

**ASSESSING KNOWLEDGE DIFFERENCES BETWEEN DAYCARE STAFF
AND PARENTS: LEAD SOURCES AND HEALTH RISKS FOR CHILDREN**

by

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Assessing Knowledge Differences Between Daycare Staff and Parents: Lead sources and health risks for children

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Abstract

Background and Purpose: Most Canadians have lead in their blood and it has been shown that even low levels of lead can cause harm. Children are the most susceptible population to the harmful effects of lead due to their increased absorption and earlier stages of brain development. Lead exposure in children has been shown to have negative and irreversible effects, including delayed development and reduced neurological function. As parents and daycare staff have the most interaction with young children, their health knowledge is important for minimizing day-to-day exposures. This research project assessed the level of knowledge of daycare staff and parents of young children on lead sources and health risks.

Methods: An in-person, self-administered knowledge survey was given to parents and Early Childhood Educators (ECEs) at daycare centres located in Surrey, BC and Burnaby, BC. The data was then analyzed using SAS statistical software to compare the two groups using a chi square test.

Results: Daycare staff and parents showed no significant differences in knowledge levels. The mean score on the knowledge test for daycare workers was $39.98 \pm 14.77\%$ and for parents was $30.73 \pm 16.53\%$. Both groups had significant gaps in knowledge on lead, its sources, its risks for children, and preventive measures.

Conclusion: Daycare staff and parents have an important role in minimizing children's exposure to lead. Identifying knowledge gaps in these groups can lead to more targeted health promotion projects as well as changes to education and training.

Key words: Lead, children, daycare, parents, exposure, public health, knowledge

Introduction

Over the past 30 years, Canada has seen a significant drop in the blood lead levels (BLLs) of its population. This is largely due to the introduction of unleaded fuels in 1972 and the phase out of lead in household paints (1). Furthermore, the inclusion of lead requirements in federal legislation has minimized Canadian citizens' lead exposure from common sources. In 1988, lead was added to the List of Toxic Substances (Schedule 1) of the Canadian Environmental Protection Act, which provides information on the toxic nature of lead as well as a list of applicable legislation. The Gasoline Regulations, introduced in 1990, limit the concentration of lead in gasoline to 5mg/L, excluding fuel used in aircraft and competition vehicles (1). To reduce exposure from paint, the Surface Coating Materials Regulations, which were amended in 2010, set limits of lead at 90mg/kg (2).

Despite these actions, lead persists today in other less obvious sources. More than 99% of Canadians have detectable levels of lead in their blood (3). Health effects range from severe damage to the organ systems at higher doses to neurological effects at lower doses, the consequences of which may be irreversible. Although most Canadians have BLLs below the intervention level of 10ug/dL, there is evidence that even low levels (1-2ug/dL) can cause neurological effects (4). The World Health Organization (WHO) states that there is no threshold limit for lead's harmful effects on brain development (5).

Of most concern are the effects of lead in children. Not only are children more likely to ingest non-food items, they have greater absorption and slower excretion of lead than adults. Children are still developing and the neurological effects of lead exposure can have a lasting impact on their development and quality of life (5). While steps have been taken to address this increased risk with children (e.g. Children's Jewellery Regulation)

it is important to examine other strategies to minimize their exposure, given the evidence of lead's health effects at low levels. Parents and Early Childhood Educators (ECEs), the main caregivers of young children, have an important role in a child's health and wellbeing. Understanding their level of knowledge in relation to health effects of lead, as well as identifying any knowledge gaps, can be useful in determining the need for targeted health promotion, training, or education of these groups.

This project used a questionnaire to compare the knowledge levels of ECEs with parents of young children. In addition to questions pertaining to lead exposure and health effects in children, the questionnaire included set of demographic questions. This provides insight into other factors relating to lead knowledge, such as age or level of education, as well as information on current levels of exposure and risk.

Literature Review

Children as an At-Risk Population

Children have inherently higher risks of lead exposure, both from physiological as well as behavioural perspectives. From a biological standpoint, the absorption rate for lead ingestion is 4-16 times higher in children as compared with adults. Children are also growing more rapidly and taking in more nutrients per kg of body weight than adults. Due to this, nutritional deficiencies are more common in children and can result in lead being more readily absorbed and stored in bones and other tissues (5). The biological effects of lead in children can be more severe at low levels than in adults due to the growth and development of the brain. At this stage in life, the brain is developing more rapidly and lead can interfere with these processes (6).

From a behavioural perspective, children are more likely than adults to put non-food objects in their mouths, including fingers as well as items that can be ingested. A study by Ko et al. (2007) examined the relationship between children's behaviour and BLLs. Children aged 1-5 were filmed in an outdoor environment over two hours and their BLLs were later tested. Researchers found a direct correlation between hand-in-mouth behaviour and increased BLLs. Another important consideration is children's closer proximity to the ground, which can also contribute to lead exposure from dust and soil (7).

Health Effects of Lead

Although lead can have a variety of physiological effects, the main concern for chronic exposure at low levels in children is neurological development and IQ. Lead has no function in the body and can displace other essential minerals, and its effects can be irreversible. Lead can also alter gene expression, leading to greater risk for certain diseases emerging in adulthood. There is evidence to suggest that the effects of lead are far-reaching in that exposure can lead to immune disorders and other chronic diseases later in life (5). Since 1970, the WHO has lowered its intervention level for lead from 60ug/dL to 25ug/dL due to emerging research on lead's health effects. In 1991, the world standard for intervention was further lowered to 10ug/dL. Currently, there is evidence being found for health effects occurring at BLLs as low as 1-3ug/dL (8). In a study on the effects of low BLLs on intelligence, Lanphear et al. (2005) found that children at lower BLLs (<7.5ug/dL) displayed a larger decrease in intelligence for the same incremental change in BLL than those at higher BLLs (>7.5ug/dL) (8). In previous studies, BLLs have been linked to effects on dental, cardiovascular, and renal health as well as poor school performance and reading problems (8).

Association Between BLLs and Exposure

While higher BLLs have been linked to increased risk for health problems, it is necessary to also examine the linkage between BLLs and lead levels in the environment. This information can be used to determine how readily lead is absorbed from the environment and under what circumstances, as well as to implicate possible sources of exposure. There must be a pathway for exposure for lead to be a health concern, and it has been shown that the two main pathways of entry are through inhalation and ingestion. A 2014 study of children in Montreal, Canada has found evidence that drinking water, house dust, and lead-based paint are all associated with increased BLLs in children aged 1-5 (9). For one of their results, they found that windowsill dust with lead levels >14.1ug/ft² were associated with BLLs >1.78ug/dL. They concluded that even relatively low levels of lead contamination in the environment were associated with a significant increase in BLLs (9). Given the evidence of health effects at low BLLs, it is important to consider how low levels of environmental lead can contribute to these BLLs. Another study by Levin et al. examined BLLs and sources of lead

exposure in the United States. For every 1000ppm increase in lead for soil and dust, they found a 1-5ug/dL increase in BLLs. There were also several risk factors identified in increasing BLLs including age, refugee or immigrant status, age of housing, income level, and parental occupations (10). In general, studies have shown that increased environmental lead levels from a variety of sources are directly linked to increased BLLs in children.

Environmental Sources of Lead

Lead is found in many places in the environment and is naturally present in some soils and rocks. In order to reduce lead exposure, it is important to consider both the various sources of lead as well as the places where children spend the most time. A comprehensive study of lead exposure in the United States (2008) implicated many significant sources of lead which included the following: air near battery and lead smelters, demolished buildings, lead-based paints, contaminated soil and dust, food, breast milk, drinking water, chocolate, candy, dietary supplements, children's products, PVC, synthetic turf, and candle wicks. All of these sources have been shown to contribute to increased BLLs in children who were exposed (10). A study by Kim and Fergusson has shown that higher levels of house dust were linked to higher levels of lead in the home. Furthermore, they concluded that the sources of lead in the dust were predominantly from lead-based paints and gasoline (11). Another study by Tsekrekos and Buka (2005) found that despite regulatory restrictions, many children's products were potential sources of lead exposure (12).

To determine which sources of lead exposure contribute most to children's BLLs, it is also important to identify where children spend most of their time. According to Statistics Canada, almost half of parents reported using childcare services in 2011 (13). Of these, approximately 60% of parents enrolled their children in full-time childcare, defined as at least 30 hours per week. Most of these children were between the ages of 2 and 4. While some studies have shown that children are more susceptible to lead at older ages (6 years) (14), others have shown that the age of greatest susceptibility is under 6 years of age (8). Different types of childcare may have implications for increased lead exposure, depending on various factors including the age, amount of dust, and presence of carpets. In Canada in 2011, 33% of parents reported using daycare centers, 31%

home-based day cares, and 28% private (14). The US Center for Disease Control has identified lead paint and lead dust as the main sources of exposure in the indoor environment (15).

Economic Costs

Lead can have subtle, but profound impacts on the health of Canadians and contribute to socioeconomic burdens. In Canada, it is estimated that the loss of potential earnings due to the effects of lead exposure in early childhood amounts to 1.5-9.4 billion Canadian dollars (CAD) per year (1). If lead exposure were completely eliminated, it is estimated that at least 9 billion CAD could be gained per year. This could be achieved by reducing the BLLs of children by 1.51ug/dL (1). Globally, the socioeconomic burden is much higher, especially in developing countries with fewer lead regulations and unsafe practices that increase lead exposure. Reducing BLLs after lead exposure is difficult so it is important to reduce exposures as much as possible. A Health Canada report on lead lists chelation therapy, where lead is bound and removed from the body, as a current treatment for lead exposure. However, chelation therapy is normally used for high BLLs (>45ug/dL) and should be used cautiously in children (16). These levels are much higher than the levels at which harm can occur, therefore the main strategy for reducing lead levels in children is to identify and reduce exposure.

Strengths and Limitations

The most relevant studies in this evidence review examined exposures and BLLs in the Canadian population. Other studies that examined sources of exposure and BLLs outside of Canada may be less applicable, despite originating from developed countries, since there are differences in the types and location of industry, as well as differences in surveillance and legislation. One limitation was the inclusion of adult data in some of the studies. While most of the studies focused on BLLs in children, other studies were more generalized and included data for all ages, limiting their application to children who have different effects and exposures of lead than adults.

Gaps in Research, Policy, and Knowledge

While the effects of lead on children have been widely studied, more research needs to be carried out on the health effects at lower BLLs (1-3ug/dL). This would

show the importance of reducing environmental lead in the environment even further, especially in cases where children may be exposed. As low levels of lead can cause neurological health effects in children, there is a need for more research on other potential sources contributing to lead exposure. Another important consideration is the effect of public health campaigns, training, and other education on increased knowledge of lead and its health effects, as well as whether these strategies result in a reduction in lead exposure.

Methods and Materials

A survey was designed to test the knowledge of lead health risks for young children. The survey was designed so that it could be self-administered in person and take only 3-5 minutes (20 questions). The survey was based off the literature review and contained only close-ended questions as part of the knowledge assessment for ease of analysis and anonymity.

30 daycare centres were selected from Fraser Health's "Public List of Licensed Child Care Facilities: Fraser South, Fraser North" (17) using convenience sampling. Daycares locations were restricted to Burnaby, BC and Surrey, BC.

The daycare centres were contacted in person and asked whether they were willing to participate in the survey using the standardized script. The daycares that consented were then given the survey in-person to complete on or off the premises (self-administered to staff and parents).

The surveys were then collected in person from each daycare and a score was tabulated for each respondent based on the number of correct answers for the knowledge assessment portion. Mean scores (%) were then assigned to knowledge level categories (0-12 = poor, 13-24 = fair, 25-36 = good, 37-48 = very good, >48 = excellent) and compared between the two groups using SAS.

Inclusion and Exclusion Criteria

ECEs and parents were chosen for this study since children are at higher risk for harmful effects from lead exposure than adults (1). Both groups work closely with children on a regular basis and are responsible for their health and well-being. The daycares were restricted to Surrey, BC and Burnaby, BC to reduce travel expense and time.

Results

This study used nominal data for the dependent variable (whether a person is an ECE or a parent) and ordinal data for the independent variable (level of knowledge based on survey). Both were summarized using proportion, percentage, ratio, and rates.

Descriptive Statistics

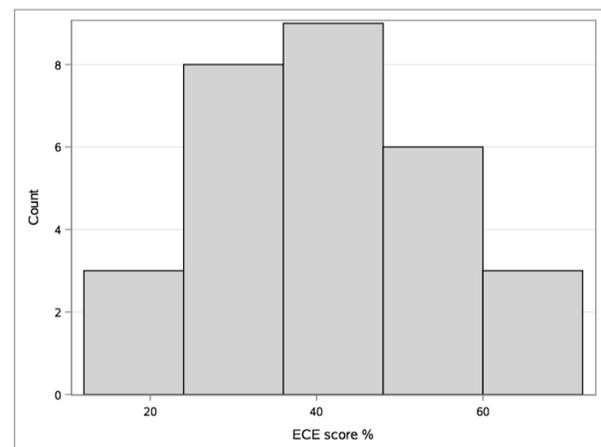
The descriptive statistics were generated using the SAS "Summary Statistics" function. The data (numerical) are shown below in Table 1. The mean score on the knowledge test for ECEs is 39.98+14.77% and for parents is 30.73+16.53%.

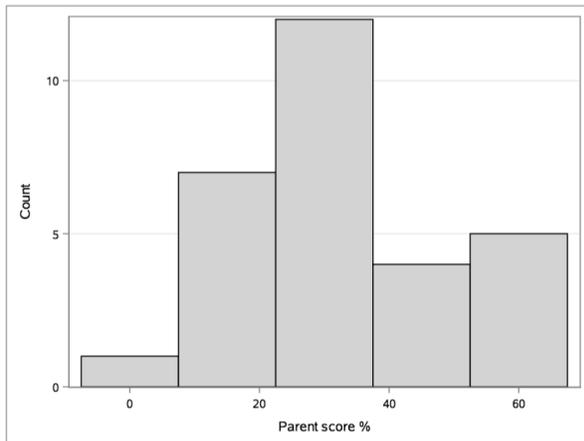
Table 1: Descriptive statistics for ECE and parent test scores

Analysis Variable: Test scores in %		
	ECEs	Parents
N	30	30
Mean	39.9791667	30.7319444
Median	40.8333333	28.1250000
Minimum	10.0000000	2.0833333
Maximum	66.2500000	63.7500000
Std. Dev.	14.7739340	16.5305168
Std. Error	2.6973390	3.0180456

Figure 1 shows the distribution of scores for parents and daycare staff. The scores have a more normal distribution for daycare staff than for parents.

Figure 1: Histogram plots for parent and ECE knowledge scores





ECEs were asked the age of the building they worked in (“built before 1960”, “between 1960 and 1990”, “built after 1990”) as well as whether there were any recent renovations performed. Out of 30 ECE respondents, 58.3% were not sure of the building age. Out of the respondents who reported the age of the building, 81.8% reported it as “built after 1990,” and 18.2% reported it as “between 1960 and 1990.”

Inferential Statistics

Data from the two variables, knowledge level (independent) and role as a parent or daycare worker (dependent), were entered into Microsoft Excel then exported to SAS University Edition. The “Table Analysis” function under “Statistics” was used to analyze the data. The raw test scores (%) were assigned to categories for levels of knowledge: categories (0-12 = poor, 13-24 = fair, 25-36 = good, 37-48 = very good, >48 = excellent). The chi square test was used to compare observed (O) and expected (E) frequencies for levels of knowledge in ECEs and parents.

Discussion

The purpose of the study was to determine (a) the overall knowledge level of parents and ECEs on lead including its sources and health effects, and (b) to determine whether there was a significant difference in knowledge between these two groups. The rationale for this study was based on a lack of information regarding public knowledge of lead risks in Canada. As lead has been phased out of many products over the years and as legislation has become more stringent, the responsibility for lead exposure prevention has shifted from the general public to regulators. There is now the question of whether this shift has decreased the overall

knowledge of lead risks in the general public, particularly in those who care for younger, more susceptible children, and whether this potential decrease in lead knowledge poses a risk to public health. There is growing evidence that what were previously considered “low” or “negligible” lead levels can have notable negative impacts on public health²⁽¹⁾⁽⁵⁾.

Public health awareness and knowledge can play an important role in shaping a population’s health. In a North Philadelphia-based study, an experimental population was involved in a lead-risk awareness project over a four year period. At the end of the study, it was found that children of those participating had significantly reduced blood lead levels as compared with the control population (18). This example highlights the potential impacts of lead knowledge on actual health outcomes, in this case lowered BLLs. It is therefore important to understand where gaps exist in public health knowledge, which can be accomplished via questionnaires, and then use appropriate intervention methods to fill these gaps. While many studies focus on lead exposure and prevention, few examine the public knowledge in these areas.

The survey for this study focused on sources of lead, lead health risks for children, and ways to prevent exposure. It also contained eight demographic questions which were critical for examining various factors that may be linked to lead risk knowledge. Due to the limited responses gathered from this study, as well as missing responses to some questions (e.g. “When was your daycare (if Early Childhood Educator) or home (if parent) built?” was marked as “Not sure” in almost 60% of the responses), it was not possible to determine whether there were any other factors associated with lead risk knowledge. A similar survey conducted in rural Ohio examined lead knowledge and related factors. It was found that most respondents were knowledgeable on groups at higher risk for lead poisoning, and that lead levels could be measured with a blood test; however, most respondents were not as knowledgeable about the various methods of exposure and prevention measures. Similarly, this study found that most respondents lacked knowledge on exposure and prevention, with an average test score of 34.2%.

The research question of this study focused on the knowledge levels between two groups that were responsible for children outside of the healthcare setting: registered ECEs and parents (non-ECE). It was expected that the ECE group would have a higher level

of knowledge than parents because they would need a minimum level of education (“some college or more”) in order to receive an ECE designation whereas parents’ education may be more varied (20). In a lead poisoning knowledge survey conducted in Chicago, IL, questions related to lead exposure were answered correctly more often in respondents with higher levels of education (21). This study, however, found that parents and ECEs had similar levels of education, with the most commonly reported level as “some college or more”. This could explain in part why there was no significant difference in lead survey scores between these groups.

Recommendations

Based on the findings of the study, it was identified that there is a need for more public education on lead risks, particularly on its sources and prevention methods as this knowledge could lead to behaviors that minimize children’s exposure to lead. Increased knowledge on lead risks has been shown to be linked to lowered blood lead levels (18). It has also been shown that health promotion campaigns focused specifically on lead risks are effective in increasing a population’s knowledge and awareness. A media campaign carried out between 2004 and 2006 in New York City sought to increase the public’s awareness and knowledge of lead risks and ways to minimize them. By conducting a pre- and post-campaign survey, it was found that the campaign was both effective in reaching parents and lead to a significant increase in awareness and knowledge levels (22).

There are multiple ways to target these groups with lead risk information. As educators, Community Care Facilities Licensing (CCFL) Officers can play a role in providing information to ECEs and parents. This can be done either verbally or by providing resources (pamphlets, HealthLink BC resources) to operators and parents. Licensing officers responsible for these facilities can also identify risk factors for lead exposure, such as buildings built before 1960 (23), especially those that have undergone recent renovations, and inform those operators or parents of lead risks associated with these conditions. Another method is to provide education classes on lead risks to parents with young children. However, this may not be an effective method for parents, especially those with low-income or busy work schedules. A 2015 study examining parents’ preferences and barriers to receiving child health

promotion information found that the main obstacles to attending classes were time, work schedules, and transportation (24).

Given the results of the survey, changes to lead legislation may also be warranted. Regulations or policies with more stringent restrictions on lead may be needed due to the public’s lack of knowledge on sources and exposure as well as the evidence that lead has toxicity at even low levels (1)(2). A study that examined the relationship between lead standards and their effect on BLLs found that only the standards with the lowest maximum limits were effective in reducing BLLs in the population as a whole. Otherwise, these standards only benefitted the small proportion of the population with the highest exposures (25).

Limitations

One of the main limitations of this study was the small sample size. Given the format (self-administered, in person survey), it was difficult to distribute the study to a larger population. Also given that many of the demographic questions had multiple response options, it was not possible to compare these responses and yield statistically significant results. In addition to this, some respondents failed to select an answer for some of the questions.

13 daycares were visited and surveys were distributed directly to ECEs on shift and were left for parents to complete when they returned to the daycare, generating a total of 30 responses for each group. It was difficult to administer the surveys in the same way to both groups since parents were generally available only during pick-up and drop-off times. While the researcher was present for the ECE responses, she was not present for the parent responses, returning after 1-2 days to collect the completed surveys. This may have resulted in bias since the ECE respondents were able to ask for clarification, unlike the parents. The survey format was selected in order to be more representative of respondents’ actual knowledge, thereby increasing the internal validity. Other methods, such as an online survey, while potentially generating more responses, would make online information more accessible while completing the survey. Respondents who completed the survey on the premises with the researcher present had limited opportunities to search for the correct answers via online resources. However, most parents had completed the survey at home without researcher

presence, giving them opportunities to look up information or ask other people, possibly reducing the internal validity of this study.

Another factor to consider for this study was that many of the ECE respondents (76.7%) were also parents, making it difficult to assess whether this factor was responsible for any differences, or lack thereof, between the two groups. Creating more well-defined experimental groups would minimize this problem. For example, surveying all parents with the distinguishing factor between the groups being those that have ECE certification and those that do not. Another example would be to survey ECEs and healthcare workers, or two other non-overlapping groups.

Lastly, the survey itself was subjective. While it may be possible to compare knowledge levels between two groups taking the same survey, it was not possible to determine whether overall knowledge among the population had increased or decreased over time by comparing results to other survey results. Other surveys would have different formats and contain different types of questions than this survey, while focusing on different populations in other regions. While the average score on the survey was 34.2%, it did not reflect whether the population has an overall “poorer” level of knowledge because in order to make this claim there needs to be some means of comparison (e.g. same survey has been administered in the past to the population). However, this type of cross-sectional study does have value in identifying areas where there are gaps in public knowledge.

Future Research

Although an online survey was avoided to increase internal validity, it would be beneficial to use this type of survey in future studies in order to get a larger set of responses. This type of survey has the additional benefit of allowing respondents to complete the survey when it is most convenient for them. One of the drawbacks of the method used for this study was that many ECEs were distracted when answering the in-person survey at the workplace, possibly introducing bias when compared with parents, most of whom completed surveys at home.

The survey used in this study focused primarily on respondents’ knowledge of lead risks. It would be beneficial to create a “KAP” style survey that not only assessed knowledge, but also attitudes and practices

with regards to lead risks. This could provide more information on the public’s behavior towards lead and allow for more well-targeted resources and education.

While some future projects may not be possible due to a lack of time and resources (e.g. comparing BLL changes over time in relation to receiving lead risk knowledge), it would be interesting to carry out physical experiments on lead in the Lower Mainland. For example, an assessment of lead levels in daycares and which areas are most concentrated. This type of study could prove valuable for enacting changes to legislation or policy, for example, legislation requiring daycare buildings that are of a certain age to undergo mandatory lead testing and remediation if necessary, or policy changes for daycare cleaning. While cross-sectional survey studies may be more feasible, other valuable information could be collected from physical studies that could have important implications for public health.

Conclusions

Based on the survey results, most respondents had a low level of knowledge on the survey, particularly on questions that asked about sources of lead, health effects of lead exposure, and factors that make children in particular more susceptible to the harmful effects of lead. In terms of demographics, most respondents were female, especially in the ECE group (96.7% female). ECEs were asked the age of the building they worked in (“built before 1960”, “between 1960 and 1990”, “built after 1990”) as well as whether there were any recent renovations performed. Out of 30 ECE respondents, 58.3% were not sure of the building age. Out of the respondents who reported the age of the building, 81.8% reported it as “built after 1990,” and 18.2% reported it as “between 1960 and 1990.” In addition to this, 46.7% of these respondents had reported recent renovations to the building. Age of the building and renovations are both factors associated with lead exposure.

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Competing Interest

The authors declare that they have no competing interests.

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