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**The Association between Mercury Emissions and Individuals with Autism Aged from 3-21 in the State of California from 2001 to 2007**

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The Association between Mercury Emissions and Individuals with Autism  
Aged from 3-21 in the State of California from 2001 to 2007

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Submitted in Partial Fulfillment of the Requirements for the Degree

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### Abstract

The paper explores how historical mercury deposition associates with the incidents of autism, identified in individuals aged from 3 to 21 in California from 2001 to 2007. The association between mercury deposits and the prevalence of individuals with autism aged from 3 to 21 in California was explored using the data from the National Atmospheric Deposition Program and the U.S. Education Department. A correlation analysis is applied to find if a relationship between mercury deposits and the autistic individuals in California. A regression test is run showing that for every 2.41ng/square meter per year increase of mercury deposits in California, there is a corresponding 3.55 person increase of autistic individuals aged from 3 to 21 historically from 2001 to 2007. Due to constraint factors in the research (please see the conclusion section), the comparison study did not show a statistically significant difference but the study indicated the importance of examining the effect of environmental toxins and their impact on human health.

## Chapter 1 Introduction

One day I roamed around online and an article on the main page of the Autism Speaks (2012) piqued my interest. It was about the study of autism and mercury. The researcher in the podcast pointed out that “Most cases of autism, however, appear to be caused by a combination of autism risk genes and environmental factors influencing early brain development” (Autism Speaks, 2012). I cannot agree more, especially when many studies have been arguing the causation between mercury and autism with respect to human exposure. Some say that autism is the product of environmental impact while some argue that autism is contributed by genes. I would say that when study the relationship between autism and mercury it is very hard to figure out the causal relationship between the two. In most cases, we study the correlation especially when the link between mercury and autism may be due to many factors.

### Statement of the Problem

Historical events thought the world exhibit how anthropogenic environmental disaster greatly impact on human health. Minamata Disease, (Ministry of the Environment Government of Japan, 2002) was first detected in the world at Minamata City, Kumamoto Prefecture, Japan in 1956, and for second time at Niigata City, Niigata Prefecture, Japan, in same year. Both diseases were due to the methyl mercury that was produced in the process for creating

acetaldehyde. Methyl mercury had bioaccumulated in the bodies of aquatic lives and the people who consumed them were therefore poisoned. Mercury is used for gold mining in East Africa and the Philippines also (Ikingura & Akagi, 1996). In Tanzania and Kenya, it was greatly concerned of the contamination of the Victoria Lake (Ogola., Mitullah, & Omulo, 2002). Although the pollution did not threaten public health because most of the mercury existed in inorganic form, people since then were highly aware of the risk of mercury to human health. In response to these environmental disasters that exposed us to danger, it of great necessity to carry out research related to the association between environmental factors and public health.

#### Purpose Statement

This paper describes the association between mercury release and the annual prevalence of the people diagnosed as autistic. The intention is to raise awareness and concern of the public to the environmental factors that influence public health.

#### Research Questions

1. What does the mercury deposition-autism prevalence correlation manifest?
2. If mercury deposition and the prevalence of autism are significantly correlated in California, should external factors of autism be put into spotlight?
3. What else should be factored in the high increase in the number of autistic individuals in California from 2001 to 2007?

4. What is the major factor that leads to the historically high increase in the number of autistic individuals in California?

### Theoretical Rationale

A fundamental illustration of how anthropogenic impact on our environment and human health is Rachel Carson's *Silent Spring* (Carson, 1962). The book documented detrimental effects of pesticides on the environment, particularly on birds. Carson blamed the chemical industry on spreading disinformation, and public officials of accepting industry claims uncritically.

Environmental science emerged as a substantive field of scientific investigation in the 1960s and 1970s driven by the need for a multi-disciplinary approach to analyze complex environmental problems, the arrival of substantive environmental laws requiring specific environmental protocols of investigation and the growing public awareness of a need for action in addressing environmental problems (National Center for Education Statistics, 2000).

Events that boosted this development included the 1969 Santa Barbara Oil Spill (Clarke & Hemphill, 2002) and the Cuyahoga River of Cleveland, Ohio, "catching fire" (also in 1969), and helped increase the visibility of environmental issues and create this new field of study.

Environmental science, an interdisciplinary academic field, stresses human interaction with the environment. It also encompasses environmental studies as well as the associated subjects, such as pollution control and the interactions between human and nature (NCES, 2003).

Therefore, the association between mercury and autism provides me with a perfect topic to display the environmental impact on human health.

## Assumptions

The study expects to see a positive correlation between the mercury deposition and the autistic individuals aged from 3 to 21 in the history of California from 2001 to 2007.

## Background and Need

In the State of California from 2001 to 2007, the annual prevalence of autistic individuals had increased from 1/250 to 1/150 (Autism Speaks, 2012). Correspondently, the annual mercury deposit has been increasing (MDN).

## Summary

Historical concerns with respect to the interaction between human actions and environment has long existed. The study aims to use the association between the mercury deposit and the annual autistic individual prevalence at the state level as a specific instance to illustrate how closely our human deeds may impact environment, which in turn takes effect on us. In response to the association between historical mercury deposition and the annual prevalence of the autistic individual in California, the study aimed to further explore the relationship of the two.

## Chapter 2 Review of the Literature

### Introduction

This review of the literature is categorized in five parts. The Historical Context refers to the initiation of the original studies on the effects of mercury and its impact on the health of the populations. The Review of the Previous Research has been proposed to explain the association between anthropogenic impacts to the environment which ends up negatively affecting human health. Although the literature covers a wide variety of the theories, this review focuses on five major themes which emerge repeatedly throughout the literature reviewed. These themes are human exposure, effects, link to autism, and source of mercury exposure. These themes are contributing to exploring the association between environmental mercury deposition and the autism prevalence.

### Historical Context

Historical events thought the world exhibit how anthropogenic environmental disaster greatly impact on human health. Minamata Disease was first detected in the world at Minamata City, Kumamoto Prefecture, Japan in 1956, and for second time at Niigata City, Niigata Prefecture, Japan, in same year (Ministry of the Environment Government of Japan, 2002). Occurrence of disease was due to the methyl mercury that was produced in the process for creating acetaldehyde. Methyl mercury had biocummulated in the bodies of aquatic lives and the people who consumed them were therefore poisoned. Mercury is used for gold mining in East

Africa and the Philippines also (Ikingura & Akagi, 1996). In Tanzania and Kenya, the contamination of the Victoria Lake raised public awareness of environmental impact on human health. Although the pollution did not threaten public health because most of the mercury existed in inorganic form people since then were highly aware of the risk of mercury to human health. In response to these environmental disasters that exposed our livelihood in danger, it of great necessity to carry out research related to the association between environmental factors and public health.

## Review of the Previous Research

### *Human Exposure*

Human exposures to organic mercury such as methyl-mercury lead to the detriment of human nervous system, the damage to cognitive thinking, memory, and language. Methyl-mercury has especially harmful impact on infants' neurological development (Centers for Disease Control and Prevention 2012). Large-scale methyl-mercury poisonings have taken great toll on human health. After the outbreak of Minamata Disease in 1956 which was caused by high-level of methyl-mercury pollutions in local water system of Japan, 2955 Japanese were certified having the disease by the end of 2001 (Ministry of the Environmental Government of Japan, 2002).

Inorganic mercury, if highly exposed, could result in damage to human digest system, nervous system and kidneys (Environmental Protection Agency [EPA], 2012).

### *Effects*

Studies have shown that inorganic mercury has neurological effects on humans through inhalation, oral and dermal exposures (Agency for Toxic Substances and Disease Registry(ATSDR), 2011). A variety of recent studies have conveyed that human exposures to mercury are ecologically related to behavioral development and learning abilities (Grether, Anderson, Croen, Smith & Windham, 2009).

Studies such as those of Cobigo, Murphy, Bielska, and Ouellette-Kuntz (2012) also explored the association between genetic and environmental elements like mercury or Stamova, et al., (2011) , studied the correlation between gene expression and mercury content in the blood. A similar comparison study by Hertz-Picciotto, Green, Delwiche, Hansen, Walker, and Pessah (2010) evaluated mercury content in the blood of children with and without autism.

Other studies concern the linkage between mercury and the prevalence of autistic individuals through mercury toxicology and human biology (DeSoto & Hitlan, 2007; Palmer, Blanchard, Stein, Mandell & Miller, 2006; Palomo, et al. 2003). Mutter, Naumann, Schneider, Walach & Haley (2005) implicated that autistic individuals have decreased detoxification capacity towards mercury.

### *Link to Autism*

A study conducted by Zhang and Wheeler (2010) reviewed the information being aware of the association between mercury exposure and autism. Some studies also provided evidence to support the argument that confluence effect from genetic and biochemical factors may

factor in the happenstance of some autism spectrum disorders(Geier, King & Sykes 2008). A recent study also argues that some ASDs may result from an interactive activity between genetic susceptibility and environmental exposures (Leslie & Koger, 2011)

#### *Source of Mercury Exposure*

Anthropogenic release is a leading source of mercury exposure. A great amount of mercury is emitted from human activities such as power plants manufacturing. The emitted mercury is airborne and transported and deposited atmospherically in either wet or dry form.

After landing, mercury transforms into methyl-mercury in soils and water. Methyl-mercury could then be bio accumulated in aquatic creatures which may later be consumed by human, which is a major way of human exposure to mercury and causes increases of mercury level in the blood and hair (ATSDR 1999). Even the association between environmentally released mercury and the rates of autistic individuals has been well-displayed (Palmer, Blanchard, Stein, Mandell & Miller, 2004) and studies such as (Wong, Ho & Lee, 2004) attempted to see the correlation between children exposure to mercury and autism spectrum disorder, no published scholar article has investigated the association between mercury deposition and the rates of autistic individuals at state level.

A variety of studies have displayed the relationship between human exposure to mercury and the prevalence of autistic individuals in the U.S. However, it is cumbersome for the researchers of this field to build a direct connection between mercury exposure and autism

prevalence simply because the field requires strong interdisciplinary studies from environmental science to neurology, physiology, behavioral psychology and special education.

With respect to the human exposure to mercury, environmental scientists at first have to know the source of mercury, which could be multiple: mercury release from local heavy industries, historical mercury deposition or even mercury releases from overseas taken into consideration that mercury could be trans boundary once it is airborne. After figuring out the source, scientists must come up with several possible routes through which human beings are exposed to mercury.

Fortunately, it is commonly known that the major way for human to expose themselves to mercury is by consuming fish, which contain mercury by consuming other aquatic creatures that are poisoned by mercury. The process is called bio-accumulation. However, other possible ways of exposing human to mercury cannot be ignored, such as the topic of whether medical use of mercury such as preservative thimerosal that results in autism prevalence remains concerned (Tomljenovic, Dorea, Shaw, 2012) or questioned (Gorski, 2007).

The other disciplinary of studies may have different arguments with regard to the cause of autism or even, some of the facts make the relationship between mercury exposure and autism nebulous. For example, fish consumption does not contribute to studying the relationship when it is known that autistic individuals take in little fish on daily basis. However, this paper appreciates certain studies (Austin, 2008) of factoring in precautions when

examining whether a causal relationship exists between mercury exposure and individuals with autism.

When the complexity of the relationship between autism and mercury exposure is fully aware, the cause of autism is likely to be a multi factorial condition. In other words, studies revolving the issue might want to stress the contributing factors to autism instead simply studying the causation. For the contributing factors, the study selected mercury deposition because in this way the complexity of looking for mercury source can be avoided because deposition does not consider where mercury came from.

### Summary

Both historical events and effluent studies have shown the interactions between environmentally released toxics and human health effect in terms of human exposure to mercury, its effect, its relationship to autism, and the sources of mercury. In respect with the complexity of the relationship between mercury release and autism, the study aims to investigate the association between mercury deposition and the autistic individuals aged from 3 to 21 during the period from 2001 to 2007 and expects to see a positive correlation between them.

## Chapter 3 Method

### Introduction

This study uses ex post facto, using quantitative data, and non-experimental design using an interview with an expert to gather qualitative information. The interview took place between with Professor Mohammed El Majdoubi, Ph.D. He was recommended by my advisor, Dr. Madalienne Peters. With regard to the quantitative analysis, I used correlation, linear regression tests on the data set.

### Sample and Site

Sample data with regard to environmentally deposited mercury in California was obtained from the National Atmosphere Deposition Program (MDN). The NADP cooperates with federal, state, tribal and local governmental agencies, educational institutions, private companies and non-governmental agencies. The NADP, initiated by the U.S. State Agricultural Experiment Stations (SAES), aims to measure atmospheric deposition and study its effects on the environment. Sites in the NADP precipitation chemistry network started to operate in 1978 whose goal stresses providing data on the amounts, trends, and geographic distributions of acids, nutrients, and base cations in precipitation. Since then the NADP began to expand its network. In 1996, the Mercury Deposition Network (MND) joined the NADP and consists of over 100 sites in the United States and Canada. All MDN samples are analyzed for total mercury, and some for the more toxic methyl mercury.

The data on the annual frequencies of individuals with autism, from “Autistic Spectrum Disorders, changes in the California Caseload”, a report from the California Health and Human Services Agency (Cavagnaro as cited in Autistic Spectrum Disorder) was analyzed. With respect to the purpose of the data, the term “autism” refers to the condition characterized by the California Department of Developmental Services (DDS) as “autistic disorder”. Without specific notes, the data relating to “autism” does not present the number of individuals with other disorders on the autism spectrum. The data on the annual frequencies of individuals with autism for the comparison study, from Autism Maps (Autism Maps –Iowa, 2013 para.4) was analyzed.

In addition to the quantitative data, I interviewed an expert on Neuroscience and Pharmacology. Prof. Mohammed set up an interview time with me on Nov. 16th 2012 at 13:30 at the lobby room of the Science Center at the Dominican University of California. The interview was conducted on a conversation basis. I prepared my interview questions and showed them to Prof. Mohammed. He affirmed with me with regards to the specific data applied to the quantitative analysis and provided me with constructive suggestions related to my data analysis. He pointed out that it was of critical importance to determine the factors affecting the correlation test, which is used in my research paper.

Prof. Mohammed suggested that I look for a state with similar health care system as California and analyze the association between the mercury deposits and the annual frequencies of the individuals with autism spectrum disorder in that state because for data analysis, samples or groups should be independently observed. He also suggested me quoting

some anecdotal evidence to support the justification of my paper, such as *Erin Brockovich* (Soderbergh, 2000). In addition, he advised me ruling out other human exposures to mercury such as vaccines made of mercury, which is an on-going controversial issue.

### Ethical Standards

This paper adheres to ethical standards in the treatment of human subjects in research as articulated by the American Psychological Association (2010). Additionally, the research proposal was reviewed by the Dominican University of California Institutional Review Board for the Protection of Human Subjects (IRBPHS), approved, and assigned number 10064.

### Data Analysis Approach

A linear regression test was conducted to exhibit the association between the environmentally deposited mercury and the individuals with autistic spectrum disorder in a historic period which the research aims to study. The linear regression test was operated on the R-command software. The independent variable is the historically annual mercury deposits in California while the dependent variable is the historically annual frequencies of autistic individuals in California.

## Chapter 4 Findings

## Overall Findings, Themes

The result of the test is shown as below:

*Table 1 Correlation Test in California*

Coefficient				
	Estimate	Standard Error	t-value	Pr(> t )
(Intercept)	1.140e+04	5.270e+03	2.164	0.06722
mercury deposits	2.413e+00	5.656e-01	4.265	0.00372**
Significance codes:				
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

The result of the test can be interpreted as for each unit of mercury increase, a correspondent increase (3.553 units) of autistic individuals occur. In order to strengthen the point that the association between the two variables of mercury deposition and autism annual frequencies is correlated, a comparison study was conducted. The historical annual frequencies of the autistic individuals in the state of Iowa from 2001 to 2007 were selected as the independent variables and the historical annual mercury deposits of Iowa as the dependent variables. A

linear regression test similar as the previous one was run and the result of the test is as following:

*Table 2 Correlation Test in Iowa*

Coefficient				
	Estimate	Standard Error	t-value	Pr(> t )
(Intercept)	977.13	161.98	6.033	0.0018 **
mercury deposits	33.95	23.70	1.433	0.2114
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

Residual standard error: 248.2 on 5 degrees of freedom

(1 observation deleted due to missing data)

Multiple R-squared: 0.291, Adjusted R-squared: 0.1492

F-statistic: 2.052 on 1 and 5 DF, p-value: 0.2114

The result of the test can be interpreted as for each unit of mercury increase, a correspondent increase (1011.8 units) of autistic individuals occur.

## Chapter 5 Discussion/Analysis

### Summary of Major Findings

The study carried out two correlation coefficient tests to respectively explore two pairs of associations between the number of the annual prevalence of the autistic individuals in the states of California and Iowa and the corresponding amounts of annual mercury deposits in the areas in the same historical period. A significant correlation occurs in the state of California (p-value = 0.00372). It is not the case, however, in the state of Iowa (p-value = 0.2114).

### Comparison of Findings to Previous Research

The study attempts to raise public concerns with regard to the impact of the environmentally toxic pollution to public health. Compared with the previous studies and researches on the impact of mercury on human health, such as mercury and autism (Hertz-Picciotto et al., 2010) and utilizing environmental elements as indicators of autism (Cobigo et al., 2012), the study emphasizes on the impact of environmental factors on human mental health.

### Limitations/Gaps in the Study

The paper aims to study the association between the mercury deposits and autism. However, more than one variable may be able to factor in or even determine the association so the study does not fully cover all the factors that may come in play in the process.

Also, the indirectness of the relationship between mercury deposits and autism may put the study result in a vulnerable situation because many routes it may take which may lead to different consequences from the moment when mercury is coming down with rainfall. For instance, mercury may deposit on land instead of in lakes or rivers so that the process of bioaccumulation could not happen. Even if mercury ends up in wet form, fish may not eat mercury-poisoned micro-organism which also does not result in the happenstance of bioaccumulation. So the problem goes as how likely human beings may end up eating fish with methyl mercury.

### Implications for Future Research

This study is among the first to illustrate an association between environmentally released mercury and the annual prevalence of the autistic individuals at the state level. Given the limitations of the data and information, future studies should focus on creating comparison studies to verify the correlation between the two variables and explore the association by applying other methodologies and samples. This line of research has important implications for public health policy and supports prior recommendations for reducing environmentally released mercury.

### About the Author

Sen Guo became interested in environmental science as an undergraduate. His concern encompasses the impact of the environmental factors to public health. He expects to raise public awareness of the anthropogenic impact on human health.



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