INDIA

A. Regulation on sources

Source of lead	Relevant legislation/regulation	Government agencies	Data source
1. Used lead-acid battery recycling	1. According to Batteries (Management and Handling) Rules, 2001 it is the responsibility of the dealer to ensure proper collection of sold batteries and file the details of sold and collection by customer after every six months. These batteries should be auctioned to the registered recyclers only. State board is the prescribed authority for ensuring compliance of these rules. 2. The draft Battery Waste Management Rules, 2020, published on February 20, 2020 were meant to supersede Batteries (Management and Handling) Rules, 2001. 3. The amendment looks to ensure safe and formalised recycling of batteries that are under use, with an emphasis on tracking batteries that have completed their useful life through online records and data management. The amendment also lays out the responsibilities of the manufacturer, importer, assembler, re-conditioner, consumer, exporter, dismantler, collection centre and state/central pollution control board explicitly and also stresses awareness on the hazards of Lead and other metals and safety measures associated with their handling.	a. Ministry of Environment, Forest, and Climate Change (formerly Ministry of Environment and Forest)	1. Ministry of Environment, Forest, and Climate Change. 2010. "Batteries (Management and Handling) Rules, 2001" Prajapati. 2016. "Lead Acid Battery Recycling In India" 2. Ministry of Environment, Forest, and Climate Change. 2020. "Battery Waste Management Rules, 2020." 3. United Nations Partnership for Action on Green Economy. 2020. "INDIA PUBLISHES DRAFT BATTERY WASTE MANAGEMENT RULES 2020"
2. Standards for lead in food	1. Food Safety and Standard (Contaminants, Toxins and Residues) Amendment Regulation, 2011 sets the maximum limits for lead contaminants	a. FSSAI b. Ministry of Health and Family Welfare	1. Food Safety and Standards Authority of India. 2011. "Food Safety and Standards {Contaminants,

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	2. This was most recently amended in Aug 2020 to specify maximum limits for metal contaminants, crop contaminants and naturally occurring toxic substances are different depending on the kind of chemicals used in foods and food categories.		Toxins and Residues) Regulation, 2011 and FAQs" 2. Food Safety and Standards Authority of India. 2020. "Food Safety and Standards (Contaminants, 3. toxins and Residues) Regulations Notificaion"
3. Standard for lead in cookware	No standards identified.		
4. Standards for occupational exposure	1. As per The Indian Factories Act 1948 3rd Schedule, Sections 89 and 90 – list of notifiable occupational disease include poisoning by metals and compounds such as lead, and tetra-ethyl lead 2. The permissible limits of exposure to lead dust and fumes in the work environment is 0.45 mg/m^3 (short term exposure limit (15 min))	a. Ministry of Labour and Employment	1. Factories Act. 1948
3. Lead in paint	1. 1. 90 ppm lead limit for manufacture, trade, import and export of household and decorative paints 2. Any manufacture, trade, import and export of household and decorative paints containing lead or lead compounds (calculated as lead metal) in excess of 90 ppm (0.009 %) of the weight of the total non-volatile content of the weight of the dried paints film is prohibited. "Household and decorative paints" means paints used as surface coating materials in interior and exterior of buildings, walls, civil structures, any consumer products meant for household purposes and shall include enamel, primer,	a. Bureau of Indian Standards	1. United Nations Environment Programme. 2019. Update on the Global Status of Legal Limits on Lead in Paint September 2019. 2. United Nations Environment Programme/World Health Organization. 2020

Source of lead	Relevant legislation/regulation	Government agencies	Data source
	interior, undercoating and finishing colouring materials as prescribed in the Indian Standards for Household and Decorative Paints published by the Bureau of Indian Standards.		
4. Waste generated from smelting or mining	1. Waste with lead concentration ≥5000 mg/kg can be considered hazardous waste as per the Hazardous Waste Rules (2008). 2. The Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008 (the "Hazardous Wastes Rules") are the primary regulations addressing the management of hazardous waste in India. These rules were established under the Environment (Protection) Act, 1989 (the "EPA"), which gives the Central Government the power to "take all such measures as it deems necessary or expedient for the purpose of protection and improving the quality of the environment and preventing, controlling and abating environmental pollution."	a. Ministry of Environment, Forest, and Climate Change (formerly Ministry of Environment and Forest)	1. Environmental Law Institute. 2014. "Enforcing Hazardous Waste Rules in India: Strategies and Techniques for Achieving Increased Compliance."

B. International Agreements

Agreement	Year Ratified
1. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal	1992
2. Rotterdam Convention on the Prior Informed Consent Procedure for certain hazardous Chemicals and Pesticides in international trade	2005 (Accession)
3. Stockholm Convention on Persistent Organic Pollutants	2006
4. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal	1992

C. Blood lead-level monitoring programs

Details	Data source
1. The National Family Health Survey 1998-1999 (NFHS 2) collected data on the BLL of children aged three and less in New Delhi and Mumbai (representative sample)	1. World Bank. 2017. National Family Health Survey 1998-1999

D. Inventory of toxic sites (Toxic Sites Identification Program (TSIP), Pure Earth)

There are at least 309 lead contaminated sites in India

(site data available on the TSIP website)

E. Scientific papers on lead exposure (Please contact info@gahp.net for information on studies not in the public domain)

Topic	Authors	Year	Title	Abstract/ description
Childhood exposure	Sharma, Shailja, Prasenjit Mitra, Pankaj Bhardwaj, and Praveen Sharma	2021	Blood Lead Level in School Going Children of Jodhpur, Rajasthan, India	**Objectives:** Lead exposure in children contributes to 600,000 new cases of intellectual disabilities every year with maximum occurrence in developing countries. Currently limited information is available on the blood lead level (BLL) in children of India. The aim was to estimate BLL in the school going children of local population of Jodhpur. **Methods:** Four hundred twenty-six primary school children of government and private schools participated in this cross sectional study. Information regarding possible lead exposure was collected. BLL was estimated on Lead Care II analyser (Magellan Diagnostics, USA). **Results:** The mean and median BLL were 4.25 ± 1.75 µg/dL (<3.3–22.6 µg/dL) and 3.5 µg/dL (Inter Quartile Range 0.9). BLL was higher in children of illiterate mothers, those residing near traffic dense areas, urban region and studying in government schools of urban region.
Childhood exposure	Ansari, Jamal Akhtar, Abbas Ali Mahdi, Promila Sharma Malik, and Tabrez Jafar	2020	Blood Lead Levels in Children Living Near an Informal Lead Battery Recycling Workshop in Patna, Bihar	**Objectives:** The present pilot study aimed to assess blood lead levels (BLLs) and hemoglobin levels among children aged between 3 to 12 years in the settlement of Karmalichak near Patna, India. **Materials and Methods**: Children residing near the informal lead battery manufacturing unit were selected for BLL assessment. A total of 41 children were enrolled in the questionnaire based survey. **Results and conclusion:** All the children in the present study had detectable lead concentrations in their blood. Only 9% of the studied children had a BLL ≤5 µg/dl, while 91% children had a BLL above >5 µg/dl. The present study carried out in children of Karmalichak region of Patna, India was an attempt to better understand the problem of lead toxicity, describe the epidemiology of its adverse effects, identify sources and routes of exposure, illustrate the clinical effects and develop strategies of prevention so that remedial measures may be taken by government agencies and regulatory bodies. In view of the high lead levels in children in the study area, attempts are being made to develop strategies for future prevention by relocating the informal battery recycling workshops from the area. Moreover, parents have been advised to increase nutritional

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				supplementation of children by providing calcium-, iron- and zinc-rich foods, including milk and vegetables.
Childhood exposure	Maqusood Ahamed Sanjeev Verma Archana Kumar Mohd. K. J. Siddiqui	2009	Blood Lead Levels in Children of Lucknow, India	**Background:** After implementing measures to control lead pollution in many countries, blood lead levels (BLLs) in children have been declined. The phase-out of leaded petrol began in Lucknow, the capital of most populated state, Uttar Pradesh in India on April 1, 2000. **Methods:** We evaluated the mean BLL and associated risk factors for lead exposure in Lucknow children (3–12 years) after petrol lead phase-out activity. **Results:**The mean BLL of the 200 children was 9.3 µg/dL (range: 1.0–27.9 µg/dL). Seventy-four children (37%) had BLL above the Centre for Disease Control and Prevention's (CDC) level of concern (10 µg/dL). When these data were compared with BLLs determined by the George Foundation among the children of Mumbai, Bangalore, Kolkata, Chennai, Hyderabad, and Delhi during the year 1997 when leaded petrol was in use, where 62%, 62%, 87%, 96%, 43%, and 95%, respectively, then exceeded the CDC intervention level. Further, BLL of present study was very close to Mumbai children (age ≤12 years) estimated following the introduction of unleaded petrol, and 33% children had BLL above the CDC concern level with an average 8.4 µg/dL. Low socioeconomic status, proximity of home to traffic density, and mother's illiteracy were the factors associated with elevated BLLs in Lucknow children ($P < 0.05$). Overall, results indicate a declining trend of BLL in Lucknow children when compared with those reported from other cities of India when leaded petrol was in practice. A national population-based study is recommended to determine the prevalence of elevated BLLs after the phase-out of leaded-petrol. In addition, future studies on other sources of lead exposure in Lucknow are warranted for public health purposes.
Childhood exposure	Roy Ananya, Bellinger David, Hu Howard, Schwartz Joel, Ettinger Adrienne S.,	2009	Lead Exposure and Behavior among Young Children in Chennai, India	**Background**: Lead exposure has long been associated with deficits in IQ among children. However, few studies have assessed the impact of lead on specific domains of behavior and cognition. **Objective:** We evaluated the associations between lead and different domains of neurobehavior and their relative sensitivity to lead. **Methods**: We determined blood lead levels using a LeadCare instrument in 756 children 3–7 years of age attending pre- and elementary schools in

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	Wright Robert O., Bouchard Maryse, Palaniappan Kavitha, and Balakrishnan Kalpana			Chennai, India. Anxiety, social problems, inattention, hyperactivity, and attention deficit hyperactivity disorder (ADHD), as well as executive function were assessed in children by their schoolteachers using Conners' Teacher Rating Scales-39, Conners' ADHD/Diagnostic and Statistical Manual for Mental Disorders, 4th Edition Scales (CADS), and the Behavior Rating Inventory of Executive Function questionnaires, with higher scores denoting worse behavior. Analyses were carried out using multivariate generalized estimating equations with comparisons of outcome Z-scores to assess the relative strengths of the associations between log-blood lead and the different domains of behavior. **Results**: Mean blood lead level was 11.4 ± 5.3 μg/dL. Blood lead was associated with higher anxiety (β = 0.27, p = 0.01), social problems (β = 0.20, p = 0.02), and higher scores in the ADHD index (β = 0.17; p = 0.05). The effect estimate was highest for global executive function (β = 0.42; p< 0.001). **Conclusions** Higher blood lead levels in this population of young children is associated with increased risk of neurobehavioral deficits and ADHD, with executive function and attention being particularly vulnerable domains to the effects of lead.
Childhood exposure	Jain, Nitin B., and Howard Hu	2006	Childhood Correlates of Blood Lead Levels in Mumbai and Delhi	**Background**: Lead exposure has previously been associated with intellectual impairment in children in a number of international studies. In India, it has been reported that nearly half of the children have elevated blood lead levels (BLLs). However, little is known about risk factors for these elevated BLLs. **Methods**: We conducted a retrospective cross-sectional analysis of data from the Indian National Family Health Survey, a population-based study conducted in 1998–1999. We assessed potential correlates of BLLs in 1,081 children who were < 3 years of age and living in Mumbai or Delhi, India. We examined factors such as age, sex, religion, caste, mother's education, standard of living, breast-feeding, and weight/height percentile. **Results**: Most children (76%) had BLLs between 5 and 20 μg/dL. Age, standard of living, weight/height percentile, and total number of children ever born to the mother were significantly associated with BLLs (log transformed) in multivariate regression models. Compared with children ≤3 months of age, children 4–11 and 12–23 month of age had 84 and 146% higher BLLs, respectively (p < 0.001). A low standard of living correlated with

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				a 32.3% increase in BLLs (p = 0.02). Children greater than the 95th percentile for their weight/height had 31% (p = 0.03) higher BLLs compared with those who were below the 5th percentile for their weight/height. **Conclusions**: Our study found various factors correlated with elevated BLLs in children. The correlation between greater than the 95th percentile weight/height and higher BLL may reflect an impact of lead exposure on body habitus. Our study may help in targeting susceptible populations and identifying correctable factors for elevated BLLs in Mumbai and Delhi.
Maternal exposure	Dhande, Leena, Kirankumar Waghmare, Neetu Badhoniya, Avinash Turankar, and Ashwita Shetty	2020	Elevated Maternal Blood Lead Level - A Risk Factor for LBW - An Observational Study	**Introduction**: Lead exposure is common in women. Lead stored in bones is released during pregnancy and can potentially affect foetal growth. We conducted this study to estimate the effect of maternal blood Lead (BPb) status on Low Birth Weight (LBW) in newborns. **Methods**: 168 mothers were selected from Special Neonatal Care Unit (SNCU) and Postnatal care (PNC) wards of a tertiary care hospital from Central India and their BPb levels analysed by Graphite Furnace Atomic Absorption Spectrophotometer. **Results**: 22 (13.10%) mothers having BPb level ≥ 5µg/dL gave 23 births (one twins); of which 65.22% mothers delivered babies with birth weight < 2500gm (LBW) (p = 0.0007). The mean birth weight of newborns of mothers with high BPb levels was significantly lower by 269 gm (p = 0.0265). Mothers with BPb ≥ 5µg/dL delivered 39% premature babies as compared to 10 % mothers with BPb < 5 µg/dL (p < 0.003). Significantly more mothers exposed to kajal, nail polish, lipstick and paints had BPb levels ≥ 5µg/dL. **Conclusion**: Significant association is detected between maternal BPb and both LBW and prematurity in the given population.

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Maternal exposure	Mittal, Anugya	2012	Study of Lead Exposure Heavy Metal in Pregnant Women and in Neonates a Possible Health Hazard	**Background:** The present cross sectional study entitled Study of Lead exposure (heavy metal) in Pregnant women and in Neonates-a possible health hazard is based on the quantitative estimation of Lead (Pb) in venous blood of pregnant women (Maternal blood Lead level i.e. MPL) and cord blood of their respective neonates (Cord blood Lead level i.e. CPL). **Methods:** It was carried out for the period of five years from January 2007 to December 2011 in the Dept. of Forensic Medicine with collaboration of Dept. of Obs. and Gyn. and Dept. of Pediatrics, Institute of Medical sciences, BHU, Varanasi. For study, total 505 blood samples each from pregnant women (maternal venous blood) and their neonates (cord blood) were collected during hospital delivery from the three selected sites i.e. Varanasi, Jaunpur and Agra region of Uttar Pradesh, India. Further, blood samples were processed for acid digestion and estimation of heavy metal lead (Pb) was done with the help of Atomic Absorption Spectrophotometer (model Elico-194 double beam). Further, the relevant socio-epidemiological parameters (residential status, educational status, source of drinking water, source of cooking media), Maternal Parameters (Maternal Age, Gravida, History of previous abortion/s, Gestational Age, Hemoglobin (Hb) level, Intake of Calcium and Iron during antenatal period) and neonate s parameter (Birth weight-B Wt, Head circumference-HC, Crown Heel Length-CHL) and blood lead levels of the studied subjects were correlated to find out their associations/effects with the help of statistical analysis by employing SPSS (statistical packages for social sciences) version-16. Chi-square test was used to find out the association between the variables. One way analysis of variance (ANOVA) was used to test the significant difference among the mean blood lead levels in different variables of studied subjects. Binary logistic regression analysis was also used to find out the significant independent variables and their quantum of contribution for maternal and cord blood lead levels.

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Occupational exposure	Mani, Monica Shirley, Divyani Gurudas Nayak, and Herman Sunil Dsouza	2020	Challenges in Diagnosing Lead Poisoning: A Review of Occupationally and Nonoccupationally Exposed Cases Reported in India	**Background:** Lead is a nonessential metal which enters the body through various means and is considered as one of the most common health toxins. Several cases of lead poisoning are reported as a result of inhalation or ingestion of lead in employees working as painters, smelters, electric accumulator manufacturers, compositors, auto mechanics, and miners. In addition to occupational lead exposure, several cases of lead poisoning are reported in the general population through various sources and pathways. Innumerable signs and symptoms of lead poisoning observed are subtle and depend on the extent and duration of exposure. **Discussion:** The objective of this review article is to discuss occupationally and nonoccupationally exposed lead poisoning cases reported in India and the associated symptoms, mode of therapy, and environmental intervention used in managing these cases. Lead poisoning cases cannot be identified at an early stage as the symptoms are very general and mimic that of other disorders, and patients might receive only symptomatic treatment. Knowledge about the various symptoms and potential sources is of utmost importance. Medical practitioners when confronted with patients experiencing signs and symptoms as discussed in this article can speculate the possibility of lead poisoning, which could lead to early diagnosis and its management.
Occupational exposure	Sharma, Shashank, Priyanka Dhingra, and Narendra S. Sisodia	2020	Contamination of Heavy Metals in Human Fingernails Due to Occupational Exposure in Agra, India	**Purpose**: In this study, the statistical method was used to determine the significant difference in various metal's (Pb, Cd, Zn, Ni) concentrations in human fingernails from different sites. **Methods**: The metals concentrations in human fingernails, used as a biomarker, were measured to estimate their exposure. Samples from fingernails were collected from different subjects concerning sex, age, occupationally exposed to heavy metals such as subjects from industrial, roadside, commercial, and residential sites of Agra district. Sample collection and preparations were carried out using standard procedures and were analyzed for Zn, Cd, Pb, Fe, and Ni by atomic absorption spectrophotometer (AAS, PerkinElmer ANALYST 100). **Results**: One-way ANOVA tests were done to find out the significant difference of mean values of heavy metals among different sites as well as pairwise comparison of dissimilar metals among different sites. The significant difference ($p < 0.05$) in concentrations of Cd, Zn, and Ni of

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				different sites was found with decreasing concentration pattern for industrial > roadside > commercial > residential sites. Further, metal concentrations in human fingernails of workers/residents of the Agra district have also been compared with other worldwide studies. **Conclusion**: Metallic discharges from various industries in Agra district contribute the largest portion of metals which is hazardous for health as well environment. The presence of these metals in different samples is an indication of the presence of these metals in the environment. Accordingly, there is an instantaneous need for public awareness about the hazards of an occupation.
Occupational exposure	Ghanwat, Ganesh Haribhau, Arun Jalindar Patil, Jyotsna A. Patil, Mandakini S. Kshirsagar, Ajit Sontakke, and Ram Krishna Ayachit	2016	Biochemical Effects of Lead Exposure on Oxidative Stress and Antioxidant Status of Battery Manufacturing Workers of Western Maharashtra, India	**Background:** Lead induces oxidative stress and alters the antioxidant status of population exposed to high lead levels, i.e. battery manufacturing workers. The aim of this study was to know the current scenario of blood lead (PbB) levels and their effect on the oxidative stress parameter, i.e. serum lipid peroxide (LP), and antioxidant parameters, such as red blood cell (RBC)-superoxide dis-mutase (SOD), RBC-catalase (CAT), plasma ceruloplasmin (CP), and serum nitrite, of battery manufacturing workers. **Methods**: Forty-three battery manufacturing workers from Western Maharashtra, India, with ages between 19 and 42 years, were selected as study group and compared with 38 age-matched, healthy male subjects (control group). From both group subjects, 10 mL of blood sample was drawn by puncturing the antecubital vein, and PbB, serum LP, RBC-SOD, RBC-CAT, plasma CP, and serum nitrite were estimated using standard methods. **Results**: The PbB levels of the battery manufacturing workers were significantly higher ($p < 0.001$, 1050%) as compared with the control subjects. The serum LP levels were significantly increased ($p < 0.001$, 96.86%); all anti-oxidant status parameters such as RBC-SOD ($p < 0.001$, –26.32%), RBC-CAT ($p < 0.001$, –51.57%), and plasma CP ($p < 0.001$, –35.13%) were significantly decreased; and serum nitrite levels ($p < 0.001$, 154%) were significantly increased in the battery manufacturing workers as com-pared with the control subjects.

Topic	Authors	Year	Title	Abstract/ description
				Conclusions: Despite modern techniques used to reduce lead exposure in battery manufacturing workers, PbB levels remain high, inducing oxidative stress and altering the antioxidant status of battery manufacturing workers.

F. Blood testing in National Health Surveys

National Health Survey	National Family Health Survey 2019-20 (NFHS-5)	Source
Purpose	The purpose of this survey is to provide estimates on population health, family planning and nutrition related key indicators like fertility, mortality, maternal, child and adult health, women and child nutrition, domestic violence, health behavior and knowledge, health care access and use, and immunization.	ICF International, International Institute for Population Sciences (India), Ministry of Health and Family Welfare (India). India Demographic and Health Survey 2019-2020.
Sample size	The nationally representative sample for this survey consists of 668,622 women (age 15 to 59) and 91,200 men (age 15 to 54) in 609,120 households.	
Blood sample testing	Blood samples were drawn to assess haemoglobin and blood glucose levels. Dried blood samples were also collected to test for malaria, HbAlC, and Vitamin D.	
Latest round	2019-20	
Next round	Unknown	