# Human Factors Contributions to Consumer Product Safety

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## ABSTRACT

The mission of the Office of Hazard Identification and Reduction at the U. S. Consumer Product Safety Commission (CPSC, Commission) drives the Division of Human Factors to evaluate corrective action plans and propose redesigns of consumer products. Human factors studies and research focus on consumer product-related injuries, including assessing system design hazards for the general United States consumer population, ranging from newborns to seniors. These assessments include: usability, safety features, choking hazards, and evaluation of potential misuse of a product that could lead to injury or death. This paper will provide an overview of human factors work conducted at the CPSC and discuss how this specialized work contributes to reducing risk to the American public.

**Keywords**: Consumer products, safety, standards, hazard, risk, warnings

## INTRODUCTION

Congress established the CPSC in 1972. The CPSC is the federal regulatory body charged with protecting the public from unreasonable risks of injury or death associated with the use of consumer products under the agency's jurisdiction. Deaths, injuries, and property damage from consumer product incidents cost the nation more than $1 trillion annually. CPSC's work to help ensure the safety of consumer products—such as toys, cribs, power tools, cigarette lighters, and household chemicals—has contributed to a decline in the rate of deaths and injuries associated with consumer products over the past 40 years. The CPSC has jurisdiction over thousands of types of consumer products used in and around the home, outdoors, in the workplace, and in schools—including everything from children's toys to portable gas generators and toasters. Although the Commission's regulatory purview is quite broad, a number of product categories fall outside of the CPSC's jurisdiction.[1]

1 Product categories such as automobiles and boats; alcohol, tobacco, and firearms; food and drugs; and pesticides, cosmetics, and medical devices are regulated by other federal agencies.

*The opinions expressed in this article are those of the authors. It has not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.*

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The following laws passed by Congress form the basis for CPSC to protect the public from unreasonable risk of injury or death associated with thousands of types of consumer products[2]:

- The Consumer Product Safety Act (CPSA), enacted in 1972, is the umbrella statute that defines CPSC's basic authority and authorizes the agency to develop standards, promulgate bans, and pursue recalls.
- The Consumer Product Safety Improvement Act (CPSIA) amended the CPSA in 2008, with new regulatory and enforcement tools. The CPSIA included provisions addressing, among other things, lead, phthalates, toy safety, durable infant or toddler products, third-party testing and certification, tracking labels, imports, all-terrain vehicles (ATVs), civil and criminal penalties and SaferProducts.gov, a publically-searchable database of reports of harm.
- The Children's Gasoline Burn Prevention Act (CGBPA) requires portable gasoline containers manufactured for sale in the United States to conform to safety requirements for child-resistant packaging.
- The Federal Hazardous Substances Act (FHSA) requires precautionary labeling on hazardous household products. The Act also allows the CPSC to ban or regulate hazardous substances and toys or other products intended for use by children.
- The Flammable Fabrics Act (FFA) authorizes CPSC to prescribe flammability standards for clothing, upholstery, and other fabrics.
- The Poison Prevention Packaging Act (PPPA) of 1970 authorizes CPSC to require special packaging to protect children under 5 from serious injury and death resulting from handling, using, or ingesting certain drugs and other hazardous household substances.
- The Refrigerator Safety Act (RSA) of 1956 mandates CPSC to prescribe safety standards for household refrigerators to ensure that the doors can be opened easily from the inside.
- The Virginia Graeme Baker Pool and Spa Safety Act (VGB Act) of 2007 establishes mandatory safety standards for swimming pool and spa drain covers.
- The Child Safety Protection Act (CSPA) of 1994 amends certain provisions of FHSA and requires the banning or labeling of toys that pose a choking risk to small children and the reporting of certain choking incidents to the CPSC.
- The Labeling of Hazardous Art Materials Act (LHAMA) requires mandatory labeling for all art materials determined by the producer or repackager to have the potential for causing a chronic hazard.

To fulfill its mission of protecting the public against unreasonable risks of injuries associated with consumer products, CPSC collects, reviews, and analyzes information on consumer-product related injuries and deaths from many sources, such as the National Electronic Injury Surveillance System (NEISS), consumer incident reports, death reports, reports from manufacturers, and news clips. CPSC uses this information to identify a hazard or hazard pattern.

CPSC staff estimates that there were approximately 38,573,000 medically treated injuries that were related to, although not necessarily caused by, consumer products in 2010 (Schroeder, 2012).

## HUMAN FACTORS CORE ACTIVITIES AT CPSC

The CPSC accomplishes its consumer protection mandate and strives to ensure that consumer products are free of unreasonable safety hazards through the following core activities:

- Working with organizations that facilitate the development of effective voluntary standards with a broad range of stakeholders, including consumers, industry, and other representatives;
- Issuing and enforcing mandatory standards or banning consumer products if no feasible standard will adequately protect the public;
- Initiating the recall or corrective action of products that pose potential risk for serious injury or death;
- Conducting research on potential consumer product hazards;
- Informing and educating consumers through news and social media, state and local governments, private organizations, and responses to consumer inquiries; and
- Encouraging industry to implement globally recognized best practices needed to ensure the manufacture of safe consumer products.

2 http://www.cpsc.gov/en/Regulations-Laws--Standards/Statutes/

The Division of Human Factors (HF) at CPSC directly participates in all of the core activities described above. The following section discusses, and provides examples of, HF contributions in these areas:

- Development of voluntary standards: In 1981, the CPSA was amended to require the CPSC to defer to a voluntary standard—rather than issue a mandatory standard—if CPSC determines that the voluntary standard adequately addresses the hazard and that there is likely to be substantial compliance with the voluntary standard. Therefore, voluntary standard development is a significant tool in CPSC's hazard-reduction efforts. HF specialists along with specialists in other engineering disciplines, laboratory sciences, and health sciences are actively involved in the development and revision of voluntary safety standards. Usually, CPSC staff reviews incident reports related to a product and if a hazard pattern is identified, a revision of the current voluntary standard or development of a new voluntary standard may be explored to address the hazard. An example of this activity is the ASTM F2951 Standard Consumer Safety Specification for Baby Monitors, which was developed mainly to address the strangulation risk associated with corded baby monitors. When initial incident reports were received, HF staff examined the incidents to identify the hazard scenarios and ages of the victims; conducted task analysis; reviewed the design, warnings and instructions of applicable products in the market; and determined how a child's physical and cognitive abilities contributed to the incidents. Staff shared the results of its review with ASTM and asked for the development of a new safety standard. The first version of the standard was published a year later. HF staff has continued to participate in the voluntary standard committee and has provided technical guidance to develop and revise performance requirements and warnings and instructions.

- Issuing and enforcing mandatory standards: CPSC may issue a mandatory standard when it determines that compliance with a voluntary standard would not eliminate or adequately reduce the risk of injury or finds that it is unlikely that there will be substantial compliance with a voluntary standard. In some cases, Congress has enacted a specific statutory requirement for CPSC to create a mandatory standard, or convert a voluntary standard to a mandatory standard. For instance, the CPSA, as amended by the CPSIA, mandated the conversion of voluntary standards for durable infant and toddler products, ATVs, and children's toys to mandatory standards. In the past 5 years, the Commission has approved new stringent federal safety standards for children's products, including full-size cribs, non-full-size cribs, play yards, baby walkers, baby bath seats, children's portable bed rails, toddler beds, infant swings, bassinets and cradles, and hand-held infant carriers. HF staff participates in the development of mandatory standards as part of a multidisciplinary team that reviews the epidemiological data, conducts engineering analysis of the current standards, identifies hazard scenarios, and determines if the hazards are adequately addressed by the current standard. If staff determines that the standard lacks requirements to address certain risks identified by the staff analysis, then staff proposes modifications to the current voluntary standard, where applicable, and may recommend that the Commission adopt the standard, with proposed changes.

- Initiating recalls: The CPSC's Office of Compliance and Field Operations negotiates recalls, communicates with companies, and encourages manufacturers to comply with CPSC regulations. A Product Safety Assessment (PSA) is the CPSC-generated document that provides the scientific and technical analysis conducted by technical staff on a specific product. HF staff typically conducts an analysis to: (1) define potential users of the product, determine age appropriateness, evaluate the anthropometry and strength of the potential users, and perform human performance analysis; (2) conduct behavioral analysis to determine incident or injury potential and define users' interaction with the product based on physical and cognitive abilities and limitations; and identify foreseeable use and misuse scenarios; and (3) assess warnings to determine their adequacy in alerting the user to the hazard as well as evaluate instructions for ease of comprehension. HF staff completed 263 PSAs in the last three years (Cotton et al., 2013). Thirty-four percent of the PSAs were for infant products, followed by home goods (28%), children's toys (19%), and outdoor recreation products (13%). The remaining products were appliances (4%) and indoor recreation products (2%).

- Conducting research about potential consumer product hazards: These are typically projects initiated by CPSC staff, based on the collection and screening of incident data. Projects usually take a few months to a few years to complete and may result in the development or revision of a voluntary standard, or if the Commission decides, in the development of a mandatory standard. An example of this activity is a decorative firepot that is used with flammable gel fuel. Due to injury reports received by the Commission that involve firepots and pourable gel fuels, staff identified these products as an emerging hazard in June 2011. A multidisciplinary team, including HF staff, was formed to identify the extent and nature of the hazard. CPSC announced a recall of pourable gel fuels intended to be used with firepots in September 2011 and subsequently published an advance

notice of proposed rulemaking (ANPR) in December 2011, which could result in a rule establishing labeling or performance standards for firepots and gel fuels. Alternatively, the Commission could ban the product, if it determines that no standard would adequately protect the public. HF staff reviewed incident reports, evaluated the firepot and gel fuel bottle design, packaging, and warnings and instructions; and identified the human factors issues contributing to the incidents. In the ANPR, HF staff noted that the majority of the incidents occurred due to pouring more fuel (refueling) into a hot firepot; firepots did not have proper warning labels on the product that could serve as a permanent reminder to the users, and the warning on the fuel bottles did not get the users' attention. Staff also raised the issue of a "hidden hazard," in which consumers would likely have difficulty complying with the instructions, particularly because the flames can be hard to see under certain lighting conditions and viewing angles (Balci-Sinha, 2011).

- Informing and educating consumers: HF staff participates in activities initiated by CPSC's Office of Communications, including the production of videos, development of safety alerts, and public messaging via social media. HF develops easy-to-follow guidelines for the public to take precautionary safety measures. An example of this activity is HF's advice on how to develop a crib safety envelope in a sleeping environment to ensure that there are no cords that are accessible to a child in the crib. HF staff developed this envelope using reach anthropometry of infants and their potential positions in a crib.

- Encouraging industry to adopt globally recognized best practices: One of CPSC's goals is to continue working with key global and domestic stakeholders to mitigate the most pressing product safety hazards. Toward this goal, CPSC staff works with its counterparts in other countries to harmonize global consumer product safety standards or to develop similar mechanisms to enhance product safety, known as the Pilot Alignment Initiative. HF staff contributes actively to the discussions with foreign counterparts and provides human factors data and analysis.

# HUMAN FACTORS METHODOLOGY AT CPSC

Human Factors staff at the CPSC uses a wide variety of methodologies to analyze consumer products. Some of the methods applied are described below:

*User Profiles*

HF staff identifies intended users of the product as well as unintended but potential users of the product. Intended users of the product are usually described in the product literature and marketing and advertisement communications or in the standard where applicable. HF staff routinely reviews incidents involving users who may be participating in the assembly or operation of the product. An example of this activity is strollers. Strollers are intended for children from infancy through 36 months of age as defined in the ASTM F833 *Standard Consumer Safety Performance Specification for Carriages and Strollers*. However, strollers are not self-propelled and remain stationary until pushed by a person other than the occupant. Caregivers are also involved in setting up and maintaining the stroller (*e.g.*, assembling, folding, unfolding, removing from trunk, and pumping air into the tire(s)). This involvement requires a different set of interactions with the stroller and poses various risks. For example, since 2008, CPSC received reports of 1,207 incidents (391 injuries) involving children under 5 years of age. In addition, 84 incidents were associated with older children and adults. Most of these reports involved adults injuring their fingers on the folding hinge of the strollers. CPSC recalled various strollers due to adult injuries.

HF staff gathers applicable anthropometric, strength, and cognitive characteristics of the users and provides the data to voluntary standards development groups. For instance, in the stroller example, HF staff participated in the revision of the ASTM F833 *Standard Consumer Safety Performance Specification for Carriages and Strollers*. Based on the incident data, staff identified a number of hazard patterns to be investigated, including wheel detachment; failures in latching and locking mechanisms; strangulation hazards associated with cords within the occupant space; pinching, shearing, and scissoring hazards at the folding hinge and canopy hinges; falls due to a child unbuckling the restraint system; failures in parking brakes; and potential head entrapment in the opening between the car seat and stroller handle. HF staff provided anthropometric and strength data to the voluntary standard committee to develop many of these requirements, such as the definition of an "occupant space" (based on anthropometric data); restrictions on the cord length that can be allowed in the occupant space (based on head and neck dimensions of children); the size of the area on the folding hinge to be tested to ensure there are no pinching

hazards (based on the child's reach abilities while seated in a stroller); and force requirements to ensure that most children will not be able to unbuckle the restraints.

*Heuristics*

HF staff routinely conducts heuristic analysis to formally evaluate the product from the perspective of users to identify possible use-related hazards. Heuristic analysis requires the Human Factors analysts to use professional judgement, experience, and best practices to guide product evaluation (Nielsen 1992). Heuristic analysis at the CPSC is conducted in table-top and simulated settings at the CPSC National Product Testing and Evaluation Center (NPTEC). While this is a subjective analysis conducted by subject matter experts, the approach is often a preferred method at CPSC for completing analysis, due to the ease and speed that work at the agency often demands while providing usable results.

*Surveys*

Standardized questionnaires and surveys are used by staff to assist in making informed and accurate expert assessments of consumer behavior. The user population that the CPSC supports ranges quite broadly from infants to senior citizens. Therefore, it is often advantageous to conduct a targeted survey to determine how the general public interacts with a specific product. This methodology entails extensive time and effort, requiring approval of the U.S. Office of Management and Budget. Thus, this methodology is used primarily to support long-term projects. One avenue that HF staff employs to collect data is through a Consumer Opinion Survey that is Internet-based and available for voluntary participation by interested consumers who are at least18 years old. One recent example is a survey conducted to gather information from consumers regarding how they set-up, use, and maintain their clothes dryers and their beliefs on the benefits of performing maintenance, primarily cleaning activities. Because this respondent population is a convenience sample rather than a random sample, the survey results may not be representative of the general population. However, the results do provide preliminary data on consumer behavior that is otherwise not available.

*Task Analysis*

Task analysis refers to the study of what a user is required to do, in terms of actions and cognitive processes, to achieve a goal presented by a product or system (Kirwan and Ainsworth 1992). Staff employs a variety of task analysis techniques to identify how incidents and accidents occur when there is interaction between a product and user. This analysis not only includes how the manufacturer wants the product to be used, but also how the product is actually used. The techniques employed include Observational Analysis, Task Decomposition, Walk-throughs, and Fault Tree Analysis.

*Scenario Analysis*

This task analysis-based approach to incident investigation is often applied to determine injury scenarios by combining the data from task analysis and user profiles, product status prior to the incident, and environmental factors such as lighting and noise.

HF staff considers the hazard control hierarchy in their assessment. Removing a hazard through design changes may be achieved at the product development stage and is considered to be the most effective hazard control strategy. If a product has hazards associated with its proper use that cannot be designed out, then guarding against the hazard may be the best approach. Warnings are needed if unreasonable risks still exist (Sanders and McCormick, 1993). Even though warnings may not be the most preferred strategy in hazard mitigation, well-designed warnings and instructions are an essential component in consumer product use. HF staff evaluates the warnings and instructions accompanied by the product and makes recommendations on how they can be improved to get and maintain the attention of the user; to communicate the message effectively; and to motivate the desired behavior. In addition, HF staff may design and develop warning labels to be part of mandatory standards.

## CONCLUSIONS

The Division of Human Factors at the CPSC studies the interaction between the product, user, and environment to determine factors that may result in hazardous situations. HF staff provides support for voluntary and mandatory standards development activities with the goal of improving the safety of new products that will come onto the market; and for CPSC's enforcement actions. This technical discipline is an important contributor to the analysis that the CPSC staff uses to understand and determine the interaction of people with consumer products to reduce the risk of injury and death.

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