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Improving International Standardization of Children's Accidental Ingestion Safety Design Based on Disaster Prevention Design

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Abstract: *This study aimed to enhance children's safety by developing an internationally standardized children's accidental ingestion safety design that could effectively prevent accidental ingestion of small objects. Although most toys and stationery are now labelled with a children's accidental ingestion safety sign, the number of childhood accidental ingestion incidents continue to increase. This paradox reveals that conventional warning symbols fail to effectively communicate hazard information to young children due to inadequate alignment with their cognitive and perceptual capabilities. Through a systematic analysis of existing international safety standards, this research identified four fundamental deficiencies in current warning symbols: visual ambiguity and cross-national inconsistency, inadequate child user identification, insufficient depiction of prohibited objects, and absence of consequence visualization of swallowing. There are factors that can collectively compromise children's risk perception. Employing a mixed-methods approach, this study conducted a comprehensive market audit of 100 toy packages across Korea and China, complemented by direct preference testing with 28 children aged 2–7 years. Findings were synthesized into an evidence-based shape–color–image design framework fully compliant with ISO 7010 and ISO 3864 standards. The proposed design added hair to clarify the image of a child and added a pained expression and tears to express pain more strongly. In addition, the unclear object to be put in the mouth was clarified by representing it as a block. This study contributes both theoretical insights into child-centered risk communication and a practical, validated symbol template. The implementation of this ISO-compliant design by regulatory bodies and manufacturers has the potential to yield measurable reductions of accidental-ingestion incidents globally.*

Keywords: Disaster Prevention Design; Children's Accidental Ingestion; Children's Cognitive; Accidental Ingestion Safety Signs; Internationally Standardized; Korea and China

1. Introduction

The global toy industry has experienced unprecedented growth, with China alone achieving US $39.87 billion in toy exports in 2024 [1]. This rapid market expansion has coincided with an alarming trend in child safety incidents. According to the Korea Consumer Agency's Child Safety Accident Survey, 8,684 accidental ingestion cases were documented between 2017 and 2021, with toys accounting for 4,029 (46.4%) and stationery contributing 603 (6.9%) of these incidents [2]. More recent data reveals an escalating crisis: a comprehensive national review counted 22,371 product-related child injuries in 2023 alone, confirming a continuing upward trend [3]. Paradoxically, despite mandatory safety labeling on most toys and stationery, accidental ingestion incidents continue their relentless rise.

This apparent contradiction highlights a fundamental design failure: the mere application of warning symbols proves insufficient when their visual language fails to align with young children's cognitive development. Extensive usability studies show that effective comprehension of safety pictograms is contingent upon three critical factors: simplicity, familiarity and concreteness [4, 5], while empirical evidence indicates

that preschoolers' interpretive accuracy deteriorates markedly when icons fail to clearly depict either the user or the forbidden action [6]. Cross-national design analyses further reveal systematic deficiencies including color inconsistency, absent user identification cues, and inadequate consequence depiction as primary obstacles to effective international harmonization [7].

In response to this critical safety challenge, this study aims to develop an internationally harmonized accidental-ingestion warning symbol based on disaster prevention design theory that addresses the specific perceptual and cognitive needs of children aged 2-7, rectifies the graphic and semantic deficiencies inherent in current ISO-compliant signs, and provides regulators and manufacturers with a scientifically validated shape-color-image guideline capable of demonstrably reducing ingestion incidents worldwide. The proposed symbol is specifically designed for toy packaging, stationery, over-the-counter medicines and household chemical product categories consistently identified as primary contributors to ingestion-related injuries in [2] Korea Consumer Agency (KCA) statistics [2, 3].

While previous research has made significant contributions to warning-label design across various domains including workplace safety and climate-disaster alerts, a notable research gap exists: no recent study has developed a child-centered, ingestion-specific pictogram that undergoes rigorous experimental validation with the target demographic [5], [7]. This study addresses this lacuna by integrating cognitive-development theory with ISO-compliant symbol design, providing the first comparative Korea–China dataset, and producing a child-tested design guideline specifically tailored to ingestion hazards. From a practical perspective, this study offers regulators and manufacturers an empirically validated, ready-to-implement design template whose adoption could significantly mitigate accidental-ingestion incidents and reduce their associated socioeconomic burden.

2. Method of Research

The research methodology for improving the international standardization of children's accidental ingestion safety design is as follows. Firstly, the background and causes of children's accidental ingestion was investigated through internet research. Second, a literature review was conducted to investigate the theoretical background of this study on the concepts of disaster prevention design, children's cognitive characteristics, and safety signs. Third, for the case study of international standardization of children's accidental ingestion safety sign design, a research sample was collected by investigating the use of children's accidental ingestion safety signs in the Korean toy market for design comparison with China, which produces the largest number of toys in the world market. In addition, design experts were asked to analyses the five evaluation factors of safety sign design: readability, communicability, clarity, aesthetics, and identification, and provide design guidelines. Fourth, based on the design guidelines, we developed an internationally standardized design for the children's accidental ingestion safety sign and proposed new improvements through a preference survey and evaluation with children.

3. Theoretical Review

3.1 Disaster Prevention design

In Disaster prevention design is defined as design that prevents various forms of disaster or protects people and property when disaster strikes, minimizing damage and facilitating recovery [8]. According to the response to disasters, it can be divided into ① mitigation and prevention design ② preparedness design ③ response design ④ recovery design [9]. This study is a safety sign design for the prevention of children's accidental ingestion accidents, which falls under the category of preventive design in disaster prevention design.

3.2 Children's cognitive characteristics and accidental ingestion accident

3.2.1 Cognitive characteristics of children

Before studying children's accidental ingestion safety labels, it is necessary to understand the cognitive characteristics of children. The cognitive characteristics of children are summarized by referring to the cognitive development theory of Jean Piaget and the literature, and the characteristics of each age group of children are as follows Table 1. Children are divided into infant, toddler, early childhood, and school children stage based on their developmental stages, ranging from 0-15 years old [10]. During the infant stage (0-2 years old), children

are unconscious and only capable of passive activities. When they reach the toddler stage (2-7 years old), children begin to have perceptual thoughts and actively explore their cognitive abilities, which leads to unconscious attention and curiosity about everything [11]. In early childhood stage (7-11 years old), perceptual thinking begins to give way to representational thinking. Children in early childhood are characterized by strong imitation and imagination, and a sense of egocentric. School children stage (11-15 years old) can make simple logical deductions and intuit reasons, but their thinking skills are relatively weak, and they judge things in pieces.

Table 1. Cognitive characteristics of children

Age Stage	Cognitive awareness	Activities
Infant (0-2)	Unconscious awareness: reacts reflexively to external stimuli; no intentional exploration	Passive activity: limited voluntary movement, mainly sensory responses
Toddler (2-7)	Perceptual awareness: understands the world through concrete sensory impressions	Active exploration / curiosity: grasps, tastes, and manipulates objects to learn
Early childhood (7-11)	Representational awareness: forms mental images; imagination and egocentrism dominate	Imitation-imagination: role-play, copying adults, vivid fantasy play
School children (11-15)	Passive activity: begins simple reasoning, but thinking remains fragmented	Fragmentary judgement: analyses parts of a situation, needs guidance for synthesis

Children have many ways of cognition, but sensory experiential cognition is the most effective and important one. Vision is the primary sensory channel through which children take in external information and plays an important role in experiential cognition, as children's growth and cognitive development gradually equips them with basic recognition of shapes, symbols and colors. Therefore, the design of child-resistant safety signs is best communicated by visualizing the graphics, text and colors that can affect children's perception.

3.2.2 Children's accidental ingestion current situation

According to the Korea Consumer Agency and Health Information Agency (2021), the number of accidental ingestion incidents among children has increased from 1,498 in 2017 to 1,712 in 2021 (see Figure 1) [2]. When looking at the main causes of childhood accidental ingestion, swallowing toys such as blocks, batteries, marbles, and magnets were the most common age of accidental ingestion was during infancy age. This is followed by toddlerhood age. When analyzing the results by age of the children, it was found that many of the accidental ingestion incidents occurred during the infancy and toddler stage, when children's cognitive abilities are still immature, due to a lack of awareness of the dangers of foreign objects (see Table 2).

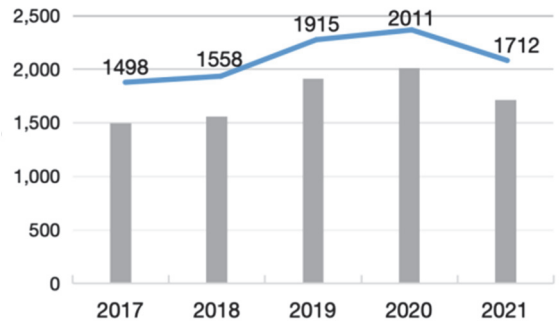


Figure 1. Number of childhood accidental ingestion incidents

Table 2. Leading causes of accidental ingestion in children (subcategories)

Age Stage	Top Causes	Number
Infant stage	Stickers, magnets, blocks, batteries, etc.	535
Toddler stage	Beads, toys, magnets, stickers, etc.	5025
Early childhood stage	Beads, blocks, toys, magnets, etc.	2231
School children stage	Magnets, toy guns, building blocks, etc.	883

3.3 Safety signs concepts and evaluation factors

A safety sign is a sign, such as a picture, symbol or letter, used to ensure safety in a workplace subject to the Labor Standards Act under Section 38 of the Occupational Safety and Health Act. They are used to prevent accidents by warning of hazardous locations and hazardous materials, providing emergency instructions or guidance, or promoting safety awareness [12]. Safety signs can be divided into five types depending on their purpose: prohibitory signs, warning signs, directional signs, information signs, and no-entry signs.

Safety signs should be readable, communicable, clear, aesthetic, and identifiable [13]. Readability includes typeface and font size, communicability includes visual comprehension, and aesthetics includes graphic beauty, elegance, and harmony with the distinguishing environment. Therefore, the design of safety signs should consider five factors to ensure that they communicate information quickly and accurately and that children understand them.

4. International Standardized Children's Accidental Ingestion Safety Signs Case Study

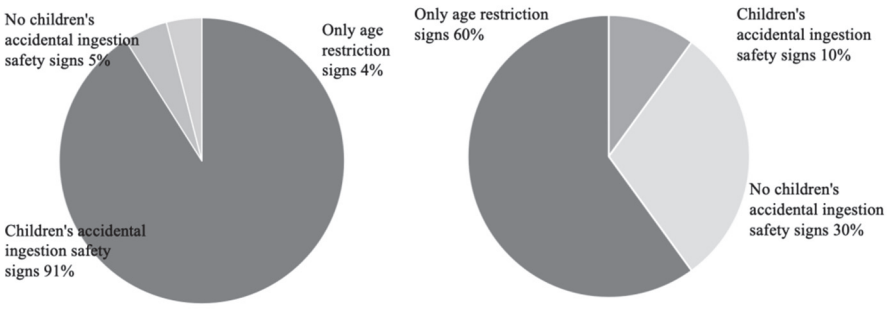
4.1 Market research on children's accidental ingestion safety signs

The market research on children's accidental ingestion safety signs was analyzed by examining the Korean toy market for design comparisons with China, which produces the largest number of toys in the world. This survey was conducted from 1 April to 30 April 2023 to identify the status and problems of children's accidental ingestion safety signs. In China, the survey covered toys (50 items in total) from hypermarkets Kidsland and Wanda Plaza, while in South Korea, the survey covered children's toys (50 items in total) from hypermarkets Homeplus and Toys Rus.

Table 3. Leading causes of accidental ingestion in children (subcategories)

Type	China	Korea
Market study image		
Number	N=50	N=50

Figure 2 (a) shows that 91% of toys in Korea have childhood accidental ingestion safety signs, while 5% do not have childhood accidental ingestion safety signs. In addition, 4% of the toy packaging had only age restriction signs. In China, a survey of children's accidental ingestion safety signs showed that only 10% of accidental ingestion safety signs were using them and 30% were not using them, as shown in Figure 2 (b). However, age restriction signals were the most common (60%). When it comes to the use of children's products in Korea and China, we found that Korea has a higher proportion of children's accidental ingestion safety signs than China, while China, the world's largest producer of toys, has only 10%, making it vulnerable to childhood accidental ingestion world.



(a) Korea (**b**) China

Figure 2. Findings from an investigation into children's accidental ingestion safety signs on Korean toys

4.2 Comparative study of children's accidental ingestion safety signs designs

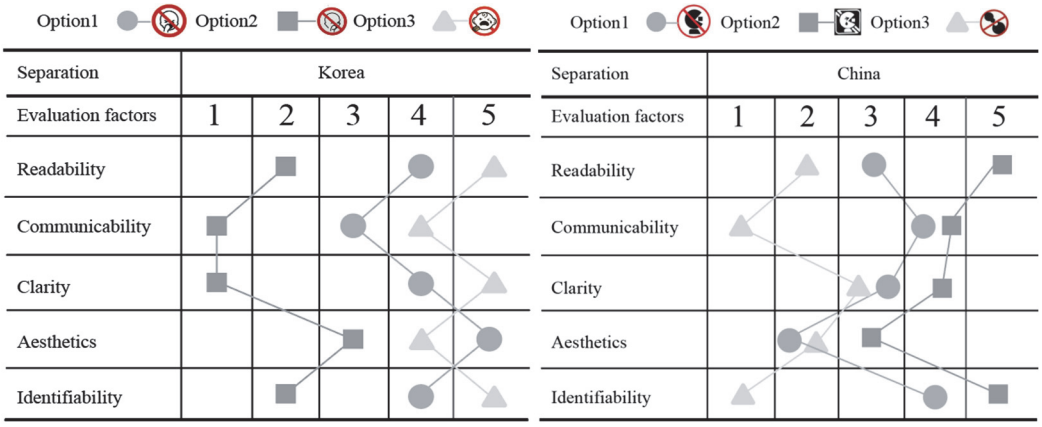
Based on the market research, we compared and analyzed the safety signs for children's accidental ingestion safety signs in China and Korea in terms of color, shape and image as shown in Table 4. The colors of the Korean children's accidental ingestion safety signs are red on the outside, white on the background, black on the inside, and circular in shape. The image is of a child covering his mouth with his hand or crying in front of a block. And the colors of China's children's accidental ingestion safety signs are red and black on the outside, with a white and black background. The colors on the inside are also black and white, which is not unified. The image shows a child's face from the side and top, eating a square block and crying.

While Korea uses most of the internationally standardized children's accidental ingestion safety signs directly or with variations, China uses a completely different set of children's accidental ingestion safety signs, which requires international standardization and utilization.

Table 4. Leading causes of accidental ingestion in children (subcategories)

Country	Children's accidental ingestion safety signs	Color	Shape	Image
Korea	 Option 1	Outside-Red Background-white Inside- black	Circle	A child is crying with their mouth covered.
	 Option 2	Outside-Red Background-white Inside- black	Circle	A side-angle view of a person covering their mouth.
	 Option 3	Outside-Red Background-white Inside- black	Circle	A block in front of a child who opens his mouth and cries.
China	 Option 1	Outside-Red Background-white Inside- black	Circle	A person opening their mouth and eating a square block.
	 Option 2	Outside- black Background-black Inside- white	Square	Side angle view of a person eating a square block with their mouth open and crying.
	 Option 3	Outside-Red Background-white Inside- black	Circle	A person opening their mouth and eating something round.

The following is an evaluation of the design of children's accidental ingestion safety signs in Korea and China based on five factors: readability, communicability, clarity, aesthetics, and identification. Seven experts currently working in the design industry were surveyed and the results are shown in Figure 3. As a result of the evaluation, Korea scored the highest with the third option, and China scored the highest with the second option.



(a) Korea **(b)** China

Figure 3. Results of the evaluation of China's and Korea's children's accidental ingestion safety signs

4.3 Analyzing the design problem of children's accidental ingestion safety signs

After comparing and analyzing the children's accidental ingestion safety signs in Korea and China, we found the following problems with the current children's accidental ingestion safety signs.

Firstly, the children's accidental ingestion safety sign is confusing, complex and inconsistent. Second, there was a gap between identifying information and children's perceptions. The wording made it difficult to identify whether the user was a child. Thirdly, the information was unclear because the figure's form did not clearly represent the inability to eat and the object being eaten. Fourth, the safety signs were designed to be insufficiently warning as they did not show the dangerous condition after eating.

4.4 International Standardized Guidelines for the Design of Children's accidental ingestion safety sign

The design guidelines (shape, color, image) for the international standardization of children's accidental ingestion safety signs through case analysis of Korean and Chinese children's accidental ingestion safety signs and evaluation using experts in this study are as follows Table 5. The design guideline should be circular in shape to symbolize prohibition and red in color to symbolize danger, in line with the International Organization for Standardization's International Safety Sign Standards. In addition, the images should be clearer and include a child's expression, distinguish the objects being eaten, and show the painful effects of eating.

Table 5. Leading causes of accidental ingestion in children (subcategories)

Shape (ISO-7010)	The shape should be circular, in line with the International Organization for standardization's international safety signing standard [14].
Color (ISO-3864)	① the background color should be white, with the inside of the circle and diagonal red. ② the graphical symbol color should be black with a white border.
Image	① the background color should be children should be clearly represented. ② the objects to be eaten should be separated into solids and liquids. ③ the painful state of children after eating should be depicted for warning purposes.

5. Improvements to the design of the International Standardized children's accidental ingestion safety signs

5.1 Improvements to the design of the International Standardized children's accidental ingestion safety signs

For the design improvement guidelines, four design prototypes were created based on the two preferred designs of the current Korea and China accidental ingestion safety signs and the design guidelines presented earlier. The shapes and colors are based on the standard graphic symbols of the International Organization for Standardization, and the images are different to show the direction of improvement. The first design, which will be used for the preference survey, is an improvement of the design that scored the highest in the Korean children's accidental ingestion safety signs evaluation, and the second design is the design that scored the highest

in the China children's accidental ingestion safety signs evaluation. The third design is a combination of the first and second designs, and the fourth design is an improved version of the international standard design.

Table 6. Leading causes of accidental ingestion in children (subcategories)

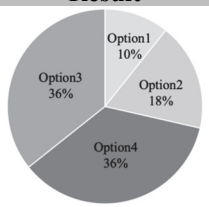
Separation	Symbol	Content
Option 1		① this is a design for an image of a child crying head-on. ② the shape of the user audience (child) is clearer, and a black rectangular object has been added.
Option 2		① the design shows a child crying while holding a square object at a side angle. ② the advantage of the side angle is that it gives a better understanding of how children eat with their mouths.
Option 3		① the design is built around a specific conditional description. ② designed more specific facial expressions to make the graphics livelier and alert.
Option 4		① the design is an improvement on the existing international standard accidental ingestion safety sign. ② it has a clearer, more distressing look than the old sign more distressing than the previous sign.

5.2 Surveying preferences for improved children's accidental ingestion safety signs

To evaluate the preferences of the newly improved design of the children's accidental ingestion safety sign, a preference survey was conducted on 5 June 2023 at 'Hanbat University Childcare Centre' located in Daejeon City with 28 children in the toddler stage (2-7 years old).

Figure 4. Results of the evaluation of China's and Korea's children's accidental ingestion safety signs

Table 7. Survey results on preferred design improved children's accidental ingestion safety signs

Plan	Total	Result
Option 1	3 people (10%)	
Option 2	5 people (18%)	
Option 3	10 people (36%)	
Option 4	10 people (36%)	
Total	28 people (100%)	

The results show that option 3 and option 4 are the most favoured with 10 votes each, followed by option 2 with 5 votes and plan 1 with 3 votes. And the results of the evaluation of the five safety sign design evaluation factors are shown in Table 8, and according to the evaluation results, the fourth option was the highest with 21 points, followed by the third option with 20 points, the second option with 17 points, and the first option with 16 points, which was the same as the preference analysis. Therefore, the final design improvement plan was decided as the fourth plan based on the results of the preference survey and evaluation factors.

Table 8. Surveying design preferences for the children accidental ingestion safety signs

Option		Evaluation scores				
	Evaluation factors	1	2	3	4	5
Option1 Option2	Readability					
	Communicability					
Option3 Option4	Clarity					
	Aesthetics					
	Identifiability					

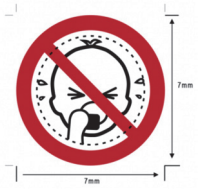
5.3 Final design for the children's accidental ingestion safety sign

The final design was based on the existing internationally standardized children's accidental ingestion safety sign, with improvements to the image of the child, the child's condition, and the objects. The before and after comparison is shown in Table 9. The improved design is more visual and clearer than the current childhood accidental ingestion safety signs and considers the cognitive characteristics of children. In addition, the minimum size of the labelling is 7 mm to be recognizable by children, as smaller labels on toy packaging may be difficult to read (see Table 10).

Table 9. Surveying design preferences for the children accidental ingestion safety signs

Before improvement	After improvement
	
① the image of the child is not clear. ② the child only covers his mouth with his hand The object is not specifically represented. ③ the expression on the face does not convey the feeling of pain the feeling of pain.	① the image of the child has been refined by adding hair. ② the black object has been added to make the misinformation clearer. ③ Tears were added to better show the pain of a crying child the pain of a crying child.

Table 10. Surveying design preferences for the children accidental ingestion safety signs

Size	Image
The minimum size of a children accidental ingestion safety sign is 7mm*7mm. Do not change the shape, thickness, proportions, etc. arbitrarily. Otherwise, the sign may become ambiguous.	

6. Conclusions

This study was conducted to improve the international standardization of the design of children's accidental ingestion safety signs based on disaster prevention design and in line with children's cognitive psychological development. The following conclusions were drawn on the improvement of the international standardization of the design of safety signs for children's accidental ingestion safety.

First, the image of the child is made clearer and more specific by adding hair. By adding hair to the image of the child who is the subject of the accidental ingestion, the image of the child is fleshed out and the image is clearer. This is a result of improving the safety sign to be perceived as a visual sensory experience from a child's perspective.

Secondly, the pain of eating was expressed more strongly. Tears were added to express the pain after eating and to emphasize the danger of eating to warn children. By expressing the painful situation of children better than before, the safety sign can increase the attention of children.

Third, it specifically represents putting a small object, such as a block, into the mouth. In the design of the safety sign, a square object was added to specifically represent the object. This clearly conveys the information of accidental ingestion to children and allows parents and guardians to recognize the object together.

The results of this study need to be verified through practical application in each country and further modified and supplemented with objective data. It is also necessary to conduct follow-up empirical studies for international standardization. Building on this, future work will compare differentiated symbol sets for infants (0-2 yrs) and preschool children (3-6 yrs) to determine whether age-tailored graphics further enhance recognition and compliance, thereby refining the guideline's precision. Finally, we hope that the research on improving the design of children's accidental ingestion safety signs and improving international standardization based on effective disaster prevention design will provide an opportunity to induce improvement efforts and interest in the safety system in our society and contribute to creating a safe society for children.

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