# Effects of Information Granularity on Health Education: An Artificial Intelligence-Based Situational R-Map Analysis

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Abstract: Unintentional injury is the leading cause of death among children in Japan and around the world. Enforcement, engineering, and education—also known as the "three Es"—currently constitute the core approach to injury prevention, and education plays a critical role in school safety. Providing information tailored to learners is an essential factor allowing educators to provide effective education, and we believe that granularity is one of the key factors for tailored messages. The purpose of this study is 1) to propose a situational R-Map analysis method to manipulate the granularity of injury data and 2) to examine how granularity affects injury prevention education design using this method. In the situational R-Map analysis method, the words contained in each sentence of an injury situation description are transformed into 100-dimensional vectors using the distributed representation method. A situation vector is created as the average of the word vectors in each sentence. The dimension of the situation vector is reduced from 100 to 2 using the "t-SNE" method. Then, we reordered these clusters in order of severity. To examine how granularity affects injury prevention education design, we conducted a workshop to see whether information granularity affects the number of preventive strategies devised by caregivers. We created a list of five bar- or slide-related injury situations (coarse list) and a list of a list of 30 bar-related or 19 slide-related injury situations (fine list). All participants first read the coarse list to devise and write down preventive strategies for each type of playground equipment. Then, they read the fine list to see whether they had come up with any additional strategies after reading the fine lists, and if so, to write them down. A total of 131 caregivers participated in the study and the results suggest that the appropriate granularity depends on the type of equipment and the learner's occupation and can be evaluated using our proposed method.

## 1 INTRODUCTION

Unintentional injury is the leading cause of death among children in Japan and around the world (Statistics of Japan, 2022, Peden et al., 2009). The top three leading causes of death in children aged 0–14 years are shown in Table 1. As such injuries are a substantial burden to society, the Japanese government has placed a high priority on reducing the incidence of childhood injuries. A government agency for children and family affairs was established in 2023 to provide seamless support for children in Japan, and injury prevention is one of the main themes (Cabinet Secretariat, n.d.). In terms of injury, school safety is an area that the Japanese government has been working on in recent decades. According to a report by the Japan Sport Council (JSC), in 2022, nine child deaths were reported in elementary schools and one in preschool, and approximately 72,000 and 282,000 injuries occurred in preschools and elementary schools, respectively, with the medical costs of each case exceeding 5000 JPY (ca. 40 USD in 2023) (JSC, 2022).

Enforcement, engineering, and education—also known as the "three Es"—currently constitute the core approach to injury prevention. Because the engineering approach typically requires no or minimal individual actions (Peden et al., 2009), this

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approach is generally considered to be more effective than enforcement and/or education. However, for many types of injuries at schools, either no engineering strategies are available, or they take a long time to implement. Consequently, education plays a critical role in school safety. With an increase in awareness about its importance at a community level, by January 2024, the International Safe Community Certifying Center had certified 17 Safe Communities (SCs) and 21 International Safe Schools (ISSs) through the Safe Community and Safe School Designation Program (Japan Institution for Safe Communities, n.d.). The SC framework, which was originally established in Sweden in 1970, seeks to systematize community activities in order to facilitate the creation of safe and secure communities in conjunction with citizens (International Safe Community Certifying Centre, n.d.). The ISS system is a version of the SC applicable to schools. Nowadays, injury prevention education directed at schoolchildren is also expanding (Oono et al., 2018, 2022).

Table 1: The five leading causes of death among persons aged 5–19 years in Japan, 2022.

| Age (years) | Ranking 1 | 2 | 3 |
|---|---|---|---|
| 0 | Congenital malformations, deformities, and chromosomal abnormalities (483) | Respiratory disorders specific to the perinatal period (202) | **Unintentional injury** (60) |
| 1–4 | Congenital malformations, deformities, and chromosomal abnormalities (114) | **Unintentional injury** (59) | Malignant neoplasm (46) |
| 5–9 | Malignant neoplasm (89) | Congenital malformations, deformities, and chromosomal abnormalities (29) | **Unintentional injury** (28) |
| 10–14 | Suicide (119) | Malignant neoplasm (84) | **Unintentional injury** (34) |

* Numbers in parentheses indicate the number of cases.

One of the most difficult, but critical, factors for injury prevention through education is to convince people of the importance of injury prevention. This is closely related to the concept of perceived susceptibility in the field of health education. Perceived susceptibility is a construct of the Health Belief Model (HBM) developed by Irwin M. Rosenstock (Glanz et al., 2008). The HBM is concerned with the likelihood of contracting a disease or developing a condition. According to the HBM, people are more likely to practice healthy behaviors if they believe that their chance of developing a negative health condition is high (Glanz et al., 2008). By applying this concept to injuries, people are most likely to adopt preventive actions only if they are convinced that serious injury can occur. Educating caregivers, including schoolteachers, parents, and staff in after-school programs is more complex, as their perception of injury is ameliorated by the fact that the injury does not affect them directly, but rather the children in their care.

We have been conducting injury prevention research for more than 20 years, and it is now well understood from our experience that people's perceived susceptibility to injury depends on their level of childcare experiences. For instance, when we discuss an injury related to a swing, people with many care experiences can think of a much wider variety of injury risks than can novices. Therefore, from the perspective of health educators, we need to provide more details to novice caregivers regarding how injuries occur so that they can assume and prepare for prevention adequately. Our underlying assumption in the present study is that information granularity is critical to maximizing one's learning ability, which is the hypothesis tested in this study. Transmitting information tailored to learners is always an essential factor for educators who wish to provide effective education (Hawkins, 2008), and we believe that granularity is one of the key factors for such tailored messages. In the present paper, we first propose a situational R-Map analysis method to manipulate the granularity of injury data. Then, we examine how granularity affects injury prevention education design using this method. Lastly, we introduce the Egao search system using the proposed method.

## 2 AN ARTIFICIAL INTELLEGENCE (AI)-BASED SITUATIONAL R-MAP

We developed a situational R-Map analysis by integrating existing R-Map analysis methods and text mining. Conventionally, a R-Map is a well-known method for prioritizing injuries from the viewpoints of both frequency and severity (Ministry of Economy, Trade and Industry, 2011). In this method, the words contained in each sentence of an injury situation description are transformed into 100-dimensional vectors using the distributed representation method (word2vec). A situation vector is created as the average of the word vectors in each sentence. The dimension of the situation vector is reduced from 100 to 2 using the "t-SNE" method (Maaten and Hinton, 2008).

We used injury data from the JSC; the JSC database is the largest school injury dataset in Japan. Figure 1 shows a t-SNE graph depicting a cluster analysis (20 clusters) of 6549 bar-related injury cases that occurred in elementary schools using a k-means approach. Each dot indicates one injury situation, and each color indicates a similar injury situation.

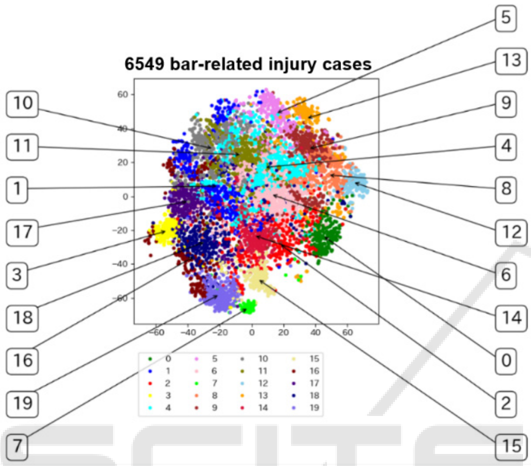


Figure 1: A t-SNE graph depicting a cluster analysis of 6549 bar-related injury cases.

Next, we reordered these clusters in order of severity. In the present study, we defined high-risk injuries as those having both high frequency and high medical costs. Figure 2 shows a situational R-Map for bar-related injury cases based on the cluster analysis.

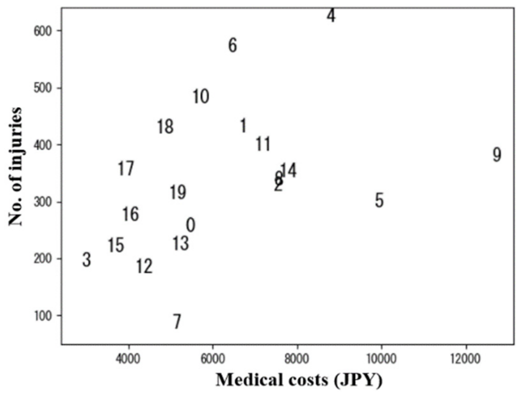


Figure 2: Situational R-map for bar-related injury cases based on the cluster analysis.

Based on each cluster, we identified typical injury situations. When situations from different clusters were similar, we considered them to be the same situation. Table 2 shows the top five examples of the cluster situations based on injury severity. Using an AI-based situational R-Map analysis makes it possible to understand typical injury situations in a data-driven way.

Table 2: Top five examples of cluster situations.

| | Cluster No. | Injury situation |
|---|---|---|
| 1 | 5, 9 | Landed on one's hands after falling. |
| 2 | 1, 10 | Hit one's back and/or face after falling. |
| 3 | 19 | Hit one's face on an unnoticed bar while playing tag. |
| 4 | 12 | Failed to land properly and twisted one's leg. |
| 5 | 15 | Some sand blew into one's eyes or someone's foot touched one's eyes. |

# 3 EVALUATION OF HOW INFORMATION GRANULARITY AFFECTS INJURY PREVENTION EDUCATION DESIGN

In terms of injury prevention education, on the one hand, vague information does not help much when thinking about preventive measures. On the other hand, too many details are ineffective because learners cannot process them to develop appropriate prevention strategies. The aim of this evaluation study is to clarify how information granularity affects injury prevention education design.

## 3.1 Method

### 3.1.1 Controlling Information Granularity

In this study, we controlled information granularity by changing the number of clusters based on our proposed method. Figure 3 shows a t-SNE graph of a cluster analysis for bar-related injuries of 4480 cases when determining the numbers of clusters as five (left) and 30 (right). Then, we identified typical injury situations for each cluster and reordered them in terms of severity, which yielded two lists (Tables 3 and 4). Interim listings were omitted in the case of the 30 clusters in Table 4. As shown in these two tables, identified typical injury situations are less detailed when the number of clusters is five. We created two lists for bar- and slide-related injuries. In the case of slide-related injuries, we determined that the number of clusters was 20 using a k-means approach.

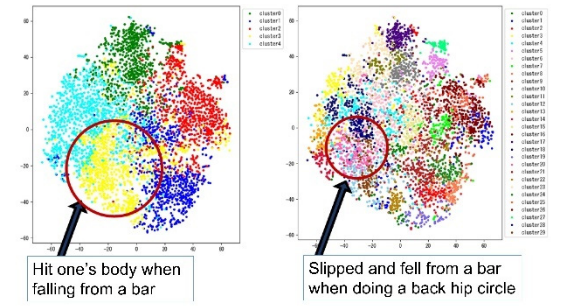


Figure 3: A t-SNE graph of a cluster analysis of bar-related injuries (No. of clusters: 5 and 30).

Table 3: Injury situation list (No. of clusters: 5).

| | Injury situation |
|---|---|
| 1 | Fell on one's hand or elbow and broke bones. |
| 2 | Fell and hit one's body. |
| 3 | A child felt pain and a teacher noticed an injury. |
| 4 | Crashed into a bar when running nearby. |
| 5 | Fell and hit one's face or a part of one's body on bars or the ground. |

Table 4: Injury situation list (No. of clusters: 30).

| | Injury situation |
|---|---|
| 1 | Slipped and fell while moving forward and backward on the bars. |
| 2 | Lost balance and fell on the arms or hands while attempting to sit on the bars. |
| 3 | Fell to the ground. |
| 4 | Fell when unsupervised by a caregiver. |
| 5 | Hands slipped off the bars; failed to grasp the bars and fell to the ground. |
| 6 | Fell and hit one's arms. Complained about the pain. |
| 7 | Complained about the pain after a short time. |
| 8 | Failed to land properly and hit one's body on the ground. |
| 9 | Hit one's face on a bar when playing tag. |
| 10 | Hit one's face on a bar while moving through or failing to notice. |
| 28 | Hit one's mouth on a bar and started bleeding from the teeth and lips. |
| 29 | Hit one's head on a bar while jumping around. |
| 30 | Some sand blew into one's eyes. |

### 3.1.2 Analysis of the Influence of Granularity on Injury Prevention Education Design

In this subsection, we describe how we quantitatively analyzed the influence of information granularity on injury prevention education design. Where the probability that event $x_1, x_2 \ldots, x_n$ can be $(x_1), (x_2), \ldots P(x_n)$, the average information $H$ can be calculated as Eq. (1). In this study, we calculated the average information $H$ for situations in clusters and used it as an indicator to determine the granularity of injury situations quantitatively. This average information for injury situations ($SH$) is defined as Eq. (2).

$$H = -\sum_{i=0}^{n} P(x_i)\log_2 P(x_i) \tag{1}$$

$$SH_{CN} = -\sum_{i=0}^{CN} P(x_i)\log_2 P(x_i)$$

$$\text{where} \quad x_i = \frac{\text{No. of clusters}_i}{\text{No. of cases}}, CN\text{: Number of cluster} \tag{2}$$

Thus, the larger the average information for injury situations ($SH$), the finer the granularity of the injury situation information categorized into clusters. Table 5 shows a summary of the average information for injury situations.

Table 5: Summary of the average information for injury situations.

| | *SH* | No. of clusters |
|---|---|---|
| Bar | 2.30 | 5 |
| Bar | 4.84 | 30 |
| Slide | 2.29 | 5 |
| Slide | 4.17 | 19 |

## 3.2 Data Collection

We conducted a workshop to examine whether information granularity affects the number of preventive strategies devised by caregivers. The workshop procedures were as follows. First, all workshop participants attended a lecture on the importance of injury prevention. Second, all participants received and read a list of five bar- or slide-related injury situations (coarse list). After reading, we asked the participants to devise and write down preventive strategies for each type of playground equipment to the best of their ability. Third, we gave the participants a list of 30 bar-related or 19 slide-related injury situations (fine list). Then, we asked whether they had come up with any additional strategies after reading the fine lists, and if so, to write them down. We conducted three workshops: one for bar-related and two for slide-related injuries.

## 3.3 Results

A total of 131 caregivers participated in this study. A summary of the three workshops is shown in Table 6. When we counted the number of preventive strategies that participants had listed by reading the coarse lists, on average, group 1 listed 2.7 strategies (range, 0–7), group 2 listed 3.81 (range, 0–8), and group 3 listed 3.44 (range, 1–6). When asked to come up with additional strategies by reading the fine lists, on average, group 1 listed 1.41 new strategies, group 2 listed 3.30, and group 3 listed 2.07. Overall, 82% of the participants successfully came up with new prevention strategies after reading the fine lists.

Table 6: Summary of the three workshops.

| Group No. | Occupation | No. of participants | Equipment type | Mode |
|---|---|---|---|---|
| 1 | Daycare teacher | 65 | Bar | Online |
| 2 | Children's center teacher | 37 | Slide | On site |
| 3 | Daycare teacher | 29 | Slide | On site |

Figure 4 shows the relationship between the average information for injury situations (*SH*) and the number of strategies devised by the participants. Regarding the number of strategies after reading the fine lists, we added the numbers from the coarse and fine lists. This figure clearly shows differences in granularity effects by equipment type. As shown in Figure 4, the slope connecting the two points for the bars regarding fine and coarse injury situations is 0.56, whereas the slope for the slide is 1.10. This means that the participants devised more preventive strategies for the slide after reading the fine lists.

Figure 5 shows that the slope connecting the two points for the slide regarding fine and coarse injury situations is 1.10 for daycare teachers, compared with 1.75 for children's center teachers. This means that the fine lists were more effective for allowing children's center teachers to think about preventive strategies for slide safety.

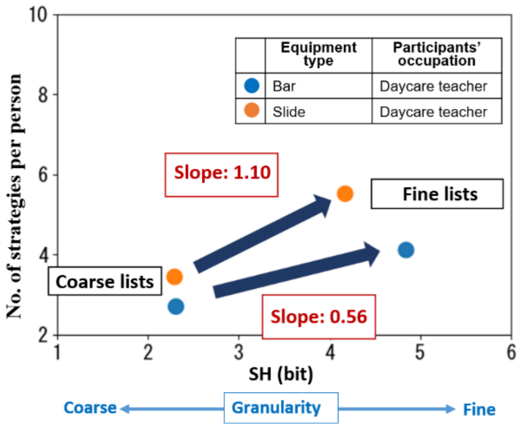


Figure 4: Relationship between the average information for injury situations (SH) and the number of strategies (equipment type difference).

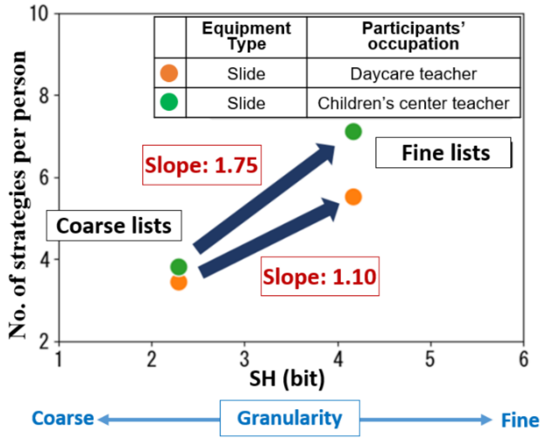


Figure 5: Relationship between the average information for injury situations (SH) and the number of strategies (occupation difference).

## 3.4 Discussion

In this study, we controlled information granularity by changing the number of clusters based on our proposed method and examined how it affected the development of preventive strategies. The number of strategies devised by learners is a critical factor in injury prevention education design.

As shown in Figure 4, the fine lists for the bars were less effective than the coarse lists in terms of thinking about injury prevention strategies. This might be because most bar-related injury situations are nearly equal to "falling off the bars" or "hitting the bars". These situations cannot be more detailed, even if the AI divides them into different clusters. By contrast, slide-related injury situations vary, and thus work well for learners to think about their actions. Our results also suggest that granularity is affected by the learner's occupation. In this study, the fine lists were more effective for children's center teachers than for daycare teachers. There are two important points that should be taken from these findings. First, our proposed method appears to be useful for quantitatively evaluating the effectiveness of educational information for learners. Health educators often discuss the importance of tailored information, and our method appears to be useful to achieve these goals. Second, the appropriate amount of granularity appears to depend on the type of equipment and the learner's occupation. This could also help health educators create information tailored to learners.

This study had several limitations. First, we did not ask the participants about their age, sex, or working experience, which could have affected the number of preventive strategies they devised. Second, we only asked the participants about two types of equipment; the findings may have differed if we had asked about other types. Third, we did not randomly assign the participants to evaluate the granularity effects. Despite these limitations, the results of the present study suggest that information granularity affects the design of injury prevention education, and that our proposed method is useful to assess such granularity from the viewpoints of equipment type and learner's occupation.

# 4 DEVELOPMENT OF THE EGAO SEARCH SYSTEM

"Egao" means smile in Japanese. We named our system Egao because a smile is one of the most important social assets of children. The Egao search system (hereafter, the Egao system) has three functions, as shown in Figure 6: 1) it facilitates user searches for high-risk injuries, 2) it provides safety tips, and 3) it allows users to ask questions of experts and other Egao users. A login ID and password are necessary to access the Egao system. The first function is implemented by a situational R-Map analysis. Egao users can search for injuries based on the locations at which the injuries are known to occur, such as classrooms, gyms, or hallways, the types of playground equipment that are known to cause the types of injury, or the types of sporting activities known to cause such injuries. Options can be selected by clicking on an icon. The users also can input text describing the cause of the injury to search for associated injury types. The current list of icons is shown in Figure 7. By clicking the search button, a list of injury cases is displayed in descending order of risk. The implementation of this function is as follows. First, by using word2vec, a text mining technique, sentences in an injury database that contain descriptions of how various injuries occurred are transformed into numerical vectors. We used injury data from the JSC for the last 5 years (approximately 990,000 injury data points). Second, the Egao system then transforms the sentences inputted by Egao users into numerical vectors, as in the first step. Third, the Egao system calculates the cosine similarities between the two vectors, using the Approximate Nearest Neighbors Oh Yeah (Annoy) algorithm (Spotify, 2022), and then extracts the top 20 most similar injury situations. Fourth, the Egao system reorders the 20 cases in order of severity.


Figure 6: Screenshot of the Egao search system menu.

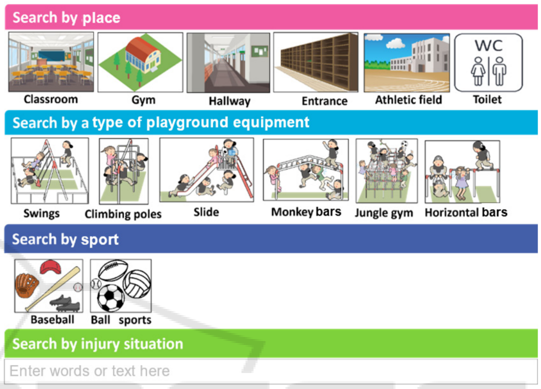


Figure 7: Screenshot of the Egao search system.

The top five examples of extracted injury cases with information on the nature and severity of the injury are as follows. These representative examples show the results in the Egao system for the sentence, "*I was going up the stairs, and I slipped and fell because the floor was wet*".

- After cleaning the classroom, the student was going up the stairs, slipped, and fell. The student hit their hand on the floor and was injured. (Broken bone, Severity: high)
- During break time, the student hurried down the stairs. The student slipped and fell because the floor was wet and hit their head and right knee on the floor. The student was pale and in shock for a while. (Bruise, Severity: high)
- The student was going down the stairs on the way to the gymnasium to play with friends during a lunch break. The student did not notice that the floor was wet, and slipped and fell. The student hit their head on the handrail and fell down several steps until reaching the landing. (Bruise, Severity: high)
- The student slipped and fell off the first step at the bottom of the stairs after descending the

stairs while holding their friend's hand. (Broken bone, Severity: high)

- During a short break between classes, the student tripped and fell and hit their face on the floor with considerable force. (Laceration, Severity: high)

Here, we describe only five examples of injuries, but as mentioned previously, users of the Egao system obtain 20 examples of high-risk injury cases based on their search terms.

In the second function of searching for safety tips, Egao users can search for safety tips based on the locations where the types of injury are known to occur, such as in classrooms, gyms, or hallways, the types of playground equipment on which they occur, or the types of sports activities that cause them. These options can be selected by clicking on an icon. Users also can input words or sentences describing the cause of injury to search for related safety tips. When the Egao system cannot find safety tips in the list based on the user's search terms, it prompts the user to ask questions; this function is explained as follows.

In the user questions function, Egao users can ask questions regarding preventive actions. They can also upload pictures and explain why they consider the situations depicted in the images to be dangerous. After posting the questions, they can receive suggestions and comments from injury prevention experts or other Egao users.

## 5 CONCLUSION

In this study, we conducted a situational R-Map analysis by integrating R-Map analysis and text mining methods. We applied the concept of information granularity to injury prevention education design to evaluate messages tailored to learners. We controlled the granularity of injury situation texts for this particular study, but this strategy can be used for any kind of health information to create effective health messages. We also introduced the Egao system, which can be used by schoolteachers. We plan to implement this system in schools so that students and teachers can have fun together learning about injury prevention. Most importantly, by revealing that information granularity influences learners' ability to think about preventive strategies, the results of this study indicate that information granularity affects injury prevention education design.

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