Exploring Consumer Awareness of Health and Environmental Implications of Lead Toxicity in Household Paints

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Abstract. Despite the dangers of lead toxicity to population and environmental health, studies have revealed proliferation of above threshold concentration of lead in household paints in several locations. This paper presents the findings from an exploratory study in Peninsular Malaysia on the level of public awareness of the adverse effects of exposure to lead-based household paints. Primary quantitative data were gathered in a cross-sectional questionnaire survey on a conveniently recruited population residing in 5 Malaysian cities. The survey generated 657 valid responses, which were subjected to statistical analysis. The results show that the survey participants are highly aware of lead usage in household paints. Furthermore, their awareness about the health and environmental implications were also high, and a significant difference was observed in association with specific demographic characteristics such as gender, age and educational level. These findings highlight that majority of the respondents are aware of the health and environmental implications of lead-based household paints. However, this result does not reflect the production quality of the household-based paint in Malaysia, which studies have shown to be above threshold concentrations. This exploratory study creates room for future studies to undertake further investigations among consumers and organizations.

Keywords: Protection implements · Energy efficiency in agriculture · Construction of agricultural buildings · Paint toxicity · Household paints · Lead-in-paints

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1 Introduction

The need for a healthier population and a safer and more sustainable environment has intensified the demand for improved public health awareness and environmental conservation efforts. This challenges more health-conscious, environmentally friendly, and sustainable production practices.

Lead, a naturally occurring metal, has found widespread use, which in toxic concentrations gives rise to significant environmental and public health challenges. It must be noted that there are widespread sources of lead; however, lead-based paint is critical to the problem [1–4]. While global attempts to minimize the use of leaded petrol has yielded positive results, there has not been much success concerning lead-based household paints. Worse still, while many developed countries have achieved below the toxic threshold level of lead contents in household-based paints, this is not the same in developing countries. Studies have revealed very high lead concentrations in household paints. Over a decade ago, in their study, Clark et al. revealed that the lead levels in samples of new household paints collected in China, India, and Malaysia greatly exceeded the U.S. standard thresholds of lead content in paints [5]. In Malaysia, 23 (72%) out of 32 paint samples tested were found to contain lead concentrations greater than 600ppm for paints in existing houses, while 20 (62%) were higher than 5000 ppm for new paints [5]. It should be noted that the U.S. standard threshold for lead in household-based paints is 90 ppm. It is a matter of concern that after many years, extant studies in Malaysia still report a prevalence of high lead concentrations in household paints with its attendant effects [6–8].

Although the significant impact of lead poisoning on public health is generally acknowledged in many parts of the world, several countries have only paid little attention to the level of public awareness of the health and environmental effect of lead-based household paints [9]. Moreover, the likely environmental and population health hazards resulting from the lead industry are more common in countries that belong to emerging and developing economies [1]. Therefore, an exploratory study must analyze the level of awareness of this fact among the general public. Hence, the importance of this study is in Malaysia, which is a developing country with an emerging economy. Moreover, recently available studies show that substantial numbers of people are at risk of high blood lead concentrations. However, there is a dearth of research information in Malaysia in the literature on the populace's awareness about the potential environmental and health effect of lead-based household paints.

The main aim of this study is to explore the awareness of consumers regarding exposure to lead-based household paints, with a specific emphasis on health and environmental implications. The outcome of the findings will help to address the knowledge gap.

2 Background

Lead, a naturally occurring element, is a toxic heavy metal that has been found in various everyday used consumer products, including household decorative paints. In the compound state, lead tetroxide is the most common form of lead, which has found its use in the production of household paints. Other common forms of lead compounds commonly used in the production of household paints include; lead sulfates, Lead carbonate, lead oxides and lead chromates [2].

According to the World Health Organization (WHO), many household paint manufacturing companies intentionally add lead compounds for the following reasons; (i) for colouring, (ii) to aid in the even spread of the paint as well as fast-drying, and (iii) to prevent rusting and corrosion on metal surfaces. However, despite these uses, there are health and environmental concerns linked to the toxicity of lead compounds in household paints. This has intensified efforts to regulate its use and strengthen global efforts to phase out lead compounds in household paint production.

2.1 Lead Toxicity as a Health and Environmental Concern

In humans, there is no significant role of lead, which is why the WHO documents a burden of diseases caused by it. According to the WHO, poisoning from lead accounts for about 0.6 percent of the global burden of diseases.

Healthwise, lead is a cumulative toxicant, and its continuous use in household paints, regardless of safer substitutes known to be globally available, can cause damage to the brain, nervous system functions, blood, kidney, as well as the reproductive system of humans [4]. Even more severe is the ingestion of lead in children below six years. Children quickly ingest dust laden with lead from the decay of lead-based household paints over time, resulting in elevated blood lead levels. Hence, triggering adverse health conditions such as slow cognitive development in children, hearing loss, and a host of behavioural disorders that are believed to be irreversible [10].

Lead can be highly toxic, thus requiring proper management and handling in environmentally sound means [1]. The United States Center for Disease Control and Prevention considers poisoning resulting from lead pollution the greatest environmental threat to children. These lead pollution in the environment results in bioaccumulation in plants and animals. Besides, over the years, the use of lead in many commercial products, including lead-based household paints, has been known to contribute to the prevalence of environmental lead contamination [11].

2.2 Lead in Paint Regulation

More than a decade ago, an investigation carried out on 80 new residential paints in four Asian countries (Malaysia, China, India and Singapore) revealed high lead in paint levels in China, India and Malaysia which had minimal/non-existent regulatory limits [11]. Similarly, an investigation was carried out in South Africa, which had no regulatory limits for lead in paints [12]. The findings revealed that a large percentage of South African children were exposed to toxic lead levels from various paint sources. Moreover, a recent study has shown that the reality of toxic concentrations of lead in household paints still exists and is primarily familiar in many low- and middle-income countries [13].

Although in many countries, no regulations define the levels of permissible lead usage in household paints, in some other countries, regulatory frameworks for permissible lead use in household paints have been established. For example, in Uruguay, the decree

069/2011 regulation is a legal framework promulgated in 2011 to enforce the standard of 600ppm as the maximum threshold limit for lead in household paints and other similar uses. Table 1 illustrates the permissible limits of lead concentrations in household paints in selected countries (Table 1) [14].

Table 1. Permissible concentrations of lead in paint in selected countries.

Country	Permissible threshold in ppm
United States of America	90
China	90–1000
Mexico	600
Australia	1000
India	90
Uruguay	600
Singapore	600
France	No defined limit
Nigeria	No defined limit
Malaysia	No defined limit

2.3 The Malaysian Scenario

In Malaysia, the household paint manufacturing industry comprises large multinational corporations, with a larger share of the market, and local firms.

There is no regulation setting a threshold limit for the amount of lead permissible for use in household paint manufacture in Malaysia. Moreover, pertinent information such as environmental lead levels, the most important sources of exposure, how much lead-based paint is produced, how much is used are not readily available. However, there are regulatory safety standards in Malaysia regarding using lead in paints for toys meant for children below 14. The standard regulation is placed at a maximum threshold of 90 ppm.

In September 2015, the Consumers' Association of Penang (CAP) study revealed that out of a total of 39 cans of solvent-based household paints from 18 brands, 41% contained a total lead concentration above 600ppm. In addition, 31% contained dangerously high lead concentrations above 10,000 ppm, including those from large multinational corporations. Worse still, the labels placed on the paint cans did not give information on the lead content of the paints, while some of the paints sold as having low lead concentrations were found to have high lead contents.

In November 2017, the Malaysian Paint Manufacturers' Association (MPMA) led the signing of a pledge by 17 major paint manufacturers to eliminate the usage of lead in the manufacturing of decorative paints and all other paint categories. This pledge was aligned with the Global Alliance to Eliminate Lead Paint (GAELP) movement.

2.4 Global Movement to Phase Out Lead from Paints

The adverse health and environmental impact associated with lead-based paints have gotten the attention of many governments worldwide. They have led interventions and put initiatives to phase out lead from household paints. However, despite success in Europe, the USA, and many other developed countries, lead is still used in household paint manufacture in many developing countries, including Malaysia [8].

GAELP, which was formed in the year 2009, was borne out of a need to phase out the manufacture and sale of lead-based paints and to eliminate the lead poisoning risks. The United Nations Environment Programme (UNEP) and the WHO jointly led this alliance to create awareness amongst government authorities and the general public on lead-based household paints' health and environmental hazards. This initiative borders on the general knowledge about lead in paints, knowledge about harmful effects caused by exposure to lead in paints, and its prevention, with an ultimate aim to do away with the production and the sale of lead-based paint worldwide.

Currently, the UNEP report as of 31 December 2020 shows that less than 50% of all countries have instituted legally binding controls to limit the production, import, and sale of lead-based household paints. More so, it is believed that the remaining countries are relatively slow in responding to the health and environmental importance of lead-free paint.

3 Materials and Methods

In this study, a descriptive research design was employed to obtain quantitative and cross-sectional primary data using a self-administered structured type of questionnaire. This was used to investigate the level of awareness of the public residing in West Malaysia on different indicators of health as well as the environmental effect of lead-based household paints. The sampling technique used was non-probability convenience sampling, without bias for age, gender, race, ethnicity, or other demographic characteristics.

The field survey involved the distribution of 716 questionnaires to make room for potential incomplete questionnaires/non-response that is typical of this type of surveys. As a result, six hundred fifty-seven valid responses were obtained after excluding incomplete questionnaires.

The primary data gathered were subjected to descriptive statistics, reliability analysis, and normality tests. In addition, testing relationships and interpretation of results were carried out through Mann Whitney U tests and the Kruskal-Wallis test. The data analysis was facilitated by SPSS version 23.0.

4 Results

4.1 Descriptive Statistics of Demographic Characteristics

A majority of the respondents were from the state of Perak (53.1%). 19% were drawn from Kuala Lumpur, 15.2% from Penang and 12.6% from Johor. In terms of gender, more females (60.4%) than males (39.6%) took part in the study. In terms of age, most were

21–30 years (42.5%). Those between 31 and 40 years made up 18.4%, 41–50 years were 16.3%, 20 years and below were 14.2% and those above 50 years were 8.7%. The education level of the respondents revealed that most of the respondents had a certificate/diploma (28.9%) and a Bachelor (28%) level of education. 11% possessed a Master's degree. The frequency of house painting for most of the respondents was once in two years (37.6%) and two years (43.4%).

4.2 Reliability Analysis

The reliability of the questionnaire measures was determined by measuring the internal consistency by the mean of the Cronbach's alpha coefficient value of the items. A threshold of 0.70 has been suggested for acceptable Cronbach alpha coefficient value [15]. Moreover, Nitzl argued that Cronbach alpha coefficients ranging between 0.60 and 0.70 are acceptable for exploratory studies, such as the present study [16]. From the results, the Cronbach alpha values were all above 0.6, ranging from 0.650 to 0.874. Thus, considered reliable.

4.3 Descriptive Analysis

Following the recommendations for 3 point Likert scale data, the constructs' mean and standard deviation were used respectively to measure central tendency and variability [17]. From Table 2, it is observed that the mean values of 1 of the constructs (Knowledge about awareness programmes) registered a mean score that was below the midpoint of 2.0. The remaining constructs registered mean scores that were above 2.0 (Table 2). This result reveals an above average level of the respondents, general knowledge about lead in paints, awareness about toxic exposure to lead in paints, knowledge about health problems associated with lead in paints and knowledge about preventive measures against lead in paints.

Table 2. Descriptive analysis of research constructs.

Awareness measures	Mean	Std. Deviation
General knowledge about lead in paints	2.31	0.342
Awareness about toxic exposure to lead in paints	2.38	0.433
Knowledge about health problems associated with lead in paints	2.50	0.490
Knowledge about preventive measures against lead in paints	2.59	0421
Knowledge about awareness programmes	1.42	0.599

4.4 Normality Test

The Kolmogorov-Smirnov and Shapiro-Wilk's tests were used to test the assumption that the sample data are drawn from a normally distributed population [18]. Table 3 shows that all the constructs reported significance (p-value) less than 0.05 in both tests. As a result, the postulation that the data is from a normally distributed population is not supported. It is, therefore, more appropriate to carry out non-parametric inferential statistical procedures (Table 3).

Table 3. Test for normality of data distribution.

Awareness measures	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
General knowledge about lead in paints	0.056	657	0.000	0.966	657	0.000
Awareness about exposure to lead in paints	0.147	657	0.000	0.890	657	0.000
Knowledge of health problems associated with lead in paints	0.211	657	0.000	0.831	657	0.000
Knowledge about preventive measures against lead in paints	0.174	657	0.000	0.844	657	0.000
Knowledge about awareness programmes	0.313	657	0.000	0.823	657	0.000
Media channel preference (newspaper)	0.149	657	0.000	0.852	657	0.000
Extent of trust of information source	0.142	657	0.000	0.904	657	0.000

4.5 Test of Relationship Between Demographic Characteristics of Respondents and Awareness Measures

In the present study, the Mann-Whitney U test was utilized for assessing the significant relationship between gender (categorical data) and awareness measures (continuous data). Further, the Kruskal-Wallis test was applied to assess the significant relationship between age, educational level, a primary area of employment, painting frequency (categorical data) and the awareness measures (continuous data). The chosen level of significance is 0.05. Tables 4, 5, and 6 are the SPSS output of the distribution of the awareness measures according to gender, age, educational level, primary area of employment and frequency of house painting, respectively. The null hypothesis shows that the distribution of awareness measures is the same across each category of demographic characteristic.

From Table 4 of the Mann-Whitney U test for a relationship between gender and awareness measures, a significant difference was observed in the distribution of awareness about effects from toxic exposure to lead in paints (awareness measures 2) amongst the different genders (male and female) of the respondents (Table 4).

Table 4. Mann-Whitney U test for relationship between gender and awareness measures.

Awareness measures	N	Mann whitney U	p value	Decision
1	657	51358.0	0.915	Retain null hypothesis
2	657	44793.0	0.003**	Reject null hypothesis
3	657	49885.5	0.452	Retain null hypothesis
4	657	48932.0	0.252	Retain null hypothesis
5	657	51305.0	0.885	Retain null hypothesis
6	657	49040.5	0.275	Retain null hypothesis
7	657	50763.0	0.721	Retain null hypothesis

1 = General knowledge about lead in paints, 2 = Awareness about effects from toxic exposure to lead in paints, 3 = Knowledge about health problems associated with lead in paints, 4 = Knowledge about preventive measures against lead in paints, 5 = Knowledge about awareness programmes, 6 = Media channel preference, 7 = Extent of trust of information source about lead in paints related issues
** Correlation is significant at the 0.01 level (2-tailed)

From Table 5 of the Kruskal-Wallis test for a relationship between age and awareness measures, it was observed that a difference exists between the distributions of knowledge about preventive measures against lead in paints (awareness measure 4) amongst the different age groups of the respondents. In addition, there was also a statistically significant difference between the distributions of media channel preference (awareness measure 6) amongst the different age groups of the respondents (Table 5).

Table 5. Kruskal-Wallis test for relationship between age and awareness measures.

Awareness measures	N	Mann whitney U	p value	Decision
1	657	4.373	0.358	Retain null hypothesis
2	657	2.501	0.644	Retain null hypothesis
3	657	4.384	0.357	Retain null hypothesis
4	657	11.074	0.026**	Reject null hypothesis
5	657	7.381	0.117	Retain null hypothesis
6	657	11.376	0.023**	Reject null hypothesis
7	657	5.308	0.257	Retain null hypothesis

From Table 6 of the Kruskal-Wallis test for a relationship between educational level and awareness measures, it was observed that a significant difference exists between the distributions of awareness about effects from toxic exposure to lead in paints (awareness measure 2) amongst the different educational levels of the respondents (Table 6). Similarly, a significant difference exists between the distributions of knowledge about health problems associated with lead in paints (awareness measure 3) amongst the different educational levels of the respondents. Moreover, a significant difference exists between the distributions of knowledge about preventive measures against lead in paints (awareness measure 4) amongst the different educational levels of the respondents.

Table 6. Kruskal-Wallis test for relationship between educational level and awareness measures.

Awareness measures	N	Mann whitney U	p value	Decision
1	657	5.177	0.395	Retain null hypothesis
2	657	11.428	0.044**	Reject null hypothesis
3	657	12.845	0.025**	Reject null hypothesis
4	657	16.742	0.005**	Reject null hypothesis
5	657	4.575	0.470	Retain null hypothesis
6	657	4.714	0.452	Retain null hypothesis
7	657	5.863	0.320	Retain null hypothesis

Moreover, the Kruskal-Wallis test for a relationship between the frequency of house painting and awareness measures showed that a significant difference exists between knowledge about preventive measures against lead in paints (awareness measure 4) amongst the different frequency of house painting respondents. Likewise, a significant difference exists between awareness about awareness programmes (awareness measure 5) amongst the respondents' different frequencies of house painting. Also, a significant difference exists between the extent of trust of information sources about lead in paints and related issues (awareness measure 7) amongst the respondents' different frequencies of house painting.

5 Discussion and Conclusion

Over the years, the education of consumers on the adverse effects of lead-in paint exposure has not received much attention. Therefore, it is uncertain if the continued purchase and use of lead-based household paint in certain countries result from limited consumer awareness. Hence, an understanding of consumer awareness is key to handling this challenge.

The present exploratory research aimed to study the level of awareness of the general public on lead-based paint hazards in West Malaysia. The results from the field survey indicate an appreciably high awareness level among the Malaysian general public about the health and environmental hazards due to toxic exposure to lead-based household paints.

Although the present study's findings highlight the respondents' high awareness of the health and environmental impact of lead-based household paints, it is a matter of concern that it has not translated to the abatement of the problem, which is a major public health issue concern. Studies reported in the literature show that household-based paints in Malaysia are still laden with toxic lead.

Hence, it can be assumed that the high awareness level of the Malaysian public has not exerted enough pressure on the household paint manufacturers, or the consciousness of the paint manufacturers is not in tune with the awareness level of the Malaysian public on the adverse health and environmental impact of lead-based household paints. Therefore, the onus lies on the Malaysian government and other stakeholders to promulgate and enforce regulations to ban lead in household paint manufacture.

Nonetheless, future researchers can consider looking into the government's role in enforcing the law that prohibits manufacturing lead-based household paints. Further, accessibility, attitude, the knowledge of the consequence of exposure to toxic paints and the level of concern of toxic household paints toward consumers' intention to purchase lead-based household paints should be investigated in the future. Additionally, future researchers can consider exploring the public's possible misconceptions about lead-based household paints that may be amenable to additional education/action.

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