar and Pastore, 2007) but the justification for the use of arsenic in toys remain unclear although some suggest it may be due to certain color dyes. Metals may be released from toys through saliva during mouthing, sweat during dermal contact, or gastric fluids after partial ingestion (i.e., scraped coatings, fibers or textile, or broken sections) (Guney and Zagury, 2012).

Mouthing in children is one important behavior that has been identified to expose them to environment chemicals. Babies and young children frequently mouth objects, including toys, resulting in saliva mobilization and oral exposure to toxic chemicals (Moya et al., 2004). Children and particularly infants are more vulnerable to heavy metal toxicity with compromised renal function, bone deformities, neurological disorders, gastrointestinal complications, cancer etc associated with exposure to these metals (Jarup, 2003; Habeler, 2008; MFMER, 2011). A

"risk triangle'' with metal-tainted children's toys, accessibility of the toys to children, and their vulnerability to exposure has been identified (IFCS, 2006).

Young children and the developing fetus are especially vulnerable to the neurotoxic effects of Pb, and subtle effects on intelligence and attention occur even at very low exposure levels (Attina and Trasande, 2013). Fatal acute poisoning in a child was reported following ingestion of a charm with very high lead content (Levin et al., 2008). Even with the regulation of Pb and Cd contamination in children's products, recent research still showed ongoing contamination in toys (Guney and Zagury, 2013; Hillyer et al., 2014).

Inorganic As is a carcinogen implicated in several cancers of the skin, lungs, liver, and bladder. Lower level of exposure can cause nausea and vomit, decreased production of red and white blood cells, abnormal heart rhythm, and damage to blood vessels. Chronic exposure to As can cause skin darkening and the appearance of small warts on the palms, soles, and torso (Ismail et al., 2017).

The information about metal contamination in toys is vital to ensure the safety of children's product. Trade liberalization in Nigeria led to the flooding of the markets with all and sundry items including cheap children's toys from China. There have been earlier reports of high lead and cadmium levels in children's toys from China in the Nigerian market

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**Table 1.** Description of the variables in Health Risk Assessment.

| Parameters | Description | Value | Unit | Source |
|---|---|---|---|---|
| THQ | Target Hazard Quotient | - | - | - |
| TTHQ | Total Target Hazard Quotient | - | - | - |
| ADI | Average Daily Intake | - | - | - |
| CS | Concentration of Metal | - | $mg/kg$ | From this study |
| ing | Ingestion Rate (Child) | 0.0002 | $kg/day$ | |
| EDnc | Exposure Duration for Non-Carcinogenic | 6 | $years$ | RAIS 2013 |
| EDc | Exposure Duration for Carcinogenic | 70 | $years$ | USEPA (2007) |
| EF | Exposure Frequency | 365 | $Days/years$ | USEPA (2007) |
| ATnc | Average Time of Exposure for Non-Carcinogenic Element | EDnc $\times$ 365 = 2190 | days | RAIS 2013 |
| ATc | Average Time of Exposure for Carcinogenic Element | EDc $\times$ 365 = 25550 | days | RAIS 2013 |
| BW | Body Weight | 15 | $kg$ | RAIS 2013 |
| SA | Surface Area | 2100 | $cm^2$ | |
| ABS | Absorption Factor | 0.001,0.03 | $mg/cm^2$ | USEPA (2004) |
| CF | Conversion Factor | $1 \times 10^{-0}$ | $kg/mg$ | USEPA (2004) |
| AF | Adherence Factor | 0.2 | $mgm^{-1}$ | - |
| RFD | Reference Dose | - | $mg/kg - day$ | RAIS 2013 |
| CSF | Cancer Slope Factor | - | $mg/kg - day$ | RAIS 2013 |

(Omolaoye et al., 2010; Oyeyeola et al., 2017). There were recalls of low-cost toys and jewelries by US. Consumer Protection Safety Commission (USCPSC) in 2007 and strict regulation for Pb in children products. This is pediatric health risk assessment of the levels of Pb, Cd and As in some "made in China'' children's toys sold in Nigeria.

## 2. Materials and method

### 2.1. Sample collection

Using a market-basket method, thirty 'made in China' low cost toys were purchased from supermarket and street vendors in Port Harcourt, Nigeria from January–February 2018. The plastic toys included teethers, balloon, toy cars/planes, and rattles. The brittle/pliable toys consisted of playdough, crayon, and watercolor pen. The paint coating was scrapped from plastic toy car and building blocks.

### 2.2. Heavy metal assay

Toy's surface paint was removed by scraping with clean razor blades. In all sample mass ranged from 15–25mg. To avoid cross-contamination of samples, fresh razor blades were used for scraping of each toy new gloves and underlying paper on the lab bench to prevent contamination.

Samples were placed in test tubes and 5 mL trace metal grade nitric acid was added, along with two small boiling chips. After initial heating at 90–100 °C until fuming stopped, samples were placed in an oil bath or heating block for vigorous digestion at more than 120 °C for 3 h (Weidenhamer, 2009). Samples were cooled and diluted to 25 mL in volumetric flasks, rinsing 4 times with 4 mL portions of water, transferring as much residue as possible. After dilution to volume, samples settled at least 0.5 h before analysis. If needed, samples were diluted further with 5% trace metal grade nitric acid. The concentrations of Pb, Cd and As in toy samples were analyzed in triplicates using an Atomic Absorption Spectrophotometer (Perkin Elmer AAS-700).

### 2.3. Quality control

The range of the calibration curve was used to calculate the range of application. Samples were also diluted and reanalysed when necessary to fit within the range of the calibration curve. The accuracy of the method was determined by analysis of a soil Certified Reference Material (CRM) (TraceCERT® 16595 for Pb, 51994 for Cd and 39436 for As). The results of this CRM analysis are required to be within the 95% confidence

interval of the corresponding certified values. Furthermore, the relative standard deviation (RSD) was measured in triplicate analyses of the CRM under repeatability conditions. The CRM was also used as quality control sample in each series of measurements. The RSD between replicate analyses was less than 4%.

### 2.4. Human health risk assessment

Human Health Risk Assessment was undertaken using methodologies proposed by the United States environmental protection (U.S. EPA, 1991). This USEPA model as described in the Risk Assessment Information System (RAIS), 2007 (http://rais.ornl.gov/), supported by the Toxicological profiles developed by the USEPA Integrated Risk Information System (IRIS) (http://cfpub.epa.gov/ncea/iris/index.cfm) and by the US Agency for Toxic Substances and Disease Registry – Toxicological profiles (ATSDR) (http://www.atsdr.cdc.gov/toxfaq.html) were all employed in the pediatric health risk assessment Table 1.

### 2.5. Oral exposure to heavy metal in toys

$$\text{ADI}_{ing} = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT} \tag{1}$$

### 2.6. Dermal exposure to heavy metal in toys

$$\text{ADI}_{dermal} = \frac{C \times SA \times SL \times ABS \times EF \times ED \times CF}{BW \times AT} \tag{2}$$

### 2.7. Non-carcinogenic risk assessment

Non-carcinogenic hazards are characterized by a term called hazard quotient (HQ). HQ is a unitless number that is expressed as the probability of an individual suffering an adverse effect. It is defined as the quotient of ADI or dose divided by the toxicity threshold value, which is referred to as the chronic reference dose (RfD) in mg/kg-day of a specific heavy metal as shown in Eq. (3) (U.S. EPA, 2004).

$$\text{THQ} = \frac{ADI}{RfD} \tag{3}$$

The non-carcinogenic effect to the population is as a result of the summation of all the THQs due to individual heavy metals or Hazard

**Table 2.** Oral and Dermal Reference dose (Rfd) for no-carcinogenic and cancer slope factor (CSF).

| Metal | Oral Rfd | Dermal Rfd | CSF oral | CSF dermal |
|---|---|---|---|---|
| Pb | 0.0035[c] | 0.0005[a] | 0.0085[a] | - |
| Cd | 0.001[c] | 0.00005[c] | 0.38[b] | - |
| As | 0.0003 | 0.00012[c] | 1.5[a] | 1.5[a] |

[a] = RAIS (2013) Risk assessment information system.
[b] = Walkes and Rehm (1994).
[c] = AERIS Software Inc., 1991.

Index (HI) as described by USEPA document (U.S. EPA, 2004). Eq. (4) shows the mathematical representation of this parameter:

$$HI = \sum_{k=1}^{n} HQI \tag{4}$$

### 2.8. Carcinogenic risk assessment

The lifetime cancer risk was calculated using:

$$Riskpathway = \sum_{k=1}^{n} ADIkCSFk \tag{5}$$

Where Risk is a unitless probability of an individual developing cancer over a lifetime. ADIk (mg/kg/day) and CSFk (mg/kg/day) are the average daily intake and the cancer slope factor, respectively for the k heavy metal, for n number of heavy metals. The slope factor converts the estimated daily intake of the heavy metal averaged over a lifetime of exposure directly to incremental risk of an individual developing cancer (U.S. EPA, 2004).

The total excess lifetime cancer risk for an individual is finally calculated from the average contribution of the individual heavy metals for all the pathways using the following equation:

$$Risk(total) = Risk(ing) + Risk(dermal) \tag{6}$$

where Risk (ing) and Risk (dermal) are risks contributions through ingestion and dermal pathways. Both non-carcinogenic and carcinogenic risk assessment of heavy metals are calculated using RfD and CSF values derived are shown in Table 2.

## 3. Results

Metal levels in the toys sample are shown in Table 3. All the 30 toy samples analyzed were found to contain Pb (4.16–9.747), Cd (1.942–6.50) and As (1.459–6.318 mg/kg). The highest Pb, Cd and As

**Table 3.** Pb, Cd and As levels (mg/kg) in children's toys.

| Sample | Description | Pb | Cd | As |
|---|---|---|---|---|
| EU Regulation | | 90 mg/kg | 23 mg/kg | 47 mg/kg |
| A1 | Toy ant | 6.435 | 4.246 | 2.184 |
| A2 | Ball 1 | 7.127 | 4.196 | 3.659 |
| A3 | Ball 2 | 5.618 | 6.5 | 3.527 |
| A4 | Toy duck | 5.152 | 4.276 | 2.572 |
| A5 | Aircraft | 6.398 | 3.513 | 1.723 |
| A6 | Jelly fish toy | 4.556 | 2.264 | 4.252 |
| A7 | Dolphin toy | 7.822 | 5.183 | 2.764 |
| A8 | Toy feeding bottle | 6.496 | 4.397 | 2.492 |
| A9 | Bird | 5.383 | 1.942 | 3.205 |
| A10 | Bat man | 4.692 | 3.282 | 4.365 |
| A11 | Donkey | 9.747 | 6.257 | 3.175 |
| A12 | Teddy bear | 4.16 | 2.482 | 1.586 |
| A13 | Baby rattle | 8.505 | 2.218 | 4.642 |
| A14 | Baby 1 | 7.213 | 5.354 | 4.294 |
| A15 | Baby 2 | 8.762 | 3.827 | 5.108 |
| A16 | Toy frog | 9.218 | 5.342 | 4.361 |
| A17 | Power rangers | 8.184 | 6.287 | 3.813 |
| A18 | Toy sheep | 7.643 | 4.1 | 2.642 |
| A19 | Toy rabbit | 8.161 | 5.082 | 6.318 |
| A20 | Pacifier | 8.374 | 4.735 | 4.273 |
| A21 | Fischerpince rattle | 6.453 | 3.517 | 1.459 |
| A22 | Mask 1 | 6.218 | 2.178 | 5.111 |
| A23 | Mask 2 | 7.832 | 3.66 | 2.253 |
| A24 | Toy cat | 6.249 | 2.835 | 3.643 |
| A25 | Toy spider | 8.177 | 4.799 | 5.432 |
| A26 | Toy bee | 5.659 | 5.255 | 3.182 |
| A27 | Robot | 7.272 | 3.723 | 1.499 |
| A28 | 4 hand reptile | 6.149 | 3.538 | 4.386 |
| A29 | Policeman | 4.592 | 4.592 | 2.178 |
| A30 | Pig head | 5.353 | 5.353 | 2.947 |

**Table 4.** Oral and dermal Chronic Daily Intake CDI (mg/kg/bw/dy), Target Hazard Quotient (THQ) and Total Target Hazard Quotient (TTHQ) of Pb, Cd and As in children toys.

| Sample | Oral | | | | | | | Dermal | | | | | | |
|--------|------|------|------|------|------|------|------|--------|------|------|------|------|------|------|
| | CDI | | | THQ | | | TTHQ | CDI | | | THQ | | | TTHQ |
| | Pb | Cd | As | Pb | Cd | As | | Pb | Cd | As | Pb | Cd | As | |
| A1 | 8.2E-05 | 5.4E-05 | 2.8E-05 | 0.0235 | 0.0543 | 0.0931 | 0.171 | 1.7E-07 | 1.1E-07 | 1.8E-06 | 0.00033 | 0.0023 | 0.0143 | 0.017 |
| A2 | 9.1E-05 | 5.4E-05 | 4.7E-05 | 0.026 | 0.0537 | 0.156 | 0.236 | 1.9E-07 | 1.1E-07 | 2.9E-06 | 0.00037 | 0.0023 | 0.024 | 0.027 |
| A3 | 7.2E-05 | 8.3E-05 | 4.5E-05 | 0.0205 | 0.0831 | 0.1503 | 0.254 | 1.5E-07 | 1.7E-07 | 2.8E-06 | 0.00029 | 0.0035 | 0.0231 | 0.027 |
| A4 | 6.6E-05 | 5.5E-05 | 3.3E-05 | 0.0188 | 0.0547 | 0.1096 | 0.183 | 1.4E-07 | 1.1E-07 | 2.1E-06 | 0.00027 | 0.0023 | 0.0168 | 0.019 |
| A5 | 8.2E-05 | 4.5E-05 | 2.2E-05 | 0.0234 | 0.0449 | 0.0734 | 0.142 | 1.7E-07 | 9.4E-08 | 1.4E-06 | 0.00033 | 0.0019 | 0.0113 | 0.014 |
| A6 | 5.8E-05 | 2.9E-05 | 5.4E-05 | 0.0166 | 0.0289 | 0.1812 | 0.227 | 1.2E-07 | 6.1E-08 | 3.4E-06 | 0.00024 | 0.0012 | 0.0278 | 0.029 |
| A7 | 0.0001 | 6.6E-05 | 3.5E-05 | 0.0286 | 0.0663 | 0.1178 | 0.213 | 2.1E-07 | 1.4E-07 | 2.2E-06 | 0.0004 | 0.0028 | 0.0181 | 0.021 |
| A8 | 8.3E-05 | 5.6E-05 | 3.2E-05 | 0.0237 | 0.0562 | 0.1062 | 0.186 | 1.7E-07 | 1.2E-07 | 2E-06 | 0.00034 | 0.0024 | 0.0163 | 0.019 |
| A9 | 6.9E-05 | 2.5E-05 | 4.1E-05 | 0.0197 | 0.0248 | 0.1366 | 0.181 | 1.4E-07 | 5.2E-08 | 2.6E-06 | 0.00028 | 0.001 | 0.021 | 0.022 |
| A10 | 6E-05 | 4.2E-05 | 5.6E-05 | 0.0171 | 0.042 | 0.186 | 0.245 | 1.3E-07 | 8.8E-08 | 3.5E-06 | 0.00024 | 0.0018 | 0.0286 | 0.031 |
| A11 | 0.00012 | 8E-05 | 4.1E-05 | 0.0356 | 0.08 | 0.1353 | 0.251 | 2.6E-07 | 1.7E-07 | 2.6E-06 | 0.0005 | 0.0034 | 0.0208 | 0.025 |
| A12 | 5.3E-05 | 3.2E-05 | 2E-05 | 0.0152 | 0.0317 | 0.0676 | 0.115 | 1.1E-07 | 6.7E-08 | 1.3E-06 | 0.00021 | 0.0013 | 0.0104 | 0.012 |
| A13 | 0.00011 | 2.8E-05 | 5.9E-05 | 0.0311 | 0.0284 | 0.1978 | 0.257 | 2.3E-07 | 6E-08 | 3.7E-06 | 0.00044 | 0.0012 | 0.0304 | 0.032 |
| A14 | 9.2E-05 | 6.8E-05 | 5.5E-05 | 0.0264 | 0.0684 | 0.183 | 0.278 | 1.9E-07 | 1.4E-07 | 3.5E-06 | 0.00037 | 0.0029 | 0.0281 | 0.031 |
| A15 | 0.00011 | 4.9E-05 | 6.5E-05 | 0.032 | 0.0489 | 0.2177 | 0.299 | 2.4E-07 | 1E-07 | 4.1E-06 | 0.00045 | 0.0021 | 0.0334 | 0.036 |
| A16 | 0.00012 | 6.8E-05 | 5.6E-05 | 0.0337 | 0.0683 | 0.1859 | 0.288 | 2.5E-07 | 1.4E-07 | 3.5E-06 | 0.00048 | 0.0029 | 0.0286 | 0.032 |
| A17 | 0.0001 | 8E-05 | 4.9E-05 | 0.0299 | 0.0804 | 0.1625 | 0.273 | 2.2E-07 | 1.7E-07 | 3.1E-06 | 0.00042 | 0.0034 | 0.025 | 0.029 |
| A18 | 9.8E-05 | 5.2E-05 | 3.4E-05 | 0.0279 | 0.0524 | 0.1126 | 0.193 | 2.1E-07 | 1.1E-07 | 2.1E-06 | 0.00039 | 0.0022 | 0.0173 | 0.02 |
| A19 | 0.0001 | 6.5E-05 | 8.1E-05 | 0.0298 | 0.065 | 0.2693 | 0.364 | 2.2E-07 | 1.4E-07 | 5.1E-06 | 0.00042 | 0.0027 | 0.0414 | 0.045 |
| A20 | 0.00011 | 6.1E-05 | 5.5E-05 | 0.0306 | 0.0605 | 0.1821 | 0.273 | 2.2E-07 | 1.3E-07 | 3.4E-06 | 0.00043 | 0.0025 | 0.028 | 0.031 |
| A21 | 8.3E-05 | 4.5E-05 | 1.9E-05 | 0.0236 | 0.045 | 0.0622 | 0.131 | 1.7E-07 | 9.4E-08 | 1.2E-06 | 0.00033 | 0.0019 | 0.0096 | 0.012 |
| A22 | 8E-05 | 2.8E-05 | 6.5E-05 | 0.0227 | 0.0278 | 0.2178 | 0.268 | 1.7E-07 | 5.8E-08 | 4.1E-06 | 0.00032 | 0.0012 | 0.0335 | 0.035 |
| A23 | 0.0001 | 4.7E-05 | 2.9E-05 | 0.0286 | 0.0468 | 0.096 | 0.171 | 2.1E-07 | 9.8E-08 | 1.8E-06 | 0.0004 | 0.002 | 0.0148 | 0.017 |
| A24 | 8E-05 | 3.6E-05 | 4.7E-05 | 0.0228 | 0.0362 | 0.1553 | 0.214 | 1.7E-07 | 7.6E-08 | 2.9E-06 | 0.00032 | 0.0015 | 0.0239 | 0.026 |
| A25 | 0.0001 | 6.1E-05 | 6.9E-05 | 0.0299 | 0.0614 | 0.2315 | 0.323 | 2.2E-07 | 1.3E-07 | 4.4E-06 | 0.00042 | 0.0026 | 0.0356 | 0.039 |
| A26 | 7.2E-05 | 6.7E-05 | 4.1E-05 | 0.0207 | 0.0672 | 0.1356 | 0.223 | 1.5E-07 | 1.4E-07 | 2.6E-06 | 0.00029 | 0.0028 | 0.0208 | 0.024 |
| A27 | 9.3E-05 | 4.8E-05 | 1.9E-05 | 0.0266 | 0.0476 | 0.0639 | 0.138 | 2E-07 | 1E-07 | 1.2E-06 | 0.00038 | 0.002 | 0.0098 | 0.012 |
| A28 | 7.9E-05 | 4.5E-05 | 5.6E-05 | 0.0225 | 0.0452 | 0.1869 | 0.255 | 1.7E-07 | 9.5E-08 | 3.5E-06 | 0.00032 | 0.0019 | 0.0287 | 0.031 |
| A29 | 5.9E-05 | 5.9E-05 | 2.8E-05 | 0.0168 | 0.0587 | 0.0928 | 0.168 | 1.2E-07 | 1.2E-07 | 1.8E-06 | 0.00024 | 0.0025 | 0.0143 | 0.017 |
| A30 | 6.8E-05 | 6.8E-05 | 3.8E-05 | 0.0196 | 0.0684 | 0.1256 | 0.214 | 1.4E-07 | 1.4E-07 | 2.4E-06 | 0.00028 | 0.0029 | 0.0193 | 0.022 |

levels were found in samples $A_{11}$ (Donkey -9.747 mg/kg), $A_3$ (Balls -6.50 mg/kg) and $A_{19}$ (Toy rabbit -6.318 mg/kg) respectively. Whereas the lowest levels of Pb, Cd and As were detected in $A_{12}$ (Teddy bear - 4.16 mg/kg), $A_9$ (Bird - 1.942 mg/kg) and $A_{21}$ (Fischerpince rattle - 1.459 mg/kg) respectively.

The oral and dermal Chronic Daily Intake CDI target hazard Quotient (THQ) and total target hazard Quotient (TTHQ) of Pb, Cd and As are shown in Table 4. The THQ and TTHQ of Pb, Cd and As were less than 1 with the highest oral and dermal THQ seen in Toy $A_{19}$ (Toy rabbit with value 0.364 and 0.045) respectively suggesting no significant health risk from heavy metal exposure in toys.

Table 5 show the oral and dermal cancer risk, total cancer risk (TCR) and hazard Index (HI). The HI of Pb, Cd and As from via oral and dermal routes ranged from 0.126-0.409 indicating es no significant non-carcinogenic health risk. The total cancer risk (TCR) of Pb, Cd and As were within the generally acceptable risk range of $1.4 \times 10^{-4} - 1.4 \times 10^{-6}$.

## 4. Discussion

Children's toys may be source of heavy metals. Lead exposure has been implicated in the impairment of cognitive development in children (Jusko et al., 2008; Kaufman et al., 2014) whereas exposure to cadmium and arsenic may give rise to neurodevelopment problems and behavioral disorders in children (Rodríguez-Barranco et al., 2013). These metals are used in stabilizing and recycling of the plastics in addition to being

applied in the attractive paint colours of the toys (Guney and Zagury, 2012; Rastogi and Pritzl, 1996). Mouthing of non-food item which peaks at 6-12-month age (39–66 min/day) is a common behavior of children plays the unwanted role of children exposure to these metals (Guney and Zagury, 2014; Smith and Norris, 2003).

According to US CPSC, 0.06% Pb by weight, or 600 ppm was chosen as the permissible limit of Pb in paint on items intended for children (United states Consumer Product Safety Commission, 2019) but was further reduced to 0.009% (Library of Congress, 2008).

The Pb, Cd and As levels in all the toys in this study were below the limit set by the European Union migration units for toy safety which includes Pb (90 mg/kg), Cd (23 mg/kg) and As (47 mg/kg) (European Council, 2009). There were higher Pb levels than Cd and As probably due to the preference for Pb because of its better stabilizing property than the other metals preventing free chlorine radicals in polyvinyl chloride PVC from reacting with hydrogen radicals to form hydrochloric acid (Tuczai and Cortolano, 1992). Although some manufactures have substituted Pb for Cd in stabilizing PVC in children products because of reported Pb toxicity, the substitution of Pb with Cd in children's toys may also pose a health threat.

Pb, Cd and As levels in this study were lower than previously reported data by other researchers in Nigeria and other countries. Studies by Omolaoye et al. in 2010 from Nigeria reported higher level Pb and Cd in the range of 2.50–1445.00 mg/kg and 0.50–373.3 mg/kg respectively. Another study by Oyeyeola et al. (2017) also in Nigeria detected high levels of Pb and Cd in a range of 36.1–106 mg/kg and 3.55–40.7 mg/kg

**Table 5.** Oral and Dermal cancer risk, Total Cancer and Hazard index of Pb, Cd and As in children toys.

| Sample | Oral Cancer Risk | | | Dermal Cancer Risk | Total Cancer Risk | Hazard index |
|---|---|---|---|---|---|---|
| | Pb | Cd | As | As | | |
| A1 | 7E-07 | 2.1E-05 | 4.2E-05 | 2.6E-06 | 6.6E-05 | 0.188 |
| A2 | 7.8E-07 | 2E-05 | 7E-05 | 4.4E-06 | 9.6E-05 | 0.262 |
| A3 | 6.1E-07 | 3.2E-05 | 6.8E-05 | 4.3E-06 | 0.0001 | 0.281 |
| A4 | 5.6E-07 | 2.1E-05 | 4.9E-05 | 3.1E-06 | 7.4E-05 | 0.202 |
| A5 | 7E-07 | 1.7E-05 | 3.3E-05 | 2.1E-06 | 5.3E-05 | 0.155 |
| A6 | 5E-07 | 1.1E-05 | 8.2E-05 | 5.1E-06 | 9.8E-05 | 0.256 |
| A7 | 8.5E-07 | 2.5E-05 | 5.3E-05 | 3.3E-06 | 8.3E-05 | 0.234 |
| A8 | 7.1E-07 | 2.1E-05 | 4.8E-05 | 3E-06 | 7.3E-05 | 0.205 |
| A9 | 5.9E-07 | 9.5E-06 | 6.2E-05 | 3.9E-06 | 7.5E-05 | 0.203 |
| A10 | 5.1E-07 | 1.6E-05 | 8.4E-05 | 5.3E-06 | 0.00011 | 0.276 |
| A11 | 1.1E-06 | 3E-05 | 6.1E-05 | 3.8E-06 | 9.6E-05 | 0.276 |
| A12 | 4.5E-07 | 1.2E-05 | 3E-05 | 1.9E-06 | 4.5E-05 | 0.126 |
| A13 | 9.3E-07 | 1.1E-05 | 8.9E-05 | 5.6E-06 | 0.00011 | 0.289 |
| A14 | 7.9E-07 | 2.6E-05 | 8.3E-05 | 5.2E-06 | 0.00011 | 0.309 |
| A15 | 9.5E-07 | 1.9E-05 | 9.8E-05 | 6.2E-06 | 0.00012 | 0.335 |
| A16 | 1E-06 | 2.6E-05 | 8.4E-05 | 5.3E-06 | 0.00012 | 0.32 |
| A17 | 8.9E-07 | 3.1E-05 | 7.3E-05 | 4.6E-06 | 0.00011 | 0.302 |
| A18 | 8.3E-07 | 2E-05 | 5.1E-05 | 3.2E-06 | 7.5E-05 | 0.213 |
| A19 | 8.9E-07 | 2.5E-05 | 0.00012 | 7.6E-06 | 0.00015 | 0.409 |
| A20 | 9.1E-07 | 2.3E-05 | 8.2E-05 | 5.2E-06 | 0.00011 | 0.304 |
| A21 | 7E-07 | 1.7E-05 | 2.8E-05 | 1.8E-06 | 4.8E-05 | 0.143 |
| A22 | 6.8E-07 | 1.1E-05 | 9.8E-05 | 6.2E-06 | 0.00012 | 0.303 |
| A23 | 8.5E-07 | 1.8E-05 | 4.3E-05 | 2.7E-06 | 6.5E-05 | 0.189 |
| A24 | 6.8E-07 | 1.4E-05 | 7E-05 | 4.4E-06 | 8.9E-05 | 0.24 |
| A25 | 8.9E-07 | 2.3E-05 | 0.0001 | 6.6E-06 | 0.00014 | 0.361 |
| A26 | 6.2E-07 | 2.6E-05 | 6.1E-05 | 3.9E-06 | 9.1E-05 | 0.247 |
| A27 | 7.9E-07 | 1.8E-05 | 2.9E-05 | 1.8E-06 | 5E-05 | 0.15 |
| A28 | 6.7E-07 | 1.7E-05 | 8.4E-05 | 5.3E-06 | 0.00011 | 0.286 |
| A29 | 5E-07 | 2.2E-05 | 4.2E-05 | 2.6E-06 | 6.7E-05 | 0.185 |
| A30 | 5.8E-07 | 2.6E-05 | 5.7E-05 | 3.6E-06 | 8.7E-05 | 0.236 |

respectively. Elsewhere other studies have reported higher levels of Pb, Cd and As than values detected in our study Hillyer et al. (2014); Mateus-Garcia and Ramos-Bonilla (2014); Cui et al., (2015), Ismail et al., (2017) and Negev et al., (2018).bib_Negev_et_al_2018

The metal levels in our study coupled with reports from studies done by Oyeyeola et al., (2017) (Pb-36.1-106 mg/kg) and Ismail et al., 2017(Pb- 1.50-171.67 mg/kg) show there is a decrease in the levels of these metals in children toys when compared with studies before and immediately after the recalls of low-cost toy and jewelry in 2007 by US CPSC in 2007 and strict regulation for Pb in children products. In 2007 alone nearly 6 million toys were recalled in the US (Schmidt, 2008). In 2010, 12 million Mc Donald's cups were recalled due to Cadmium content in the painted coating (CPSC, 2010). Also, in 2010 bracelet were voluntarily recalled due to high levels of Cd.

The THQ, TTHQ, and HI of Pb, Cd and As in the children toys, via oral and dermal exposures were below the threshold of 1. The carcinogenic health risks of these metals were within the acceptable limit $1 \times 10^{-4} - 1 \times 10^{-6}$. Although Pb, Cd and As determined in this study did not show any significant health risk but bioaccumulation after chronic exposure may pose health risk in children especially for Pb which has no safe levels in blood.

## 5. Conclusion

There were low levels of Pb, Cd and As in some "made in China'' toys lately imported into Nigeria.

## Declarations

### Author contribution statement

O. Orisakwe: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper

Z. Igweze: Performed the experiments; Contributed reagents, materials, analysis tools or data.

O. Ekhator: Analyzed and interpreted the data; Wrote the paper.

### Competing interest statement

The authors declare no conflict of interest.

### Additional information

No additional information is available for this paper.

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