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ASSESSING STUDENT'S KNOWLEDGE OF THE HEALTH RISKS OF PLASTICIZER EXPOSURE

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Abstract

This study assessed students' level of awareness and knowledge in probable modes of exposure to plasticizers. A descriptive survey of 200 people (60 each of science and non-science students) in Senior High Schools, 60 Junior High School students and 20 food vendors in the Awutu Senya East Municipality, Central Region was conducted from November 2014 to March 2015. One hundred and twenty Senior High School students (30 males &30 females each from science & non science programmes), 60 Junior High School students (30 males & 30 females) and 20 (females) food vendors were purposively selected. Observation, interview and questionnaires were used to collect data which was analyzed using cross tabulations. A response rate of 88.5% was obtained. Findings showed 94% of the respondents had no knowledge of plasticizers and probable routes of exposure. The remaining students who had some knowledge of plasticizers and their routes of exposure obtained that knowledge from watching television. In conclusion, awareness and knowledge of plasticizers, possible routes of exposure to plasticizers and their associated health risks were found to be low among the students. Packaging materials used for packaging foods for the students were found to be the major routes of exposure to plasticizers.

Keywords: Plasticizers, Knowledge, Exposure, Ghana

1. INTRODUCTION

The global emergence of plasticizer-tainted food incidents as a result of plasticizer leach keep causing panic among consumers about the health safety of consuming foods packaged in plastics (Chen, 2011). Migration of plasticizers into food is an important food safety concern because depending on the concentration and the toxicological properties of the plasticizer of concern, it may pose a serious health risk to consumers'. In most developing countries, limited regulatory bodies and non-performance of these few existing bodies create a dilemma regarding the limitation and control of these chemicals particularly in food products. This makes the health risks of plasticizers an important issue in the food packaging industry and health sector in particular warranting urgent and critical attention.

With the recent explosion of plastic packaged foods and drinks from both foreign and local sources on the Ghanaian market which are often left in the hot sun and sometimes frozen for long periods enhancing migration of plasticizers from the containers to the foods and drinks, it is time to look at what consumers are been exposed to by patronizing these products. Also, the disposal of these packaging materials is of great concern since plasticizers have been found to leach from these

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packages when placed in rivers and other water bodies, and the toxins from them accumulate in the fauna especially the fish which are often eaten by humans.

Plastics are synthetic or artificial materials made from used crude oil and natural gas. They consist of several monomers like ethylene, styrene and vinyl chloride lined together in a chain-like form during production by a process called polymerization. In this process, polymerization of polymers such as ethylene, vinyl chloride and styrene produce polyethylene (PE), polyvinyl chloride (PVC) and polystyrene (PS). Plasticizers are normally clear, organic, liquid materials added to Polyvinylchloride (PVC) during processing to soften, make it more flexible, durable and transparent. The three main types are Phthalate, Adipate and Polymeric Plasticizers referred to as primary plasticizers because they mix well with PVC resin even at very high levels. The use of phthalate is of great concern in reference to its toxicity as employed in some consumer products such as food packaging materials, medical devices, toys and cosmetics (Petersen and Jensen, 2010). Although plastic packaging is versatile, it goes with certain responsibilities to ensure their use in packaging products especially food does not promote any health hazards and concerns.

Due to the low molecular weight of the plasticizer compounds, they are able to migrate from packaging material into food (Petersen and Jensen, 2010). The rate of loss of plasticizer depends on plasticizer type, temperature, sheet thickness, environment and exposure time. There is sufficient proof that when plastic materials are exposed to high temperatures, certain molecules in them like plasticizers leach (Xu *et a1.*, 2010; Nara *et a1.*, 2009; Wagner & Oehlmann, 2009; Fankhauser-Noti *et al.*, 2006). The actual mechanism behind this loss is migration of plasticizer from the surface membrane. Generally higher molecular weight plasticizers used in a variety of product applications including PVC geo-membranes and medical bags, have significantly improved plasticizer loss rates over lower molecular weight plasticizers used in low end products such as shower curtains, book binding, etc. Studies have shown that some fatty foods such as edible oils, oil-based sauces and cheese were found to contain low levels of phthalates, possibly related to environmental contamination or inappropriate use of food contact materials (Chen, 2011; McNeal *et al.*, 2000; Castle *et al.*, 1998). Foods which contain high fats and oils are more likely to withdraw additives from PVC –made packaging materials (Bosnir *et al.*, 2007; Petersen & Jensen, 2010). Alternatively, phthalates can easily break up in fat or oils and become absorbed through the skin's fatty tissue. Goulas *et al.*, (2008) reported the possibility of accumulating high levels of DEHA when consumers often ate fatty foods wrapped in cling film. Consumer concern over the migration of chemicals from food packaging materials into foods and the public health and safety risks associated with this migration has been something of the past and continues to be a real concern (Xu *et al.*, 2010). The diethyhexyl phthalate (DEHP), the most notorious toxin usually leach from plastic container into food or water. Moreover when these plastic containers are discarded improperly, they often continue to leach these phthalates for a longtime on account of being non-biodegradable. The plastics that enter water bodies like lakes and rivers continue to get leached on their journey down stream to the oceans. Sometimes they may be eaten up by fishes and sea animals and these results in the accumulation of toxins in their bodies.

Irrespective of incomplete documented information on the carcinogenicity of plasticizers, there have been several strong and clear reports on the negative impact of plasticizers on reproductive organs in animals including man such that the associated health risks that come along cannot be overlooked (Xu *et al.*, 2010). Consumers as a result of this are often concerned over the migration of chemicals from food packaging materials into foods and the public health and safety risks associated with this migration (Xu *et al.*, 2010). Montuori *et al.* (2008) reported the global insurgence of drinking water packaged and stored in plastic bottles and plastic sachet bags. WHO recommends absorption levels of not more than 0.025gm//kg/day/person for plasticizers while the European Union recommends not more than 0.025mg/k/day/person.

The purpose of the study was to find out if Ghanaians are aware of plasticizers, the health risks and routes of exposure to these plasticizers, and encourage proper disposal of plastic waste to reduce plasticizer exposure using some students and food vendors from Awutu Senya East Municipality. It is hoped that findings from this study will serve as baseline for further studies into plasticizers and their associated health risks.

2. METHODOLOGY

2.1. Sample and sampling procedure

The target population for the study were 7 private Senior High Schools and 21 public Junior High Schools (n= 5253; males= 2557 and females=2696) in the Awutu Senya East Municipality in Ghana. The Senior High School students were 1829 with 872 females and 957 males. The lottery method was used to select one each of the Senior High schools and Junior High schools in question. For the lottery, all the names of the Senior High schools were written on pieces of paper, placed in a bowl and one picked out by a blind folded teacher. This was repeated for the Junior High Schools. A total of 200 respondents made up of 120 Senior High School students (60 Science -30 males and 30 females- and 60 non- Science-30 males and 30 females), 60 Junior High School students (30 males and 30 females) and 20 food vendors (all females) in the Awutu Senya East Municipality were purposively sampled for the study.

Observation, self developed questionnaires and interview guides were used in collecting data. Prior to administering the questionnaires to the study group, they were pilot tested at two schools in the same municipality, the Atlantic Wesleyan Senior High school and Epinal Junior High school using 10 students from each school. Two Food Vendors from each school were also interviewed. Oral consent was obtained from each student and vendor after which they were assured of confidentiality and anonymity prior to participating in the study. They were also given the chance to opt out of the study anytime they felt the need to. Questions covered students' and vendors' awareness of plasticizers, students and vendors knowledge of the health risks of plasticizer exposures and the common routes that predispose them to plasticizers.

2.2. Data analysis

Pearson's chi-square was used to compare the knowledge female students had about the health risks of plasticizers to that of male students. Also difference in knowledge of the health risks of plasticizer exposures of science students were compared to that of non science students, and lastly, knowledge of Senior High School students about the risk of plasticizer exposures were compared to that of Junior High School students. After analysis, results were presented in frequencies, percentages and cross tabulation tables.

3. RESULTS AND DISCUSSION

A total of 177 completed questionnaires were retrieved from the students giving a response rate of 88.5%. Signs of puberty such as menstruation in females and voice breaking in males were identified among the students. Irrespective of incomplete documented information on the carcinogenicity of plasticizers, there have been several reports on the negative impact of plasticizers on reproductive organs in animals including man such that the associated health risks that come along cannot be overlooked (Xu *et al.*, 2010). Chou and Wright (2006) suggested developmental and reproductive effects or malformations, allergy or asthma and carcinogenicity as three common types of possible health concerns that could emerge from plasticizer exposure.

Findings showed that the female students started menstruating at different ages. One female (0.6%) had her first menses at age 10; 2 (1.1%) at age 11; 16 (9%) at age 12; 28 (15.8%) at age 13; 14 (7.9%) at age 14 and 13 (7.3%) at age 15. The remaining female students had not yet menstruated. Although Koo and Lee (2005) reported that past studies regarding the reproductive effects of plasticizers in females were almost non-existent, Colon *et al.* (2000) from a study they conducted in India revealed that an increase in the concentration of Di (2-ethylhexyl) phthalate (DEHP) and Mono-ethyl-hexyl phthalate (MEHP) in the blood serum of girls with an average age of 8 years led to premature breast development. They further observed higher serum levels of several phthalates in girls with premature breast development at the beginning of puberty compared with girls in a control group.

Voices of majority of the male students 60.5% (n=107) had not yet broken. About 0.5% (n=1) had their voices broken at age 9; 1% (n=2) at age 10; 5% (n=9) at age 11; about 3% (n=5) at age 12; 4% (n=7) at age 13; 15% (n=26) at age 14; 6% (n=11) at age 15; about 3% (n=6) at age 16;1% (n=2) at age 17 and 0.5% (n=1) had their voices broken at age 18 years. Some findings attest to the reproductive negative effects of some plasticizers in males. Animal experiments in the past established that coming into contact with fair amounts of DEHP and Butyl benzyl phthalate (BBP) leads to changes in the reproductive hormone levels in males (Akingbemi *et al.*, 2004; Kurahashi *et al.*, 2005; & Wang *et al.*, 2005). Subsequently, Chou and Wright (2006) observed slight effects on hormonal balance, sperm production and sperm motility in men which could affect fertility. Others reported a relationship between high concentrations of urinary phthalate mono esters and reduced sperm counts, little sperm motility and low DNA integrity (Duty *et al.*, 2003a; Duty *et al.*, 2003b).

Majority of the students (n=156; 89.8%) bought lunch from food vendors selling in their schools. Only about 10% (n=17) of the students brought cooked food from their homes for lunch, with the remaining students obtaining their lunches from other sources. If 76.8% (n=136) of the students reported eating their lunches from plastic bowls and polythene "rubber bags" then probably most of the 90.0% of students who bought lunch from vendors in the school and the few who brought lunch food from home may have been eating from these two materials and easily exposed to plasticizers. Of all the routes of exposure, intake of contaminated food sources have been indicated as the most likely single means of plasticizer exposure among populations (Schettler, 2006; Fromme *et al.*, 2004). Most of the respondents were exposed to plasticizers through their choice of food and the type of material the food was packaged in.

Table 1: Students report on common routes of exposure to plasticizers

Indicator	Frequency	Percentage
How do you obtain your lunch?		
Buy	159	89.80%
Carry from home	17	9.60%
Others	1	0 .6%
What type of food do you usually take for lunch?		
Waakye and stew	54	30.50%
Rice and stew	56	31.60%
Banku and okro soup	29	16.40%
Gari and beans	22	12.40%
Others	16	9.00%
What type of material is the food packaged in?		
Leafs	26	14.70%
Plastic bowls	97	54.80%
Polythene "rubber bag"	39	22.00%
Styrofoam "Take away"	4	2.30%
Others	11	6.20%
Total number of students	177	100.00%

Majority of the students 94% (n=166) reported that they barely knew about plasticizers and their lack of knowledge about plasticizers with the remaining 6% (n=11) either describing them as chemicals added to rubber bowls or as poisonous chemicals. All the 11 students who reported knowing about plasticizers learned about them from watching televisions.

Table 2: Students perceived health risks of plasticizers

Indicator	Frequency	Percentage
What are plasticizers?		
No idea	166	93.80%
Chemicals added to rubber bowls	6	3.40%
Very poisonous	5	2.80%
Total number of students	177	100%

There was a slight difference between the males and females when their knowledge in plasticizers was compared. Seven (4.0%) males had knowledge in plasticizers compared to 4 (2.3%) females Table "3". The male students were found to have had slightly higher knowledge on plasticizers than the female students. Although the above difference in the perceived knowledge in plasticizers was not significant (*P*=0.37), it was very low for both sexes.

Table 3: Differences in the knowledge about the health risks of plasticizers by gender

Variables	Risk of Plasticizers				p-value	df	$\chi2$	Total	
	No Idea		Yes						
	Freq.	(%)	freq.	(%)				freq.	(%)
Gender					0.373	1	0 .417		
Boys	89	50.50%	7	4.00%				96	54.20%
Girls	77	43.50%	4	2.30%				81	45.80%
Total number of students								177	100%

Only 2 (1.7%) out of the 62 non science students had knowledge of plasticizers Table "4". On the contrary, none of the science students reported having knowledge about plasticizers. The few who had knowledge of plasticizers obtained such knowledge from sources other than the classroom which implies that plasticizers were not taught in schools. One would have expected the science students to have learned about plasticizers in one of their science classes but their lack of knowledge about plasticizers proved otherwise. Additives and polymers were topics covered in their chemistry lessons but although plasticizers are classified as additives, nothing seemed to have been mentioned about them in these lessons. There was no significant difference (*P*=0.27) between Science and Non Science students' knowledge of plasticizers.

Table 4: Differences in the knowledge about the health risks of plasticizers among science and non-science students

Variables	Risk of Plasticizers				p-value	df	$\chi2$	Total	
	No Idea		Yes						
	Freq.	(%)	freq.	(%)				freq.	(%)
					0.274	1	1.838		
Science	56	47.50%	0	0.00%				56	47.50%
Non -science	60	50.80%	2	1.70%				62	52.50%
Total number of students								118	100%

Only 2 (1.1%) SHS students had knowledge about plasticizers compared to 9 (5.1%) Table "5" J.H.S. students. A total of 116 (65.5%) S.H,S, students and 50 JHS Students (28.2%) responded to the questionnaires. Those who had knowledge about plasticizers obtained it from watching television and learned that plasticizers are poisonous substances added to plastic bags during production. Considering the fact that students complete JHS before entering SHS, one sees clearly from these results that knowledge about plasticizers cannot be linked to level of education. More of the JHS students in this study had knowledge about plasticizers compared to the S.H.S. students. Again, the level of knowledge of plasticizers was low. Findings also showed that the knowledge Junior High School students had on the possible routes of exposure to plasticizers was slightly higher than that of the Senior High School students There was significant difference (*P* <0.001) between Science and Non Science students' knowledge of plasticizers..

Table 5: Differences in the knowledge about the health risks of plasticizers among SHS and JHS students

Variables	Risk of Plasticizers								
	No Idea		Yes		p-value	df	χ2	Total	
	Freq.	(%)	freq.	(%)				freq.	(%)
					0.001	1		12.407	
SHS	116	-65.5	2	-1.1				118	-66.7
JHS	50	-28.2	9	-5.1				59	-33.3

The total number of respondents (N) is 177

Three out of the 20 food vendors interviewed reported they had attended nutritional programs and learned how to enhance the nutritional content of the food they sell to the students but not necessarily learned about the packaging materials used in packing the food for the students. They sold variety of cooked food including fried yam, gari and beans stew, banku and okro or groundnut soup, Hausa porridge and "koose", and rice and stew. Most of these foods contain oil or fat. With earlier reports, foods which contain high fats and oils are more likely to withdraw additives from PVC –made packaging materials (Bosnir *et al.*, 2007; Petersen & Jensen, 2010). The fried foods and sauces do have oil and if they are served hot in these plastic packaging, then there is the chance of some amount of leaching of plasticizers from the containers to the food. Packaging materials used by these food vendors to package food for the students ranged from plastic bowls or plates, polythene bags popularly known as rubber bags in Ghana, styrofoam popularly called "take away boxes" and leaves. Only a fifth of the food vendors knew about plasticizers and 3 out of the 4 heard about plasticizers when they attended a seminar and the fourth vendor learned of plasticizers from her customers. We found out that usually, school authorities do give permission to food vendors to sell food to their students but never really agree on the type of materials to use in packaging the food.

The food vendors either burned used plastic packages after the students were done eating or disposed of them in a refuse dump. Burning these plastic materials could release plasticizers into the atmosphere which when inhaled may negatively impact the health of people. Research has revealed that some form of plasticizers particularly phthalates can be released into the atmosphere when plastic materials are burned (Simoneit *et al.* 2005). Inhalation and dermal absorption are also considered important direct routes of exposure although this is not well documented (Blount *et al.*, 2000). Phthalates could leach out of the dumped plastic waste into the soil or end up in rivers and other water bodies' and further end up in crops that are cultivated on the soil or fish found in the rivers. Eating these crops and fish could expose people to these phthalates. A health risk assessment study by Fatoki *et al.* (2009) on phthalates suggested potential carcinogenic and other toxic effects they could pose to communities downstream which might be exposed either through drinking untreated water from the rivers, through dermal absorption or by using fresh water sources to water their vegetable garden.

4. CONCLUSION

In conclusion, awareness and knowledge of plasticizers, possible routes of exposure to plasticizers and their associated health risks were found to be low among the students. Also, the packaging materials used for packaging foods for the students were found to be the major routes of exposure to plasticizers. The oil content of the foods served together with the high temperature at which these foods were served and consumed could enhance the migration of plasticizers into the foods. Based on the findings, students should be encouraged to eat foods especially hot and fatty foods from glass, ceramic or stainless steel containers rather than from plastic containers and food vendors need to serve food in the same containers for the students. Considering the health risks associated with ingesting plasticizers, it is important that education on plasticizers be tackled as a national priority issue to help reduce the public health burden that it may impose on the people if ignored and empower individuals to take action to minimize their own exposures to plasticizers.

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