



Assessment of Heavy Metal Content in Some Baby Foods Sold in Uyo, Akwa Ibom State, Nigeria

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ABSTRACT

Global food safety is a major issue, particularly for vulnerable newborns and infants who are fed infant formula. This is due to their underdeveloped organs and relatively small body size. Seventeen (17) brands of infant formulas were analyzed in triplicate for trace elements using ICP-OES. The Estimated Daily Intake (EDI), carcinogenic risk (CR) and non-carcinogenic risk were also determined to assess the safety of these products. Cd (0.04 mg/kg) and Cu (0.6 mg/kg) concentrations were greater in the 0 to 6 month age group, whereas Al (37.5 mg/kg), Fe (46.2 mg/kg), and Zn (18.5 mg/kg) concentrations were higher in the 1 to 6 year age group. The average EDIs were Cd (0.0003), Cu (0.006), Al (0.41), Fe (0.5), and Zn (0.2) in mg/kg bw/day. Cereal products contributed higher levels of Zn, Cd and Al to the diet, while milk products contributed more Cu and Fe. Milk products had higher levels of Cu and Fe in the diet, while cereal items had higher levels of Zn, Cd, and Al. The THQ values were below the threshold of one. In all samples for infants aged 0-6 months and 1-6 years, the carcinogenic risk values for Cd surpassed the permissible level of 10^{-4} . This means that baby foods studied for children aged 0-6 months and 1-6 years have the potential to cause cancer if consumed over an extended period. Infant formula should be regularly checked for trace element contaminations by regulatory bodies.

Keywords: Trace elements, Infant formula, Contamination, Estimated daily intake (EDI), Carcinogenic risk

INTRODUCTION

- Balanced nutrition in early childhood is crucial for adequate growth and development
- WHO recommends exclusive breastfeeding for the first six months of life, however, 44% of infants aged 0-6 months are exclusively breastfed.
- Factors like medical restrictions, social duties, sickness or death may hinder breastfeeding, in such situations, complementary feeding, such as infant cereals, can be an alternative.
- Infant cereals, made from corn, rice, wheat, and oat flour, enriched with specific nutrients, are considered excellent alternatives. Infant formula when contaminated with potentially toxic elements may pose health risk.
- Heavy metal contamination in infants is more critical due to immature development, high gastrointestinal tract uptake, and high food consumption relative to body mass.
- Excessive intake of toxic metals such as Cd can lead to carcinogenic and neurological health risks, Essential elements like Cu, Fe, Zn, Al play vital roles in human health, but deficiency or excess can be detrimental to baby's health.

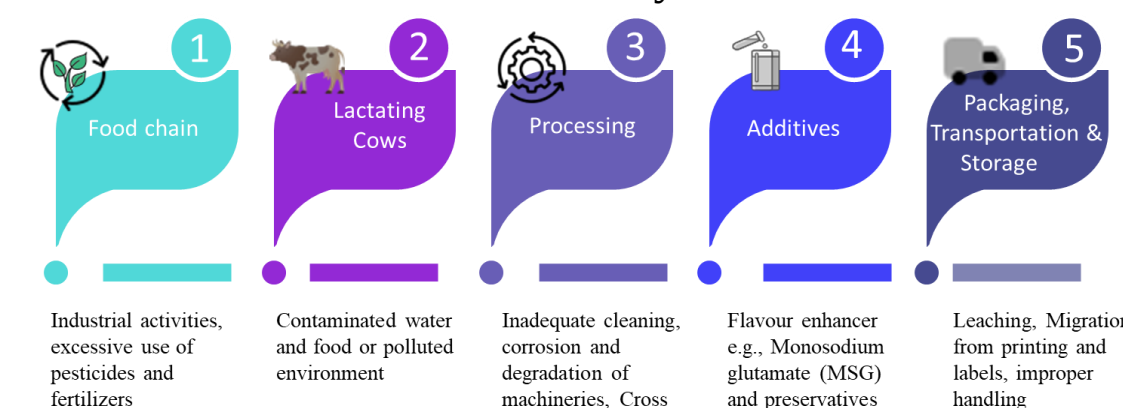
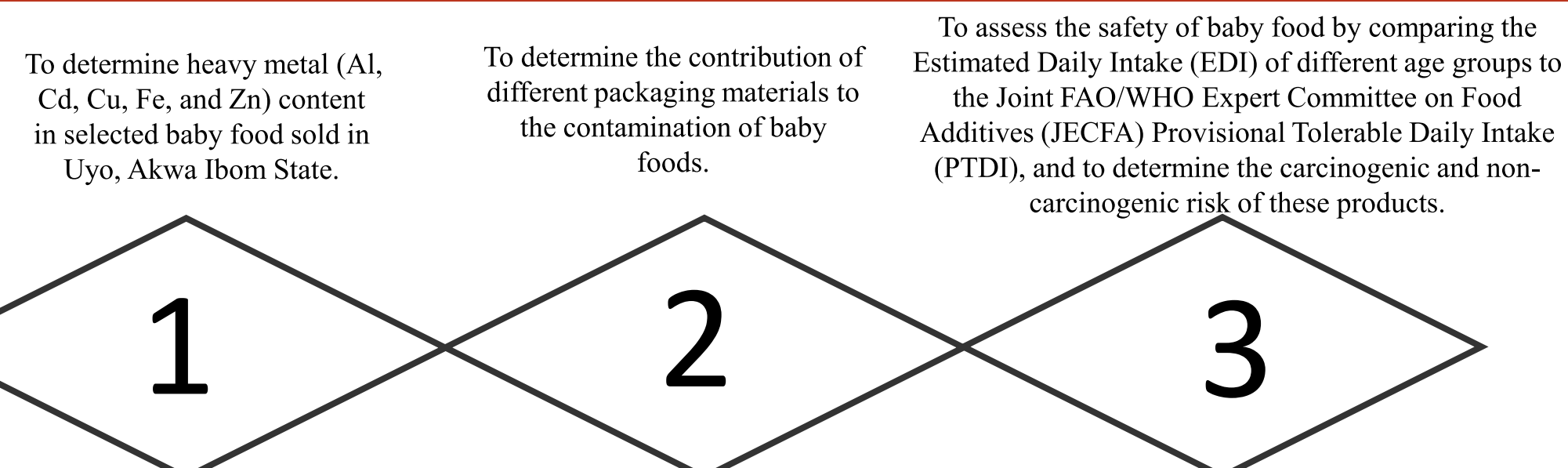


Fig 1: Various mode of infant formula contamination

OBJECTIVE OF STUDY



METHODS & MATERIALS

- Seventeen (7 milk products, 4 cereal products, and 6 mixed products) brands of baby foods
- Uyo, Akwa Ibom state, Nigeria
- 0.5 g of sample digested in a mixture of 20 mL HNO_3 and H_2O_2 in the ratio 3:1
- Sample was analyzed in triplicate using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES)

The models and formulas used to assess the safety of baby food are below:

- Metal concentration ($\frac{\text{Mg}}{\text{kg}}$) = $\frac{\text{Vol of Digest (L)} \times \text{Metal concentration} (\frac{\text{Mg}}{\text{L}})}{\text{Wt of Sample (kg)}}$
- EDI (mg/kg/day) = $\frac{\text{C} \times \text{IR}}{\text{BW}}$
- Non-carcinogenic risk
- Hazard Quotient (HQ) = $\frac{\text{Estimated Daily Intake (EDI)}}{\text{Reference Dose (RfD)}}$
- Hazard Index (HI) = $\text{HI} = \text{HQ}_1 + \text{HQ}_2 + \dots \text{HQ}_n$
- Estimated Cancer risk (ECR) = $\text{EDI} \times \text{Cancer Slope Factor (CSF)}$

Table 1: Elements, Wavelength of measurement, ICVs in ppm, SRM 1568B (rice flour) and LOD

Metal (wavelength-nm)	ICV (n = 3) ppm			SRM 1568B (rice flour; mg/kg; n = 3)			LOD
	Certified value	Obtained value	% Recovery	Certified value	Obtained value	% Recovery	
Al (396.152)	1	109.1667	109	4.21	3.081	73	0.025972
Cd (214.439)	1	0.979167	97.9	0.00224	0.0209	93	0.000038
Cu (327.395)	1	0.9725	97.2	2.35	2.226	95	0.000125
Fe (238.204)	1	0.96733	96.7	7.42	1.235	98	0.000454
Zn (213.857)	1	0.9975	99.7	19.42	19.764	102	0.000059

RESULTS

Metal Concentration

Table 3: Summary of metal concentration (mg/kg) in baby foods

	Al	Cd	Cu	Fe	Zn	Moisture content (%)
Min	20.4	4.6X10 ⁻³	0.25	9.28	8.86	2.00
Max	64.5	0.06	0.71	83.7	24.7	22.0
Mean	35.5	0.03	0.47	44.0	18.4	10.05
STD	11.1	0.02	0.13	22.4	4.69	5.01

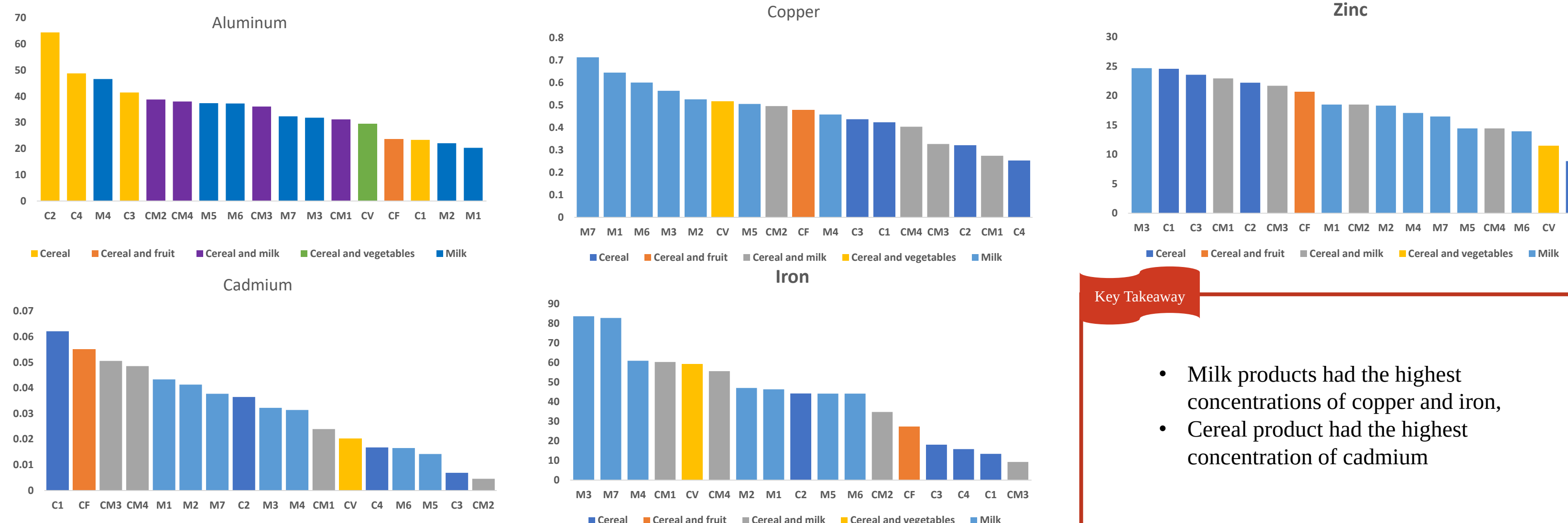


Fig 2: Heavy metal concentrations (mg/kg) of Al, Cu, Zn, Cd and Fe

Estimated Daily Intake (EDI)

Table 4: Mean EDI (mg/kg bw/day) of heavy metals by different age groups

Age group	Al	Cd	Cu	Fe	Zn
0 - 6 months	0.27	3.5 X 10 ⁻⁴	6.1X10 ⁻³	0.47	0.17
6 - 12 months	0.43	3.7 X 10 ⁻⁴	5.7 X 10 ⁻³	0.49	0.22
1 - 6 years	0.48	3.9 X 10 ⁻⁴	5.8 X 10 ⁻³	0.60	0.24
^a PTDI (mg/kg bw/day)	0.28	8.3 X 10 ⁻⁴	0.5	0.80	1.00

^a Provisional Tolerable daily Intake (mg/kg/day) of heavy metal based on data by Joint FAO/WHO Expert Committee on Food Additives

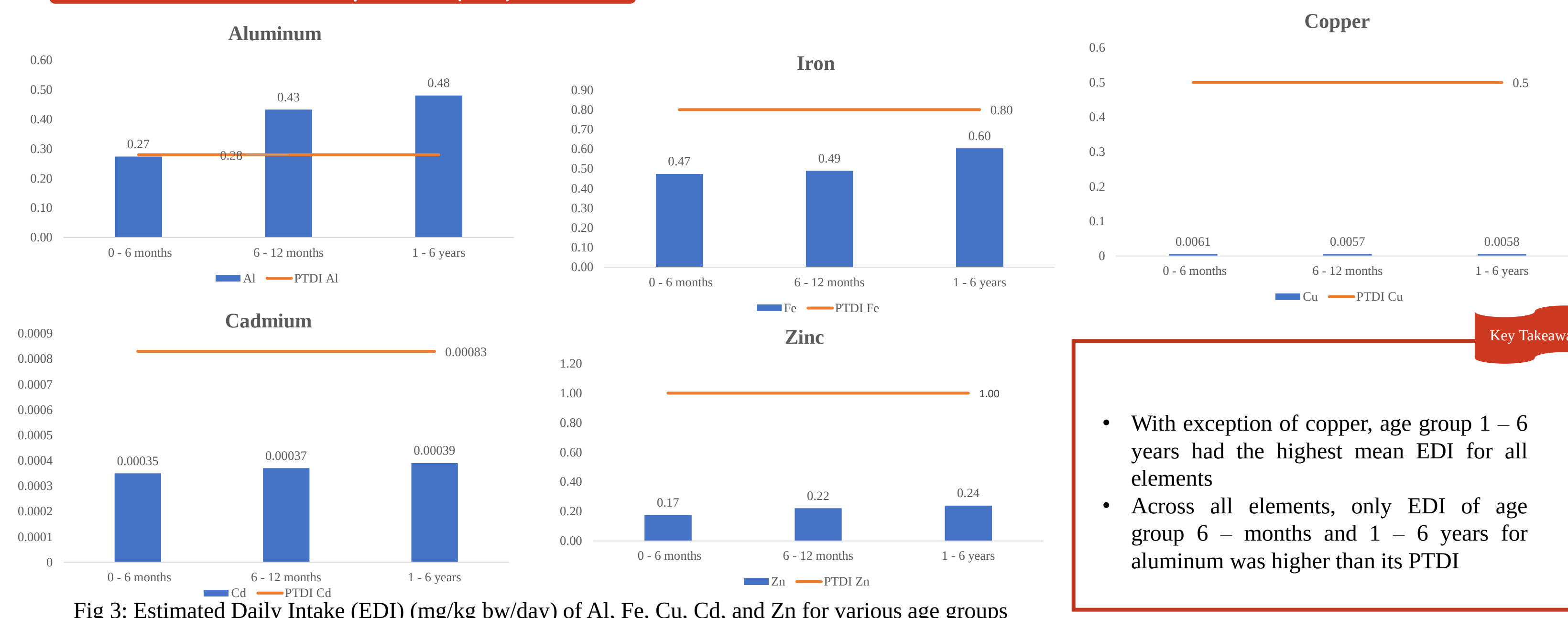


Fig 3: Estimated Daily Intake (EDI) (mg/kg bw/day) of Al, Fe, Cu, Cd, and Zn for various age groups

Contribution of Packaging Material

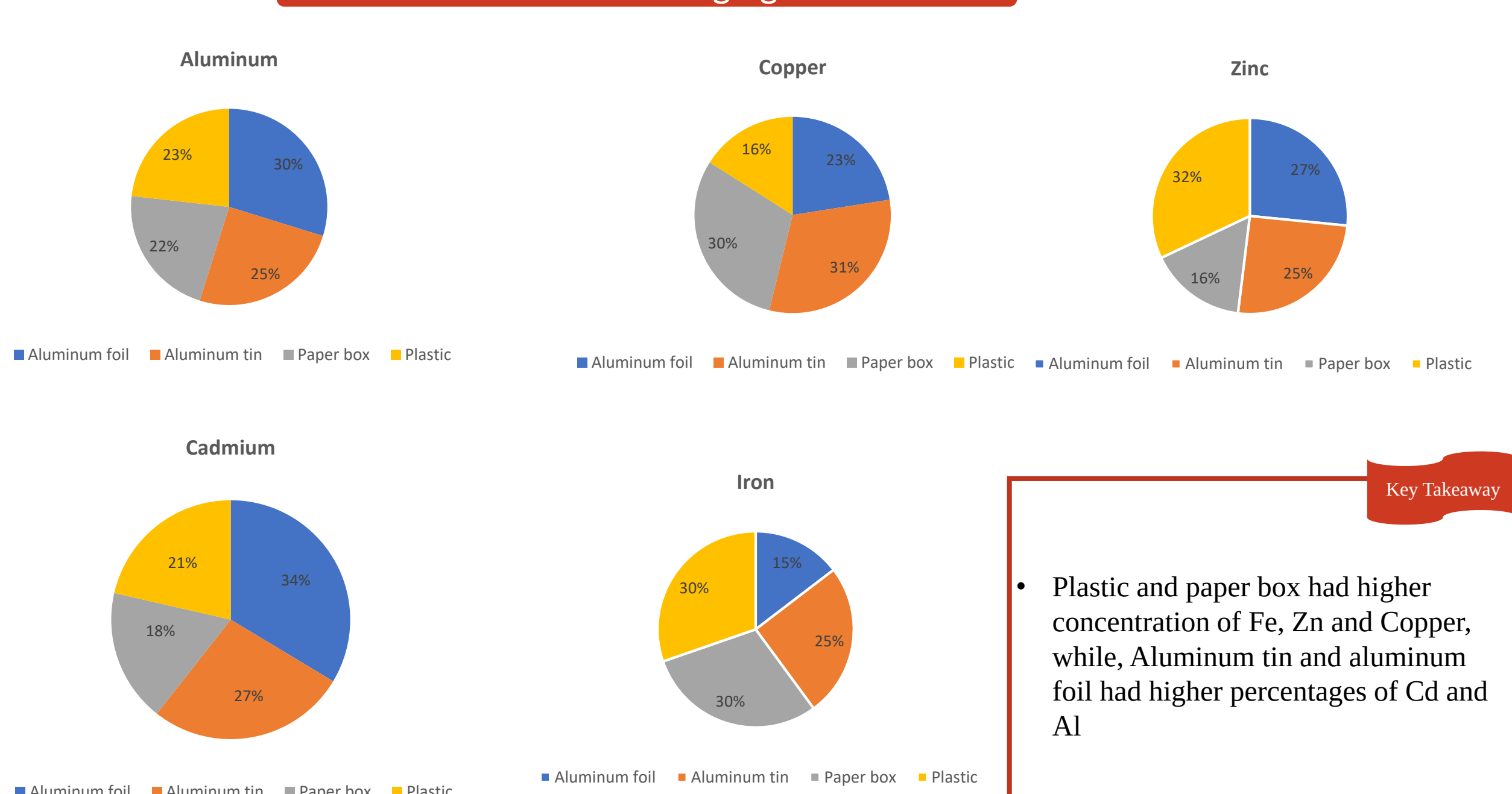


Fig 6: Metal concentrations (mg/kg) by packaging material

Non-carcinogenic and Carcinogenic risks

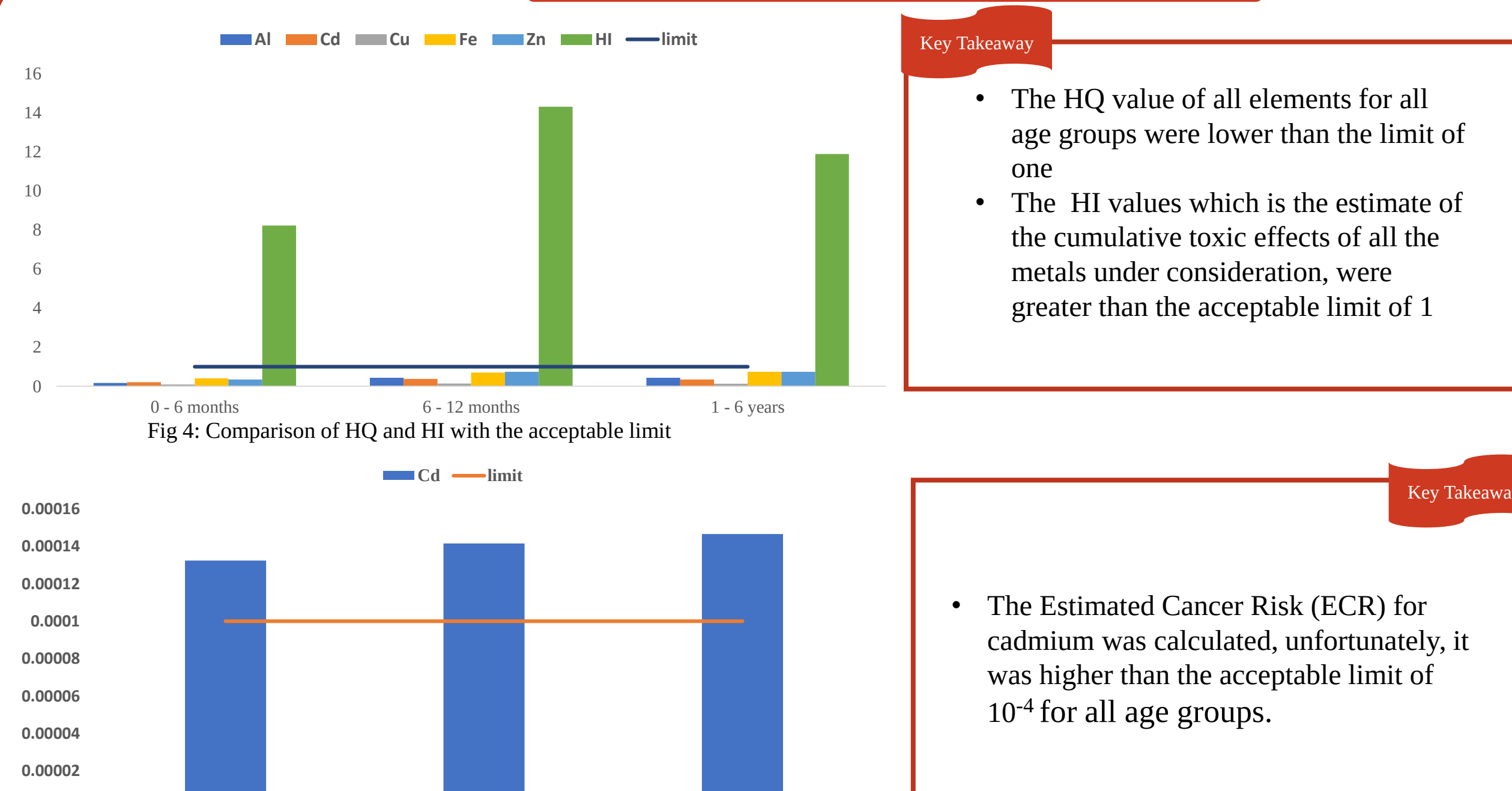


Fig 4: Comparison of HQ and HI with the acceptable limit

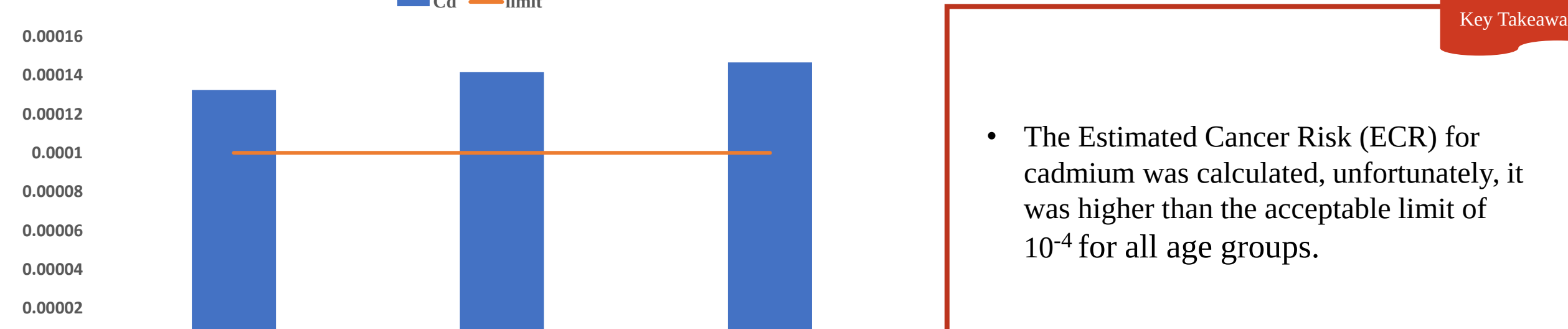


Fig 5: Estimated Carcinogenic Risk (ECR) of Cadmium for all age groups

SUMMARY & CONCLUSION

- The mean metal concentrations ranged from 4.6 X 10⁻³ mg/kg (Cd in milk) – 83.7 mg/kg (Fe in milk product). Al, Zn, and Fe had concentrations greater than the recommended values.
- The concentration of elements follow the trends Fe > Al > Zn > Cu > Cd for all age groups
- For elemental pollution paper box and plastic materials may be a safer option for packaging, as it contributes lesser concentration of elements like Al and Cd in baby foods.
- Across all age groups the estimated daily intake (EDI) ranged from 4 X 10⁻⁵ mg/kg bw/day (Cd in baby milk) – 0.8 mg/kg bw/day (Fe in baby milk). The estimated daily intake of Al was found to exceed the PTDI established by JECFA.
- Cereal products contributed higher levels of Zn and Al to the diet, while milk products contributed more Cu and Fe.
- The THQ values were below the threshold of one
- The carcinogenic risk value of Cd exceeded the acceptable limit of 10⁻⁴ for infants aged 0 – 6 months and 1 – 6 years, and in 50 % of samples for babies age 6 – 12 months.
- Baby food Sold in Uyo, Akwa Ibom state, especially those targeting children between the age of 0 to 6 months should be regularly checked for heavy metal contamination, as they contain high Cd concentration

RECOMMEDATIONS

- Regular checks should be carried out on baby food sold in Uyo, Akwa Ibom State.
- Industries where these products are produced should be monitored by the task force to ensure the cleanliness of the environment and to see that manufacturing guidelines are followed adequately
- Since infant formulas sold in paper boxes and plastic materials contributed the least to Cd and Al concentration they are a safer choice for packaging and should be considered over aluminum tin and foils.

KEY REFERENCES

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