Assessing the Human Health and Safety Impacts of Voluntary Consensus Standards

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Abstract

The goal of this project was to evaluate the health and safety impact of voluntary consensus standards on consumer products using the principles from ANSI's working group guidelines. We identified consumer products for possible analysis through conversations with members of the ANSI group, selected a sample group of products using information learned from interviews, and formulated narratives about the impact of voluntary standards for the selected products. After data collection and analysis, our results included narratives around hoverboards, baby cribs, hairdryers, and toys. Future project frameworks included further work and data analysis to be done around other products. Recommendations on redefining terms within the whitepaper and expanding the scope of the whitepaper were proposed.

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- The helpful staff from the CPSC for allowing us to interview them for our project along with giving us a tour of their facility.
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Assessing the Human Health and Safety Impacts of Voluntary Consensus Standards

Executive Summary

December 15, 2022

Government standards are an often-transparent aspect of daily life that give consumers and manufacturers the confidence to use consumer products without fear of harm or illness. Organizations like the Consumer Product Safety Commission (CPSC) participates in the development process of both voluntary and mandatory safety standards for consumers and manufacturers for products ranging from infant cradles to all-terrain vehicles (ATVs). They use a combination of regulations, bans, and safety standards for consumer products, but mostly focus on voluntary consensus standards, private sector standards developed in an open and fair environment with consensus from the stakeholders. With many agencies, such as Underwriters Laboratories (UL) and CPSC, there is a lack of consistency in the development process of these standards.

Standards developing organizations lack an established method to measure how well voluntary consensus standards have impacted the health and safety of consumers. Thus, the CPSC is not able to reliably or consistently determine the impact of voluntary standards on product safety. This problem has been addressed by organizations including the CPSC, but none have yet established a methodology for assessing the impact voluntary consensus standards.

Prior efforts to test the principles of voluntary consensus standards (from OMB Circular A-119) have encountered confounding factors, a lack of methodology, and even insufficient data. Intending to develop a more accurate and measurable solution, American National Standards Institute (ANSI) formed a working group of interested stakeholders including the CPSC and UL. Together, these organizations are developing a whitepaper, an in-depth report describing a problem and proposing a solution.

Voluntary consensus standards are a set of product requirements, developed through a process which includes participation from all interested parties, that manufacturers are recommended to follow (*Voluntary Standards Development FAQ for Consumers*, n.d.). Unlike federally mandated product safety standards, voluntary consensus standards are usually not enforced by law. However, if a company reaches a level of noncompliance where the CPSC can determine substantial product hazards, then the CPSC may begin enforcement through rulemaking. This may turn the voluntary consensus standard into a mandatory standard.

ANSI is a non-profit body that helps promote coordination among standards organizations and accredits the standards development processes of those organizations. ANSI is not involved with the technical aspects of standards but is more concerned with the requirements to ensure the standard creation process is fair. Although they do not create standards, they recognize and approve them, allowing organizations to receive ANSI's accreditation. One process for developing voluntary consensus standards was developed by ANSI, and are part of the process to create an

ANSI approved standard or American National Standard (ANS). ANSI outlines in the guidelines for an ANS, 10 essential requirements for due process. Although, there is no enforcement to follow these guidelines, they need to be followed if the standard-creating organization wants their standard to become an ANS. Along with these requirements and OMB Circular A-119, there are also principles that standard developers keep in mind when constructing voluntary standards; principles are foundational factors to consider when creating the standard. Some examples of a principle are death rates, incident rates, and product lifecycle (S. Ayers, personal communication, October 6, 2022).

A consequence of not having an established method to determine the impact of voluntary consensus standards is the effect it will have on the products and the consumers using those products. If the impact of a standard is not evaluated, then the success of that standard is unknown which means that products could still be dangerous and causing injuries.

Some past efforts have tried to measure the impact of voluntary consensus standards but have encountered several problems. For example, in 2021, UL developed a way to measure the impact of certain UL standards. Through that study, they learned that the existing data was not detailed enough, such as reports only coming from emergency hospital trips (Wroth, Chapter 2). The UL study also noted there could be several reasons why the injury rate for a product decreases; it may not be only changes in standards.

Goals and Objectives

The goal of this project was to evaluate the health and safety impact of voluntary consensus standards on consumer products using the principles from ANSI's working group guidelines. To achieve this goal, we identified the following three objectives:

1. Identify consumer products for possible analysis through conversations with interested parties.
2. Select a sample group of products with input from subject matter expert interviews and data analysis.
3. Critically evaluate the sample group and formulate narratives around the impact of voluntary consensus standards on the sample group of products using the principles.

Methodology

We identified which products should be reviewed by consulting with the ANSI working group and expert personnel at the CPSC. Through this process, a large list of products was created. We then narrowed the product list down through subject matter expert interviews with members of the CPSC, UL, and International Safety Equipment Association (ISEA). We then used the ANSI working group principles to create a sample group of products that best represent changes in impact. We continued to research the sample group of products using reputable databases like CPSC's National Electronic Injury Surveillance System (NEISS), CDC's National Health and Nutrition Examination Survey (NHANES),and CPSC Clearinghouse database. Using what was learned about the selected consumer products and the whitepaper, we created a report which details

narratives around the impact of health and safety standards related to these products using the principles outlined in ANSI's whitepaper.

Results

To identify possible products for further analysis, we met with members of the ANSI working group and other interested organizations working on the whitepaper. We were able to organize a very broad diverse list of products including safety equipment, electronic products, and consumer products. These products were chosen because they have had significant changes to their standards within roughly the past twenty years.

Cribs	Hairdryers	Candles	Hoverboards	Work Gloves	Work Helmets
Portable Generators	Face Masks	Home Sprinklers	Button Cell Batteries	Mechanical Garage Door System	ATV/ROVs
Ladders	Ceiling Fans	Blinds	Grills	Coffee Makers	Glass Front Fireplaces
Microwave Ovens	Washing Machines	Toasters	Deep Fryers	Paper Shredders	Lawnmower
Fall Protection Tethers	Gear for heat stress	Body Harness	LED Lights	Drying Machines	Baby Swings
Sports Helmets	Lead in Toys	Backyard Trampolines	Heating Blankets	Baby Walkers	Smoke Alarms

Table 1: Broad list of possible products to analyze

Using this broad list of products, we conducted interviews with subject matter experts. The interviewees talked about the product that they specialized in, providing a brief history of the product standard, standard changes within roughly the last 20 years, and provided information on whether there is accessible data on a product. Using the principles from the ANSI working group's whitepaper, we were able to further narrow the list of products. One principle was associated with one product to see how the adoption of voluntary standards affected the safety of the product. As a result, from these interviews and principles, a sample group of products were created and were split into two categories: narratives and frameworks. A narrative is a product that has a principle associated with it. Frameworks do not have principles due to the lack of information such as data but have an interesting case for further analysis.

Conformance	Effectiveness
Motivation	Death/injury rates
Knowledge	Ratios vs. Raw Numbers
Time	

Table 2: List of Principles from the Whitepaper

Narratives	Project Frameworks
Hover Boards	Candles
Cribs	Construction Helmets
Lead In Toys	Portable Generators
Hair dryers	Sprinklers for Homes
	Drying Machines

Table 3: Sample Group of Products

To begin forming narratives, the first step was to further research data collected through interviews with the subject matter experts. This data was found in three major places: the NEISS, the CDC's NHANES, and the CPSC's Clearinghouse Data. After the data points were collected, graphs and figures were created. Using the qualitative data from the interviews, the principles from the whitepaper, and quantitative data from the databases, we wrote narratives around the four products chosen and frameworks were created for the other products from the sample group.

Recommendations

We would like to provide three recommendations to improve the whitepaper.

1. The ANSI working group should reconsider the definition of effectiveness in the whitepaper, basing the definition on separately measured principles.

The ANSI working group should create a definition of effectiveness that is based on separately measured principles instead of using data alone. There should be clearer principles under effectiveness similar to the conformance section of the whitepaper. The current definition of effectiveness should also try to isolate itself from conformance.

2. The ANSI working group should expand the scope of the paper to include other types of voluntary consensus standards.

The ANSI working group should expand the scope of the paper to include other types of voluntary consensus standards. Including other types of voluntary consensus standards would broaden the audience and content of the whitepaper.

3. The ANSI working group should create antoher version of the whitepaper for end users.

The ANSI working group should create a second version of the whitepaper that is written in a language meant for end users not in standards development. Creating another version for end users would educate more people and increase awareness of voluntary consensus standards.

Authorship

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Chapter 2: Background: 2.1 Voluntary Consensus Standards	Nico, Jagger	ALL
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Chapter 3: Methodology Objective 1	Max	ALL
Chapter 3: Methodology Objective 2	David	ALL
Chapter 3: Methodology Objective 3	Jagger	ALL
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Appendix C:	Max, Jagger, David, Nico	ALL
Appendix D:	Nico, Jagger	ALL
Appendix E:	Jagger, Max	Nico, Jagger, Max
Appendix F:	Jagger, Max	Nico, Jagger, Max
Appendix G:	David	ALL
Appendix H:	David	ALL
Appendix I:	David	ALL

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1.0 Introduction

Government standards are an often-transparent aspect of daily life that give consumers and manufacturers the confidence to use consumer products without fear of harm or illness. For example, the Food and Drug Administration (FDA) is responsible for protecting and promoting public health through the control and supervision of various substances ranging from food safety to over-the-counter medications. Other organizations such as Underwriters Laboratories (UL) resolve safety, security, and sustainability challenges and is responsible for managing and issuing the portfolio of UL Marks (Background). Organizations like the Consumer Product Safety Commission (CPSC) participates in the development process of both voluntary and mandatory safety standards for consumers and manufacturers for products ranging from infant cradles to all-terrain vehicles (ATVs). They use a combination of regulations, bans, and safety standards for consumer products, but mostly focus on voluntary consensus standards.

Voluntary consensus standards are private sector standards developed in an open and fair environment with consensus from the stakeholders. These standards can come in different forms. For example, voluntary consensus standards can be guides, test methods, and definitions. While voluntary standards can be created more easily than the traditional rulemaking process of mandatory standards, they may not be appropriate for every circumstance. With many agencies, such as UL and CPSC, there is a lack of consistency in the development process. Further, there is no established way of measuring the effectiveness, conformance, and impact of voluntary standards.

Standards developing organizations lack an established method to measure how well voluntary consensus standards have impacted the health and safety of consumers. Thus, the CPSC is not able to determine product safety problems reliably or consistently. For a select group of consumer products, it is unknown whether a voluntary standard has the intended impact for making a product safer. This problem has been addressed by organizations including the CPSC, but none have yet established a methodology for assessing voluntary consensus standards. The American National Standards Institute (ANSI) develops criteria for these organizations. Some of these criteria include openness, lack of dominance, and balance. In these criteria along with OMB Circular A-119, there are principles used and considered when developing voluntary standards, but there is no enforcement to follow those criteria.

Prior efforts to test the effectiveness of the principles of voluntary consensus standards have encountered confounding factors, a lack of methodology, and even insufficient data. Intending to develop a more accurate and measurable solution, ANSI formed a working group of interested stakeholders including the CPSC and UL. Together, these organizations are developing a whitepaper, an in-depth report presenting a problem and proposing a solution. Since a large amount of data is needed to assess the impact of voluntary standards on human health and safety, there is a need to clarify the data collection approach and the analytical measures that would help CPSC, and ANSI implement their programs.

The goal of this project was to evaluate the health and safety impact of voluntary consensus standards on consumer products using the principles that the ANSI group intends to include in their whitepaper. To achieve this goal, we developed three objectives. First, we identified consumer products for possible analysis through conversations with members of the ANSI working group. Second, with input from subject matter expert interviews and data analysis, we selected a sample group of products for a detailed review. Third, we formulated narratives about the impact of voluntary consensus standards for the sample group of products and how the principles affected the impact on each product. These principles can be applied to the impact relationship that the ANSI group has identified and were used as the basis of our analysis. The results from this project may inform the whitepaper.

2.0 Background

This chapter will summarize voluntary consensus standards, some of the organizations that are involved with standards, and how the impact of standards can be measured. In this report, it is important to remember that standards are documents that can include rules, conditions, guidelines, methods, and terminology. There can be many types including but not limited to voluntary consensus standards.

2.1 Voluntary Consensus Standards

Voluntary consensus standards are a set of requirements, developed through a process which includes participation from all interested parties, that manufacturers are recommended to follow (*Voluntary Standards Development FAQ for Consumers*, n.d.). Included parties may consist of manufacturers, consumers, and standard development organizations. Types of voluntary consensus standards include test methods, guidelines, and terminology. The voluntary consensus standards involved with this project contain product requirements to help reduce or prevent injuries to protect the consumers.

2.1.1 What Voluntary Consensus Standards do

Unlike federally mandated product safety standards, voluntary consensus standards are usually not enforced by law. However, if a company reaches a level of noncompliance where the CPSC can determine substantial product hazards, then the CPSC may begin enforcement through rulemaking. This may turn the voluntary consensus standard into a mandatory standard. The purpose of voluntary consensus standards is to maintain manufactures to a certain level of performance for their products. The existence of these standards allows for the private sector to participate in the standardization process and minimizes the reliance on the government for standards development and enforcement.

2.1.2 What is a Voluntary Consensus Standards Body

Voluntary consensus standards bodies are associations, organizations, technical societies that plan, develop, establish, or coordinate voluntary consensus standards. These standards bodies use a voluntary consensus standards development process which is based on attributes such as openness, balance, due process, appeals process, and consensus. Although these bodies consist of participants from the private sector, the development bodies are encouraged to have a federal representative participate.

2.1.3 Voluntary Consensus Standard Lifecycle

Voluntary consensus standards go through development, awareness, adoption, implementation, revision, and then retirement. From development to revision, leading indicators are emphasized. From implementation to retirement, lagging indicators appear and are focused on. Leading indicators can show potential for impact while the standard is still in the preliminary stages. Through the years, standards will have a larger impact which leads to lagging indicators being a more useful measurement of impact. A leading indicator is a “performance measure that is capable of influencing and/or predicting results and is often aimed at the prevention and control

of future events or results" (McCabe et al., 2022). A lagging indicator is a "performance measure that represents the consequences of actions previously taken or not taken" (McCabe et al., 2022).

2.1.4 American National Standards

ANSI is a non-profit body that helps promote coordination among standards organizations and accredits the standards development processes of those organizations. ANSI's goal is to "provide a framework for fair standards development and quality conformity assessment systems and continually works to safeguard their integrity" ("ANSI Introduction", 2022). ANSI is not involved with the technical aspects of standards but is more concerned with the requirements to make sure the standard creation process is fair. Although they do not create standards, they do recognize and approve them, allowing organizations to receive ANSI's accreditation. One process for developing voluntary consensus standards was developed by ANSI, and are part of the process to create an ANSI approved standard or American National Standard (ANS).

ANSI's approval of voluntary consensus standards was designed to establish a fair and responsive development process, open to all interested parties. ANSI oversees the integrity of the consensus process but doesn't determine the technical content of the standard. Only ANSI-accredited standard developing organizations can submit standards for approval. ANSI outlines in the guidelines for an ANS, 10 essential requirements for due process, which are summarized here:

- Openness – All parties interested in the activity may participate in creating the standard. There cannot be a financial or membership requirement to join the process of creating standards.
- Lack of Dominance – One group cannot exercise dominant authority, leadership, or influence through superior leverage, strength, or representation over others.
- Balance – Standards should be created with a balance of the interests of all parties involved.
- Coordination and Harmonization – There should be good faith efforts to resolve conflicts with all American National Standards organizations.
- Notification of Standards Development – There should be timely and adequate notice when there is a development of standards.
- Consideration of Views and Objections – There must be prompt consideration for all views given by the participants, including the responses to the public announcement of the standards
- Consensus Vote – There should be evidence of a vote that shows some level of consensus in accordance with these requirements across the group of interested parties
- Appeals - All written procedures should have a realistic appeals mechanism that handles procedural appeals.
- Written Procedures - Should be available to anyone interested and should control the methods used for the development of standards.
- Compliance with Normative American National Standards Policies and Administrative Procedures - All developers are required to follow all policies and

procedures created by the ANSI executive council. (*ANSI Essential Requirements*, n.d.)

Although, there is no enforcement to follow these guidelines, they need to be followed if the standard-creating organization wants their standard to become an ANS. Along with these requirements, there are also principles that standard developers keep in mind when constructing voluntary standards. Principles are foundational factors to consider when creating the standard. These principles stem from the impact relationship, which is mentioned later in this chapter. Some examples of a principle are death rates, incident rates, and product lifecycle (S. Ayers, personal communication, October 6, 2022).

Creation of a voluntary consensus standard can begin in many ways. The development process can start when a manufacturer informs the standard-developing organizations of a new product they're releasing. The creation of these standards can also be a reactionary response when a released product has an unforeseen consequence, impacting consumer safety. In either case, a committee comprised of CPSC, and related organizations, manufacturers, and consumers convene to discuss whether a new voluntary consensus standard should be introduced or if a prior standard needs to be updated. This committee must also be fair as described in the Balance essential requirement of an ANS.

As described in Figure 1 for a decision to be reached, there must be consensus. If one group or another disagrees with the majority, they are allowed to share why, and a new vote will be cast until a consensus is reached. The standard will then be reviewed internally by the subgroup before returning the standard back to the larger committee. Finally, the standard is debated by the full committee in its revised form. Once this revision is agreed upon, the standard will be published.

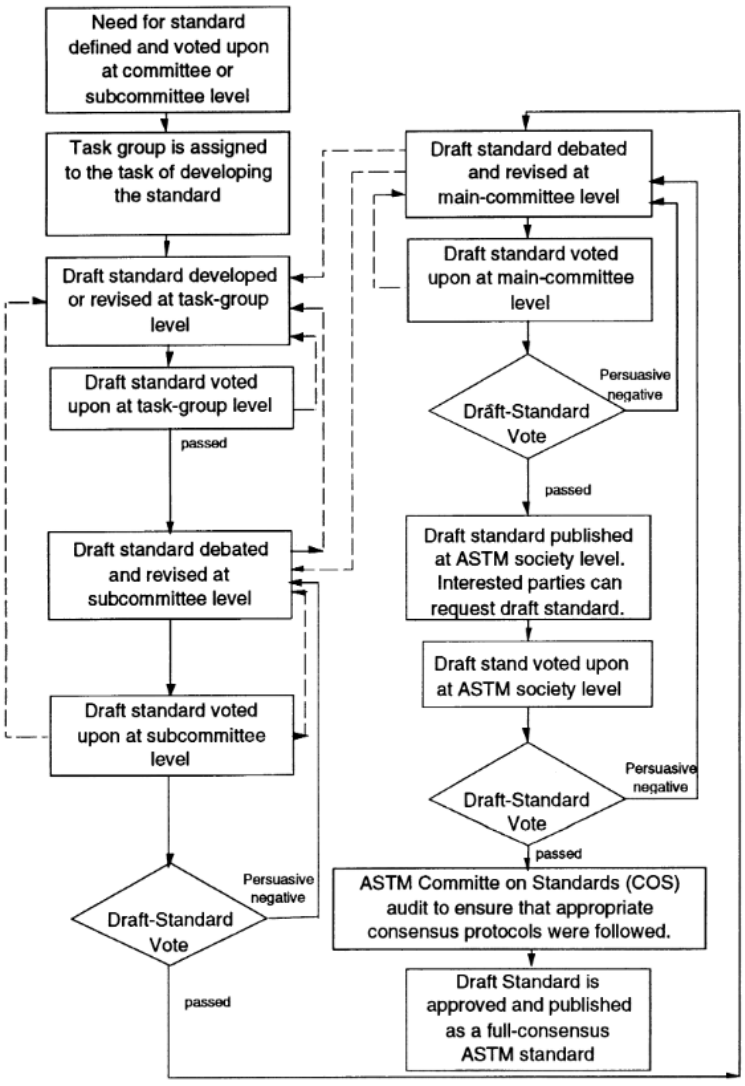

Figure 1: ASTM's Procedure on How to Develop a Standard (Marpet, 1998)
Note. From "An Ethical Issue in Voluntary-Consensus-Standards Development: A Decision-Science View", by Mark I. Marpet,1998, https://www.jstor.org/stable/25074007, Copyright 1998 by Journal of Business Ethics. Reprinted with permission

2.2 Organizations Involved with Voluntary Consensus Standards

2.2.1 The Consumer Product Safety Commission (CPSC)

The CPSC was founded in 1972 with a goal to develop standards that are not under the jurisdiction of other organizations ("Consumer product safety act", 1972). The CPSC "works to save lives and keep families safe by reducing the unreasonable risk of injuries and deaths associated with consumer products and fulfilling its vision to be the recognized global leader in consumer product safety" (CPSC, n.d.). The CPSC is a participant in the development process of voluntary consensus standards alongside other organizations that eventually publish them. As a participant, they do not create or publish standards. However, if there is a high product hazard, the CPSC can turn voluntary standards into mandatory standards.

There are many well-known voluntary consensus standards that the CPSC has participated in. These include those to help prevent young children from ingesting button cell batteries, like in the standard "UL 1642, 5th Edition Standard for Safety for Lithium Batteries" ("Batteries, Ingestion," 2021) and improve safety of bicycle helmets in the regulation "16 CFR Part 1203 – Safety Standard for Bicycle Helmets" ("Bicycle Helmets Business Guidance," 1998). The CPSC also responded to the rapid emergence of liquid laundry packets and the increasing trend of them being ingested in their collaboration with the American Society for Testing and Materials to make the standard "ASTM F3159-15" ("Liquid Laundry Packets," 2015). As described in this chapter, the CPSC has established itself as a strong contributor to voluntary consensus standards for consumer products.

2.2.2 Underwriters' Laboratories

UL is a private standards organization that focuses on technology and was originally established in 1894. UL works to "support the production and use of products which are physically and environmentally safe and to apply our efforts to prevent or reduce loss of life and property", which is very similar to CPSC's goal statement ("Our Mission", 2022). UL has developed more than 1,500 of its own standards which makes UL a very sought-after accreditation for products. UL's accreditation can be seen on many products, like on the bottom of most laptops.

2.2.3 American National Standards Institute

ANSI is a private organization that was founded in 1918 and coordinates the voluntary consensus standards system, conformity assessments, and other related activities nationally. This organization is not a government agency and does not develop standards but instead accredits standards developing organizations. ANSI's mission is different in that it concerns the creation of standards instead of protecting people from potentially dangerous products. ANSI's goal is to "promote and facilitate voluntary consensus standards and conformity assessment systems and safeguarding their integrity" ("ANSI Introduction", 2022). They bridge the public and private sectors, providing neutral forums. ANSI represents the interests of over 270,000 different companies and with them have approved over 10,000 standards.

2.3 ANSI Whitepaper

2.3.1 The Problem with Voluntary Consensus Standards

There is no agreed upon, universal method to measure the health and safety impact of voluntary consensus standards. Major organizations, like ANSI, that create the requirements for standards, only look at the fairness of the standards and whether they are fair for both the consumers and manufacturers. ANSI does not consider the technical aspects of standards because that is the role of the standards developing organizations.

The absence of an established method to determine the impact of voluntary standards affects end users such as consumers. Many products' standards are in place to make the product safe to use, preventing injuries to the consumer. If the impact of a standard is not being analyzed, then the success of that standard is unknown, which means that products could still be dangerous and cause injuries. The standard developing organizations could be spending resources on fixing

the standard but since they do not know if it is effective, these resources are going elsewhere. Also, the resources that are being spent towards the standard could be a waste if the standard has no impact. It could turn into an endless cycle of resources being spent and no issues being solved.

Multiple organizations have attempted to formulate a methodology to determine the impact of voluntary consensus standards but there are many factors to consider. At times, it is difficult to prove why a standard had a desired impact. For example, reduced production of a product would lead to fewer injuries but does not necessarily prove that the standard was impactful. Another example is that a new version of the product is released which results in fewer injuries.

2.3.2 Past Efforts to Measure the Impact of Voluntary Consensus Standards

Some past efforts have tried to measure the impact of voluntary consensus standards but have encountered several problems. For example, in 2021, UL developed a way to measure the impact of certain UL standards. They selected three different standards and then collected data on injuries from products associated with them. Data from the CPSC and the National Electronic Injury Surveillance System (NEISS) (Wroth, Chapter 2) was included in their study. Through that study, they learned that the existing data was not detailed enough, such as reports only coming from emergency hospital trips (Wroth, Chapter 2). A lack of sufficient data makes it difficult to determine causation since the data is not a clear representation of the entire population and important data is missing. The UL study also noted there could be several reasons why the injury rate for a product decreases; it may not be only changes in standards.

Some organizations, like the American Society of Safety Professionals (ASSP), are conducting impact studies with different goals than UL. For example, the ASSP is documenting the financial benefits of following voluntary standards, but unlike the UL study the ASSP study is not addressing product health and safety impacts (Wroth, Chapter 2). Additionally, the Canadian Standards Association Group (CSA Group) and the Association of Home Appliance Manufacturers (AHAM), maintain similar projects to UL but they are still being developed (Wroth, Chapter 2).

2.3.3 Current Efforts to Measure the Impact of Voluntary Consensus Standards

Our sponsor, tasked with formulating a methodology for determining the impact of voluntary consensus standards, reached out to UL, who had created their own ideas and possible solutions. This initiated a collaborative effort for both organizations to create their own methodology to measure the impact of voluntary consensus standards. They decided that they needed more input from different organizations to address the impact problem, so the CPSC and UL staff working on this project sought the help of ANSI. With ANSI, they were able to plan a presentation at the 2021 ANSI World Standards Week to discuss the possibility of creating a way to measure the health and safety impact of voluntary consensus standards. Through this event the CPSC and UL were able to convince a group of stakeholders to join them. Together, they formed a working group, known in this paper as the "ANSI working group", with the goal of writing a whitepaper that provides principles and a methodology that could be used to solve the issue at hand. A whitepaper is a report or guide that informs readers concisely about a complex issue and

presents a solution to that issue. It is meant to help readers understand an issue or make an informed decision. This work has already begun, which leads to what this project is about.

2.4 Measuring the Impact of Voluntary Consensus Standards

The whitepaper centers around one key idea: Impact. The goal is to determine what measure best represents the impact of a voluntary consensus standard, then, the causes of impact can be explored. This can be divided into two separate factors: Effectiveness and Conformance.

$$Impact = Effectiveness \cdot Conformance$$

2.4.1 The Impact Relationship

The impact relationship is a function consisting of effectiveness and conformance (McCabe et al., 2022). They are multiplication factors because there can be a very effective standard but if there is no conformance, then there will be no impact. The impact of a standard is any change that the standard has produced on the impacted population (McCabe et al., 2022). The impacted population is the part of the group that is directly affected by the change in the product such as the customers or consumers of the product (McCabe et al., 2022). The purpose of the impact relationship is to help provide meaning to the impact of standards on the health and safety of consumers within an impacted population.

2.4.2 What is Effectiveness?

Effectiveness is the "ability of the standard to produce a desired change in the impacted population" (McCabe et al., 2022). Effectiveness is the quantitative aspect of the impact relationship because it concerns the safety of the product and the injuries or deaths that occur (Kapp, Chapter 5). Effectiveness looks at data within a fifteen-year period, before and after a voluntary consensus standard was implemented, and compares the data. Some of the data includes death and injury rates, economic effect of these injuries, accident rates, and near misses.

There are many factors that affect the impact of standards so just looking at data within this fifteen year per before and after a standard was implemented may not be enough depending on the product and standard (Kapp, Chapter 5). The time before and after a standard can also change depending on the product. This is the product's lifecycle, which is the time it takes for a product to become replaceable. If a product has a very long lifecycle, such as a fireplace, a longer time period of data will need to be analyzed to determine the effectiveness of the standard. Similarly, for a shorter life cycle product, such as hoverboards, consumers must buy the same product more often and thus a shorter time span is required to achieve a similar amount of data.

2.4.3 What is Conformance?

While a voluntary consensus standard can be 100% effective, the standard will have no impact if consumers and manufacturers are not following the standard. That is why conformance is the other major element of the impact relationship. Conformance is defined as the "fraction of the end product, service, process, or concept that meets the standard and is in possession on the product's user" (McCabe et al., 2022). In summary, conformance the percentage of products owned by consumers that meet current standards for that product.

While researchers are confident about what causes effectiveness, the availability of known data about conformance is significantly less certain. This is because there are a variety of factors that can change conformance and makes it hard to identify and collect. Factors considered for conformance include the motivation for the industry to meet standards, assurance that the product meets the standard, the knowledge of people assessing the assurance of the standard and the ability of the tools used, and the time needed to replace old products with the new ones that follow the standards (McCabe et al., 2022). The way these are measured is by a percentage from zero percent to one hundred percent on how well the factor is being performed.

3.0 Methodology

The goal of this project was to evaluate the health and safety impact of voluntary consensus standards on consumer products using the principles from ANSI's working group guidelines. We worked with the ANSI working group to help analyze and produce data using their proposed impact relationship method from their developing whitepaper. To achieve this, we identified the following three objectives:

- Identify consumer products for possible analysis through conversations with interested parties.
- Select a sample group of products with input from subject matter expert interviews and data analysis.
- Critically evaluate the sample group and formulate narratives around the impact of voluntary consensus standards on the sample group of products using the principles.

The methods associated with each objective are detailed below.

3.1 Identify consumer products through conversations with interested parties.

We identified which products should be considered for review by consulting multiple organizations that are working on the whitepaper and consulting expert personnel at the CPSC. The criteria for products to make the list were changes to safety standards (which may lead to changes in conformance), and how long ago the change to the standard was made. These criteria are needed to have sufficient associated data to show impact.

In a meeting with the ANSI working group, we deliberated on what products may be productive for this project. This was a combination of consumer products and safety equipment that are used in the workplace. CPSC, UL, ANSI, and ISEA all participated in the review. Afterwards, we consulted with CPSC personnel about other products that could be interesting to analyze. We then created an extensive list of products to consider for review and analysis.

3.2 Select a sample group of products with input from subject matter expert interviews and data analysis

Using the list created from objective one, we narrowed the initial product list down through subject matter expert interviews with members of the CPSC, UL, and International Safety Equipment Association (ISEA). Then we used the ANSI working group principles to create a sample group of products that best represent changes in impact. We interviewed subject matter experts for each product to improve our understanding of each product and to identify the most relevant products needed to measure the impact of voluntary consensus standards on human health and safety (Appendix C). Before starting each interview, consent was established for the interview and recording (see Appendix A and Appendix B). Finally, we used the principles provided by ANSI's working group to select our final sample list of products to review. The principles stem from the IMPACT relationship and could be anything from incident rates to conformance

motivation. These factors will help analyze selected consumer products to see how the adoption of voluntary standards affects the safety of the product.

3.3 Critically evaluate and formulate narratives around the impact of voluntary consensus standards on the sample group of products using the principles.

Utilizing qualitative data to filter the list along with the ANSI working group's principles, we continued to research the sample group of products using reputable databases like NEISS, NHANES (National Health and Nutrition Examination Survey), and CPSC Clearinghouse database. We also conducted interviews with ANSI's working group to gain different perspectives about the whitepaper (see Appendix D). Using what was learned about the selected consumer products and the whitepaper, we created a report which details narratives around the impact of health and safety standards related to these products using the principles outlined in ANSI's whitepaper.

After applying the principles, two viewpoints were used to assess a standard's overall success. The first lens is how effective the voluntary consensus standard is. The data needed to be within a 15-year time span from before and after the implementation of a voluntary consensus standard. Some key data to focus on includes death and injury rates, economic impact, and accidents avoided. This evaluation is influenced by UL's part of the working whitepaper where they have supplied various principles that we used to gauge the effectiveness of a safety standard. The second viewpoint used to decipher whether manufacturers are meeting the standard, which is supplied by CPSC. Approaching a standard from this lens can be more difficult in that data is not as concrete as looking strictly at numerical data and drawing conclusions. Combining these two lenses allows us to better discover whether a voluntary consensus standard is impactful. We compiled different products to create a diverse narrative.

4.0 Results

4.1 Objective 1 – Products to Consider for Evaluation

We met with members of the ANSI working group to discuss a list of possible products to further analyze. We were able to organize a very broad list of products including safety equipment, electronic products, and consumer products. These products were chosen because they have had significant changes to their standards within roughly the past twenty years. Our list included the products listed in Table 4.1:

Cribs	Hairdryers	Candles	Hoverboards	Work Gloves	Work Helmets
Portable Generators	Face Masks	Home Sprinklers	Button Cell Batteries	Mechanical Garage Door System	ATV/ROVs
Ladders	Ceiling Fans	Blinds	Grills	Coffee Makers	Glass Front Fireplaces
Microwave Ovens	Washing Machines	Toasters	Deep Fryers	Paper Shredders	Lawnmower
Fall Protection Tethers	Gear for heat stress	Body Harness	LED Lights	Drying Machines	Baby Swings
Sports Helmets	Lead in Toys	Backyard Trampolines	Heating Blankets	Baby Walkers	Smoke Alarms

Table 1: Broad list of possible products to analyze

4.2 Objective 2 – Sample Group of Products

From the subject matter expert interviews, the interviewees talked about the product that they specialized in, provided a brief history of the major standards and standard changes within roughly the last 20 years and provided information on whether there is accessible data on a product. What resulted from these interviews was a reduced list of products that required more thorough data analysis to decide whether the product could be used in a narrative or framework.

To inform which products were on the narrowed down list, data from the interviews such as how accessible is product data, how much data is there on a product, whether there was a subject matter expert to talk about the product, and how recent the standard changes were. This reduced list was further refined by dividing the list into two different categories, one for the products that would have narratives written about them, and another for the products that would have frameworks written about them. A product that has a narrative written about it is a product that has accessible data that can be analyzed to show either effectiveness or conformance**. To select which**

products would have narratives written about them, the products were assigned to a principle based on whichever principle the product best represented. To obtain these principles, interviews with the ANSI working group were used to collect their perspectives on the value and meaning of different principles. These interviews resulted in four different principles that could be used to reflect conformance and one principle that could be used to reflect effectiveness. These are the principles in the whitepaper that were applied to a product:

Conformance	Effectiveness
Motivation	Death/injury rates
Knowledge	Ratios vs. Raw Numbers
Time	

Table 2: List of Principles from the Whitepaper

From here five products were selected to meet each of the six different principles with one product representing two different principles. This product list included hover boards for the injury rates principle, cribs for motivation factor, lead in toys for both assurance factor and knowledge factor and hair dryers for time factor. The products that would have frameworks written about them were products that had missing data or were not products that best represent a principle. After consulting the subject matter experts and using the principles from the whitepaper, we were able to finalize a sample group of products as presented in table 4.2.2:

Narratives	Project Frameworks
Hover Boards	Candles
Cribs	Construction Helmets
Lead In Toys	Portable Generators
Hair dryers	Sprinklers for Homes
	Drying Machines

Table 3: Sample Group of Products

4.3 Objective 3 – Forming Narratives for our Select Group of Products

To begin forming narratives, the first step was to further research data first collected through interviews with the subject matter experts. This data was found in three major places: the CPSC'c National Electronic Injury Surveillance System (NEISS), the CDC's National Health and Nutrition Examination Survey (NHANES), and the CPSC's Clearinghouse Data.

NEISS is a database that takes data from a sample of emergency room visits due to consumer products and puts anonymized information regarding each case into a database that is accessible to the public. Due to this database's ability to sort by which product to look at, it was the most helpful tool for analyzing rates for consumer products. The public version of the NEISS database only covers 2002-2021 as of this paper's writing, however some data from before 2002 was made available. The expanded NEISS data was used for the narratives created for hair dryers and cribs.

NAHNES is a national survey performed by the CDC on a random sample of Americans to assess the current health of the nation. The goal of NHANES is to find the average health of the

country by performing a variety of tests on the random sample chosen. The tests performed include scanning for diseases, taking a blood test, gaining dietary information, and many other tests. NHANES is great for product standards that might not cause an individual incident like what is seen in NEISS, but an issue that affects the long-term health of a products user. However, for NHANES to be used in that way, it needs to be a product that is seen in extremely large quantities. For that reason, NHANES was used in the toy's narrative.

Lastly, the CPSC's Clearinghouse Database is a searchable public database which compiles all the CPSC's data into one place. It includes data from select states' deaths certificates, comments from saferproducts.gov (a public place to report safety hazards of consumer products), news articles about consumer products that the CPSC has access to, and all the data from the NEISS database. Due to the larger number of sources, the qualitative data of the Clearinghouse Data is not as strong as NEISS, however it is still good for finding trends, especially among products that have lower incident counts. The clearinghouse data was used in the hoverboard narrative.

Once access was granted to the database used, analysis was done on that data to create useful information to be used in the narrative. The data for each narrative was different, so each narrative contains a method of how the data was obtained for it but there were some universal actions taken for all narratives. Any NEISS data taken from after 2002 was taken from the public NEISS website. For each narrative, the query builder was used to find exclusively the data needed for the product looked at. For clearinghouse data from after 2011, a similar tool exists which was used. For NEISS data from before 2002 and all Clearinghouse data from before 2011, the private program 'EPIR' was used to obtain the data, which requires CPSC clearance to obtain access to. Both the NEISS and clearinghouse data were obtained in the form of an Excel spreadsheet. For BLS data, the information is only able to be obtained through an online tool on the BLS website. A computer program was written in Python to obtain this information in an easy-to-read format. This program connected to the BLS server with a specific request for the information wanted and would record the response in an Excel spreadsheet.

There was some further analysis needed, as the requests that were possible to give to the query tools of the databases were generally not able to be to the level of specificity needed for the narratives. To further narrow down the results, another computer program was written in Python to be able to narrow down the information to what was needed. It worked by importing all the data from the Excel documents that were downloaded from the data's respective website, filtering the data by whatever the Narrative needed to select its required data, then exporting the data back to Excel, combining it all into one document in the process. This code used two free-to-use libraries in its implementation: pandas and xlwt. This code is in Appendix G. In addition, a change to the code was written to analyze the NHANES data as it did not come in Excel-type files. Instead, a different library was used to interpret the data: xport. Once the data was run through xport, it was able to be interpreted the same way as previous data. This alternative code can be seen In Appendix H. Once the correct data was selected, the last step was to create a graph to represent this information. Bar graphs were chosen for all the narratives as they most clearly showed the

information that was trying to be communicated. These graphs were generated using another Python library: matplotlib. The code used to create the graphs can be found in Appendix I.

4.3.1 Narrative 1 – Hoverboards

The effectiveness section of the whitepaper will emphasize using rates and ratios instead of raw numbers. Doing so normalizes the data and accounts for changes in sales, usage, and supply of the product. Ideally, the effectiveness of a standard should be measured by looking at the number of incidents in a set time divided by the number of that standard's respective product(s) that are used. However, knowing the number of a product that exists in the world can be nearly impossible in many cases. Therefore, the use of sales data, market size, and other public information can be used to estimate the number of products that exist.

An example of using this would be hoverboards. When hoverboards were first introduced to the public market in December of 2015, no existing product standards included requirements specific to hoverboards. However, UL 1642 Standard for Lithium Batteries did include requirements for the lithium-ion batteries used in hoverboards. Hoverboard incidents quickly proved to be a major issue; reports showed that their batteries were potentially dangerous. Hoverboards unexpectedly were igniting, burning and combusting. In 2015 alone, the CPSC's clearinghouse recorded 350 cases of hoverboards either "exploding" or "igniting".

In response to these reports, UL developed UL 2271 Standard for Batteries for Use in Light Electric Vehicle (LEV) Applications which was released in December 2016. UL 2271 included requirements that addressed issues with the hoverboard batteries (Tritek, 2022). To accomplish this, UL 2271 required more rigorous testing than what was required in UL 1642 to ensure the batteries used within hoverboards and other 'micro mobility' products within the scope of UL 2271 would not ignite or combust. The CPSC, through their office of compliance and field investigations, were able to determine substantial product hazards and mandated this standard so all new hoverboards sold in the US were mandated to follow UL 2271.

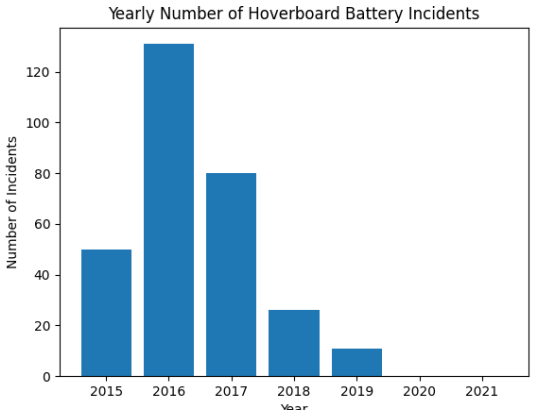

Figure 2: Bar Graph Comparing Number of Hoverboard Incidents Including the Terms "burn", "fire", or "explode" on the CPSC's Clearinghouse database by year

As a result of the standard being mandated, reported incidents of hoverboard battery issues started to decrease rapidly. In the meantime, the sales for hoverboards rapidly increased until 2017 and has since only slightly increased. Despite hoverboards' increased sales and presence on the market, there are fewer reported issues with hoverboard batteries now than in 2016. According to the CPSC's clearinghouse database, the number of incidents of hoverboards combusting or "exploding" decreased by nearly 40% from 2016 to 2017. This decline continued as the hoverboards manufactured before UL 2271 was published gradually were removed from consumers possession, either from recalls or being

discarded and replaced by newer products that meet UL 2271. By 2020, the CPSC clearinghouse data does not show any incidents regarding hoverboards combusting or exploding. This occurred during a time of sales numbers increasing for hoverboards. This example shows how UL 2271 was effective at preventing battery combustion and explosion, as the rate of reported hoverboards experiencing these issues fell to zero.

4.3.2 Narrative 2 – Baby Cribs

The conformance section of the whitepaper will introduce the motivation factor as an important principle to consider when measuring the impact of voluntary consensus standards. The motivation factor captures the reasons a manufacturer would want their product to meet a standard. The higher the degree of motivation the higher the conformance to the standard. Motivation can be viewed as a spectrum from very high motivation, such as a standard being mandated by law, to a very low motivation, such as not knowing of the standard (McCabe et al., 2022). Some of the levels in between include standards viewed as best practices by the industry, standards recommended by authorities and required by the industry, and producer desired standards (McCabe et al., 2022).

An application of this principle is seen in baby cribs. Before the ASTM F1169 *Standard Consumer Safety Specification for Full-Size Baby Cribs*, was published in 1999, cribs had one of the highest infant death incidents among juvenile consumer products. Problems included infants stuck in the slat spacings on the side of the crib, infants caught in between the mattress and the side of the crib, and cribs falling apart. A popular feature on cribs was a drop side that allowed parents easier access to their child. ASTM F1169 included a requirement for the strength of the drop side of the crib, but few cribs in the market met this requirement. However, the crib incidents increased each year after the standard was published. The US Congress passed the Consumer Product Safety Improvement Act (CPSIA) of 2008 to help alleviate these issues. The CPSIA allowed the CPSC to mandate voluntary consensus standards for juvenile products (*The Consumer Product Safety Improvement Act (CPSIA)*, n.d.). Analysis of crib incidents revealed that the drop side was a main cause of many of the serious infant injuries. ASTM F1169 was revised to prevent the hazards seen from drop side incidents and then ASTM F1169 was quickly mandated through the CPSIA. According to the CPSC NEISS database, the total number of reported incidents involving cribs increased from 357 in 2002-2003, to 368 in 2004-2005, to 486 in 2006-2007, and to a peak of 579 in 2008-2009. The incidents generally decreased each year after 2009

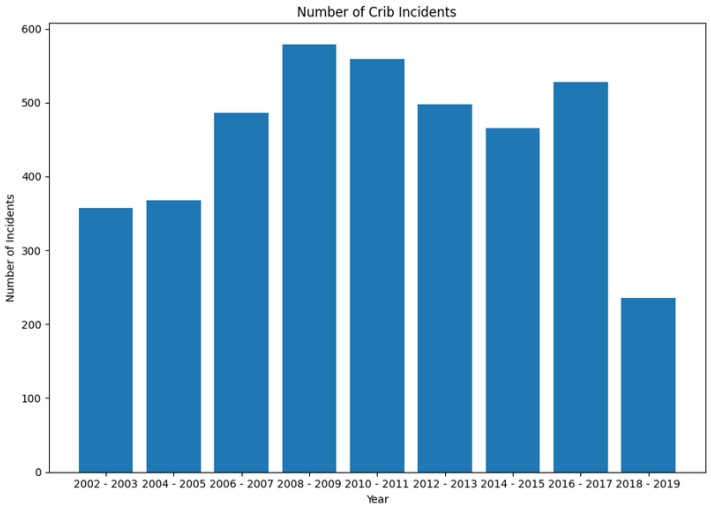

Figure 3: Bar Graphs Comparing the Number of Crib Incidents on the CPSC NEISS Database by Year

(see figure 3). When ASTM F1169 was published in 1999, the motivation to comply to the standard was low, thus incidents still occurred and increased. Once ASTM F1169 was mandated in 2008, the motivation to comply to this standard increased. This change in motivation increased the health and safety impact of ASTM F1169 as fewer infants were injured.

4.3.3 Narrative 3 – Lead in Toys

The conformance section of the whitepaper will introduce the knowledge factor as an important principle to consider when measuring the impact of voluntary consensus standards. The knowledge factor describes the effect that the tools used to assess the product have on the overall conformance to a voluntary standard. The higher the quality of tools used to assure the compliance of the standard leads to a higher conformance of that standard. Tools include the x-ray fluorescence (XFR) which is currently used to check the lead content levels in toys. This principle in action can be seen through the example of lead in toys.

Before ASTM F963 Standard Consumer Safety Specification for Toy Safety was introduced, lead was in many products such as toys. This was causing rising lead levels in blood which was dangerous for many people. There has been progress in creating standards to limit the amount of lead in products since the 1970s. ASTM F963 Standard Consumer Safety Specification for Toy Safety was published in 1996 and included requirements for the amount of lead and other chemicals in children's toys (*Standard Consumer Safety Specification for Toy Safety*, n.d.). ASTM F963 influenced the decrease in lead blood levels seen since the late 1990s. In 2008, the CPSIA allowed the CPSC to mandate voluntary consensus standards for juvenile products like toys. This act lowered the allowable amount of lead in paint from 600ppm to 90ppm and restricted the amount of lead in toy component parts to 100ppm. According to the National Health and Nutrition Examination Survey (NHANES), the average blood level for people ages six and up across the

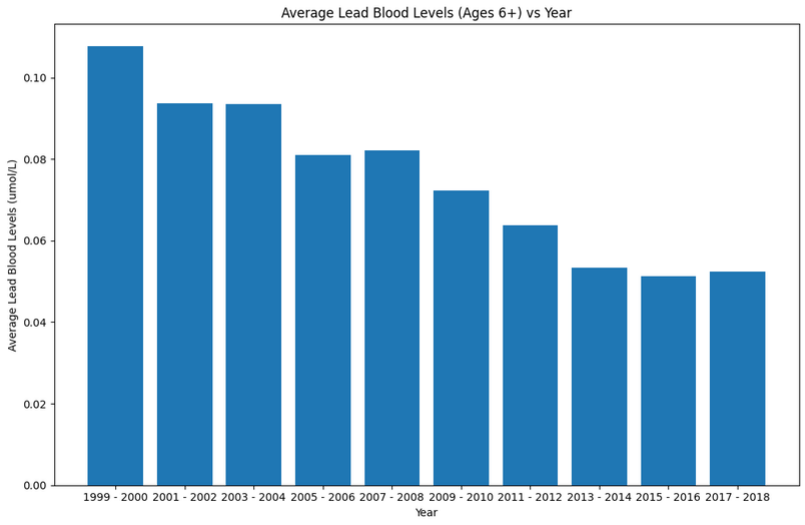

Figure 4: Bar Graph Comparing the Average Lead Blood Levels of People ages 6+ by year from the CDC NHANES Database

United States decreased from 2008 to 2012, which was 64 percent faster than from 2004 to 2008. Before the CPSIA, the leech test was used to measure lead in toys. The leech test assessed how much lead could potentially fall off the product. After the CPSIA passed, the CPSC began using the XFR to test for lead in toys at different ports across the United States. The XFR is used to check the lead content levels within a product. Additionally, as a result of the CPSIA, more CPSC staff were testing for lead in toys. Not only was there more testing after the CPSIA but the tools used in these tests were improved. Using the same data as above, there was a larger decrease in lead blood levels after 2008 than before. There was higher knowledge of testing methods used to check the conformance of the product to the standard, so the conformance was higher, the impact was greater, and the lead blood levels were lower.

4.3.4 Narrative 4 – Hairdryers

The conformance section of the whitepaper will introduce the time factor as an important principle to consider when measuring the impact of voluntary consensus standards. The time factor describes how the time needed to replace older, non-conforming products with newer, conforming products (product lifespan) can affect the impact. Products with short lifespans are quickly replaced by consumers with newer products, consumables such as liquid laundry packets are an example.

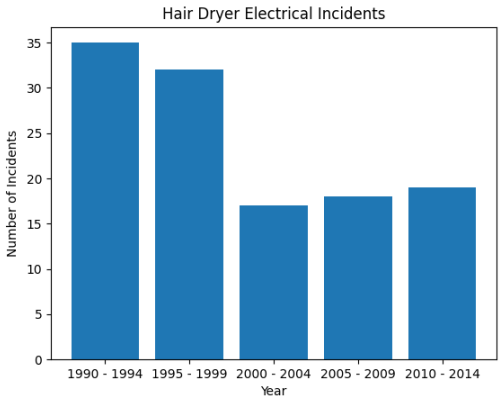

Figure 5: Bar graph comparing the number of hair dryer incidents including the terms "electric", "electrocution", "short", and "spark" on the CPSC NEISS database by year

Liquid laundry packets are small plastic packets that contain liquid laundry detergent, used by consumers for washing clothing. However, in 2012 incidents started appearing in the CPSC's NEISS and Clearinghouse databases about the ingestion of these liquid laundry packets, particularly among young children. This led to the CPSC to push for new standardization to address this issue. By 2015, ASTM published their F3159 *Standard Safety Specification for Liquid Laundry Packets* standard to make these packets hard to get into young children's hands. It did this by making them harder to access and required two separate motions to open, like medication. With a short lifespan, consumers are replacing older liquid laundry packets with newer ones within generally a few months. This means that consumers should have, within a few months of the change to ASTM F3159, liquid laundry packets that mitigate the identified hazard. Therefore, when the injury data is viewed, the drop in cases happens within a few months of the change in standard (*CPSC Report to ASTM International F15.71 on Liquid Laundry Packet Injuries*, 2018). However, for a product with a longer lifespan, it may take a long time for consumers to replace their older non-conforming products with newer, conforming products, handheld personal appliances such as hair dryers are an example.

Hair dryers are hair grooming devices that blow hot air out to expediate the process of drying hair. It does this with two mechanisms: a small electric heater (like portable heaters) to heat up the air around it and a fan to blow that warm air in the desired direction. However, prior to the publication of UL 859 *Household Electric Personal Grooming Appliances*, hair dryers shocked and electrocuted numerous consumers. A typical scenario involved dropping the hair dryer into a sink or bathtub filled with water. UL 859 addressed this issue in 1987 by requiring GFCI capabilities, immersion protection, and reduced risk of electric shock if energized and immersed in water (*Substantial Product Hazard List*, 2011). According to the CPSC NEISS database, the total number of reported electrical incidents for hair dryers went from 25 before 1987, to 35 in 1990-1994, to 32 in 1995-1999, to 17 in 2000 - 2004(see figure 5). Note: the relatively low number of cases before 1990 is due to a significant change in how NEISS data was collected in 1990, case numbers were likely like what was seen 1990-1994 (National Injury Examination Surveillance Survey). This illustrates the time delay due to the product lifespan, consumer will typically keep these appliances for several years before replacing. The new requirements to UL 859 were added in 1987 and it took approximately twelve years before the impact of fewer hair dryer shocks and electrocutions were seen. After the initial decline in incidents, there was an increase in incidents from 2000 to 2014 most likely due to better data collection and reporting resulting in the improved overall quantity and quality of data.

4.4 Objective 3 - Future Product Frameworks

In the research for the five main products that were used to create the narratives, there were other products that were found to have an interesting case for further analysis that were not chosen due to the short amount of time of the IQP. These products could be the center of future IQPs or other projects, as all of them involve aspects that were unable to be done in this IQP.

4.4.1 Candles

In the late 1990's, the number of fire related incidents had noticeably increased due to candles over time. It was also during this time that candle sales were at their peak. As a result, there was an ASTM subcommittee dedicated to developing voluntary consensus standards relating to candles. When analyzing how impactful the candle standards were, however, there was a key aspect to the analysis that was missing: the number of candles in the marketplace. Most industry experts agree that the number of sales for candles has gone down since the year 2000, but the scope of how much they went down is unknown. The issue with this is that there have been standards released on top of the falling sales data. As a result, there is no way to separate the declining sales and the impact of the standard. Future project groups could work with the candle industry to find a method to measure the sales of candles. Finding these sales numbers would allow that group to find what proportion of the decrease in injuries is due to a decrease in the number of candles and what proportion of the decrease in injuries is due to the change in standard. Data on the proportion of injuries to the total number of sales allows for candle voluntary consensus standards to more accurately be tested for impact using the current impact relationship.

4.4.2 Construction Helmets

Currently, construction helmet standards being worked on by standard developing organizations such as the International Safety Equipment Association (ISEA). These standards look to address the problem of helmets falling off workers by adding chin straps to secure the helmet to the heads of the workers. They are in the revision process at the time of writing this report, so it is impossible to conduct data analysis to determine the impact of this standard as there is very little data. This would replicate something similar to a snowboarding helmet. This standard has not been widely adopted, since it has not been published, but instead was adopted on a company-by-company basis. These companies have already started implementing the ideas of the standard even though it has not been published. One such organization is the Clark Construction Group and they have seen a reduction in injuries. Therefore, a future project group could choose to work with a company that uses helmets that follow the new or upcoming standard and compare the injury rates to another company that does not use helmets that follow the new or upcoming standard. This is a more direct approach when working with a smaller sample size instead of using nationwide databases that require time to pass after the standard is published and adopted to let the data catch up. This is a different approach that can be used to measure the impact of voluntary consensus standards but would only be successful for workplace or industry products. This project focused on consumer products so this different method would not have worked for the type of analysis done in this project. This other method of determining impact could also be done in anticipation of a standard being published because it could give standard developing organizations new information when establishing standards

4.4.3 Portable Generators

The cases that were examined were cases where the voluntary consensus standards were impactful. This was intentional, as having a case that is not impactful wouldn't show the principles in a clear way, which is one of the main purposes of the narratives. However, it is important to show the failures of voluntary consensus standards, and how if any of the principles are not met, a standard will not be impactful. Portable generators exemplify this issue most. The subject matter expert for portable generators talked about how a split industry, a lack of motivation to solve the problem, and even some level of corruption has led to two standards being formed for portable generators: UL 2201 and PGMA G300. Nearly every other product only has one standard for it to prevent inconsistent standardization, however due to the issues already stated portable generators have two: yet neither of them is particularly impactful. PGMA G300 fails to be impactful because the problems that it attempts to solve were already addressed by the industry and were a small portion of the total number of incidents relating to portable generators. UL 2201 does successfully address the main issue causing portable generator incidents (that being their abnormally large amount of Carbon Monoxide release), but due to a lack of motivation within the portable generator industry, only one major manufacturer follows this standard, making its motivation factor exceptionally low and its impact by proxy. A future project could analyze these two standards – among other standards that have failed to have a major impact – to reenforce the point that to have an impactful standard a following of all of the principles laid down by the ANSI working group should be targeted.

4.4.4 Sprinklers for Homes

Commercial sprinklers were a product that was considered throughout the process of Objective 2, however there was one main reason for the removal of it: the spread-out nature of the data. The standard for sprinklers, UL 199, applies to residential sprinkler systems and is impactful in preventing house fires. When recording sprinkler incidents however, unlike injury data, the data that is obtained from fires is not centralized or even required to be recorded in the first place. This means that an analysis of commercial sprinklers would lack sufficient data to make a comparison to the data of other counties. However, a comparison of Prince George's County – one of the only counties in America to mandate residential single-family homes to install sprinklers – to another county that does not mandate sprinklers would be an informative analysis for a future project. In addition to lacking a unified database, commercial sprinklers are heavily intertwined with state or county building codes. Since sprinkler systems are not available at retail stores, installing a sprinkler system requires a third party that would install the system adhering to state and county building codes. The issue with commercial sprinkler systems is that information regarding whether local authorities are enforcing the installation of sprinkler heads into homes is lacking A future project group can work with counties to record better data by investigating if there is a way to better detail if sprinkler installation is enforced or not and to gather the data into a single database. Additionally, since local authorities are charged with enforcing sprinkler standards and there is no comprehensive data source, it is difficult to recommend enforcing sprinkler system installation to the counties that may require it the most.

4.4.5 Drying Machines

The time factor of conformance is harder to analyze the longer a product's life cycle is. Home appliances are an example of a product that has an extremely long-life cycle, and the case that would be of most interest to further investigate would be dryers. In addition to the time factor aspects of dryers, the information for electric dryers is a case of reading data in a qualitative way. Prior to the implementation of a standard there were roughly 4000 cases of electric dryer fire incidents with a very low number of these incidents resulting in death. To address this the UL standard UL 2158 reduced the spread of an internal fire to an outside source as opposed to stopping internal fires completely. Conformance to this standard is high throughout industry. However, the number of cases for dryer fires didn't significantly decrease even among newer dryers despite the cases of dryer fires being more contained and did not lead to fires spreading beyond the dryer which could cause extreme property damage. This reduced the amount of property damage caused by clothing dryer fires. This means that incident data need to be looked at in a qualitative way as a group should look for a decrease in dangerous dryer fires and not just overall dryer fires.

5.0 Recommendations for the ANSI Working Group

Among the time spent interviewing members of the ANSI group, some concepts were brought up by some of the interviewees that should be reconsidered by the group. In this process, three recommendations were found to hopefully improve the whitepaper.

1. **The ANSI Working group should reconsider the definition of effectiveness in the whitepaper, basing the definition on separately measured principles.**

The ANSI working group defines effectiveness as a measurement of the change in the rate of incidents, using databases like the CPSC's NEISS database to assist with this. This method of measuring effectiveness has issues. The rate of incidents for a product gets changed by conformance just as much as it does effectiveness. This means that the rate of incidents better measures impact rather than effectiveness: as it consists of both the effectiveness and conformance sections of the impact relationship. The ANSI Group has acknowledged this, and there is a section of the whitepaper planned to show the interdependence of effectiveness. The recommendation for this section of the whitepaper would be to make a stronger effort to make the definition of effectiveness independent from conformance. The current definition of conformance is far less intertwined with effectiveness than the reverse. To solve this issue, there should be a reexamination of the definition of effectiveness.

The definition of effectiveness should consist of principles that can be measured independently, like the principles of conformance. The two principles of effectiveness should be a rating of how much a standard solves the problem and a rating of how many of the incidents of a product are solved by the standard. The section on how much a standard solves the problem could be tested in a lab. If a standard X solves every instance of the problem it is attempting to solve, it will receive the highest rating for this principle, however, if it only solves some cases, it would be lower. The second rating stating how prevalent the problem would be a measurement of how prevalent the problem is among all the incidents of a product. If standard X solves every case of a specific problem, but that problem is only prevalent in 5% of cases, then that standard would be less effective than a standard that would solve a problem that is prevalent in 50% of cases. More principles may be added as seen fit. This new definition of effectiveness, while still not completely independent from conformance, would be much more self-standing and would make the ability for standards developers to estimate impact by estimating values for all the principles, then use the data to see if their estimates are correct. If they are not correct, they can look at each of the principles to find an explanation for why the standard is not impactful, and where they can focus to look to make it more impactful – whether in effectiveness or conformance.

2. **The ANSI working group should expand the scope of the paper to include other types of voluntary consensus standards.**

In the ANSI working group, there are many standards developing organizations that work to create a plethora of different voluntary consensus standards. However, because many of the writers of the whitepaper work with voluntary consensus standards on consumer products, the whitepaper is clearly written with a narrowed perspective, focusing on product standards, rather

than voluntary consensus standards of all types. To attain a broader audience, it's imperative for the ANSI working group to also broaden the content. The working group should agree on a way to move forward with a more inclusive whitepaper. There are many ways to accomplish this; for example, the group could add writers with different backgrounds or increase the role of organizations that work with other types of voluntary standards like the EPA.

3. The ANSI working group should create another version of the whitepaper for end users.

The ANSI working group should create a second version of the whitepaper meant for end users not in standards development. The ANSI working group has worked incredibly hard over the past year to create a product that will help the creation of standards across the United States. However, an emphasis on making this paper more accessible to people outside of the standards development world would make this paper even more valuable. The accessibility of standards was brought up by Interviewee 23 as a key goal for ANSI and a more open whitepaper would help immensely in that goal. Many consumers outside the world of standards don't understand the importance of voluntary consensus standards in their daily lives. Since the whole purpose of the ANSI Working Group is to create a methodology to show the impact of voluntary consensus standards, the resulting studies using the principles outlined in the whitepaper will start to shed the light on this great level of importance. The people who read these studies may want to know exactly how these standards were formulated without reading long sections about definitions and purpose. For this purpose, a version of the whitepaper after it is complete that explains the goal and different principles in an easy-to-read way would be incredibly useful. A lot of the terms used in the whitepaper are defined in a different way than many people outside the standards world use them, and a supplementary document would create a version of the whitepaper that is more understandable to people outside the standards world without dampening the highly specific language used in the main whitepaper. While this is an important addition to the whitepaper, it shouldn't be done until after the main whitepaper is complete, as a complete whitepaper is necessary for this to be complete.

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Appendix A: Interview Consent Form (Recording)

Informed Consent Agreement for Participation in a Research Study

Investigators: Nicholas Uy, David Rosenstein, Max Kanefsky, Jagger Polvino

Contact Information: Group Email: gr-dc22-cpsc@wpi.edu

Title of Research: Assessing the Human Health and Safety Impacts of Voluntary Consensus Standards

Sponsor: WPI

Introduction: You are being asked to participate in a group interview. Before you agree, however, you must be fully informed about the purpose of the research, the procedures to be followed, and any benefits, risks or discomfort that you may experience as a result of your participation. This form presents information about the study so that you may make a fully informed decision regarding your participation.

Purpose of the research: The goal of our project is to evaluate the health and safety impact of voluntary consensus standards on consumer products using the principles identified by an ANSI working group.

Procedures to be followed: There will be a series of questions asked by the interviewer(s) to be answered by the interviewee. All questions are optional and do not need to be answered. The interviewee may leave at any time for any reason. The interview will be recorded for the entire time. If the interviewee wishes to not be on the recording, they can ask to not be on camera in a physical interview or turn off their camera in an online interview, however their voice will be recorded. This recording will be held by the research group for the duration of the group. It may be shown to the sponsor of the group but will not be shown to anyone else. Once the research is complete this video will be deleted and not kept long term.

Risks to participants: There are no known risks if the person participates in this interview.

Benefits to research participants and others: Participants would be contributing to important research on voluntary consensus standards. Improving these standards may prevent future harm for consumers and manufacturers.

Record keeping and confidentiality: Records of your participation in this study will be held confidential so far as permitted by law. However, the study investigators, the sponsor or it's designee and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (WPI IRB) will be able to inspect and have access to confidential data that identify you by name. Any publication or presentation of the data may identify you if deemed necessary.

Compensation or treatment in the event of injury: There is a low likelihood of participants being injured or physically harmed in this group interview. No compensation will be provided if this event does occur.

Cost/Payment: There are no known costs or payments required to set up this interview.

For more information about this research or about the rights of research participants, or in case of research-related injury, contact:

Group email is mentioned at the top of this form.

IRB Manager: Ruth McKeogh, Tel. 508 831- 6699, Email: irb@wpi.edu

Human Protection Administrator: Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu

Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits. The project investigators retain the right to cancel or postpone the experimental procedures at any time they see fit.

By signing below, you acknowledge that you have been informed about and consent to be a participant in the study described above. Make sure that your questions are answered to your satisfaction before signing. You are entitled to retain a copy of this consent agreement.

_____ Date: _____ Study

Participant Signature

_____ Study

Participant Name (Please print)

_____ Date: _____

Signature of Person who explained this study

Appendix B: Interview Consent Form (Non-recording)

Informed Consent Agreement for Participation in a Research Project

Investigators: Nicholas Uy, David Rosenstein, Max Kanefsky, Jagger Polvino

Contact Information: Group Email: gr-dc22-cpsc@wpi.edu

Title of Research: Assessing the Human Health and Safety Impacts of Voluntary Consensus Standards

Sponsor: WPI

Introduction: You are being asked to participate in an interview. Before you agree, however, you must be fully informed about the purpose of the research, the procedures to be followed, and any benefits, risks or discomfort that you may experience as a result of your participation. This form presents information about the project so that you may make a fully informed decision regarding your participation.

Purpose of the research: The goal of our project is to evaluate the health and safety impact of voluntary consensus standards on consumer products using the principles identified by an ANSI working group.

Procedures to be followed: There will be a series of questions asked by the interviewer(s) to be answered by the interviewee. All questions are optional and do not need to be answered. The interviewee may leave at any time for any reason. The interview will not be recorded at any point.

Risks to participants: There are no known risks if the person participates in this interview.

Benefits to research participants and others: Participants would be contributing to important research on voluntary consensus standards. Improving these standards may prevent future harm for consumers and manufacturers.

Record keeping and confidentiality: Records of your participation in this study will be held confidential so far as permitted by law. However, the study investigators, the sponsor or it's designee and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (WPI IRB) will be able to inspect and have access to confidential data that identify you by name. Any publication or presentation of the data may identify you if deemed necessary.

Compensation or treatment in the event of injury: There is a low likelihood of participants being injured or physically harmed in this interview. No compensation will be provided if this event does occur.

Cost/Payment: There are no costs or payments required to set up this interview.

For more information about this research or about the rights of research participants, or in case of research-related injury, contact:

Group email is mentioned at the top of this form.

IRB Manager: Ruth McKeogh, Tel. 508 831- 6699, Email: irb@wpi.edu

Human Protection Administrator: Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu

Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits. The project investigators retain the right to cancel or postpone the experimental procedures at any time they see fit.

By signing below, you acknowledge that you have been informed about and consent to be a participant in the study described above. Make sure that your questions are answered to your satisfaction before signing. You are entitled to retain a copy of this consent agreement.

_____ Date: _____

Participant Signature

_____ Participant

Name (Please print)

_____

Signature of Person who explained this study

Appendix C: Interview Questions and Concepts

Interviewee information

- Name, title, and affiliation
- Can you describe your role in the organization?

Background on our work

- Explain IQP project to the participants:
    - Goal: To evaluate the health and safety impact of voluntary consensus standards on consumer products using the principles identified by an ANSI working group.
    - Objectives:
        - Identify selected consumer products through research and interviews
        - Assess health and safety impacts for a sample of consumer products based on identified principles
        - Analyze and describe the impact of principles for our test cases.

Interview Topics and Questions

- Can you describe your experience with [product]?
    - What previous issues with [the product] did you see?
- Can you give a brief history of the product's voluntary standards? What voluntary standard(s) are applicable to [the product]?
- What change(s) were made to the voluntary standards for [this product]?
    - When did this change take effect?
- Have you looked at the data since the voluntary standard change(s)? If so, does the data show the effects of the change in standards?
    - Where can you find this data?
- Are there any important things to know about the history of this product?
- Are you aware of any other changes to the voluntary standard that may affect the analysis?
    - Are you aware of any other confounding factors that may affect the analysis?
- Are there other products that you are aware of that may be interesting to look at regarding our work? More specifically, we are interested in voluntary standard changes that were made far enough in the past that sufficient data may exist to analyze the impact.

Concepts we would like to cover during the interview:

1. Info. on interviewee
2. Our background and our project

3. Experience that the participant has with the product
    a. Relevant voluntary standards, previous issues, issues identified, when the standard was changed, and when it was put into effect
4. Data: Databases used to research [product]
5. Any recommendations of other products to add
6. Any other recommendations on how to move forward

Appendix D: ANSI Interview Questions and Concepts

Interviewee information

1. Name, title, and affiliation
2. Can you describe your role in the organization?

Background on our work

- Explain IQP project to the participants:
    - Goal: To evaluate the health and safety impact of voluntary consensus standards on consumer products using the principles identified by an ANSI working group.
    - Objectives:
        - Identify selected consumer products through research and interviews
        - Assess health and safety impacts for a sample of consumer products based on identified principles
        - Analyze and describe the impact of principles for our test cases.

Interview Topics and Questions

- What is your role in the whitepaper?
- Given your role at ANSI [working group], what is your perspective on the purpose of the whitepaper?
- What is the impact of the whitepaper regarding the stakeholders?
    - How do you think this will change voluntary standards?
    - What part of the paper do you think is the most important?
- How will this project affect your respective organization?
- Do you expect that changes will need to be made/ a new white paper will need to be drafted in the future?

Concepts we would like to cover during the interview:

- Info. on interviewee
- Our background and our project
- Experience that the participant has with their organization
- Gaining their perspective and purpose of the paper

Appendix E: Consumer Product Subject Matter Expert Interview Summaries

Interviewee 1

Interviewee 1 is the associate executive director for engineering science for the CPSC. They provide expertise for mechanical, human factor, electrical, and fire safety engineering. They develop regulations and determine the defects of products and work to correct them.

The first product that was discussed was baby cribs. Cribs had one of the highest infant death rates among all products due to problems in the slat spacing, mattress, stability, and moving parts such as the side door. Standards have been worked on since the 1970s to try and fix these issues, but the real change happened in 2008 with the Consumer Product Safety Improvement Act, which was a Congressional Act. This act developed mandatory regulations for juvenile products and turned voluntary consensus standards into mandatory standards. The already established standard for cribs was one of the first standards ever to go through this process and it resulted in the elimination of the drop side on the crib. The standard becoming mandatory was very effective and the conformance level was obviously very high since the government was involved.

Baby walkers were discussed next, however not much information was received. The issue with baby walkers was that children were falling down the stairs in them. Baby walkers went through a similar process to cribs since the CPSC sent out an advanced notice of proposed rulemaking, which lets manufacturers know that baby walkers were going to be regulated. CPSC was ordered by Congress to send this advanced notice out, and the voluntary consensus standards followed.

Garage door operators came up next, and their issue was malfunctioning and causing the garage door to crush children underneath. This issue happened in the 1970s and 1980s and the standard quickly followed so a lot of time has passed. The standard created a sensor on the garage door to sense obstruction, and a sensitivity adjustment that returns the door after hitting something. Conformance could have been an issue if the standard remained voluntary, but it became mandatory, as well as the new revisions, so it never was an issue. We then discussed the data involving garage door incidents and learned that since garage door operators have a long lifecycle, the data will be skewed. To get sufficient and accurate data, data from ten to twenty years after the standard was mandated would need to be analyzed.

Interviewee 2

Interviewee 2 is the research manager for the data science team in UL tasked with applying research to help find solutions.

The product that was discussed with this interviewee was hair dryers. Hair dryers were accidentally electrocuting consumers, and some were resulting in fatality. The standard that fixed this issue included Ground Fault Circuit Interrupters (GFCI) capability and was published on March 27, 1987. Data that was analyzed five years after the standard was not entirely conclusive based on the limitations of the databases, but a significant amount of time has passed since then. Also, UL did not perform an in-depth analysis of the Clearing house database, which showed better

results, so hair dryers could still be useful to do further analysis on. The conformance level for this standard was possibly high since many manufacturers want the UL label on their products so that they can sell more.

Interviewee 3

Interviewee 3 is the CPSC EXHR Fire Program Area Manager.

The first product discussed was candles. During the late 1990s there was an increase in incidents relating to fires due to candles. The industry responded by creating a subcommittee in ASTM dedicated to creating voluntary standards around candles. After that the CPSC was petitioned by the National Association of State Fire Marshals to make these candle standards mandatory since they did not expect conformance to be high. However, this decision was deferred since the CPSC wanted to wait to see if the data backs up the expectation of low conformance. In 2015, there was a substantial decrease in injuries, deaths, and fires so the standard stayed as a voluntary consensus standard since it was effective and there was conformance. Since then, the issues with candles have continued to decrease. A large component of that decrease has to do with the candle usage rate decreasing, so to get a more accurate analysis of the impact of the standard, candle sales would need to be collected. This data is very hard to receive, but 90 percent of candles sold in the USA are manufactured by companies that are members of a trade association that is interested in safety candles. This trade association could be something of interest to investigate.

The next product that was discussed was grills. The problem with grills was with the venturi, a hole in the pipe that allows air to flow in and does not allow fuel to flow out since the fuel is moving at sufficient speeds. The issue with this is that grills are kept outside, so insects and debris were getting into the pipes and clogging them. This caused the flames to jump through the venturi which resulted in many near misses but not many injuries. The ANSI z21.89 standard addressed this issue by placing a screen over the venturi, but it is hard to perform impact analysis on a standard that solved an issue that did not result in injuries. Near misses are not recorded nearly as often as injuries.

The last product was sprinklers, however there was not much to be said about them. The standard is a model code that is adopted based on jurisdiction. It has an interesting case for the conformance side, but the data is very complex and there are many confounding variables.

Interviewee 4 and 5

Interviewee 4 is an EXHR for the risk management group of the CPSC and interviewee 5 is part of the division of engineering sciences of the CPSC.

The product discussed with these interviewees was hoverboards. Since hoverboards are a relatively recent product, the entire history of hoverboards was discussed and the information received was very detailed. Hoverboards were introduced in the Consumer Products Show in

January of 2015 but were not entered into the market until December of 2015. In less than a year, incidents started to pop up with fires and batteries exploding. Since the product was the first of its kind, there were no voluntary consensus standards yet. This made it difficult for data to be collected and for the manufacturers to determine the issue with hoverboards since other countries were constructing their own hoverboards with different parts and selling them in the US. With no standards there was no regulation. UL 2272 was first drafted in January of 2016, and it covered all micro mobility. Since the standard was drafted and published so quickly and the injuries from hoverboards were severe, letters were sent for compliance from the CPSC. These letters let manufacturers know that they may take recall action if the product is not meeting the standards. This led to a very high conformance which led to a positive impact on human health and safety. Even though this product has not been on the market for a long time, there still is sufficient data since hoverboards were recalled and were covered in the news.

Interviewee 6

Interviewee 6 is the director for electrical engineering sciences at the CPSC.

The first product discussed with this interviewee was toasters. Food was getting caught in the toasters which led to around 2500 fires before the standard was published. UL addressed this problem when they introduced standard UL 1026 which included fire containment tests to try and prevent fires and mitigate their spread. Fire losses went down since fires were contained but they still happened. In 1997 through 1998, a change in the standard was made to automatically turn off the heating elements in toasters. This change has been mostly implemented but toasters have a short life span so the data should have caught up by now.

Slow cookers and deep fryers also fell under UL 1026. For them the standard addressed the issue of children pulling on cords which pulled down the cooker or fryer onto them. An attachable cord was added so that when children pull on it, the cord detaches. For slow cookers, this standard was not as effective as UL had hoped because there were low numbers of reports due to offsetting hazards.

Ground fault circuit interrupters were discussed next, but the information and data are hard to find. The electric shock incident went from 160 a year to way down, but it is hard to determine the cause as only the standard. There are hazard assessment projects that may contain data, cost/benefit analysis, and some other information but

Interviewee 7

Interviewee 7 is the director of standards for the ISEA and is a member of the association of manufacturers that develop safety equipment.

In this interview safety equipment and work products were discussed instead of the usual consumer products. The first product was hand protection, and the most significant standard was

published in 2019. It is currently in the process of being updated so it would be impossible to find sufficient data to perform any analysis on. The standard addressed the problem of objects being dropped on hands so a foam was developed that can be used in impact resistant gloves. The standard was developed by ISEA in accordance with ANSI requirements. There is also a slower conformance for these types of products since companies need to gain access to these gloves and get them to their workers.

A similar problem is happening with work helmets since the changes to the standards are happening right now. Additional protection is being worked on to add to helmets, such as chin straps and a bump cap. These additions would better secure the helmet on heads and better protect the user when falling. Smaller case studies have been done, so analysis could be done for further investigation. Clark Construction for example has moved from hard hats to more of a sports helmet style hat.

The standard for tethers and body harnesses came out in 2018 which may be too recent to see significant data but according to the interviewee there might be. OSHA records drop object incidents so it would not be difficult to find the correct database, but again not enough time may have passed to see changes in the data.

Interviewee 8

Interviewee 8 is a mechanical engineer for the directorate of laboratory sciences and mechanical engineering for the CPSC. They are also the head for helmet testing and voluntary consensus standards creation for the CPSC.

The product that was discussed with this interviewee was bike and sports helmets. Before 1994 there were many voluntary consensus standards on bike helmets, which approved many different aspects, but there were still plenty of bike related injuries. In 1994, bike helmets became a regulated product and in 1999 it went into effect. The bike helmet standard before the regulation is CPSC-16-1203 and it contains a few things that the regulation does not cover such as variable head forms and rotational impacts. ASTM published a standard, ASTM 1447, that matches the regulation but also includes variable mask head forms with different weights for different heads.

Sports helmets are a little different since the National Operating Committee on Standards for Athletic Equipment (NOCSAE) covers them, CPSC also does, and there is a high conformity to their standards. For example, the NFL helmets are covered by NOCSAE and if the helmets are not up to standard, then the players will complain. The NFL is technically under the CPSC jurisdiction, but NOCSAE is the group that really handles sports equipment standards, since again they have a high conformity. Sports helmet standards have more activity around them, since there is more interest and more impact that occurs to the head when used. For example, ASTM sports helmets standards are updated twice a year. The standards around sports helmets are complicated because head injuries in general, such as concussions, are complicated. On top of that, there is a push to make helmets lighter, smaller, more dynamic, and to add accessories (like go-pros) which

can contradict the purpose of the helmet. The major change in sports helmets has been the foam used. It Is now expanded polystyrene (EPS) foam which prevents waterlogging.

The data for bike helmets, regarding injuries, is not detailed enough since it does not say whether people are wearing helmets when they are injured, where they got hit, and how they got hit. All of this is necessary to determine if it is the helmets' fault that people are getting hurt. There is also no data that the CPSC has access to from the NFL, so the same issue applies to sports helmets.

Interviewee 9

Interviewee 9 is a mechanical engineer at the CPSC, has been there since 1999, and is the project manager for portable generators. More specifically, they analyze the carbon monoxide poisoning hazard. In 2002, operating plans were introduced to estimate the annual number of deaths caused by CO. Shortly after, manufacturers formed their own organization to create their own standard which was not ANSI approved. It was not until 2014 that a task group was created in UL to develop requirements to address the CO hazards, however industry members essentially sabotaged the group every time to ensure that the requirements were not ANSI approved. Later in 2018, UL standard 2201 was established that added shut off requirements if a certain level of CO was detected by the generator. The problem that arose was that there was major pushback from manufacturers with the standard reaching very little conformance. As a result, the standard was not too impactful. The interviewee highlighted how difficult it was to get so far as creating the standard due to major pushback from industry. Currently, standards for portable generators are not adequately managing the injury and death rates related to CO as much as standards organizations would like which highlights one factor of developing standards which is the political aspect.

Interviewee 10

Interviewee 10 is a fire protection engineer at the CPSC tasked with electrical and fire protection. An expert in sprinkler systems, this interviewee described sprinkler standards as uniquely different from other consumer product voluntary consensus standards. Some of these differences include that you cannot buy these sprinkler systems from retail stores. Additionally, the standard itself is called UL 199 and largely focuses on residential sprinklers and there is no doubt that the sprinklers and the standard are working as intended. However, the key issue with this standard is that it is difficult to find data on whether local authorities are enforcing the installation of the sprinkler systems or not. Another thing that makes sprinklers unique is that they require an entire system to function which involves various building codes. There are three different regulations for how to install sprinklers, the least strict is NFPA 13(r) which provides regulations for how to install sprinkler systems in common buildings or low rises, NFPA 13(b) provides regulations for two family homes or single-family homes and is stricter than NFPA 13(r),

and NFPA 13 is the strictest and provides regulations for how to install sprinkler systems for high rise buildings.

Interviewee 11

Interviewee 11 is a project manager mechanical engineer and physical scientist who deals with ATV's, ROV's and power sport vehicles. One example of the type of standards this interviewee works with includes ASTM 2019 standard which was revised to include a youth ATV category and different categories within the youth category such as ages six through 10, 10 through 12, 12 through 16 and 16 and above. The purpose of this change was to create a more precise way to address issues involving a certain age range. This interviewee stated that one of the difficult things about data analysis involving specifically ATVs is that it is very difficult to research the age of the ATV's that are reporting incidents. For example, a rider of an ATV from 40 years ago that does not meet current standards can still report an injury and in this report, there is no indication as to whether this ATV is meeting the current standards. Additionally, current ride on toys and youth 6 ATV are being developed in a very similar way meaning that it is difficult to differentiate between the two. The issue that this presents is that some ride on toys are classified under ATV standards and some ATVs are classified under ride on toy standards. However, the interviewee stated that there are many positives to ATV's and ROV's when it comes to data analysis is that due to the popularity of these products, there is a significant amount of data to look at.

Interviewee 12

This interviewee is a chemist who works in the laboratories science chemistry division of the CPSC and is tasked with testing children's products for lead and phthalates and testing drugs and cleaning products for protective packaging. One of the more recent standards introduced was ASTM F2923 which required initial testing for cadmium and other harmful metals and creating methods to test how much of the metal would extract off if it was ingested. This standard had a high compliance for lead testing because it was mandatory but metals such as cadmium, the standard was still mandatory but was not enforced as strongly as with lead. From a testing standpoint, the instrumentation for testing was excellent and as a result, the amount of lead allowed in most children's products has lowered from 600 parts per million to 300 parts per million and currently is 100 parts per million. Unlike other product standards, the standard for testing for harmful metals is proactive in that chemists and standard developing organizations know the harmful effects of lead and so they can create standards prior to the release of a product onto the market.

Interviewee 13

This interviewee is the director of engineer sciences in the division of electrical engineering. The products discussed were clothing dryers and paper shredders. In the case of clothing dryers, UL implemented standard UL2057 which included a performance test to test whether the dryer could constrain a fire internally. The purpose of this test was to reduce the hazard of fire spreading from the dryer to the surrounding areas. This standard ended up having a high conformance rate, but the rate of fires remained consistent. In this case, the standard was impactful in reducing the number of property damage caused by fires, but the data did not reflect this as the database largely contained information on whether there was a fire. This revealed that a change in standard may still be considered successful even if there is little to no representation in the data. The next product discussed by the interviewee was paper shredders. Originally, the size of the slit to enter the shredder was not small enough meaning that small children could still get their fingers between the slit. In response, CSA/UL 60950-1 was introduced to make the slit small so that a small child's finger could not fit through the gap. This standard also failed as the plastic around the slit was not strong enough to resist the force of a small child attempting to forcefully push their hand into the shredder. As a result, the standard was revised to include small rods inserted under the plastic around the slits to prevent bending of the plastic. These changes were adopted very quickly, and current data supports the standards' impact as there have been no new reports of finger-related injuries in paper shredders.

Interviewee 14

This interviewee is a mechanical engineer and was the project manager for the hot glass petition. In 2012, a petition was filed by consumer safety advocates who investigated glass-front fireplace injury and incident data to address the problems causing the injuries. What was found was that the glass fronts of the fireplaces would heat up and remain hot even after the source of the heat was turned off. The difference from other similar products that heat up such as oven tops was that there was no indicator on the glass-front fireplaces to inform the consumer that the glass was still hot. A voluntary consensus standard was then created that highlighted the importance of a visual indicator on the glass-front fireplaces that showed whether the glass-front was still hot. Additionally, a protective barrier that dissipated the heat from the glass-front was also added to attempt to further reduce injuries. In order to test the glass-front fireplaces, special devices were required. However, these special tools had little to no manufactures manufacturing them at the time which greatly slowed the amount of it before manufactures could test their glass-front fireplaces. In addition to the product itself, there are other standards involved with glass-front fireplaces. For example, it is required by states and building codes that the installation of a glass-front fireplace meets certain installation standards.

Interviewee 15

This interviewee is a mechanical engineer who specializes in outdoor power equipment, which includes lawnmowers, yard trimmers, chainsaws, snowblowers and more. In specifically lawnmowers, there are no mandatory standards associated with the product with the original standards first developed to encompass both walk behind and riding lawnmowers. For specifically consumer lawnmowers, the standard operator presence control ANSI/OPEI B71.1 was created in 1987 that stated that if the rider got off the seat of the lawnmower, then the motor would turn. Due to the age of this voluntary consensus standard and the prevalence of lawnmowers on the market, there is a significant amount of data on lawnmowers. In the year 2000, there was a significant change that required roll-over protective structures for heavier lawnmowers. Another significant change occurred in 2003 which created a requirement for lawnmower ability to roll backwards and increased the stability requirements so that mowers would be less likely to tip over. Over time, the standards have been incrementally changed. However, there has been no analysis of the data in the past seven years to understand whether these incremental changes are impact at preserving the health and safety of consumers.

Interviewee 16

Mechanical engineer at the CPSC who was tasked with reviewing trampoline safety. Originally, the CPSC proposed 10 changes that they believed would help reduce trampoline related injuries. Among those proposed changes were netting and targeting in the center of the trampoline. There was pushback from industry regarding the changes, however, 4-5 firms consolidated and offered netting as an option. Injuries went down significantly as a result of the netting but the changes in injuries were not reflected in the data for many years due to the long lifecycle of trampolines.

Interviewee 17

This interviewee is a mechanical engineer who investigates a variety of different products including vehicle, baby walkers and helmet hazards, fire hazards for cooking ranges and carbon monoxide hazards such as camp heaters. On example of a product that has a significant amount of data for it is baby walkers. There is the ASTM F977 standard that was introduced to help prevent walkers from falling down the stairs, however there were compliance issues where many walkers did not comply with the stair fall test. If the manufacturer could not follow the standard or choose not to comply, they could potentially go out of business. Another product provided by the interviewee was lawnmowers which had the standard OPEI B71 10 created to address the gasoline systems of lawnmowers. The issue was that there was a fire hazard that resulted in the recall of dozens of products. However, after the standard went into effect it was found that the number of recalls related to the gasoline system was reduced to one. This interviewee has written a report analyzing the standard and provides more information on the nature of the standard and data from before and after the implementation of the standard.

Interviewee 18

This interviewee is a toxicologist involved with the health and science aspect of toys. One example of an issue with toys is their lead content. The ASTM F963 toy standard was created that provided a requirement for the about of lead and other chemicals that could be present in the paint on the toys. The paint was tested to see how much lead and other harmful chemicals leeched out of the paint and into a solution made to emulate the stomach of a small child. The standard is voluntary but is deferred to by the CPSC meaning that the standard is impactful. After the CPSIA act of 2008 the toy standard ASTM F963 was made mandatory and changed the lead in pant standard from 600 parts per million to 90 parts per million. The impact of this change had a relatively lower impact on consumer health and safety because many manufactures had already reduced the amount of lead in paint in their products to below 90 parts per million. As a result, many manufacturers have moved away from using paints with any harmful chemicals and elements in them. However, there are some exceptions to the rule such as bicycles which can have 300 parts per million of lead in them. This is because limits do not apply if it is decided by the CPSC that it is not technologically feasible to test for the lead in a part, if the product or part will not increase the child's blood lead level or if the part cannot be swallowed by a child. However, the toys that were affected by this change the most was molded plastics for toys, toys that relied on lead for coloration purposes and products that included plastisol which is a soft plastic material that is used in the graphics on shirts and jerseys. In order to find data for this subject, national studies were conducted that included methods such as statistical surveying. However, as described by the interviewee, there is most likely no data that exists to prove the impact of the standard despite the interviewee belief that the standard has made a positive change.

Appendix F: ANSI Working Group Interview Summaries

(Note: During the time of these interviews the “Impact Relationship” was known as the “Impact Equation”)

Interviewee 19

Data science team leader at UL tasked with finding data to help UL understand the safety risks of products and to inform technical committees to help them write the appropriate standards to address the health and safety risks of products. Additionally, this interviewee is tasked to document the impact of standards and the types of initiatives covered by the standard. This includes looking for the appropriate methodologies and looking for additional ways to access the impact of voluntary consensus standards outside of just looking at raw incident data. In this interviewee's opinion, the purpose of the white paper is to bring together standard’s organizations who have all struggled with creating a concrete way of evaluating whether a voluntary consensus standard has had an impact on consumer health and safety. According to this interviewee, the most important part of the white paper in its current form is the impact equation. The equation is helpful because a complex topic such as evaluating the health and safety impact of voluntary consensus standards is broken down into two complimentary and independent variables. The scope of the white paper in the interviewee's opinion should remain technical at a higher level but should be digestible by someone with a lower knowledge base in standards. Thus, the final product of the white paper should be a group of documents that have both a high-level technical detailing of the process in addition to summaries written in plain English. The impact of the white paper on UL as expected by the interviewee is that it will provide a guideline for every standard creating organization to evaluate the health and safety of standards based on each organization's specialty.

Interviewee 20

Research manager for the data science team tasked with applying research to help find solutions. This interviewee is tasked with creating a guideline for how to measure the effectiveness of the impact equation. In this interviewee’s opinion, the high-level purpose of the whitepaper is to give guidance to other stakeholders who want to approach the issue of determining the impact of standards on health and safety. On a more foundational level, when looking at effectiveness there are principles applied that help guide thinking about how to approach solving the impact equation through the lens of effectiveness. These principles include death and injury data, near miss data and the cost associated with injuries and death. The main idea surrounding data analysis from the effectiveness portion of the whitepaper is to be mindful of what the data is representative of. The interviewee highlighted the importance of looking at incident rates rather than just the raw numbers. By looking solely at raw numbers, the data may be affected by the number of products that are on the market or sold. One of the setbacks of using this approach as stated by the interviewee is that it is difficult to obtain the data for products that are on the market and that are sold. This is data that comes from the companies selling the products and is very difficult to obtain. Some of the other problems with the effectiveness portion of the white paper is that there is a lag

time between when a standard goes into effect and when the data reflecting that change appear. This is due to factors such as product lifetime and availability of the product on the market. This lag time is an issue because product lifetime varies between different products so there is no blanket solution to this issue.

Interviewee 21

EXHR fire program area manager for the CPSC and is tasked with the conformance aspect of the impact equation in the whitepaper. The most important role of the whitepaper is understanding that effectiveness and conformance are not mutually exclusive with overlap in the data for effectiveness. Conformance, like effectiveness, can be broken up into multiple different principles which serve as a foundation for explaining conformance. Some of these principles include time factor which is the time after the release of a standard for manufacturers to adopt the change and for the newly changed product to make it onto the market and be purchased. Other principles include motivation factor which is how motivated manufactures are to follow voluntary consensus standards. A high motivation factor would be a voluntary consensus standard shifting from voluntary to federally mandated. According to this interviewee, the whitepaper should include narratives about the other human factors regarding conformance. One example provided by the interviewee was to include a narrative about the inspectors of products to see if they meet the standard. The purpose of this narrative is to express that even if a standard is designed to have minimal faults, there can still be a low overall impact if there is a lack of training for the inspectors looking at the products. Data for this narrative can be found in what the CPSC has done where inspectors received both better training and better tools resulting in a signifyingly higher success rate when inspecting incoming products.

Interviewee 22 and 23

Interviewee 22 recently joined ANSI and is a part of ANSI's initiative to increase consumer and legislative outreach. The goal of this initiative is to get the average nonprofit consumer organization more involved in the standard creation process. Interviewee 23 is ANSI's vice president for government relation and public policy charged with working with federal agencies on their use of voluntary consensus standard, maintaining a equation with the congressional industry involving standard's issues and increasing legislative outreach. In both interviewee 22 and interviewee 23 opinion, the goal of the whitepaper is to address the long-standing perceived gap in evaluating the health and safety impact of voluntary consensus standards. The whitepaper itself will not change how these standards are created in the first place and updates to the voluntary consensus standard process happen independent of the whitepaper. In interviewee 23 opinion, the whitepaper should maintain its current level of technical speak and additional documents should be created to fit the needs of other involved organizations. In this additional documentation, interviewee 23 expects that the language will become less technical and easier for consumer organizations to understand. In interviewee 23 opinion, scope may play a major role in the success

of the whitepaper. Understanding the audience of the whitepaper and other related documents helps to narrow the scope and provides a more precise way to look at how to approach evaluating the impact of voluntary consensus standards. Given interviewee 22 and interviewee 23 background, the whitepaper will hopefully spark broader interest in standards and the standard creation process and will lead to more involvement from consumer organizations.

Interviewee 24

Standards executive at the EPA tasked with coordinating the implementation of standards for the technology and support staff. Additionally, participates in the development of standards to advance policy objectives. In the interviewee's opinion, the goal of the whitepaper should be to cover a broader range of standards rather than just focusing on consumer product standards as the whitepaper does in its current state. Some examples of ways to broaden the scope of the paper as provided by the interviewee include test methods such as the limit on how much pollutant can go into the air or the water, and guides such as the ASTM guide on how to clean contaminated sites which is also regulated through voluntary consensus standards. Currently, according to the interviewee, the whitepaper is too focused on consumer products and the physical injuries from products and is missing the illness portion of health and safety. By broadening the scope of the whitepaper in this regard, other organizations such as the EPA will be able to draw more from the whitepaper. Additionally, in the interviewee's opinion, broadening the scope of the whitepaper and providing more data may lead to more resources invested into standards and the standard creation process.

Interviewee 25

Director of standards and technical services at ASSP who works with various government agencies. In this interviewee's opinion, the current formulation of the impact equation has been productive and believes that the equation is in an acceptable spot, however this interviewee highlights that creating an equation that encompasses the entirety of trying to evaluate the health and safety impact of voluntary consensus standards is too difficult for one formula to cover. Additionally, this interviewee stated that although the IMPACT equation is not an exact formula, it is very foundational and can be customized based on the needs of the end user. As a representative from ASSP, this interviewee agrees that the whitepaper will have a major impact on their organization as they have been trying to solve the issue of how to evaluate the impact of the standard that they create for a long time. Additionally, this interviewee stated that the whitepaper should remain a fluid document and be updated as data collection improves overtime. However, this interviewee thinks that the whitepaper should maintain a technical language throughout and if the end user requires that the whitepaper be in a language that is more digestible, then the whitepaper can be adapted.

Interviewee 26

Senior standards advisor at the Center for Radiological Devices, this interviewee is tasked with assessing and managing the total lifecycle for products and looking into risk management for radiology and nanotechnology. This interviewee stated that the most important part of the whitepaper is to consider the values of the stakeholders involved and to appeal to their interests. The stakeholders include those in the ANSI working group along with the consumer groups who have an interest in the outcome of the whitepaper. However, this interviewee stated that the whitepaper should maintain its current high level technical language and continue its foundational approach. By keeping the whitepaper foundational, there is more flexibility for the different stakeholders and people in the industry to adapt the whitepaper based on their needs. Additionally, this interviewee believes that the whitepaper will impact the voluntary consensus standard creation process as the outcome of the whitepaper will hopefully lead to less guess work for the standard developing organizations to research whether the standard is working as intended and the resources are applied in the appropriate areas.

Interviewee 27

Director of standards for ISEA involved with standards development and is a part of an association of manufacturers that develop safety equipment. This interviewee is more focused on the effectiveness portion of the whitepaper and most specifically, how to measure the impact of a standard through the effectiveness lens. In addition, the impact equation between effectiveness and conformance is also important to ISEA as they would like to learn the meaning of the equation between the two along with the principles involved. In this interviewee's opinion, their role in the whitepaper is to focus on the user aspect and provide a perspective that is different from a consumer product standpoint. This interviewee also believes that the whitepaper should remain a living document that should involve interested parties to help incorporate feedback and other critique every few years or so. In this interviewee's opinion, ANSI is a fantastic organization to help facilitate this continuing development of the whitepaper as the needs of the consumer organizations and standard developing organizations change.

Appendix G: Code used for NEISS and Clearinghouse Data

This is the code used to analyze NEISS and clearinghouse data. The data was first taken off their respective query builders, which filters out a large portion of the unwanted information. Next, all the exported Excel files were put in a folder that is in the same directory as the Python file, named 'data'. If NEISS data was being analyzed, then the years list needs to be a list of strings of the years of the NEISS files. If Clearinghouse data was being analyzed, years should be a list with one element (it doesn't matter what) and the function setting the dataframe variable should use 'Results.xlsx' as the first parameter. This code was made for Python 3.8 and was coded in PyCharm Community Edition. The code was run on a Windows 10 Laptop.

```
import pandas as pd
import xlwt

years = ['2004', '2005', '2006', '2007']  # all years of data analyzed should be listed separately as strings
all_entries = []
wb = xlwt.Workbook()
sheet = wb.add_sheet("Sheet 1")

for year in years:  # this loop iterates through all the different files
    dataframe = pd.read_excel('data/NEISS_' + year + '.XLSX', na_values=None)  # this is the name of files from
NEISS

    for row in dataframe.iterrows():  # this loop iterates through all the entries in each file
        data = row[1].to_dict()
        if data["Narrative"].rfind("SHREDDER") != -1:  # this gets replaced with whatever is being looked for.
            data["Searched"] = True
            # in this example, it looks for the term "shredder" in the narrative part of the case
        else:
            data["Searched"] = False

        all_entries.append(data)  # all the entries with the new value get added to this array

keys = all_entries[0].keys()  # now the program needs to put all the entries into one spreadsheet

for i, key in enumerate(keys):  # first it puts all the catagories at the top of the spreadsheet
    sheet.write(0, i, key)

for i, entry in enumerate(all_entries):  # then it goes through each of the entries and puts its data into the sheet
    for j, key in enumerate(keys):
        if key in entry.keys() and entry[key] is not None:
            sheet.write(i + 1, j, entry[key])

wb.save("PS-Cases-2004-2007.xls")  # lastly it exports the spreadsheet to an Excel file.
```

Appendix H: Code used for NHANES and Clearinghouse Data

This is the code used to analyze NHANES data. The data was first downloaded from the different years taken on the CDC's website. Then, the files were renamed so that they were named 'PBCD_<year>.XPT', replacing <year> with the first year that the data is from. Next, all the exported XPT files were put in a folder that is in the same directory as the python file, named 'data'. This code was made for Python 3.8 and was coded in PyCharm Community Edition. The code was run on a Windows 10 Laptop.

```
import pandas as pd
import xlwt
from matplotlib import pyplot
import xport.v56
import datetime as dt
import math


years = []
for i in range(1999, 2018, 2):  # generates all the file names. this case is every 2
years 1999-2017
    years.append(('data/PBCD_' + str(i) + ".XPT", i))

all_entries = []
wb = xlwt.Workbook()
sheet = wb.add_sheet("Sheet 1")

for file in years:  # this loop iterates through all the different files
    dataframes = []
    with open(file[0], 'rb') as f:
        library = xport.v56.load(f)  # this function loads all the information from the
files
        for key in library.keys():
            dataframes.append(library[key])  # this takes the pandas dataframe(s) out of
the library type

    for dataframe in dataframes:
        data = dataframe.to_dict()  # this turns the pandas data into a python dictionary
        leadvalues = data["LBDBPBSI"]  # this is the term used by NHANES for lead levels
        totalLead = 0
        caseNum = 0
        for val in leadvalues:  # this calculates the average lead level
            if not math.isnan(leadvalues[val]):
                totalLead += leadvalues[val]
                caseNum += 1

        all_entries.append(
            {"year": file[1], "totalLead": totalLead, "caseNum": caseNum,
"avgLeadLevels": totalLead / caseNum,
             "raw": leadvalues})  # this appends that year's lead level to the array of
all values
```

Appendix I: Code used for Generating Bar Graphs

This is the code used to generate the bar graphs used in the narratives. First, the all_entries variable needs to be filled with dictionaries of all the cases. These dictionaries needs "year" values and the cases can be appended with any value in the dictionary. The title and axis names also need to be changed for the graph being generated. This code was made for Python 3.8 and was coded in PyCharm Community Edition. The code was run on a Windows 10 Laptop.

```
import pandas as pd
import xlwt
from matplotlib import pyplot
import xport.v56
import datetime as dt
import math

all_entries = [] # this array would be filled with the dictionaries to create the graph
with


times = []
cases = []

for entry in all_entries: # note: all_entries should be sorted in the order they should
be on the graph
    year = int(entry["year"])
   time = str(year) + " - " + str(year + 1) # this is an example for 2-year graphs,
larger or shorter ranges are used
    times.append(time)
    cases.append(entry["avgLeadLevels"]) # "avgLeadLevels" changes based on which number
should be graphed

print(times, cases) # optional, but helpful if precise numbers are neneded

pyplot.title("Average Lead Blood Levels (Ages 6+) vs Year")
pyplot.xlabel("Year")
pyplot.ylabel("Average Lead Blood Levels (umol/L)") # needed to change the title, and
labels for the x and y axis's
plt = pyplot.bar(times, cases)
pyplot.show()
```