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ESTIMATION OF THE DIETARY INTAKES OF HEAVY METALS BY CHILDREN, ADOLESCENTS, ADULTS AND SENIORS CONSUMING CHICKEN MEATS WITHIN AWKA AND ENUGU METROPOLIS AND ITS ENVIRONS.

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ABSTRACT: *This study was carried out to estimate the dietary intakes of heavy metals (Pb, As, Cd, Cr, Hg, Ni, V and Cu) by the inhabitants consuming chicken meats within Awka and Enugu metropolis and its environs. The concentration of the heavy metals were determined in the chicken samples collected from major farms and markets within Awka and Enugu metropolis and its environs. The kidney, liver, gizzard and muscle of chicken samples were analyzed for heavy metal concentrations using flame atomic absorption spectrometer. Heavy metal intakes on daily and weekly basis were determined for the five population groups; children, adolescents, male and female adults and seniors using food frequency questionnaire approach administered to six hundred (600) respondents in the population. The data obtained from the FFQ was subjected to Monte Carlo simulation analysis and mathematical evaluations. The analysis showed that the range of the total mean dietary intake of the heavy metals in mg/kg body weight/wk increased in the following order; seniors, (0.98 – 5.18) > male adults, (0.96 – 5.02) > adolescents, (0.96 – 4.75) > female adults, (0.81 – 4.05) > children, (0.50 – 3.06) The weekly intakes of heavy metals by the five population groups were compared with the established provisional tolerable weekly intakes set for these metals. The total mean dietary intakes of seven of the eight heavy metals estimated were below the established PTW1. On the other hand, the mean dietary intake of mercury by the five population groups consuming chicken liver and kidney exceeded the PTW1 by between 130 to 175.63%.*

KEYWORDS: Heavy metals, dietary intake, chicken meats, PTW1

INTRODUCTION

Heavy metals are widely dispersed in the environment. Arsenic, cadmium, mercury and lead in particular have no known beneficial effects in humans and there is no known homeostasis mechanism for them (Ysart et al., 1997). The consumption of polluted food is the main source of heavy metals intake in the non-smoking population (Ciobanu et al., 2012).

In humans, heavy metals toxicity have been associated with fatigue, headache, bone damage, liver and kidney damage, cancer, diarrhea, diabetes, pneumonitis, eye irritation, cardiovascular diseases, severe, vomiting intestinal cramps, anemia, central nervous system effects and sometimes death (Forstner et al., 1983, Varsha et al., 2010 and WHO, 2001). Although some individuals are primarily exposed to heavy metals in the work place, for most people the main route of exposure to these toxic elements is through the diet.

Consequently, information about dietary intake is very important to assess risks to human health. To evaluate the health risks to consumers, it is necessary to determine the specific dietary intake of each pollutant for comparison with toxicologically acceptable levels (Leblanc et al., 2000).

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In relation to this, it is well known that there are notable difference in both food consumption and food contamination by metals among groups in a given population (Iyenger et al., 2000). In this study, to estimate dietary exposure to heavy metals by the population consuming chicken meats, a food frequency questionnaire was adopted and the data obtained was analyzed using monte-carlo simulation procedure.

The following equations was relevant in the analysis,

Average daily intake =

$$\frac{\text{Mean concentration of heavy metal in the meat part x Mean food intake in g/person/day}}{\text{Average body weight of that group}}$$

Weekly intake of heavy metals = Average daily intake x 7days /week

In view of the fact that there is no sufficient data on the dietary intake of heavy metals on consumption of chicken meats by the five population groups living in Awka metropolis and its environs, this study was undertaken.

MATERIALS AND METHODS

Sample Collection: The chicken samples were collected from the different farms in Awka metropolis and its environs. The chickens were processed and the meat parts (muscle, gizzard and liver) were sent to the laboratory for analysis.

Sample Preparation

2g of each dried meat sample was weighed into a 100ml polythene bottle 10ml of the digestion mixture (3:2 65% HNO_3 and 70% $HClO_4$) were added. The bottles were tightly closed and the contents were gently swirled and allowed to stand overnight. The samples were heated for 3hours in a water bath adjusted to 70^oC with occasional swirling at 3mins interval to ensure complete digestion of the samples. Finally, the digest was allowed to cool and then transferred into a 20ml standard flask. The solutions were transferred into an acid leached poly-ethlene bottles and kept at room temperature until analysis with AAS.

Spectroscopic Analysis

The sample solutions were subsequently analyzed for heavy metal contents as wet weight basis using atomic absorption spectrometer. Measurements were made using the hollow cathode lamps for Pb, As, Cd, Cr, Hg, Ni, V and Cu at the proper wave length and other AAS conditions were employed in the determinations. Working solutions were prepared by dilution just before the use of standard solutions for atomic absorption spectroscopy.

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Dietary exposure estimates

Six hundred food frequency questionnaires based on chicken meat consumption were used to estimate the daily and weekly intakes of the chicken parts under study by the five groups of the population. The questionnaires were distributed to different categories of the population, children (80), adolescents (120), male and female adults (150 per each) and senior (100). The body weights of the different groups were taken and recorded accordingly. The chicken meats were cut into sizes; large, moderate and small and were cooked for thirty minutes after which their different weights were taken. Thus the portion size were large (195g), moderate (105g) and small (45g) for muscle; large (75g), moderate (40g) and small (25g) for liver; large (65g), moderate (30g) and small (15g) for gizzard and large (25g), moderate (12g) and small (7g) for kidney. The dietary intake of heavy metals on consumption of chicken meats by the five population groups was calculated by subjecting the data to monte-carlo simulation analysis and mathematical evaluations.

RESULTS AND DISCUSSIONS

Table 1: Mean daily consumption (g/person/day) of the different parts of the chickens by the five population groups.

Group		Muscle	Gizzard	Liver	Kidney
	Mean ± SD	21.07 ± 1.28	10.45 ± 3.17	11.32 ± 1.30	5.28 ± 1.57
Children	Range	18.65 – 24.12	7.22 – 15.08	7.59 – 16.11	4.21 – 8.35
	n	80	80	80	80
	Mean ± SD	51.74 ± 2.11	33.65 ± 2.03	29.05 ± 1.44	14.26 ±1.30
Adolescent	Range	30.31 – 89.06	22.31 – 53.19	19.43 – 40.87	10.68 – 19.05
	n	120	120	120	120
	Mean ± SD	70.92 ± 4.13	51.47 ± 2.28	45.93 ± 1.56	20.51 ± 3.01
Female adults	Range	37.58 – 125.82	30.61 – 65.19	24.43 – 58.87	15.87 – 26.74
	n	150	150	150	150
	Mean ± SD	65.19 ± 3.15	53.88 ± 2.07	49.85 ± 1.49	23.50 ± 2.51
Male adults	Range	40.75 – 116.82	28.59 – 71.59	23.05 – 56.84	19.53 – 30.17
	n	150	150	150	150
	Mean ± SD	51.02 ± 1.86	55.65 ± 1.47	49.07 ± 2.36	23.13 ± 2.24
Seniors	Range	33.72 – 99.02	29.83 – 72.40	21.85 – 58.72	18.53 – 30.09
	n	100	100	100	100

Table 1 showed that the mean daily consumption of chicken muscles by the five population groups living within Awka and Enugu metropolis and its environs increased in the following order; female adults > male adults > adolescents > seniors > children. The mean daily consumption of chicken gizzard by the five population groups increased in the following order; seniors > male adults > female adults > adolescents > children. The mean daily intake of chicken liver and kidney by the five population groups followed the same order of increase as follows: male adults > seniors > female adults > adolescents > children.

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Table 2: Mean dietary intake of lead by the five population groups.

Group		Mean metal (mg/g)	Mean daily consumption g/person/day	Mean weekly consumption g/person/wk	Mean dietary intake mg/p/wk	Mean dietary mg/kg body weight/wk	Provisional tolerable weekly intake (PTW1) mg/kg body weight/wk	Mean intake % of PTW1
	Muscle	0.055	21.07	147.49	8.11	0.42	25	1.68
	Gizzard	0.157	10.45	73.15	11.48	0.59	"	2.36
Children	Liver	0.432	11.32	79.24	34.23	1.76	"	7.04
	Kidney	0.396	5.28	36.96	14.64	0.75	"	3.00
	Total	**1.044**	**48.12**	**336.84**	**68.46**	**3.51**	"	**14.08**
	Muscle	0.055	51.74	362.18	19.92	0.45	"	1.80
	Gizzard	0.157	33.65	235.55	36.98	0.83	"	3.32
Adolescents	Liver	0.432	29.05	203.35	87.85	1.98	"	7.92
	Kidney	0.396	17.26	99.82	39.53	0.89	"	3.56
	Total	**1.044**	**128.70**	**900.90**	**184.28**	**4.15**		**16.6**
	Muscle	0.055	70.92	496.44	27.30	0.35	25	1.40
	Gizzard	0.157	51.47	360.29	56.56	0.72	"	2.88
Female adults	Liver	0.432	45.93	321.51	138.89	1.76	"	7.04
	Kidney	0.396	20.51	143.57	56.85	0.72	"	2.88
	Total	**1.044**	**188.83**	**1321.81**	**279.60**	**3.55**		**14.2**
	Muscle	0.055	65.19	456.33	25.10	0.37	"	1.48
	Gizzard	0.157	53.88	377.16	59.21	0.86	"	3.44
Male adults	Liver	0.432	49.85	348.95	150.75	2.20	"	8.80
	Kidney	0.396	23.50	164.50	65.14	0.95	"	3.80
	Total	**1.044**	**192.42**	**1346.94**	**300.20**	**4.38**		**17.52**
	Muscle	0.055	51.02	357.14	19.64	0.31	"	1.24
	Gizzard	0.157	55.65	389.55	61.16	0.97	"	3.88
Seniors	Liver	0.432	49.07	343.49	148.39	2.36	"	9.44
	Kidney	0.396	23.13	161.91	64.12	1.02	"	4.08
	Total	**1.044**	**178.87**	**1252.09**	**293.31**	**4.66**		**18.64**
	Muscle	0.055	51.98	363.92	20.01	-	-	-
	Gizzard	0.157	41.02	287.14	45.07	-	-	-
Whole population	Liver	0.432	37.04	259.31	112.02	-	-	-
	Kidney	0.396	17.34	121.35	48.06	-	-	-
	Total	**1.044**	**147.38**	**1031.72**	**225.16**	-	-	-

Average body weight (kg), a = 19.5, b = 44.3, c = 79.1, d = 68.7, e = 62.8 for children , adolescents , female adults , male adults and seniors respectively,

Table 2 showed that the total mean dietary intake of lead in mg/kg body weight/wk by the five population groups consuming chicken meats increased as follows; seniors(4.66) > male adults (4.38) > adolescents (4.15) > female adults (3.55) > children (3.51). The total mean dietary intakes of lead by the five population groups consuming chicken meats were within the permissible tolerable weekly intake of 25 mg/kg body weight/wk established by (FAO/WHO, 2006). The total mean dietary intakes of lead in mg/kg body weight/wk by the five population groups consuming chicken meats was between 14.04% to 18.64% of the established PTW1.

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Mean weekly dietary intakes of lead in mg/kg body weight/wk by the five population groups consuming chicken liver and kidney were higher that other studied parts of the chickens. Bio-accumulation of Pb primarily in the liver followed by the kidney could have been responsible for the increased exposure by the five population groups consuming the said chicken meat parts.

The people living within the studied environments consuming chicken meats are at no risk of toxicity of lead. Lead being a heavy metal that accumulates in the internal organs of animals and man does not involve in any essential metabolic processes in the body.

Table 3: Mean dietary intake of arsenic by the five population groups.

Group		Mean metal (mg/g)	Mean daily consumption g/person/day	Mean weekly consumption g/person/wk	Mean dietary intake mg/p/wk	Mean dietary mg/kg body weight/wk	Provisional tolerable weekly intake (PTW1) mg/kg body weight/wk	Mean intake % of PTW1
	Muscle	0.088	21.07	147.49	12.98	0.66	15	4.40
	Gizzard	0.180	10.45	73.15	13.17	0.68	"	4.53
Children	Liver	0.204	11.32	79.24	16.16	0.83	"	5.53
	Kidney	0.165	5.28	36.96	5.99	0.31	"	2.06
	Total	**0.637**	**48.32**	**336.84**	**48.30**	**2.48**	"	**1652**
	Muscle	0.088	51.74	362.18	31.87	0.72	"	4.80
	Gizzard	0.180	33.65	235.55	42.40	0.96	"	6.40
Adolescents	Liver	0.204	29.05	203.35	41.48	0.94	"	6.27
	Kidney	0.165	14.26	99.82	16.47	0.37	"	2.47
	Total	**0.637**	**128.70**	**900.90**	**132.22**	**2.99**		**19.94**
	Muscle	0.088	70.92	496.44	43.69	0.55	15	3.67
	Gizzard	0.180	51.47	360.29	64.85	0.82	"	5.47
Female adults	Liver	0.204	45.93	321.51	65.59	0.83	"	5.53
	Kidney	0.165	20.51	143.57	23.69	0.300	"	2.00
	Total	**0.637**	**188.83**	**1321.81**	**197.82**	**2.50**		**16.67**
	Muscle	0.088	65.19	456.33	40.15	0.58	"	3.87
	Gizzard	0.180	53.88	377.16	33.19	0.48	"	3.20
Male adults	Liver	0.204	49.85	348.95	62.81	0.92	"	6.13
	Kidney	0.165	23.50	164.50	27.14	0.39	"	2.6
	Total	**0.637**	**192.42**	**1346.94**	**163.29**	**2.37**		**15.8**
	Muscle	0.088	51.02	357.14	31.43	0.50	"	3.33
	Gizzard	0.180	55.65	389.55	70.12	1.12	"	7.47
Seniors	Liver	0.204	49.07	343.49	70.07	1.11	"	7.40
	Kidney	0.165	23.13	161.91	27.72	0.44	"	2.93
	Total	**0.637**	**178.87**	**1252.09**	**199.34**	**3.17**		**21.13**
	Muscle	0.088	51.98	363.92	32.02	-	-	-
	Gizzard	0.180	41.02	237.14	44.75	-	-	-
Whole population	Liver	0.204	37.04	259.31	51.22	-	-	-
	Kidney	0.165	17.34	121.35	20.20	-	-	-
	Total	**0.637**	**14.738**	**1031.72**	**148.19**	-	-	-

Average body weight (kg), a = 19.5, b = 44.3, c = 79.1, d = 68.7, e = 62.8 for children , adolescents , female adults , male adults and seniors respectively,

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Table 3 showed that the total mean dietary intake of arsenic in mg/kg/body weight/wk by the five population groups consuming chicken meats increased in the following order: seniors (3.17) > adolescents (2.99) > female adults (2.50) > children (2.48) > male adults (2.37). The difference in body weight of the population groups consuming chicken meat and the concentrations of the metal (arsenic) in the meat parts of the chickens could be accounted for the respective dietary intakes. The total mean dietary intake of arsenic in mg/kg/body weight/wk by the five population groups consuming the studied parts of the chicken meats was within the provisional tolerable weekly intakes of 15mg/kg/body weight/wk set for the metal. The total dietary intake of arsenic by the five population groups consuming chicken meats was between 15.80 to 21.13% of the PWT1. This implies that the entire population consuming chicken meats are at no risk of the toxicity of the metal.

Table 4: Mean dietary intake of cadmium by the five population groups

Group		Mean metal (mg/g)	Mean daily consumption g/person/day	Mean weekly consumption g/person/wk	Mean dietary intake mg/p/wk	Mean dietary mg/kg body weight/wk	Provisional tolerable weekly intake (PTW1) mg/kg body weight/wk	Mean intake % of PTW1
	Muscle	0.046	21.07	147.49	6.78	0.35	7	5.00
	Gizzard	0.163	10.45	73.15	11.92	0.61	"	8.71
Children	Liver	0.510	11.32	79.24	40.41	2.07	"	29.57
	Kidney	0.435	5.28	36.96	16.08	0.82	"	11.71
	Total	**1.154**	**48.12**	**336.84**	**75.19**	**3.82**	"	**54.99**
	Muscle	0.046	51.74	362.18	16.66	0.38	"	5.43
	Gizzard	0.163	33.65	235.55	38.38	0.87	"	12.42
Adolescents	Liver	0.510	29.05	203.35	103.70	2.34	"	33.42
	Kidney	0.435	14.26	99.82	43.42	0.98	"	14.00
	Total	**1.154**	**128.70**	**900.90**	**202.17**	**4.57**		**65.27**
	Muscle	0.046	70.92	496.44	22.83	0.29	7	4.14
	Gizzard	0.163	51.47	360.29	58.73	0.74	"	10.57
Female adults	Liver	0.510	45.93	321.51	163.97	2.07	"	28.57
	Kidney	0.435	20.51	143.57	62.45	0.79	"	11.29
	Total	**1.154**	**188.83**	**1321.81**	**307.98**	**3.89**		**55.57**
	Muscle	0.046	65.19	456.33	20.99	0.31	"	4.43
	Gizzard	0.163	53.88	377.16	61.48	0.89	"	12.71
Male adults	Liver	0.510	49.85	348.95	177.96	2.59	"	37.00
	Kidney	0.435	23.50	164.50	71.56	0.90	"	12.86
	Total	**1.154**	**192.42**	**1346.94**	**331.99**	**4.69**		**67.00**
	Muscle	0.046	51.02	357.14	16.43	0.26	"	3.71
	Gizzard	0.163	55.65	389.55	63.50	1.01	"	14.43
Seniors	Liver	0.510	49.07	343.49	175.18	2.79	"	39.86
	Kidney	0.435	23.13	161.91	70.43	1.12	"	16.00
	Total	**1.154**	**178.87**	**1252.09**	**325.54**	**5.18**		**74.00**
	Muscle	0.046	51.98	363.92	16.72	-	-	-
	Gizzard	0.163	41.02	287.14	46.80	-	-	-
Whole population	Liver	0.510	37.04	259.31	132.24	-	-	-
	Kidney	0.435	17.84	121.35	52.79	-	-	-
	Total	**1.153**	**147.38**	**1031.72**	**248.55**	-	-	-

Average body weight (kg), a = 19.5, b = 44.3, c = 79.1, d = 68.7, e = 62.8, for children, adolescents, female adults, male adults and seniors respectively,

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Table 4 showed that the total mean dietary intake of cadmium in mg/kg body weight/wk by the five population groups consuming chicken meats increased in the following order; seniors (5.18) > male adults (4.69) > adolescents (4.57) > female adults (3.89) > children (3.82). More than 70% of the total mean dietary intake of cadmium by the five population groups came from consumptions of the liver and kidney of the chickens. Knowing the toxicity of cadmium even at low concentrations, it was observed that the total mean dietary intake of cadmium in mg/kg body weight/wk by the five population groups consuming chicken meats was between 54.99 to 74.00% of the PWT1 of the metal. To the population consuming chicken meats it is good news, however, anthropogenic activities must be regulated so as not to cause the exposure of the metal above the PTW1 through food consumption by the people.

Table 5: Mean dietary intake of chromium by the five population groups

Group		Mean metal (mg/g)	Mean daily consumption g/person/day	Mean weekly consumption g/person/wk	Mean dietary intake mg/p/wk	Mean dietary mg/kg body weight/wk	Provisional tolerable weekly intake (PTW1) mg/kg body weight/wk	Mean intake % of PTW1
	Muscle	0.096	21.07	147.49	14.16	0.73	420	0.17
	Gizzard	0.154	10.45	73.15	11.27	0.58	"	0.14
Children	Liver	0.134	11.32	79.24	10.62	0.54	"	0.13
	Kidney	0.116	5.28	36.96	4.29	0.22	"	0.05
	Total	**0.500**	**48.12**	**336.84**	**40.34**	**2.07**	"	**0.49**
	Muscle	0.096	51.74	362.18	34.77	0.78	"	0.19
	Gizzard	0.154	33.65	235.55	36.27	0.82	"	0.20
Adolescents	Liver	0.134	29.05	203.35	27.25	0.62	"	0.15
	Kidney	0.116	14.26	99.82	11.58	0.26	"	0.06
	Total	**0.500**	**128.70**	**900.90**	**109.87**	**2.48**		**0.60**
	Muscle	0.096	70.92	496.44	47.58	0.60	420	0.14
	Gizzard	0.154	51.47	360.29	55.48	0.70	"	0.17
Female adults	Liver	0.134	45.93	321.51	43.08	0.54	"	0.13
	Kidney	0.116	20.51	143.57	16.65	0.21	"	0.05
	Total	**0.500**	**188.83**	**1321.81**	**162.79**	**2.05**		**0.49**
	Muscle	0.096	65.19	456.33	43.81	0.64	"	0.15
	Gizzard	0.154	53.88	377.16	58.08	0.85	"	0.20
Male adults	Liver	0.134	49.85	348.95	46.76	0.68	"	0.16
	Kidney	0.116	23.50	164.50	19.08	0.28	"	0.07
	Total	**0.500**	**192.42**	**1346.94**	**167.73**	**2.45**		**0.58**
	Muscle	0.096	51.02	357.14	34.29	0.55	"	0.13
	Gizzard	0.154	55.65	389.55	59.99	0.96	"	0.23
Seniors	Liver	0.134	49.07	343.49	46.03	0.73	"	0.17
	Kidney	0.116	23.13	161.91	18.78	0.30	"	0.07
	Total	**0.500**	**178.87**	**1252.09**	**159.09**	**2.54**		**0.60**
	Muscle	0.096	51.98	363.92	34.92	-	-	-
	Gizzard	0.154	41.02	287.14	44.22	-	-	-
Whole population	Liver	0.134	37.04	259.31	34.75	-	-	-
	Kidney	0.116	17.34	121.35	14.08	-	-	-
	Total	**0.500**	**147.38**	**1031.72**		-	-	-

Average body weight (kg), a = 19.5, b = 44.3, c = 79.1, d = 68.7, e = 62.8 for children, adolescents, female adults, male adults and seniors respectively,

Table 5 showed that the total mean dietary intake of chromium in mg/kg body weight/wk by the five population groups consuming chicken meats increased in the following order; seniors

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(2.54) > adolescents (2.48) > male adults (2.45) > children (2.07) > female adults (2.05). All the population groups consuming chicken meats within the studied environments have their total mean dietary intakes of chromium respectively within the established provisional tolerable weekly intake of 420 mg/kg body weight/wk set for the metal by FAO/WHO. Chromium is an essential metal required by the body for metabolic processes, however, can become toxic at very high concentrations.

The low concentration of the metal in the meat parts of the chickens, digestibility of the metal and the consumption pattern of chicken meats by the people could have accounted for the low dietary exposure of chromium to the people.

Table 6: Mean dietary intake of mercury by the five population groups

Group		Mean metal (mg/g)	Mean daily consumption g/person/day	Mean weekly consumption g/person/wk	Mean dietary intake mg/p/wk	Mean dietary mg/kg body weight/wk	Provisional tolerable weekly intake (PTW1) mg/kg body weight/wk	Mean intake % of PTW1
	Muscle	0.057	21.07	147.49	8.41	0.43	1.6	26.87
	Gizzard	0.165	10.45	73.15	12.07	0.62	"	38.75
Children	Liver	0.513	11.32	79.24	40.65	2.08	"	130
	Kidney	0.46	5.28	36.96	17.30	0.89	"	55.62
	Total	**1.203**	**48.12**	**336.84**	**78.43**	**4.02**	"	**251.24**
	Muscle	0.057	51.74	362.18	20.64	0.47	"	29.38
	Gizzard	0.165	33.65	235.55	38.87	0.88	"	55
Adolescents	Liver	0.513	29.05	203.35	104.32	2.35	"	146.88
	Kidney	0.46	14.26	99.82	46.72	1.05	"	65.63
	Total	**1.203**	**128.70**	**900.9**	**210.55**	**4.75**		**296.89**
	Muscle	0.057	70.92	496.44	28.30	0.36	1.6	22.50
	Gizzard	0.165	51.47	360.29	59.45	0.75	"	46.88
Female adults	Liver	0.513	45.93	321.51	164.93	2.09	"	130.63
	Kidney	0.46	20.51	143.57	67.19	0.85	"	53.13
	Total	**1.203**	**188.83**	**1321.81**	**319.87**	**4.05**		**253.14**
	Muscle	0.057	65.19	456.33	26.01	0.38	"	23.75
	Gizzard	0.165	53.88	377.16	62.23	0.91	"	56.88
Male adults	Liver	0.513	49.85	348.95	179.01	2.61	"	163.13
	Kidney	0.46	23.50	164.50	76.99	1.12	"	70
	Total	**1.203**	**192.42**	**1346.94**	**344.24**	**5.02**		**313.76**
	Muscle	0.057	51.02	357.14	20.36	0.32	"	20
	Gizzard	0.165	55.65	389.55	64.28	1.02	"	63.75
Seniors	Liver	0.513	49.07	343.49	176.21	2.81	"	175.63
	Kidney	0.46	23.13	161.91	75.77	0.56	"	35
	Total	**1.203**	**178.87**	**1252.09**	**336.62**	**4.71**		**294.38**
	Muscle	0.057	51.98	363.92	20.74	-	-	-
	Gizzard	0.165	41.02	287.14	47.34	-	-	-
Whole population	Liver	0.513	37.04	259.31	133.02	-	-	-
	Kidney	0.46	17.34	121.35	56.79	-	-	-
	Total	**1.203**	**147.38**	**1030.72**	**257.89**	-	-	-

Average body weight (kg), a = 19.5, b = 44.3, c = 79.1, d = 68.7, e = 62.8 for children, adolescents, female adults, male adults and seniors respectively,

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Table 6 showed that the total mean dietary intake of mercury in mg/kg body weight/wk by the five population groups consuming chickens meats increased as follows; male adults (5.02) > adolescent, (4.75) > seniors (4.71) > female adults (4.05) > children (4.02).

The dietary exposure to mercury by the five population groups consuming chicken meats was above the provisional tolerable weekly intake limits set for it in consumable meat products by FAO/WHO. Infact, consumption of chicken livers by the five population groups resulted to intake of mercury by between 130 to 175.63% of the PTW1. To the population of the people who love eating chicken meats especially chicken livers, dietary exposure to mercury on weekly basis is worrisome and a serious cause for concern. The implication of this is obvious considering the toxicity of this metal. Children and female adults of the population groups could be at the highest detrimental risk of health issues considering the toxicity effects of mercury to the development of children and the reproductive health of women and their babies.

Table 7: Mean dietary intake of nickel by the five population groups

Group		Mean metal (mg/g)	Mean daily consumption g/person/day	Mean weekly consumption g/person/wk	Mean dietary intake mg/p/wk	Mean dietary mg/kg body weight/wk	Provisional tolerable weekly intake (PTW1) mg/kg body weight/wk	Mean intake % of PTW1
	Muscle	0.127	21.07	147.49	18.73	0.96	35	2.74
	Gizzard	0.226	10.45	73.15	16.53	0.85	"	2.43
Children	Liver	0.148	11.32	79.24	11.73	0.60	"	1.71
	Kidney	0.154	5.23	36.96	5.69	0.29	"	0.83
	Total	**0.655**	**48.12**	**336.84**	**52.68**	**2.70**	"	**7.71**
	Muscle	0.127	51.74	362.18	45.99	1.03	"	2.94
	Gizzard	0.226	33.65	235.55	53.23	1.20	"	3.43
Adolescents	Liver	0.148	29.05	203.35	30.09	0.68	"	1.94
	Kidney	0.154	14.26	99.82	15.37	0.35	"	1.00
	Total	**0.655**	**128.70**	**900.90**	**144.68**	**3.26**		**9.31**
	Muscle	0.127	70.92	496.44	63.04	0.78	35	2.23
	Gizzard	0.226	51.47	360.29	81.42	1.03	"	2.95
Female adults	Liver	0.148	45.93	321.51	47.58	0.60	"	1.71
	Kidney	0.154	20.51	143.57	22.11	0.28	"	0.80
	Total	**0.655**	**188.83**	**1321.81**	**214.15**	**2.69**		**7.69**
	Muscle	0.127	65.19	456.33	57.96	0.84	"	2.40
	Gizzard	0.226	53.88	377.16	85.24	1.24	"	3.54
Male adults	Liver	0.148	49.85	348.95	51.64	0.75	"	2.14
	Kidney	0.154	23.50	164.50	25.33	0.37	"	1.06
	Total	**0.655**	**192.42**	**1346.94**	**220.17**	**3.20**		**9.14**
	Muscle	0.127	51.02	357.14	45.36	0.73	"	2.09
	Gizzard	0.226	55.65	389.55	88.04	1.40	"	4.00
Seniors	Liver	0.148	49.07	343.49	50.84	0.81	"	2.31
	Kidney	0.154	23.13	161.91	24.93	0.40	"	1.14
	Total	**0.655**	**178.87**	**1252.09**	**209.17**	**3.34**		**9.54**
	Muscle	0.127	51.98	363.92	46.22	-	-	-
	Gizzard	0.226	41.02	287.14	64.89	-	-	-
Whole population	Liver	0.148	37.04	259.31	38.38	-	-	-
	Kidney	0.154	17.34	121.35	18.69	-	-	-
	Total	**0.655**	**147.38**	**1031.72**	**168.18**	-	-	-

Average body weight (kg), a = 19.5, b = 44.3, c = 79.1, d = 68.7, e = 62.8 for children, adolescents, female adults, male adults and seniors respectively,

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Table 7 showed that the total mean dietary intake of nickel in mg/kg body weight/wk by the five population groups consuming chicken meats increased in the following order; seniors (4.27) > adolescents (3.26) > male adults (3.20) > children (2.70) > female adults (2.69). The total mean dietary intake of nickel by the five population groups was within the established provisional tolerable weekly intakes of 70mg/kg body weight/wk. The total percentage weekly intake of the metals by the population groups was between 7.69 to 9.54% of the PTW1. The low dietary exposure to nickel on weekly basis by the population groups consuming chicken meats could be due to the low concentrations of the metal in the meats parts and the fact that the body have the mechanism to digest and excrete the metal easily.

Table 8: Mean dietary intake of vanadium by the five population groups.

Group		Mean metal (mg/g)	Mean daily consumption g/person/day	Mean weekly consumption g/person/wk	Mean dietary intake mg/p/wk	Mean dietary mg/kg body weight/wk	Provisional tolerable weekly intake (PTW1) mg/kg body weight/wk	Mean intake % of PTW1
	Muscle	0.037	21.07	147.49	5.46	0.28	70	0.40
	Gizzard	0.054	10.45	73.15	3.95	0.20	"	0.29
Children	Liver	0.053	11.32	79.24	4.20	0.22	"	0.31
	Kidney	0.059	5.28	36.96	2.18	0.11	"	0.16
	Total	**0.680**	**48.12**	**336.84**	**15.79**	**0.81**	"	**1.16**
	Muscle	0.037	51.74	362.18	13.40	0.30	"	0.43
	Gizzard	0.054	33.65	235.55	12.72	0.29	"	0.41
Adolescents	Liver	0.053	29.05	203.35	10.78	0.24	"	0.34
	Kidney	0.059	14.26	99.82	5.89	0.13	"	0.19
	Total	**0.680**	**128.70**	**900.90**	**42.79**	**0.96**		**1.37**
	Muscle	0.037	70.92	496.44	18.37	0.23	70	0.33
	Gizzard	0.054	51.47	360.29	19.46	0.25	"	0.36
Female adults	Liver	0.053	45.93	321.51	17.04	0.22	"	0.31
	Kidney	0.059	20.51	143.57	8.47	0.11	"	0.16
	Total	**0.680**	**188.83**	**1321.81**	**63.34**	**0.81**		**1.16**
	Muscle	0.037	65.19	456.33	16.88	0.25	"	0.36
	Gizzard	0.054	53.88	377.16	20.87	0.30	"	0.43
Male adults	Liver	0.053	49.85	348.15	18.49	0.27	"	0.39
	Kidney	0.059	23.50	164.50	9.71	0.14	"	0.20
	Total	**0.680**	**192.42**	**1346.94**	**65.45**	**0.96**		**1.38**
	Muscle	0.037	51.02	357.14	13.21	0.21	"	0.30
	Gizzard	0.054	55.65	389.55	21.04	0.33	"	0.47
Seniors	Liver	0.053	49.07	343.49	18.20	0.29	"	0.41
	Kidney	0.059	23.13	161.91	9.55	0.15	"	0.21
	Total	**0.680**	**178.87**	**1252.09**	**62.00**	**0.98**		**1.39**
	Muscle	0.037	51.98	363.92	13.64	-	-	-
	Gizzard	0.054	41.02	287.14	15.51	-	-	-
Whole population	Liver	0.053	37.04	259.31	13.79	-	-	-
	Kidney	0.059	17.34	121.35	7.16	-	-	-
	Total	**0.680**	**147.38**	**1031.72**	**5.01**	-	-	-

Average body weight (kg), a = 19.5, b = 44.3, c = 79.1, d = 68.7, e = 62.8, for children, adolescents, female adults, male adults and seniors respectively,

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Table 8 showed that the total mean dietary intake of vanadium in mg/kg body weight/wk by the five population groups consuming chickens meats increased in the following order; senior, (0.98) > adolescents, male adults (0.96) > children > female adults (0.81).

Vanadium is an essential metal that is required by the body for metabolic activities, hence, this could have accounted for the low rate of exposure to it by the population groups consuming chicken meats. The total mean dietary intake of vanadium in mg/kg body weight/wk by the entire population groups consuming chicken meats was within the provisional tolerable weekly intakes of 70mg/kg body weight/wk set for the metal by FAO/WHO.

Table 9 Mean dietary intake of copper by the five population groups

Group		Mean metal (mg/g)	Mean daily consumption g/person/day	Mean weekly consumption g/person/wk	Mean dietary intake mg/p/wk	Mean dietary mg/kg body weight/wk	Provisional tolerable weekly intake (PTW1) mg/kg body weight/wk	Mean intake % of PTW1
	Muscle	0.141	21.07	147.49	20.79	1.07	3500	0.03
	Gizzard	0.237	10.45	73.15	17.34	0.89	"	0.03
Children	Liver	0.204	11.32	79.24	16.16	0.83	"	0.02
	Kidney	0.185	5.28	36.96	6.84	0.35	"	0.01
	Total	**0.767**	**48.12**	**336.84**	**61.13**	**3.14**	"	**0.09**
	Muscle	0.141	51.74	362.18	51.07	1.15	"	0.03
	Gizzard	0.237	33.65	235.55	55.82	1.26	"	0.04
Adolescents	Liver	0.204	29.05	203.35	41.48	0.94	"	0.03
	Kidney	0.185	14.26	99.82	18.47	0.42	"	0.01
	Total	**0.767**	**128.70**	**900.90**	**166.84**	**3.77**		**0.11**
	Muscle	0.141	70.92	496.44	69.99	0.88	3500	0.03
	Gizzard	0.237	51.47	360.29	85.39	1.08	"	0.03
Female adults	Liver	0.204	45.93	321.51	65.59	1.48	"	0.04
	Kidney	0.185	20.51	143.57	26.56	0.34	"	0.01
	Total	**0.767**	**188.83**	**1321.81**	**247.53**	**3.78**		**0.11**
	Muscle	0.141	65.19	456.33	64.34	0.94	"	0.03
	Gizzard	0.237	53.88	377.16	89.39	1.30	"	0.04
Male adults	Liver	0.204	49.85	348.15	71.19	1.04	"	0.03
	Kidney	0.185	23.50	164.50	30.43	0.44	"	0.01
	Total	**0.767**	**192.42**	**1346.94**	**255.35**	**3.72**		**0.11**
	Muscle	0.141	51.02	357.14	50.36	0.80	"	0.02
	Gizzard	0.237	55.65	389.55	92.32	1.47	"	0.04
Seniors	Liver	0.204	49.07	343.49	70.07	1.12	"	0.03
	Kidney	0.185	23.13	161.91	29.95	0.48	"	0.01
	Total	**0.767**	**178.87**	**1252.09**	**242.70**	**3.87**		**0.10**
	Muscle	0.141	51.98	363.92	51.31	-	-	-
	Gizzard	0.237	41.02	287.14	68.05	-	-	-
Whole population	Liver	0.204	37.04	259.31	52.90	-	-	-
	Kidney	0.185	17.34	121.35	22.45	-	-	-
	Total	**0.767**	**147.38**	**1031.72**	**194.71**	-	-	-

Average body weight (kg), a = 19.5, b = 44.3, c = 79.1, d = 68.7, e = 62.8 for children, adolescents, female adults, male adults and seniors respectively,

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Table 9 showed that the total mean dietary intake of copper in mg/kg body weight/wk by the five population groups consuming chickens meats increased in the following order; seniors (3.87) > female adults (3.78) > adolescents (3.77) > male adults (3.72) > children (3.14). The PTW1 of 3500 mg/kg body weight/wk for copper were not exceeded by the five population groups consuming of chicken meats. Copper being an essential metal is required by the body for metabolic functions.

The results obtained in this study compared very well with 4.9 mg/kg body weight/wk for copper on consumption of meat products by the population of Rio Janeiro, Brazil (Santos et al; 2004). (Clobet et al; 2013) reported higher values for dietary intake of arsenic on consumption chicken meats by the Catalonia people in Spain. They reported average dietary intake as follows; male adults, 4.44 mg/kg body weight/wk; adolescent, 4.01 mg/kg body weight/wk; female adults, 3.17 mg/kg body weight/wk, children, 3.36 mg/kg body weight/wk and senior, 2.70 mg/kg body weight/wk .Of the four studied parts of chicken consumed by the five population groups, the liver and kidney provided the greatest intakes of heavy metals when compared to the other parts of the chicken. The accumulation capacity of these two organs were responsible for the higher dietary intake of heavy metals than the other meat parts by the population groups consuming chicken meats.

CONCLUSION

The total mean dietary intakes of seven of the eight selected heavy metals in mg/kg body weight/wk by the five population groups consuming chicken meats were all within their respective provisional tolerable weekly intakes. The PTW1 of mercury was exceeded by the entire population consuming chicken liver and kidney by between 130 to 175.63%. Consistent exposure to mercury at this rate by the population groups consuming the liver and kidneys of the chicken meats could pose serious health problems to the people.

Reduction in anthropogenic activities with the studied environments could help minimize the rate of risk exposure to heavy metals by the population consuming meat products.

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