Chapter 1
What Do Societal Safety Sciences Aim at?

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Abstract Societal safety sciences are new academic systems of interdisciplinary studies that combine specialized fields of social science and humanity in addition to those of science and technology for the purposes of preventing accidents and disasters that threaten human society, containing their severity and frequencies, reducing damages, rescuing the victims, and recovering and reconstructing the disaster areas. This chapter explains the position of societal safety sciences in issues related to our safety and outlines their methodologies and scopes.

Keywords Accident · Disaster · Incident · Risk · Societal safety

1.1 Is the Unexpected and the Unpredictable on the Steady Increase in the Twenty-First Century?

1.1.1 Unexpected Accidents

Every person wants to lead a safe and happy life. Advancements in science and technology have made our society convenient and comfortable. On the other hand, however, a variety of accidents and events take place to threaten our safety.

About 1.3 million people (2015) die annually in Japan. The Japan Ministry of Health, Labour and Welfare (MHLW) published in its “2017 Vital Statistics of Japan” (MHLW 2017) that the first cause of death was malignant neoplasms (cancer) followed by heart disease in the second place, then by other diseases of pneumonia, and cerebrovascular disease. Among the causes of death, “unexpected accident” ranks number six or so each year.

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Unexpected accidents are causes of death listed in the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10. Version 2010) by the World Health Organization (WHO) including "transport accidents"; "accidental suffocation"; "slipping, tripping, stumbling, and falls"; "accidental drowning and submersion"; and so on (WHO 2010). The death toll due to unexpected accidents include victims of earthquakes or tsunami and those who died of food poisoning during their normal lives, and the total figure reached as high as 38,306 in 2015. In other words, among annual deaths in Japan, about three out of a hundred are due to unexpected accidents. As we will explain later, unexpected accidents in societal safety sciences are not just natural disasters or accidents, but they also include a wide range of events like terrorism, war, influenza pandemics, and drug toxicity. Reducing the number of deaths caused by unexpected accidents is one of the primary targets of societal safety sciences.

MHLW translated "transport accidents" by WHO to the Japanese phrase "traffic accidents" commonly used narrowly for accidents involving automobiles (traffic accidents on roads). The wide meaning of traffic accidents in Japan also includes those with railway, aircraft, and watercraft. "Vital Statistics of Japan" by MHLW uses the phrase "traffic accident" in this wide sense. In this book, we use the word traffic accidents to mean automobile accidents in the narrow sense and stick to the original phrase by WHO "transport accidents" for all transportation-related accidents including automobiles.

The historic transition of deaths due to unexpected accidents shows an annual count about 20,000, i.e., about 2% of the total deaths, in the late 1800s to the early 1930s but jumped above 30,000 before World War II. During the high-growth period of the mid-1950s to mid-1970s, the large number of traffic accidents pushed the deaths by unexpected accidents up, and in the mid-1960s to the early 1970s, the count exceeded 40,000. In the mid-1970s to the early 1990s, the number dropped to about 30,000; however, it came back up to about 40,000 in the later 1990s and has stayed at this level till today.

The current death count of about 40,000 annually seems significantly larger than the 20,000 in the late 1800s to the early 1930s; however, we must recognize that the population back then was about 40–50 million, i.e., less than half of our population now. The ratio of deaths due to unexpected accidents among the total death count, however, at about 3% now is much higher than the 2% back then. The higher rate is probably due to the large number of post-World War II transport accidents including traffic accidents that were almost none back then.

A major natural disaster temporarily boosts up the deaths caused by unexpected accidents high. In fact, the year of the Great Kanto earthquake, 1923, saw 71,322, about 2.8 times the number in the previous year; the year 1995 of the Great Hanshin-Awaji earthquake marked 45,323, a little over 9200 more than the previous year; and 2011 with the Great East Japan earthquake had a sudden increase of over 20,000, compared to other years, leaving 59,416 dead.

1.1.2 Unexpected Accidents and Societal Safety

In 2010, MHLW published “Mortality Statistics from Accidents” with detailed analysis of unexpected accidents from 1995 to 2008 (MHLW 2010). It was the second publication of this type following the 1984“Mortality Statistics from Accidents and Adverse Effects.” These statistical data are effective in understanding the detail of unexpected accidents.

Reviewing the accidental deaths in 2008 by type, “suffocation” by, for example, choking on food, ranked first with 9419. Then “traffic accident (transport accident)” at 7499, “fall” at 7170, and “drowning” at 6466 followed. These four types of accidents caused over 70% of the total number of accidental deaths. Other accidental death types in 2008 were 1452 due to “smoke inhalation or exposure to fire” and 895 caused by “poisoning from or exposure to hazardous material.”

During post-War Japan, transport accidents stayed at the first type of cause of accidental deaths for an extended time. At its peak in 1970, the transport accident deaths exceeded 20,000 annually, amounting to 55% of the entire count. Today, the number of traffic accident caused deaths has dropped significantly to about 1/3 of the number back then.

In general, transport accidents occur away from home; however, about 40% of accidents of deaths of other types take place in home, and about 80% of those victims are elderlies at 65 or over. The breakdown of types of in-house accidental deaths was 85.3% fire, 63.1% drowning (mostly in bathtubs), 58.2% poisoning, 42.4% suffocation, and 35.7% falls. These numbers indicate that home, where safety and security have to be assured, is, in fact, the place where the biggest dangers hide.

By the way, some point out that the numbers of accidental deaths in MHLW’s statistics are underestimated and that they should be greater in reality. For example, the real number of accidents during medical treatment is unknown and such type of death counts is unknown. The real number of accidental deaths may well exceed 40,000; however, published data from MHLW make a certain powerful measure for evaluating the degree of societal safety.

1.2 Alleviating and Living with Disasters?

1.2.1 Purpose of Societal Safety Sciences

As we live our daily lives, we are surrounded by a number of possible hazards including earthquake, transport accidents, fires, food poisoning, environmental contamination, and health disorders.

If we look around us, there are a great number of highly capable and complex industrial products. We take the high convenience these products offer for granted without knowing their detailed structures or operational principles. Machines, however, fail. Some industrial products, like an automobile, can turn into a deadly weapon if we mishandle them. Once an industrial product has some kind of failure, in the worst case, we may not only lose our lives, but it can cause damage to lives and properties of others.

The 1995 Great Hanshin-Awaji earthquake and the 2011 Great East Japan earthquake took away large numbers of lives and properties, and they destroyed the infrastructures. During the Great East Japan earthquake, tsunami waves attacked the Tokyo Electric Power Company-owned Fukushima Daiichi Nuclear Power Plant (NPP), and loss of the nuclear reactor core cooling function led to devastating core meltdowns. We have been repeatedly exposed to disasters caused by natural phenomena, that we have no control over, like earthquakes, tsunami, typhoons, and torrential rain. Japan is a "country of earthquakes" with about 20% of all magnitude 6 or bigger earthquakes in the world occurring in and around Japan.

Industrial products, various machinery and apparatus are called artificial products. In general, events that cause bodily injury or property damage are "accidents." When sizes and capacities of artificial products are large, the magnitudes of suffering grow accordingly.

James Reason categorized accidents into two types: an "individual accident" that causes effects only on individuals and an "organizational accident" that affects the entire organization or the society (Reason 1997).

On the other hand, damages caused by natural phenomena like earthquakes or typhoons are generally called "natural disasters." We call accidents that take place while at work "labor accidents." In Japan, we sometimes call such accidents "industrial disasters," that is, to call an accident a disaster. In Europe and the USA, they are called work accidents or occupational accidents.

The purposes of "societal safety sciences" involve preventing accidents and disasters that threaten human society from occurring, controlling their magnitudes and frequencies, reducing damages caused, saving the victims, and promoting recovery and reconstruction of disaster-struck areas. Problems that societal safety sciences face are all not simple with complex facets. For analyzing the processes and recommending policies for resolving and improving problems, as we will detail later, we need interdisciplinary approaches that combine not only the fields of engineering, but also specialized fields of law, economics, sociology, psychology, science, information technology, social and occupational medicine, and all.

1.2.2 Hazards, Incidents, Accidents, and Disasters

Physical or chemical factors or dangerous sources that cause accidents or disasters are called "hazards." Earthquake hazards, for example, are the inter-plate forces. The hazard of poisoning accidents from incomplete combustion is carbon monoxide

(CO) produced during combustion processes. Whether a hazard directly or indirectly causes damage to humans or the society depends on its size, strength, environment, and intervention with social organizations or human.

An “incident” is an event of temporary minor damage to human, society, or an organization caused by a hazard. Incidents include narrow escapes that are worth investigating their causes (Reason 2008) to events of major damages like human death or injury or loss of property values caused by not avoiding such critical crises. When, especially, damages to people or their properties are serious, we call such cases accidents. For example, a near miss between airplanes is an incident because there were no human or physical damage, whereas, if they actually collide, it is an accident. Accidents vary in their magnitudes from small ones to those that lead to hundreds of victims. Especially, NPP accidents that spatially affect wide areas for extended long times are sometimes called mega-accidents or mega-disasters.

As we will discuss in Chap. 6, suffering and damages to the human society caused by natural phenomena are called “natural disasters.” This book, in contrast, calls human-caused disasters, like aviation accidents, NPP accidents, or major explosions, “social disasters.” The phrase social disaster has a different meaning in English, and in Europe and the USA, such accidents are called “man-made disasters.”

A disaster that affects a nation, beyond what a social organization can handle, is called a “mega-disaster.” When the disaster causes huge sorrow and destruction to the society, we sometimes call such an event a “catastrophe.”

1.2.3 Reducing and Coping with Risks?

Hazards, whether they affect us or not, are always around us. They are hard to control and suppress in case of natural disasters. Preparatory actions to prevent incidents causing hazards from developing into accidents or disasters are “disaster prevention,” and suppressing the severity and spread of damages after accidents or disasters that have taken place is called “disaster mitigation.” For example, setting automatic train stops (ATS) on railways are acts of disaster prevention to prevent collision or derailing. Seatbelts and airbags in cars are types of disaster mitigation for reducing the severity of human suffering in case of collision accidents.

Human and material resources our societies possess are finite. In modern society, social agreements determine where and how to distribute the resources. These agreements take certain quantitative scales for their settlements. “Risk” is one of the concepts that affect these agreements. The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) define risk as the “effect of uncertainty on objectives” (ISO/IEC 2014). Risk is a quantitative measure that depends on projected magnitudes of damages and their probabilities of occurrence. Risk is the sum of products of the magnitude and chance of events; however, in some cases it is determined just by the size of damage or frequency.

ISO further defines "safety" to mean freedom from intolerable risk. Here, freedom from intolerable risk does not necessarily mean zero risk, but it evaluates minor dangers as risk and, however in turn, allows certain level of risk (Slovic et al. 2000). The society determines the tolerable range of risk which varies depending on time and cases.

Direct comparison of different measures is difficult. Risk is a method of relative evaluation among a variety of measures. "Risk assessment" is the safety of systems or their parts by, for example, identifying relative weaknesses. There are two types of risk assessment: "deterministic risk assessment" and "probabilistic risk assessment" (Lee and McCormick 2011).

Deterministic risk assessment qualitatively evaluates risks of accidents and disasters with conformance or other qualities to safety standards. Probabilistic risk assessment, on the other hand, evaluates risks associated with a system or its specific part with all scenarios that lead to accidents or disasters from hazards by calculation based on reliabilities of parts, elements, and operator interventions related to each scenario. Probabilistic risk assessment is often used for evaluating risks with complex systems like NPPs or airplanes.

Scenarios in probabilistic risk assessment are generally called an "event tree." The safety and reliability of an entire system largely depend on probabilistic reliability of each elements of the system as well as the construct of the event tree. Probabilistic risk assessment, thus, requires evaluating errors, that is, the uncertainty evaluation of the risk assessment itself. In that sense, probabilistic risk assessment works well in identifying weaknesses of a system instead of as a tool in evaluating the safety of an entire system.

1.3 Building Safe and Secure Society Together

1.3.1 Events That Threaten Human and Examining Them

We do not call a tsunami attack on a deserted island a disaster. The same applies to a major avalanche in an uninhabited forest area. When the event affects people or the society, it is an accident and a disaster.

Figure 1.1 shows issues that societal safety sciences handle among problems that pose threats to people or their societies. They cover a large variety from accidents and natural disasters to terrorism and wars. In facing these issues, we have to not only analyze the characteristics, features, and structures of them but also have to propose policies to resolve and improve them.

We cannot select or control sizes or regions of natural disasters, like torrential rain; thus, we need to quickly evacuate disaster-struck areas to avoid dangers. Nevertheless, no matter how urgent the situation may be, whether the people actually

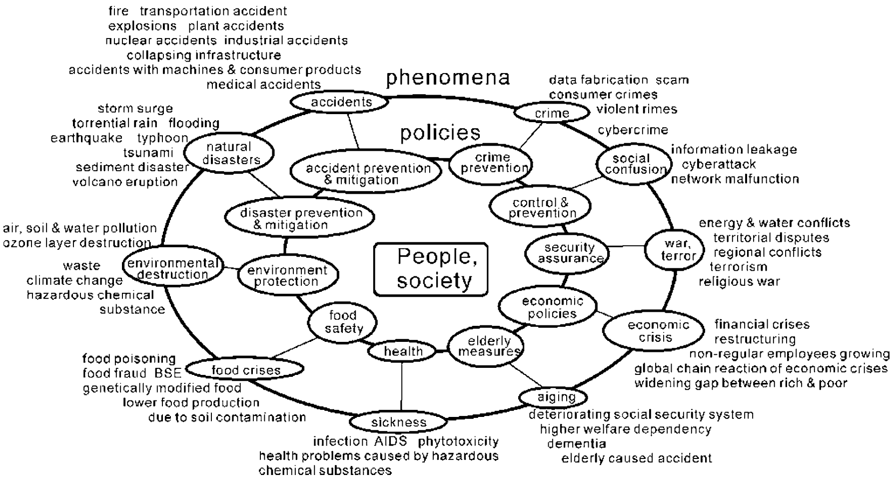

Fig. 1.1 Topics in societal safety science

evacuate the area or not depends on past individual experiences and their psychological states. Quite a number of people, in fact, ignore evacuation orders by local administration offices. Such reality suggests that authorities have to consider psychological factors in deciding whether to enforce evacuation. On the other hand, matters for saving disaster victims and supporting reconstruction of disaster-struck areas relate to socioeconomic evaluation, legal systems, and financial constraints; thus, they require approaches from economics and public administration.

Preparing against a large-scale tsunami disaster, like the one that hit during the Great East Japan earthquake, takes an enormous amount of budget for hardware preparation. If we want to reduce the hardware preparation cost, we have to build software measures, like educating the residents about disaster prevention and clarifying the evacuation routes, and, at the same time, prepare improved systems for resident notification and develop procedures for helping those that require assistance. Such preparations require not just engineering knowledge but also specialized knowledge over a wide range of specialties. The same applies to accidents as well. Airplanes are means of transportation through the air, and damage to their engines or fuselages caused by aging, poor maintenance or bird strikes, as well as stalls due to pilot error or turbulence can immediately lead to their falls. Preparing against them means to have knowledge in not only aviation engineering, mechanical engineering, and human engineering but additionally in biology for countering bird strikes and public administration for safety regulations. Dealing with problems that surround societal safety, thus, requires not only revealing the physical and chemical mechanisms of accidents and disasters but also studying human, social, and economic environments that the problems relate to.

1.3.2 Societal Safety Sciences as a Field of Synthetic Science

Conventionally, academic fields that study natural disasters include civil engineering and architecture, and those that study accidents and industrial safety are engineering fields of mechanical, chemical, safety, and so on. All these specialized fields handle disaster and safety issues with engineering methodologies. In modern days, complex and diversified problems in safety revealed limitations with such engineering approaches alone. Yoichiro Murakami advocated "safety studies" (Murakami 1998) to cover a wide range of safety issues including drug toxicity, medical accidents, and food safety in addition to those industrial safety concerns like nuclear accidents. In fact, the Science Council of Japan (SCJ), in February of 2000, published the following recommendation (SCJ 2000). "Safety engineering has made large contributions in realizing safety from engineering standpoints. With such changes, however, of our technology growing much larger and our living environment globalizing, simple engineering analytic approaches alone are facing difficulty in handling safety problems. We now need to construct "safety studies," an academic field that deals with safety problems from a wide viewpoint beyond the conventional scope of safety engineering."

Various problems within nature, our environment, artificial structures, and functions cause accidents and disasters. These problems turn into incidents following some physical or chemical laws and finally break out. We also design and manufacture artificial products following some physical or chemical laws; however, before they enter the market as industrial products, factory workers and organizational activities of quality and value evaluation affect them. Solving societal safety problems that relate to people's safety and security, thus, requires multi-angled viewpoints over a synthetic framework that covers human, society, scientific technology, and nature.

Societal safety sciences offer a new multi-angled integrated field of study about safety and security. Technical prevention and mitigation of disasters are insufficient for building a safe and secure society. This study has to involve regulation by standardizing artificial products, provide compensation through insurance if human and physical damages are foreseen, and also look into saving victims as well as regional recovery and reconstruction. In contrast to safety engineering that empathizes safety measures, societal safety sciences not only study accidents and disasters, but form a synthetic field of science that comprehensively and practically approaches common social and economic effects and their mitigation caused by such accidents and disasters.

1.3.3 Methodologies and Problems with Societal Safety Sciences

Kansai University advocated societal safety sciences in 2009 and, to promote research and education in the field, established new Faculty of Societal Safety Sciences and the Graduate School of Societal Safety Sciences. For reducing disasters and mitigating the damages to the minimum, we need to first understand their risks and then establish policies and systems to prepare against them. The Graduate School of Societal Safety Sciences at Kansai University is actively involved with research and education of disaster prevention and mitigation, i.e., disaster management, with three basic fields of science and engineering systems, societal systems, and humanities systems.

The science and engineering systems consist of fields in science and engineering that contribute to preventing and mitigating disasters by clarifying their mechanisms. Conventional academic fields they cover are earth science, system engineering, civil engineering, mathematics, and so on. Societal systems cover administrative policies about disasters and damages, their underlying laws, economics and operations, social system design, and so on. Conventional academic fields they involve are law, public administration, economics, operations research, public health, and so on. Finally, humanities systems handle the psychology and ethics of people in disasters and victims, people-to-people and people-to-society communications, and so on. Corresponding conventional academic fields are psychology, theory of communication, sociology, ethics, and so on. We designed our schools for these three areas to overlap and synthesize with overlaps instead of having exclusive visions.

As we can see from the establishment of the Integrated Disaster Risk Management (IDRiM) Society, the importance of an integrated approach to safety-related problems is a globally recognized movement. Societal safety sciences, however, is not an internationally recognized academic field of “new safety studies.” Kansai University first advocated it in 2009 and built a faculty with the name in 2010. Societal safety science is a new academic field born in Japan.

Some countries in northern Europe gave birth to a research field, in the late 1990s, with the name “Societal Safety” with scopes similar to those of societal safety sciences. When Kansai University writes societal safety sciences in English, it uses the phrase Societal Safety.

Researchers concerned with safety all recognize the need for an interdisciplinary approach to handle problems in the field. Researches about safety in Europe and the USA merely cross existing academic fields. If we describe these methods with trees,

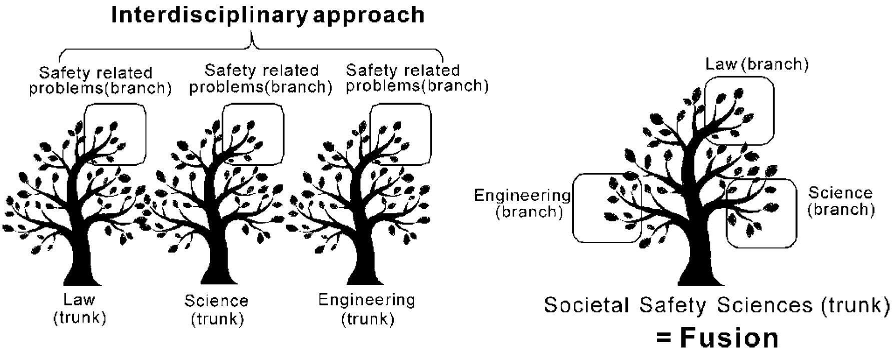

Fig. 1.2 Difference of "interdisciplinary approach" and "fusing fields"
Note: Existing academic fields are not just the three in the figure

there are multiple trees, one for each academic field, with branches of problems related to safety. The researches collect all these branches keeping them at levels of simple additions of the problems.

Our studies form a trunk of societal safety sciences with branches extending to their own fields of study and the branches are fused into the trunk (Fig. 1.2). In the state of fusion, a safety section of the tree trunk shows an organic combination of the existing academic fields. The authors aim to develop into this direction that synthesizes multiple academic fields to give birth to a new academic field of fusion. This book is an experimental publication of our direction.

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