Study on Reconstructing Disaster Propagation Patterns to Evaluate Evacuation Actions in Emergencies with Adequate Lead Time

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Abstract

In the response phase of a disaster, inadequate actions by on-site commanders or followers can lead to significant loss of life. Therefore, it is essential to educate and train them to take appropriate action based on historical Disaster Propagation Patterns (DPPs). This study proposes a tool for reconstructing DPPs to evaluate evacuation actions. The tool, referred to as the Hazard–Action Tool, consists of two columns: the Hazard column, which describes what hazards do as active agents, and the Action column, which describes what actors (e.g., responders or civilians) do in response. Each column presents key scenes along a timeline. Each scene is structured using the E5W1H framework, which includes 'When', 'Where', 'Who', 'What', 'How', 'Why', 'Sequel', and 'Image'. Using the Hazard–Action Tool, we reconstructed four historical cases in which there was sufficient lead time before the impact. From the findings of these cases, we suggest that on-site commanders must understand the expected scenarios and assumptions in emergency manuals or plans and must continuously assess whether real-time emergency conditions deviate from those scenarios. If a deviation is identified, they must promptly adjust or revoke previous orders or policies. In emergencies, most people are likely to be followers. However, no matter how urgent the situation may be, we must not abandon our sense of agency. Simply waiting for instructions without acting is no different from surrendering our autonomy. Followers should actively observe situational changes and report them to commanders to facilitate timely and appropriate actions.

Keywords

Disaster Propagation Patterns, Evacuation Actions, Emergency, Lead Time, Hazard-Action, E5W1H

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1. Introduction

Background

Although it is impossible to completely prevent disasters from occurring, continuous efforts toward Disaster Risk Reduction (DRR) are essential. All phases of the disaster management cycle—including prevention, preparedness, response, and recovery—are crucial for DRR. Nevertheless, mistakes made during the response phase tend to receive the least public tolerance. Errors at this stage can lead to widespread confusion and chaos, not only within local communities but across an entire nation. For example, in South Korea, intense public criticism of the government's inadequate response to the tragic 2014 Sewol ferry disaster ultimately became a catalyst for the impeachment of President Park Geun-Hye (Song, 2016).

Purpose

To prevent the recurrence of such failures, many governments and institutions document and publish lessons learned from past disasters. For instance, the Japan National Research and Development Agency (2021) compiled a collection of near-miss cases in flood disaster response. Kee et al. (2016) performed a causal analysis of the Sewol ferry disaster using the AcciMap method. Additionally, Katada and Kanai (2016) highlighted the so-called "Kamaishi Miracle" during the 2011 Great East Japan Earthquake as a valuable example to foster students' judgment in emergency situations.
Many studies focus on identifying the causes of accidents to develop solutions that prevent their recurrence. However, this paper specifically targets inappropriate actions taken not only by commanders but also by followers during the response phase of a disaster. The author aims to explore how everyone can survive through appropriate actions even in emergency situations and ultimately seeks to provide education that empowers the public to make proper decisions and take appropriate actions when facing such situations.

Objectives

While establishing and training for an emergency action plan is crucial to avoid mistakes during the response phase, real-life emergencies often differ significantly from the scenarios outlined in manuals or plans. Therefore, flexible response capabilities are essential. Such flexibility enables responders to adapt effectively to unforeseen circumstances. These capabilities can be cultivated through a deeper understanding of Disaster Propagation Patterns (DPPs)—that is, how the effects of a disaster unfold and spread. With this knowledge, we can conduct more realistic simulation exercises, ultimately enhancing overall disaster response performance. In this paper we reconstruct DPPs for evaluating evacuation actions in emergencies with adequate lead time.

Scope

Although numerous emergency situations exist, this study specifically focuses on cases where evacuation issues arose despite having sufficient time to evacuate. By examining the DPPs in these cases, this research evaluates actions taken during emergencies. It also aims to discuss appropriate actions from the perspective of commanders who issue evacuation orders and followers who must comply with these orders.

The 2011 Okawa Elementary School tragedy highlights the critical importance of the actions and decisions made by on-site commanders (or leaders). At the time, the vice principal, who was both the on-site commander and the person in charge of the school's disaster evacuation plan, failed to adjust the general wording of the national disaster evacuation guidelines to fit the surrounding environment of the school in advance. As a result, during the disaster, valuable time was wasted interpreting the general wording, and he directed students to evacuate in the wrong direction, leading to the tragic deaths of 74 out of 78 students. (Parry, 2017)

The primary cause of the 2014 Sewol ferry tragedy can be attributed to the inadequate emergency response capabilities of the captain and crew members. From the moment the Sewol ferry began to tilt, four consecutive announcements instructing passengers to remain inside the vessel were broadcast and remained unchanged until the captain and his crew evacuated. This failure deprived passengers of the opportunity to escape independently, becoming a critical factor that led to the deaths of over 300 individuals. (Hong, 2015)

Let's reflect on the 2017 Grenfell Tower fire in London. The fire started on the 4th floor of a 23-story building. Upon receiving the initial fire report, the London Fire Brigade (LFB) advised residents to follow the "stay put" policy, assuming a typical fire scenario. This policy, commonly implemented in most high-rise buildings during fires, depends heavily on the building being correctly constructed. Regulations require that fire must not spread from one flat to another for at least 60 minutes. However, in the Grenfell Tower incident, the "stay put" policy remained in place for an hour and 53 minutes, despite the rapid spread of fire beyond regulatory expectations. This delay resulted in many residents losing precious time to evacuate, ultimately leading to the tragic loss of 72 lives. (Lamble & Casserly, 2024)

It is important to monitor the situation until the emergency is over and to respond according to changing circumstances. We can learn this lesson from the 2011 Kamaishi Miracle in Japan. During the 2011 Tōhoku earthquake and tsunami, Kamaishi Higashi Junior High School and the adjacent Unosumai Elementary School were located outside the hazard map's danger zones. However, instead of relying solely on this information, they continuously monitored the tsunami situation and adjusted their action plans accordingly. Recognizing that the tsunami was larger than expected, they decided to evacuate to a safer area. This proactive response allowed them to survive a disaster that exceeded initial predictions. (Katada & Kanai, 2016)

Can we ensure our survival merely by following the instructions of emergency commanders? If, while monitoring an emergency, your judgment conflicts with official instructions, what course of action should

you take? If you strictly adhere to official instructions and lose your life, you risk becoming a victim of unreasonable guidance. Conversely, if you act independently based on your own judgment and still perish, you might be remembered as having acted recklessly.

Ideally, the best decision is to persuade the incident commander that your assessment is more rational, thereby prompting them to reconsider their initial orders. However, this is undoubtedly a challenging endeavor, especially during a crisis.

Chapter 2 proposes the Hazard–Action Tool for reconstructing DPPs. Chapter 3 applies the tool to four historical cases, reconstructs their DPPs, evaluates the response actions identified, and explores guidelines for preventing recurrence. Chapter 4 presents the results of the case studies. Finally, Chapter 5 offers conclusions based on the findings.

2. The Hazard-Action Tool for Reconstructing DPPs

2.1 Basic Concept of DPP

A DPP can be understood, in simple terms, as a structured disaster story that unfolds over time. It describes how a disaster develops, spreads, and impacts people, systems, or environments across various stages. Much like a narrative, a DPP helps us organize the sequence of events in a coherent manner, offering valuable insights into how a situation evolved and how people responded.

DPPs can be expressed in different formats depending on the context and purpose of their use. One common approach is to present them in a narrative form, like a news article or incident report. This format is especially useful when the goal is to communicate the overall storyline—what happened, who was involved, and how events unfolded. Such narrative DPPs are intuitive and accessible for a wide range of audiences, including policymakers, researchers, and the public.

Alternatively, if the purpose is to emphasize the chronological order of events or analyze the timing of decisions and actions, a timeline-based format may be more appropriate. In this case, key events are organized along a temporal axis, allowing readers to visualize how one action or hazard led to another. This method is particularly useful for training, simulation, and reviewing disaster response performance.

In cases where the goal is to analyze the root causes or the mechanisms behind a disaster, more technical tools such as AcciMap, Event Tree Analysis (ETA), or Fault Tree Analysis (FTA) can be used. These tools break down complex systems and interactions to identify contributing factors, decision points, and possible failures. They are often used in engineering, risk assessment, and safety investigations.

Ultimately, the form of a DPP should be aligned with its intended purpose:

- ✧ For storytelling and communication → Narrative format
- ✧ For temporal clarity and decision analysis → Timeline format
- ✧ For causal analysis and risk investigation → Structured analytic tools (AcciMap, ETA, FTA)

By selecting the right format for a DPP, practitioners can better understand disasters, draw meaningful lessons, and improve future preparedness and response.

2.2 Hazard-Action Tool

To easily explain DPPs to readers, it's essential to describe it sequentially, following the flow of time. Visual materials can also significantly enhance understanding. Readers need clear guidance to grasp how actors take certain actions in an emergency triggered by hazards, and what consequences arise from these actions. Achieving this goal requires developing a new tool specifically designed for DPP.

We propose the Hazard-Action tool, which consists of two columns: the left column relates to hazards, and the right column relates to actions. Each column contains key scenes described using the extended 5W1H (E5W1H) framework, as shown in Table 1.

In the Hazard column, 'Who' identifies hazards; 'When' indicates the starting point of 'What'; 'Where' specifies the location where 'What' occurs; 'What' describes emergencies caused by 'Who'; 'How' refers to direct consequences following 'What'; 'Why' explains reasons or causes for 'How' (if 'How' is unspecified, then for 'What'); and 'Sequel' represents cascading consequences resulting from 'How'. In the Action column, 'Who' identifies actors; 'What' describes actions taken by 'Who'; the remaining items follow the same definitions as in the Hazard column.

In the Hazard-Action tool, only one type of scene, either Hazard or Action, can be placed on a single timeline. Thus, when a Hazard scene appears, the slot reserved for Action remains empty, and vice versa. These empty slots, called 'Image' here, can then be used to provide visual materials, helping readers easily understand the context of each scene.

Table 1. The extended 5W1H (E5W1H) framework used for describing scenes in the Hazard-Action tool

E5W1H	Hazard	Action
Who	Hazards	Actors
When	The starting point of 'What'	The starting point of 'What'
Where	Location where 'What' occurs	Location where 'What' occurs
What	Emergencies caused by 'Who'	Actions taken by 'Who'
How	Direct consequences following 'What'	Direct consequences following 'What'
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	Reasons or causes for 'How'; if 'How' is not specified, then for 'What'
Sequel	Cascading consequences resulting from 'How'	Cascading consequences resulting from 'How'
Image	Visual materials to facilitate understanding	Visual materials to facilitate understanding

3. Reconstructing and Reviewing DPPs Using the Hazard-Action Tool

In this chapter, we reconstruct the DPPs of real cases using the Hazard-Action tool and evaluate the actions taken by actors identified in these cases. Furthermore, we discuss appropriate actions that should be taken to survive when encountering similar situations.

3.1 The 2011 Okawa Elementary School Tragedy in Japan

We reconstructed the DPP of the 2011 Okawa Elementary School Tragedy in Japan using the Hazard-Action tool, consisting of 14 scenes, as shown in Table 2.

(Scene #1) At 2:45 PM on March 11, 2011, an earthquake hit Okawa Elementary School at Nirashima-94 Kamaya, Ishinomaki, Miyagi. Students and teachers in the classroom went out and gathered in the playground, lined up by class. This followed the emergency action plan.

(Scene #2) At 2:59 PM on March 11, 2011, the JMA (Japan Meteorological Agency) issued a warning: A six-meter-high tsunami was expected; everyone on the coast in northeastern Japan was advised to evacuate to higher ground.

(Scene #3) At 3:03 PM, 3:06 PM, and 3:12 PM on March 11, 2011, more aftershocks shook Okawa Elementary School at Nirashima-94 Kamaya, Ishinomaki, Miyagi.

(Scene #4) At 3:14 PM on March 11, 2011, the JMA updated its warning: The tsunami was expected to reach a height of 10 meters.

(Scene #5) Around 3:14 PM on March 11, 2011, the deputy headmaster, Toshiya Ishizaka, who was responsible for revising the Education Plan, was trying to direct emergency actions during the tsunami according to the Education Plan in the playground. He found only these vague words in the Education Plan to puzzle over: "Primary evacuation place: school grounds. Secondary evacuation place, in case of tsunami: vacant land near school, or park, etc." because he left the generic wording of the template (the Education Plan) unchanged. The school was located immediately in front of a forested hill, 220 meters high at its highest point. He didn't consider the hill to be vacant land or a park.

(Scene #6) A senior teacher, Junji Endo, asked Ishizaka: "What should we do? Should we run to the hill?" in the playground. Endo was told that it was impossible due to the shaking.

(Scene #7) Parents and grandparents of the students arrived by car and on foot to pick up their children in the playground. However, they stayed in the playground because the teachers told them it was better to stay at school.

(Scene #8) Local people from the village arrived at Okawa Elementary School, which was designated as an official evacuation site for the village of Kamaya.

(Scene #9) Toshinobu Oikawa, a worker at the local branch of the Ishinomaki town government, was driving fast and shouting through the car's loudspeaker around Okawa Elementary School: "A super-tsunami has reached Matsubara. Evacuate! Evacuate to higher ground!"

(Scene #10) At 3:25 PM, Oikawa and the three loudspeaker vans drove past; the teachers were preparing to burn wood in oil drums to keep the children warm in the school playground.
(Scene #11) Around 3:30 PM on March 11, 2011, the deputy headmaster, Toshiya Ishizaka, called out in the school playground, "A tsunami seems to be coming! Quickly! We're going to the traffic island. Get in line, and don't run."
(Scene #12) At 3:30 PM on March 11, 2011, an elderly man named Kazuo Takahashi, who suddenly became aware of the tsunami, parked his car next to the school. As he climbed out and headed for the hill, he saw a large number of children rushing out of the school in a hurry.
(Scene #13) Barely a minute had passed since they left the playground when the tsunami, a sheet of white spray rising above the dark waters, moved in the direction near the school where the children had been ordered to evacuate and engulfed them. Of the 78 students present at the moment of the tsunami, 74, along with 10 out of the 11 teachers, lost their lives.
(Scene #14) On April 26, 2018, the Sendai High Court ordered the governmental authorities to pay around 1.4 billion yen ($13 million) in damages to the families of the pupils, raising the amount of compensation by about 10 million yen from a lower court ruling. The authorities "failed to fulfill their obligation to revamp a risk management manual in line with the realities of Okawa Elementary School," Presiding Judge Hiroshi Ogawa said, adding, "If the manual had designated a 20-meter-high location for evacuation," the deaths could have been prevented.

Table 2. DPP of the 2011 Okawa Elementary School Tragedy in Japan

Hazard

Hazard	Alias	Description
Who	Hazards	An earthquake
When	The starting point of 'What'	At 2:45 PM on March 11, 2011
Where	Location where 'What' occurs	At Nirashima-94 Kamaya, Ishinomaki, Miyagi
What	Emergencies caused by 'Who'	Hit Okawa Elementary School
How	Direct consequences following 'What'	Students and teachers in the classrooms went out and gathered in the playground, lined up by class.
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	Because of the emergency action plan.
Sequel	Cascading consequences resulting from 'How'	

Image

Hazard	Alias	Description
Who	Hazards	More aftershocks
When	The starting point of 'What'	At 3:03 PM, 3:06 PM, and 3:12 PM on March 11, 2011
Where	Location where 'What' occurs	At Nirashima-94 Kamaya, Ishinomaki, Miyagi
What	Emergencies caused by 'Who'	Shook Okawa Elementary School
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Action

Image


Action	Alias	Description
Who	Actors	The Japan Meteorological Agency
When	The starting point of 'What'	At 2:59 PM on March 11, 2011
Where	Location where 'What' occurs	In northeastern Japan
What	Actions taken by 'Who'	Issued a warning: A six-meter-high tsunami was expected; everyone on the coast of northeastern Japan was advised to evacuate to higher ground.
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Action	Alias	Description
Who	Actors	The Japan Meteorological Agency
When	The starting point of 'What'	At 3:14 PM on March 11, 2011
Where	Location where 'What' occurs	In northeastern Japan
What	Actions taken by 'Who'	Updated its warning: The tsunami was expected to reach a height of 10 meters.
How	Direct consequences following 'What'	

Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Action	Alias	Description
Who	Actors	The deputy headmaster, Toshiya Ishizaka, who was responsible for revising the Education Plan.
When	The starting point of 'What'	Around 3:14 PM on March 11, 2011
Where	Location where 'What' occurs	In the playground
What	Actions taken by 'Who'	Was trying to direct emergency actions during the tsunami according to the Education Plan.
How	Direct consequences following 'What'	He found only these vague words in the Education Plan to puzzle over: "Primary evacuation place: school grounds. Secondary evacuation place, in case of tsunami: vacant land near school, or park, etc."
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	Because he left the generic wording of the template (the Education Plan) unchanged.
Sequel	Cascading consequences resulting from 'How'	The school was located immediately in front of a forested hill, 220 meters high at its highest point. He didn't consider the hill to be vacant land or a park.

Image

Action	Alias	Description
Who	Actors	A senior teacher, Junji Endo
When	The starting point of 'What'	
Where	Location where 'What' occurs	In the playground
What	Actions taken by 'Who'	Asked Ishizaka: "What should we do? Should we run to the hill?"
How	Direct consequences following 'What'	Endo was told that it was impossible due to the shaking.
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Action	Alias	Description
Who	Actors	Parents and grandparents of the students
When	The starting point of 'What'	
Where	Location where 'What' occurs	In the playground
What	Actions taken by 'Who'	Arrived by car or on foot to pick up their children.
How	Direct consequences following 'What'	They stayed in the playground.
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	Because the teachers told them it was better to stay at school.
Sequel	Cascading consequences resulting from 'How'	

Image

Action	Alias	Description
Who	Actors	Local people from the village
When	The starting point of 'What'	
Where	Location where 'What' occurs	In the playground
What	Actions taken by 'Who'	Arrived at Okawa Elementary School, which was designated as an official evacuation site for the village of Kamaya.
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Action	Alias	Description
Who	Actors	Toshinobu Oikawa, a worker at the local branch of the Ishinomaki town government.
When	The starting point of 'What'	At 3:25 PM
Where	Location where 'What' occurs	Around Okawa Elementary School
What	Actions taken by 'Who'	Was driving fast and shouting through the car's loudspeaker: "A super-tsunami has reached Matsubara. Evacuate! Evacuate to higher ground!"
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Action	Alias	Description
Who	Actor	The teachers
When	The beginning of 'What'	At 3:25 PM, Oikawa and the three loudspeaker vans drove past.
Where	Currently or potentially affected areas	In the school playground
What	Actions that actors take	Were preparing to burn wood in oil drums to keep the children warm.
How	Direct consequences of 'What'	
Why	Causes or reasons for 'How'; if 'How' is not specified, then for 'What'	
Sequel	Cascading Consequences	

Image

Action	Alias	Description
Who	Actors	The deputy headmaster, Toshiya Ishizaka
When	The starting point of 'What'	Around 3:30 PM
Where	Location where 'What' occurs	In the school playground
What	Actions taken by 'Who'	Called out, "A tsunami seems to be coming!" "Quickly! We're going to the traffic island. Get in line, and don't run."
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image	

Action	Alias	Description
Who	Actors	An elderly man named Kazuo Takahashi, who suddenly became aware of the tsunami.
When	The starting point of 'What'	At 3:30 PM
Where	Location where 'What' occurs	Near the school playground
What	Actions taken by 'Who'	Parked his car next to the school. As he climbed out and headed for the hill, he saw a large number of children rushing out of the school in a hurry.
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Hazard	Alias	Description
Who	Hazards	The tsunami, a sheet of white spray rising above the dark waters.
When	The starting point of 'What'	Barely a minute had passed since they left the playground.
Where	Location where 'What' occurs	Near the school
What	Emergencies caused by 'Who'	Moved in the direction where the children had been ordered to evacuate and engulfed them.
How	Direct consequences following 'What'	Of the 78 students present at the moment of the tsunami, 74, along with 10 out of the 11 teachers, lost their lives.
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image	

Image	

Action	Alias	Description
Who	Actors	The Sendai High Court
When	The starting point of 'What'	On 26 April, 2018
Where	Location where 'What' occurs	
What	Actions taken by 'Who'	Ordered the governmental authorities to pay around 1.4 billion yen ($13 million) in damages to the families of the pupils, raising the amount of compensation by about 10 million yen from a lower court ruling.
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	The authorities "failed to fulfill their obligation to revamp a risk management manual in line with the realities of Okawa Elementary School," Presiding Judge Hiroshi Ogawa said, adding, "If the manual had designated a 20-meter-high location for evacuation" the deaths could have been prevented.
Sequel	Cascading consequences resulting from 'How'	

From 3:00 PM, when the JMA issued a tsunami warning, to 3:30 PM, evacuees spent 30 critical minutes waiting in the playground for instructions on the next emergency step. According to the existing emergency plan, in the event of a tsunami, they were supposed to evacuate to vacant land or a park near the school, but no clear guidance was provided during this time.

In disaster situations, it is beneficial to distinguish clearly between on-site commanders and followers. Commanders may have extensive experience and competence in emergency management, or they may lack such qualifications. Followers, on the other hand, may either passively depend solely on instructions from their commanders or actively propose their own courses of action. For followers to effectively persuade commanders to accept their suggestions, it is essential that they possess strong capabilities in gathering and utilizing information.

Therefore, to increase one's chances of survival during an emergency, individuals should not passively waste valuable time depending solely on the commander's instructions. Instead, it is essential to continuously seek new information through various means, such as listening to the radio, watching television, or observing the surrounding environment. Equally important is sharing this newly acquired information, not only with the commanders but also with colleagues, to collaboratively identify better actions and solutions.

The tragedy at the Okawa Elementary School clearly illustrates that, as evacuees rather than commanders, it is vital not to depend exclusively on the commander's decisions. Instead, followers should persistently seek updated information throughout the disaster until the situation concludes and share it proactively. Such active participation and information-sharing significantly enhance the likelihood of survival.

3.2 The 2014 Sewol Ferry Tragedy in Korea

We reconstructed the DPP of the 2014 Sewol Ferry Tragedy in Korea using the Hazard-Action tool, consisting of 9 scenes, as shown in Table 3.

(Scene #1) At 9:05 PM on April 15, 2014, Captain Lee Joon-seok of the Sewol Ferry departed from the Coastal Passenger Terminal in Incheon Port with 29 crew members, 325 students, 14 teachers, 108 civilians, and 2,142.7 tons of cargo onboard.

(Scene #2) At approximately 8:46 AM on April 16, 2014, the third officer on duty, who was responsible for navigation, gave the first helm order to the duty helmsman to change the course from 135 degrees to 140 degrees while passing through the waters east of Byeongpungdo.

(Scene #3) At approximately 8:49 AM on April 16, 2014, the third officer on duty issued a second course-change order to 145 degrees in the waters east of Byeongpungdo, Jindo-gun, Jeollanam-do. The vessel failed to stabilize on the intended course and began turning rapidly to starboard due to the duty helmsman's poor steering skills. In response, the third officer instructed the helmsman to steer to port to counteract the unintended turn. However, the Sewol ferry continued to turn rapidly to starboard, causing an excessive outward heel to port. As a result, poorly secured cargo and other onboard items shifted, further increasing the vessel's list to port.

(Scene #4) From 8:55 AM to 9:20 AM on April 16, 2014, Hye-Sung Gang (33), a crew member of the Sewol Ferry, announced, "Do not move from your current location," and, following the instructions of the late Chief Purser Yang Dae-hong, "Wear life jackets" inside the Sewol Ferry.

(Scene #5) At 9:46 AM on April 16, 2014, Captain Lee Joon-seok of the Sewol ferry and his crew members escaped alone from the ferry without issuing an evacuation order, leaving passengers behind inside the Sewol Ferry. This ultimately made it impossible for the passengers to escape on their own.

(Scene #6) At approximately 10:25 AM on April 16, 2014, seawater flooding into the vessel through gaps in the hull openings and other structural crevices caused the ferry to capsize with a lateral inclination of about 108 degrees in the waters north of Byeongpungdo, Jindo-gun, Jeollanam-do.

(Scene #7) At 10:31 AM on April 16, 2014, seawater flooding into the vessel through gaps in the hull openings and other structural crevices caused the vessel to fully submerge beneath the surface, leaving only its bulbous bow visible above the water approximately 3.5 nautical miles north of Byeongpungdo, Jindo-gun, Jeollanam-do, at coordinates 34° 12'33" N, 125° 57'24" E.

(Scene #8) On April 16, 2014, the capsizing and sinking of the Sewol ferry claimed 302 lives (including 250 of 325 students, 9 of 11 teachers, 32 of 108 civilians, and 9 of 29 crew members) in the waters north of Byeongpungdo, Jindo-gun, Jeollanam-do.

(Scene #9) On December 12, 2015, Captain Lee Joon-seok of the Sewol ferry was unanimously sentenced to life imprisonment by the Supreme Court of South Korea.

Table 3. DPP of the 2014 Sewol Ferry Tragedy in Korea

Hazard

Image

E5W1H	Alias	Description
Who	Hazards	Seawater flooding into the vessel through gaps in the hull openings and other structural crevices.
When	The starting point of 'What'	At approximately 10:25 AM on April 16, 2014.
Where	Location where 'What' occurs	In the waters north of Byeongpungdo, Jindo-gun, Jeollanam-do.
What	Emergencies caused by 'Who'	Made the ferry capsize with a lateral inclination of about 108 degrees.
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

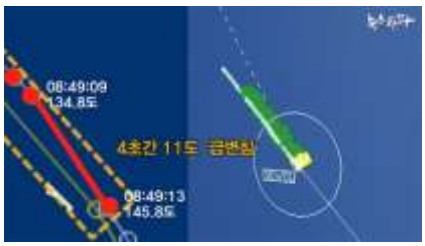
E5W1H	Alias	Description
Who	Hazards	Seawater flooding into the vessel through gaps in the hull openings and other structural crevices
When	The starting point of 'What'	At 10:31 AM on April 16, 2014
Where	Location where 'What' occurs	Approximately 3.5 nautical miles north of Byeongpungdo, Jindo-gun, Jeollanam-do, at coordinates 34°12'33" N, 125°57'24" E.
What	Emergencies caused by 'Who'	Caused the vessel to fully submerge beneath the surface, leaving only its bulbous bow visible above the water.
How	Direct consequences following 'What'	

Action

E5W1H	Alias	Description
Who	Actors	Captain Lee Joon-Seok of the Sewol ferry
When	The starting point of 'What'	At 9:05 PM on April 15, 2014
Where	Location where 'What' occurs	At the Coastal Passenger Terminal in Incheon Port
What	Actions taken by 'Who'	Departed with 29 crew members, 325 students, 14 teachers, 108 civilians, and 2,142.7 tons of cargo onboard
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

E5W1H	Alias	Description
Who	Actors	The third officer on duty, who was responsible for navigation
When	The starting point of 'What'	At approximately 8:46 AM on April 16, 2014
Where	Location where 'What' occurs	In the waters east of Byeongpungdo, Jindo-gun, Jeollanam-do
What	Actions taken by 'Who'	Gave the first helm order to the duty helmsman to change the course from 135 degrees to 140 degrees while passing through the waters east of Byeongpungdo
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image



E5W1H	Alias	Description
Who	Actors	The third officer on duty
When	The starting point of 'What'	At approximately 08:49 AM on April 16, 2014
Where	Location where 'What' occurs	In the waters east of Byeongpungdo, Jindo-gun, Jeollanam-do
What	Actions taken by 'Who'	Issued a second course change order to 145 degrees
How	Direct consequences following 'What'	The vessel failed to stabilize on the intended course and began turning rapidly to starboard
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	Due to the duty helmsman's poor steering skills
Sequel (1)	Cascading consequences resulting from 'How'	In response, the third officer instructed the helmsman to steer to port to counteract the unintended turn.
Sequel (2)	Cascading consequences resulting from 'How'	However, the Sewol ferry continued to turn rapidly to starboard, causing an excessive outward heel to port.
Sequel (3)	Cascading consequences resulting from 'How'	As a result, poorly secured cargo and other onboard items shifted, further increasing the vessel's list to port.

Image

E5W1H	Alias	Description
who	Actors	Hye-Sung Gang (33), a crew member of the Sewol Ferry
When	The starting point of 'What'	From 8:55 AM to 9:20 AM on April 16, 2014
Where	Location where 'What' occurs	Inside the Sewol Ferry
What	Actions taken by 'Who'	Announced, "Do not move from your current location," and, following the instructions of the late Chief Purser Yang Dae-Hong, "Wear life jackets."
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

E5W1H	Alias	Description
Who	Actors	Captain Lee Joon-Seok of the Sewol ferry and his crew members
When	The starting point of 'What'	At 9:46 AM on April 16, 2014
Where	Location where 'What' occurs	Inside the Sewol Ferry
What	Actions taken by 'Who'	Escaped alone from the ferry without issuing an evacuation order, leaving passengers behind.
How	Direct consequences following 'What'	This ultimately resulted in making it impossible for the passengers to escape on their own.
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Image

Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

E5W1H	Alias	Description
Who	Hazards	The capsizing and sinking of the Sewol ferry
When	The starting point of 'What'	On April 16, 2014
Where	Location where 'What' occurs	In the waters north of Byeongpungdo, Jindo-gun, Jeollanam-do
What	Emergencies caused by 'Who'	Claimed 302 lives (including 250 of 325 students, 9 of 11 teachers, 32 of 108 civilians, and 9 of 29 crew members)
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Image

E5W1H	Alias	Description
Who	Actors	Captain Lee Joon-Seok of the Sewol ferry
When	The starting point of 'What'	On December 12, 2015
Where	Location where 'What' occurs	In the Supreme Court of South Korea
What	Actions taken by 'Who'	Was unanimously sentenced to life imprisonment by the Supreme Court.
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

In a situation where a ship is gradually tilting, and repeated announcements instruct passengers to remain inside, how should we respond? In the aftermath of the Sewol Ferry tragedy, an unsettling phrase spread virally throughout South Korea: "Students who obediently followed their teachers' instructions perished, while those who disobeyed survived." This tragic irony highlights a critical lesson—placing one's survival entirely in the hands of others is tantamount to giving up on life. Even in dire situations, we must constantly question our circumstances.

Inside a sinking ship, passengers face severe limitations in acquiring information. The vessel's distance from communication towers disrupts network access, and being confined indoors further restricts awareness of the evolving situation. However, the increasing tilt of the ship was a clear indicator that conditions were deteriorating. The primary reason for instructing passengers to stay inside was likely safety concern remaining on deck posed a risk of falling overboard. However, being on the deck also increased the chance of escaping into the sea.

In ferry accidents, the 'stay put' policy may be effective only when the vessel's tilting angle remains below a certain threshold. However, we have rarely been educated about the limitations of such a policy. Consequently, even when conditions deviate significantly from the effective range, people tend to adhere to the 'stay put' instructions for too long. As the saying goes, "The devil is in the details." Therefore, before blindly following instructions or policies, we must clearly understand the specific conditions under which they remain effective. If available information indicates the situation no longer aligns with these conditions, we must promptly request revisions to the original instructions or policies.

3.3 The 2017 Grenfell Tower Fire in London

We reconstructed the DPP of the 2017 Grenfell Tower Fire in London using the Hazard-Action tool, consisting of 7 scenes, as shown in Table 4.

(Scene #1) On June 14, 2017, a fire broke out in the kitchen of a fourth-floor flat in the 23-story Grenfell Tower, a residential high-rise in West London. The fire was reported to 999.

(Scene #2) At 12:54 AM on June 14, 2017, 999 call handlers working for the LFB (London Fire Brigade) told residents not directly affected by fire, heat, or smoke to remain in their flats until help arrived at Grenfell Tower. The effectiveness of the "stay put" policy, which remains the standard response to fires in most high-rise buildings—depends on a building being properly constructed. Regulations should prevent fire from spreading from one flat to another for at least 60 minutes.

(Scene #3) At 12:55 AM on June 14, 2017, the North Kensington unit of the LFB arrived at Grenfell Tower.

(Scene #4) At 1:19 AM on June 14, 2017, the fire, in less than 20 minutes, had climbed all 23 stories to the top of the tower, fueled by flammable materials. As part of a refurbishment, combustible cladding and insulation had been fitted to the exterior of the building.

(Scene #5) At 2:30 AM on June 14, 2017, Andy Roe, a London Fire Assistant Commissioner, arrived and was overwhelmed by disbelief and horror upon seeing three sides of the building engulfed in flames. People were screaming.

(Scene #6) At 2:47 AM on June 14, 2017, one hour and 53 minutes after the first emergency call, Andy Roe, a London Fire Assistant Commissioner, gave the order to revoke the "stay put" policy.

(Scene #7) On June 14, 2017, the fire at Grenfell Tower in West London claimed the lives of 72 people.

Table 4. DPP of the 2017 Grenfell Tower Fire in London

Hazard

Hazard	Alias	Description
Who	Hazards	A fire
When	The starting point of 'What'	On June 14, 2017
Where	Location where 'What' occurs	At the West London tower block
What	Emergencies caused by 'Who'	Broke out in the kitchen of a fourth floor flat at the 23 storey Grenfell tower
How	Direct consequences following 'What'	The fire was reported to 999.
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Image

Action

Image

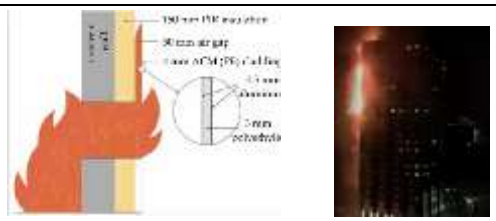
Action	Alias	Description
Who	Actors	999 call handlers working for the LFB (London Fire Brigade)
When	The starting point of 'What'	At 00:54 AM On June 14, 2017
Where	Location where 'What' occurs	In the Grenfell Tower
What	Actions taken by 'Who'	Told residents not directly affected by fire, heat or smoke to remain in their flats until help arrived
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	The effectiveness of "stay put" - which remains the policy in the event of fire in most high-rise buildings - relies on a building being properly constructed. Regulations should prevent fire spreading from one flat to another for at least 60 minutes.
Sequel	Cascading consequences resulting from 'How'	

Action	Alias	Description
Who	Actors	North Kensington unit of the LFB
When	The starting point of 'What'	At 00:55 AM On June 14, 2017
Where	Location where 'What' occurs	At the Grenfell Tower
What	Actions taken by 'Who'	Arrived.

How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Hazard	Alias	Description
Who	Hazards	The fire
When	The starting point of 'What'	AT 1:19 AM on June 14, 2017
Where	Location where 'What' occurs	At the West London tower block
What	Emergencies caused by 'Who'	In less than 20 minutes, climbed 23 storeys to the top of the tower, fueled by the flammable materials.
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	In the case at Grenfell Tower, as part of a refurbishment, combustible cladding and insulation had been fitted on the outside of the building
Sequel	Cascading consequences resulting from 'How'	

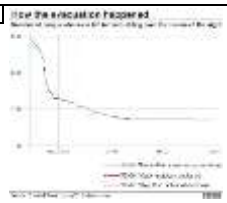
Image



Image

Action	Alias	Description
Who	Actors	Andy Roe, a London Fire Assistant Commissioner
When	The starting point of 'What'	At 2:30 AM on June 14, 2017
Where	Location where 'What' occurs	At the West London tower block
What	Actions taken by 'Who'	Arrived and felt his disbelief and horror to find three sides of the building alight.
How	Direct consequences following 'What'	People were screaming
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image



Action	Alias	Description
Who	Actors	Andy Roe, a London Fire Assistant Commissioner
When	The starting point of 'What'	At 2:47 AM on June 14, 2017, one hour and 53 minutes after the first emergency call
Where	Location where 'What' occurs	At the West London tower block
What	Actions taken by 'Who'	Gave the order to revoke the "stay put" policy
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Hazard	Alias	Description
Who	Hazards	The fire
When	The starting point of 'What'	On June 14, 2017
Where	Location where 'What' occurs	At the West London tower block
What	Emergencies caused by 'Who'	Killed 72 of 295 residents
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Preventing fire spread is crucial in fire incidents. In a well-constructed apartment building, it typically takes at least an hour for the fire to spread to the upper or adjacent units. Another important consideration is the need for a **stairwell** that does not obstruct the movement of firefighters and fire equipment (Tom, 2022). For these reasons, in the United Kingdom, the "stay put" policy is maintained for units that are not in the immediate vicinity of the fire. However, in South Korea, the "stay put" policy is not applied in high-rise apartment fires. Instead, all residents are encouraged to evacuate immediately. This difference arises because South Korea has a high density of tall apartment buildings, and access via aerial ladders is preferred over stairwell access for firefighting operations.

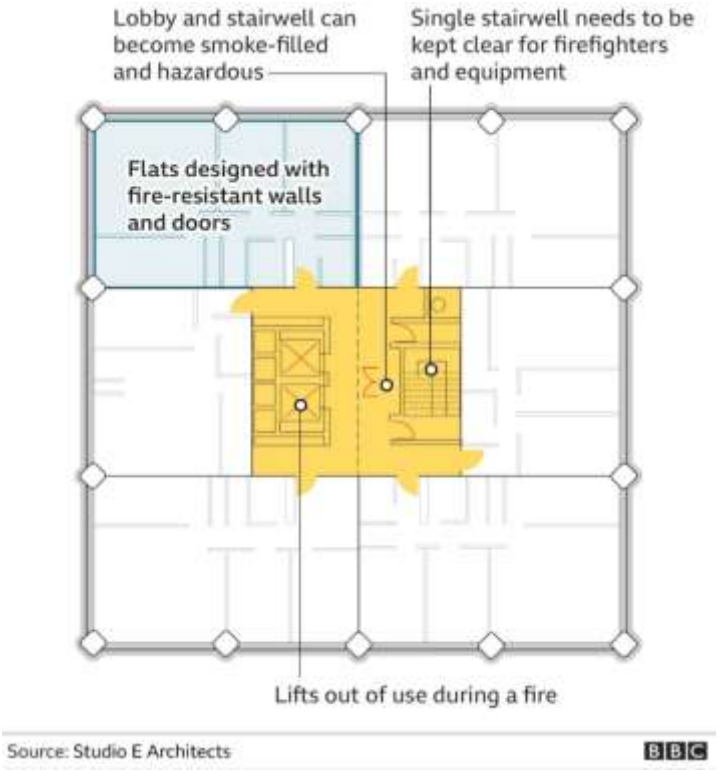


Figure 1. Why tower block residents are advised to stay put. (Tom, 2022)

The London Fire Brigade (LFB) should have withdrawn the "stay put" policy and ordered an immediate evacuation as soon as they realized that the fire was spreading faster than expected. However, the "stay put" policy remained in place for 1 hour and 53 minutes, which significantly hindered a swift evacuation.

In the Grenfell Tower fire, seventy people died at the scene, and two more died later in the hospital, with over 70 people injured and 223 escaping. The mortality rate for this incident was an alarming 20%, making it a catastrophic disaster.

If a safe evacuation route is available, evacuating as quickly as possible is always the best option. However, if a safe route cannot be found, staying in the safest possible location and awaiting rescue is crucial. For this reason, in South Korea, early evacuation is strongly recommended while a safe escape route is still accessible.

The "stay put" policy in high-rise building fires remains highly controversial. If more residents ignore the "stay put" policy and evacuate early via the stairwell, firefighters may face difficulties in conducting initial fire suppression efforts. However, the strategy of prioritizing the stairwell as a firefighting route rather than an evacuation route needs to be reconsidered and improved.

3.4 The 2011 Kamaishi Miracle in the GEJE and Tsunami

We reconstructed the DPP of the 2011 Kamaishi Miracle in the GEJE and Tsunami using the Hazard-Action tool, consisting of seven scenes, as shown in Table 5.

(Scene #1) At 2:46 PM on March 11, 2011, an earthquake struck Kamaishi Higashi Junior High School and Unosumai Elementary School and lasted for about five minutes in Unosumaicho, Kamaishi, Iwate.

(Scene #2) On March 11, 2011, the vice principal of Kamaishi Higashi Junior High School attempted to announce an evacuation via the school's broadcasting system but was unable to do so due to a power outage.

(Scene #3) On March 11, 2011, students engaged in sports activities in the schoolyard of Kamaishi Higashi Junior High School shouted loudly toward the school building, "A tsunami is coming! Run away!" and ran from the school. Other students heard the shouting and followed them.

(Scene #4) On March 11, 2011, the students of Unosumai Elementary School, adjacent to Kamaishi Higashi Junior High School, initially attempted to evacuate to the third floor of their school building but changed their action when they saw the junior high school students—who had participated in a joint evacuation drill—running outside. They then ran downstairs, following the junior high school students.

(Scene #5) On March 11, 2011, the junior high and elementary school students of Kamaishi Higashi and Unosumai arrived safely at an elderly welfare facility, which was designated as an evacuation site.

(Scene #6) On March 11, 2011, some junior high school students at the elderly welfare facility observed a cliff near the facility collapsing, the tsunami striking a levee and causing a large splash, and smoke rising from damaged houses nearby. They informed the teachers who were checking attendance, "It's not safe here," and suggested evacuating to a safer facility on higher ground. On the way to the second evacuation site, the junior high school students held the hands of the elementary school students and assisted nursery teachers evacuating children from a nearby nursery school. Nearby residents noticed the evacuating students and followed them to safety.

(Scene #7) Only 30 seconds after all students arrived at the second evacuation site, a tsunami approached very close but did not reach it. There were no casualties.

Table 5. DPP of the 2011 Kamaishi Miracle in the GEJE and Tsunami

Hazard

Hazard	Alias	Description
Who	Hazards	An earthquake
When	The starting point of 'What'	At 2:46 PM on March 11, 2011
Where	Location where 'What' occurs	In Unosumaicho, Kamaishi, Iwate
What	Emergencies caused by 'Who'	Hit Kamaishi Higashi junior high school and Unosumai elementary school and lasted for about 5 minutes
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Action

Image


Action	Alias	Description
Who	Actors	The vice principal of Kamaishi Higashi Junior High School
When	The starting point of 'What'	On March 11, 2011
Where	Location where 'What' occurs	At Kamaishi Higashi Junior High School
What	Actions taken by 'Who'	Attempted to announce an evacuation via the school's broadcasting system but was unable to do so because of a power outage.
How	Direct consequences following 'What'	

Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Action	Alias	Description
Who	Actors	Students doing sports activities in the schoolyard
When	The starting point of 'What'	On March 11, 2011
Where	Location where 'What' occurs	At Kamaishi Higashi Junior High School
What	Actions taken by 'Who'	Shouted loudly towards the school building, "A tsunami is coming! Run away!" and ran away from the school.
How	Direct consequences following 'What'	Other students heard the shouting and followed them.
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Action	Alias	Description
Who	Actors	The students of Unosumai Elementary School
When	The starting point of 'What'	On March 11, 2011
Where	Location where 'What' occurs	At Unosumai Elementary School, adjacent to Kamaishi Higashi Junior High School
What	Actions taken by 'Who'	Initially attempted to evacuate to the third floor of their school building, but changed their action when they saw the junior high school students—who had participated in a joint evacuation drill—running outside.
How	Direct consequences following 'What'	They then ran downstairs, following the junior high school students.
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Action	Alias	Description
Who	Actors	The junior high and elementary school students of Kamaishi Higashi and Unosumai
When	The starting point of 'What'	In 10 minutes on March 11, 2011
Where	Location where 'What' occurs	At an elderly welfare facility, which was designated as an evacuation site
What	Actions taken by 'Who'	Arrived safely at the designated evacuation site
How	Direct consequences following 'What'	
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

Action	Alias	Description
Who	Actors	Some junior high school students
When	The starting point of 'What'	On March 11, 2011
Where	Location where 'What' occurs	An elderly welfare facility designated as an evacuation site
What	Actions taken by 'Who'	Observed the cliff near the facility collapsing, the tsunami striking a levee causing a large splash, and smoke rising from damaged houses nearby.
How	Direct consequences following 'What'	They informed the teachers who were checking attendance, "It's not safe here," and suggested evacuating to a safer facility located on higher ground.
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel(1)	Cascading consequences resulting from 'How'	On the way to the second evacuation site, the junior high school students held the hands of the elementary school students and even assisted nursery teachers evacuating children from a nearby nursery school.
Sequel(2)	Cascading consequences resulting from 'How'	Nearby residents noticed the evacuating students and followed them to safety.

Hazard	Alias	Description
Who	Hazards	A tsunami
When	The starting point of 'What'	Only 30 seconds after all students arrived at the second evacuation site
Where	Location where 'What' occurs	At the second evacuation site
What	Emergencies caused by 'Who'	Approached very close to the second evacuation site but did not reach it.
How	Direct consequences following 'What'	There were no casualties.
Why	Reasons or causes for 'How'; if 'How' is unspecified, then for 'What'	
Sequel	Cascading consequences resulting from 'How'	

Image

During the evacuation, the students in the schoolyard actively monitored whether a tsunami was approaching. As soon as they saw it, they immediately shouted for others to evacuate and acted without hesitation. Their quick response set an example, and others followed as soon as possible.

What I find particularly important is that the students took the initiative to observe the ocean instead of waiting for instructions. This highlights a crucial point: the responsibility for evacuation should not rest solely on instructors. Evacuees also have a responsibility to remain aware of their surroundings, gather

information about urgent situations, and report it to those in charge. Rather than passively waiting for instructions, evacuees should take proactive steps to ensure their safety.
This proactive approach is a key factor in survival during emergencies. However, in disaster education, we often focus only on training leaders while neglecting the majority of people. It is essential to educate all evacuees on what actions they should take in emergency situations. By doing so, we can enhance overall preparedness and improve survival chances for everyone.

4. Results

In this study, we examined the actions of on-site commanders and followers during emergency situations in four cases—three in which evacuation failed despite sufficient initial lead time, and one in which evacuation was successful—within the framework of the Disaster Progression Pattern (DPP).
The DPP was reconstructed using the hazard-action tool, which consists of two columns: *Hazard* and *Action*. Each column is composed of a series of scenes arranged in chronological order. Each scene is structured using E5W1H (Enhanced 5W1H), which extends the traditional 5W1H by adding a new element called "Sequel". Additionally, visual information (*Image*) can be added to enhance clarity and readability.
The E5W1H elements in the *Hazard* column include:
When, Where, Who, What, How, Why, Sequel, and Image.

- *Who* provides information about the source of the hazard.
- *When* indicates the starting point of *What*.
- *Where* refers to the location where *What* occurs.
- *What* describes the emergency caused by *Who*.
- *How* explains the direct consequences following *What*.
- *Why* provides the reasons or causes for *How*; if *How* is unspecified, then for *What*.
- *Sequel* describes the cascading consequences resulting from *How*.
- *Image* presents visual information that helps describe the scene.

The *Action* column is structured similarly, but with two key differences:

- In *Action*, *Who* refers to the actors involved.
- *What* describes the actions taken by the actors.
  The remaining elements (*When*, *Where*, *How*, *Why*, *Sequel*, and *Image*) function in the same way as in the *Hazard* column.

In this study, using the hazard-action tool, we reconstructed the DPP for four cases with sufficient lead time for evacuation, and evaluated the actions taken by both commanders and followers.

Table 6. Evaluation of commanders' and followers' actions for four cases with adequate lead time

Disasters	Lead time (min)	Commanders	Followers	Deaths
Okawa Elementary School Tragedy	31 min (2:59 - 3:30 PM)	The on-site commander wasted a significant amount of time interpreting the phrase 'vacant land near school, or park, etc.' as written in the manual. As a result, he ultimately misinterpreted it and took incorrect evacuation actions.	They wasted time waiting for the commander's instructions and took no proactive actions to obtain updated information on the emergency.	74 of 78 students (MR=94.9%) 10 of 11 teachers (MR=90.9%) Where MR means mortality rate.
Sewol Ferry Tragedy	57 min (8:49 - 9:46 AM)	The captain and crew ordered passengers to remain on board but did not give them an evacuation order until they themselves disembarked.	Most of the students and teachers actively followed the crew's instructions until the end. However, it is presumed that many civilians did not fully comply with the crew's orders.	250 of 325 students (MR=77.0%) 9 of 11 teachers (MR=81.8%), 32 of 108 civilians (MR=29.6%), 9 of 29 crews (MR=31.0%)
Grenfell Tower Fire	25 min (0:54 - 1:19 AM)	LFB (London Fire Brigade) adhered to the standard evacuation guideline (stay put). Even when they recognized that the situation was different, the guideline remained unchanged.	In the early stages of a fire, when evacuation is possible, the "stay put" policy is followed. However, during later stages, when evacuation becomes difficult, some individuals attempt to evacuate. See Figure 2.	72 of 295 residents (MR=24.4%)
Kamaishi Miracle	10 min	The commanders accepted the followers' judgment. At certain points, they ended up becoming followers themselves.	The followers who observed the tsunami early and shouted loudly, "A tsunami is coming! Run away!" took the lead and started fleeing. Seeing this, all the other followers also followed. They expressed their judgment to their commanders.	No victims (MR=0%)

Table 6 presents an evaluation of the actions of commanders and followers in four cases with adequate lead time. In the case of the Okawa Elementary School tragedy, the on-site commander wasted a significant amount of time trying to interpret the phrase "vacant land near school or park, etc." as written in the manual. To make matters worse, he ultimately misinterpreted its meaning and made incorrect evacuation decisions. Meanwhile, the followers lost valuable time waiting for the commander's instructions and took no proactive steps to obtain updated information about the evolving emergency. Consequently, 74 out of 78 students

and 10 out of 11 teachers were killed when a powerful tsunami suddenly engulfed the area.

In the case of the Sewol Ferry tragedy, the captain and crew ordered passengers to remain on board and did not issue an evacuation order until they themselves disembarked. Most of the students and teachers strictly followed the crew's instructions until the very end. However, it is presumed that many civilian passengers did not fully comply with the crew's orders. As a result, 250 out of 325 students and 10 out of 11 teachers lost their lives, with a mortality rate of approximately 80%. In contrast, the mortality rate among civilians was around 30%.

In the case of the Grenfell Tower fire, the London Fire Brigade (LFB) adhered to the standard evacuation guideline—the "stay put" policy. Even after realizing that the situation was exceptional, the guideline was not revised. In the early stages of the fire, when evacuation was still feasible, residents complied with the "stay put" policy. However, in the later stages, when evacuation became much more difficult, some individuals attempted to escape, but most of them failed (see Figure 2).

In the case of the Kamaishi Miracle, the commanders accepted the judgment of the followers. At certain points, they even ended up becoming followers themselves. Some followers, who observed the approaching tsunami early and shouted loudly, "A tsunami is coming! Run away!", took the lead and began evacuating. Seeing this, the rest of the followers joined them. These followers expressed their judgment to the commanders. The proactive actions of the followers were a driving force behind the fact that there were no casualties.

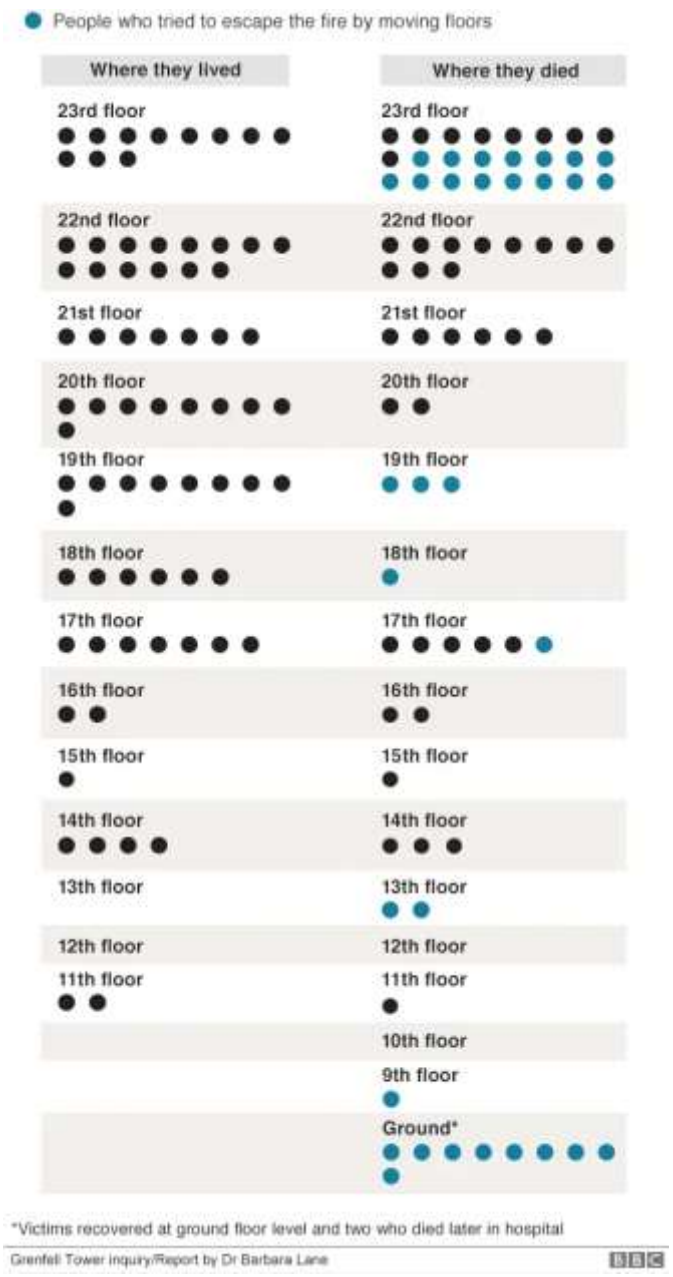


Figure 2. Where the Grenfell Tower fire victims lived and died. (BBC, 2019)

5. Conclusion

In emergency situations with sufficient lead time for evacuation, the rational and timely decisions of on-site commanders are undoubtedly crucial for ensuring everyone's survival. Commanders must clearly understand the scenarios upon which the instructions or policies in their manuals or plans are based. Therefore, they need to continuously monitor whether the current situation remains within these anticipated scenarios. If the situation remains within the expected range, they should maintain the existing

course of action; however, if conditions deviate, commanders must promptly adjust or revoke previous instructions or actions accordingly.

The author would like to emphasize that the role of followers is equally important. In general, manuals are designed based on a command-follow structure in which commanders issue instructions and followers carry them out. However, to improve the chances of survival, followers must also play an active role during emergencies. One of the most essential responsibilities of a follower is to collect updated information about the evolving situation, share that information with other followers, and report it to the commander. This process can help the commander make better-informed decisions.

The importance of such a role was clearly demonstrated in the case of the Kamaishi Miracle.

In military organizations, when a unit temporarily rests or stays at a location, soldiers are assigned to stand guard and monitor changes in the surrounding environment. Similar practices should be incorporated into disaster response manuals. For instance, after an earthquake, if evacuees gather at a primary assembly point such as a school playground, the commander could assign some followers to monitor the perimeter for changes in the situation. Others should be instructed to actively seek updates through available channels such as radio, TV, or the internet.

In most disaster scenarios, we are more likely to find ourselves in the role of a follower rather than a commander. If we rely solely on the commander for our survival, it is equivalent to relinquishing our own agency. Personal agency and decision-making must never be surrendered, even in the most extreme emergencies. Based on the findings of this study, the author intends to further develop this research and design an educational program that highlights the critical role of followers during emergencies.

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