Chapter 7
Social Disasters and Damages

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Abstract This chapter discusses actual social disasters and damages they caused. The first section starts with some societal problems we face today. They are accidents due to aging infrastructures and difficulties in preventing them, nature and trends in accidents involving airplanes which are one of the most advanced industrial products today, characteristics of automobile accidents with the most serious social disasters in modern society in terms of the number of deaths and injured, and drug toxicity and safety in medical care. The following Sect. 7.2 analyzes human error, which is the most important factor in conducting analysis and investigation of accidents. Lastly, the third section closes the chapter with an overview of the history of major social disasters and their countermeasures.

Keywords Aging infrastructures · Automobile accidents · Drug toxicity · Human error · Maintenance · Safety-I · Safety-II · Transportation war

7.1 Social Disasters and Damages

7.1.1 Accidents with Infrastructures

Infrastructures are basic systems and services for countries, industries, or organizations to function effectively. For example, roads, railways, electrical grids, communication networks, ports, dams, water supply and sewage, schools, hospitals, parks, and public housing are systems of facilities that form bases for industries and social livings. In Japan, the ceiling-slab collapse accident took place in December 2012 in Sasago Tunnel on Chuo Expressway and caused nine fatalities. This accident triggered large concerns for people over aging of social infrastructures like tunnels, bridges, water supply, and sewage.

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Infrastructures are said to last, in general, 50 years; thus social infrastructures built during the high economic growth period in the 1960s have now served functions for over 50 years, and their maintenance, repair, and renewal are urgent matters. The 2014 "White Paper on Land, Infrastructure, Transport and Tourism" reports that by 20 years later in 2033, social infrastructures that have surpassed 50 years of existence will make about 67% of road bridges, about 50% of tunnels, about 24% of sewage drainage, and about 58% of harbor piers. Maintenance management and renewal cost was about 3.6 trillion yen (about 34 billion US dollars) in 2013 and is estimated to grow to 4.6–5.5 trillion yen (43–52 billion US dollars) in 2033 (MLIT 2014).

The USA, under the New Deal in the 1930s, had its infrastructures built earlier than Japan, and already their aging was a serious problem in the 1980s. Pat Choate and Susan Walter in their 1981 book *America in Ruins* warned about accidents that the aged infrastructures would cause.

In Japan, local public organizations control most of the social infrastructures. For example, among the about 730,000 bridges in the nation, about 520,000, which is over 70%, are on municipal roads, and in 2025, 44% of them will be in service for over 50 years (MLIT 2015). There are about 4000 roadway collapses caused by sewage line failures annually. This amounts to about 1.0 roadway collapse a year for every 100 km of sewage pipe (NILIM 2012). Local public organizations, thus, have the important role of maintaining, managing, and renewing social infrastructures; however, their organizations are short of what are sufficient, and they are in need for people resources and skills. Budgets for such maintenance, management, and renewal are also short. Since the Sasago Tunnel accident, managing organizations have the liable responsibilities, and "lack of personnel" or "lack of budget" cannot make reasons for not performing maintenance and management. Local public organizations have the urgent need to secure and educate technicians for maintenance and management of social infrastructures.

Social infrastructures are important factors in national resilience for disaster prevention and its mitigation. Making necessary preparations is an urgent matter so they can remain safe and serve their functions at times of disasters. For maintenance, management, and renewal of social infrastructures to meet local needs and demands of the time, efficient and effective asset management of the facilities is in need. The management should be based on mid- to long-term total and strategic maintenance plans to, for example, make preventive maintenance based on time degradation forecast. Under the circumstances of lack of budget and workforce, we need to promote development and application of new technologies that can effectively maintain and manage infrastructures, so we can cope with aging social infrastructures.

7.1.2 Accidents with Industrial Products

Industrial products include a wide variety with different sizes and uses. Gas water heaters and air conditioners for home use; machining tools like lathes for factories; transportation machines like automobiles, railway coaches, ships, and airplanes assembled in factories; large facilities like nuclear reactors, boilers, and turbines for power generation; and chemical plants for petroleum products are all industrial products. This section explains the transition in accidents about industrial products. It takes airplane accidents as the primary example because the industry has outstanding advancement in the technologies involved over the past 50 years and reliable statistical data about their accidents.

Figure 7.1 shows the number of commercial flights and their accidents over the past 55 years. As Fig. 7.1a shows, the number of flights was small in the 1960s, but with economic growth and lowered airfare, it grew roughly linearly over the years till now. The number of accidents also grew at a high pace in the 1970s but then leveled off at a rate of 10–25 a year. On the other hand, as Fig. 7.1b shows, the number of accidents per one million flights exceeded 50 per year around 1960; however, it rapidly went down to about 5 a year in 1970 or so, and since then it is maintaining a slow but gradual decline.

Through a large number of accidents they experienced, airplane manufacturers and airline companies overcame a large number of problems and advanced their manufacturing technologies and flight control systems. The introduction of computers especially made large contributions to enhancing the reliability. Even so, aging equipment and the problem of human factors persist, and the accident count does not drop to zero. This trend of accidents is not unique to airplanes and is common to all accidents involving industrial products.

7.1.3 Automobile Accidents

During the postwar period of high economy growth, automobiles spread widely in Japan, and the number of owners increased rapidly. On the other hand, building infrastructures like sidewalks and traffic lights lagged behind as well as regulations for traffic control, and deadly automobile accidents reached 16,765 in the single year of 1970 (First Traffic War). The victims back then were pedestrians, especially infants and children.

In 1970, Basic Law on Traffic Safety Measures was enacted to promote well-planned and overall safety measures for land, oceanic, and aero transportation. When the law went in effect, the administration took on building infrastructures like sidewalks, pedestrian bridges, and guardrails. Promotion of traffic safety education and campaigns reduced the number of automobile accidents and the number of victims injured or killed.

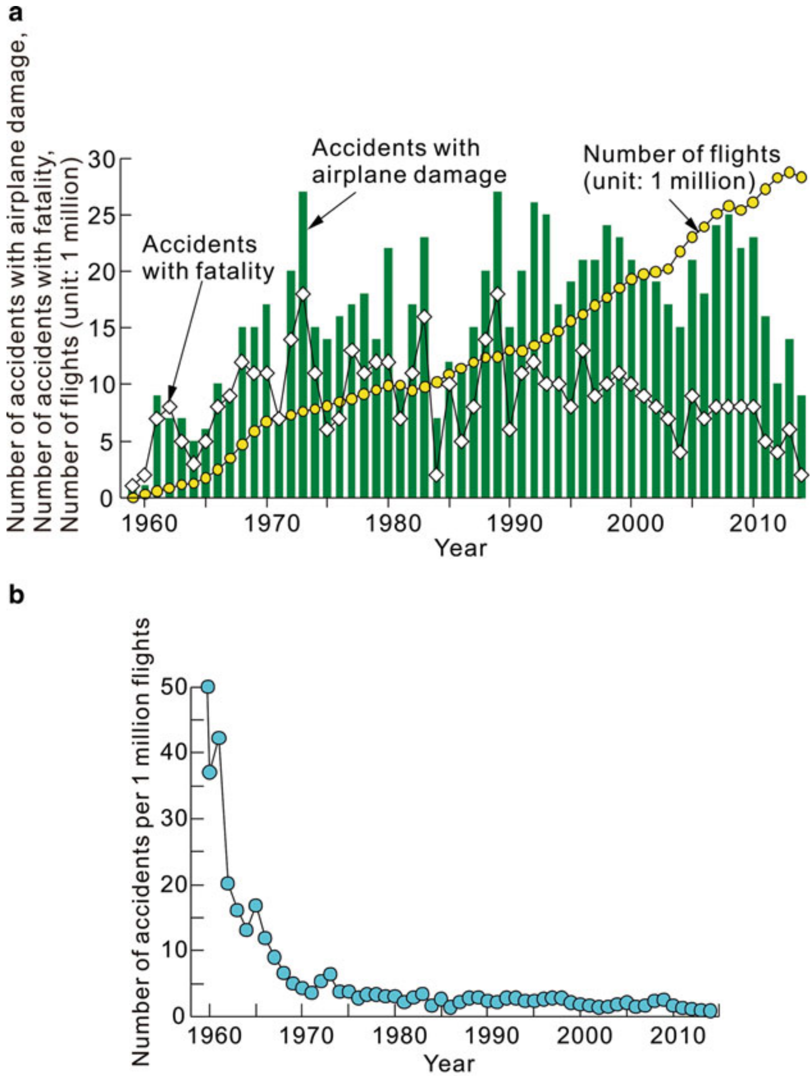


Fig. 7.1 History of airplane accidents, based on data from Airbus (2015) and Boeing (2014). (**a**) Number of accidents, fatal accidents, and number of flights. (**b**) Number of accidents per one million flights

Later, the number of automobiles kept growing, and the shortage of budget for adding more traffic-control policemen or building more traffic infrastructures of safety facilities caused the number of deaths due to automobile accidents to turn around and start growing again in 1980. Especially from 1988 to 1995, the number of deaths constantly exceeded 10,000 a year (Second Traffic War). During this period, the number of accidents by young drivers increased rapidly, and another distinct point was that the rate of those killed while in the car at the time of accident was high.

In 1996, the number of annual deaths with automobile accidents went below 10,000 and started to decrease. The number of accidents and injured, however, increased until 2004 with growing quantity of automobile traffic. Although the number of accidents increased, the development and spread of safety technologies at the time of impact, airbags and antilock braking systems, turned the vehicles safer, and regulations like mandatory seatbelts in the front seats (1992) and mandatory child seats (2000) contributed to reducing the number of deaths. Further the tighter penalty against driving under the influence, criminal charges against reckless driving leading to death or injury (2001), and continued efforts in improving automobile safety technology led to drop in all numbers of accidents, injured, and deaths.

As our society rapidly turned to an aged society, however, more than half of the automobile-caused deaths has been with elderlies at 65 or older since about 2010. As our society will grow even older in the coming years, the trend in automobile accidents will be affected, and further measures for accident prevention will be necessary.

By the way, automobiles turned into practical tools in the early twentieth century. Since then, the societies have been dealing with the social problems of driving manners and noise, in additions to accidents. The measures cover a wide range of improving vehicle performance including safety, constructing and developing technologies for infrastructures about road traffic systems, regulation and enforcement of traffic rules, and training and education of drivers and others involved with transportation.

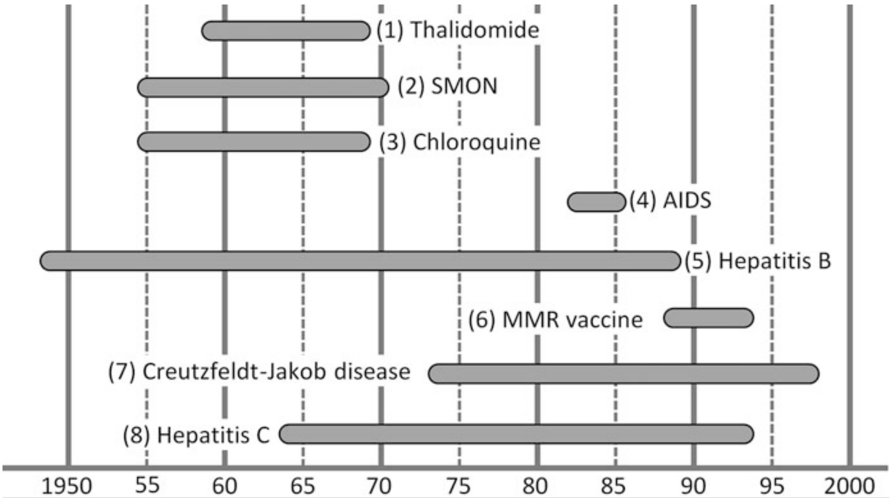
In recent years, advancement of various sensors and camera technology as well as automobile safety technologies like damage-reducing braking systems was developed, and by coordinating them with information and communication systems like intelligent transportation systems (ITS), "automatic driving" that does not rely on the driver's operations is turning into reality. Nevertheless, a number of problems still remain like the fact that a set of certain conditions need to be met for driving assistance systems to work or who is liable in case of an accident while driving with automated assistance.

7.1.4 Drug Toxicity and Safety in Medical Care

Throughout the history of mankind, drugs have been in use for curing diseases since the ancient times. Especially since the twentieth century, advancements in chemistry and medicine led to mass production of drugs as industrial products. Drugs have saved a large number of human lives but, at the same time, have caused drug toxicity.

The phrase "drug toxicity," in general, has a broad meaning of "damage caused by drugs"; however, in the medical and pharmaceutical fields, the phrase is specifically used for the narrow meaning of "damages caused by harmful side effects of pharmaceuticals"; however, not all damages caused by harmful side effects of pharmaceuticals are called drug toxicity. Special administration of pharmaceuticals has strong relations to this practice.

Pharmaceuticals, in principle, provide healing effects, but at the same time, their applications cause inconvenient side effects to human bodies. The extremely complex nature of human body enjoys the expected effect (primary function), however, with a number of side effects in general. Some side effects may benefit human body; however, some are harmful. A drug is a product to use carefully with knowledge of the target effect and accompanying side effects, especially harmful side effects, and apply just the right amount at the right time. Fault in drug administration is, thus, not drug toxicity but it is a medical accident. On the other hand, negligence in identifying harmful side effects of pharmaceutical and hiding or falsifying them to cause delay in response or unnecessary expansion and severity are called drug toxicity. Figure 7.2 shows major drug toxicities in Japan in the past.



(1)	Side effect of sleeping pills caused birth defects	(~300)
(2)	Side effect of stomach drugs caused walking or vision disorder	(~11,000)
(3)	Stomach pain and arthritis drugs caused retinopathy	(~1,000)
(4)	Contaminated blood products caused hemophilia, amounting to about 40% of the patients	(~2,000)
(5)	Mostly due to sharing needles during vaccination	(est. ~450,000)
(6)	MMR vaccine caused side effects like meningitis	(~1,000)
(7)	Infected by transplant of human dried dura	(~150)
(8)	Infected by contaminated blood products to treat bleeding	(est. ~10,000)

Fig. 7.2 Major drug toxicities in Japan [durations (victims count)]. (Original source: Medwatcher Japan meeting handouts. Source: Mainichi Newspaper, morning edition, Aug. 20, 2017)

Quality of drugs directly relates to safety of life; thus, in modern pharmaceutical industry, good laboratory practice (GLP), good manufacturing practice (GMP), and good clinical practice (GCP) are in place to establish high-quality safety evaluation systems that are unequaled with any other industrial product. Safety evaluation of pharmaceutical, however, takes specialized knowledge; thus, pharmaceutical companies often directly or indirectly take part in research activities that can easily lead to problems of conflict of interest with medical facilities, organizations for medical research, or academic institutes. The industry has a problem of being under the threat that social anxiety or distrust could spread with rumors that expert judgments are distorted and unfair evaluations are made.

The 2012 Diovan scandal in Japan was a typical example of such social problems. This scandal involved a pharmaceutical company employee taking part in a clinical research of his company's new drug Diovan and publishing forged data with the doctor in a paper. The result was a blockbuster (a code word in the pharmaceutical industry for a drug that led to sales of 100 billion JPY or more) among its competitors, and the profit was enormous.

In the medical field, new problems continue to arise including but not limited to drug toxicity, like safety concerns with fair drug treating. Further, with the June 2014 amendment of Medical Care Act, the system of medical accident investigation just started on October 1, 2015. Countermeasures for these problems are equally important to the safety and security of the citizens in addition to the problems we have had over the years.

7.2 Human Errors and Accidents

7.2.1 Hazardous Human Errors

Even under the circumstances when the given information is insufficient, conditions are unknown, or unexperienced people can flexibly carry out problem-solving based on experience and knowledge. When a performance has to continue, however, and for an extended period of time, people cannot continue the precise work no matter how serious they are. On the other hand, machines can repeat the same work precisely even if the work may be complex and hard as long as the expected performance is within the design and specification of the machine. When, however, information to perform the task is insufficient, or it is out of the design specification, a machine cannot carry out the work. Its work also has to be stopped in case of unexpected events.

Human can flexibly react to a variety of situations and can carry out redundant actions as well. In short, human has the characteristics of flexibility, redundancy, and variety. If we look for flexible judgment by machines in response to the situations, the ranges that they can handle have technical limitations, and they cannot meet the needs. The recent advancement of artificial intelligence (AI), however, is gradually giving machines flexibility, redundancy, and variety that human has.

Humans have demanded reliability, accuracy, and repeatability to machines and have realized them with scientific technology. Given the right specifications, we can design and assemble the machine, and by giving them proper maintenance, machines can continuously carry out the given precise performance with high reliability. There are some exceptions to human work, like cases of craftsmanship that far outperforms machines. Human ability, however, has limits both qualitatively and quantitatively, and if we ask them to perform accurate work continually, there will mostly be some level of variation.

Ever since the industrial revolution, humans developed a wide variety of technologies to cover the characteristics they lacked. The development of technologies has made our lives comfortable and effective. As long as men and machines compensated each other, there were no big concerns. The social demand for efficiency and productivity these days, however, is so high, and as people started to see AI with human-like characteristics, the demand against human for reliability, accuracy, and repeatability rose up to the level of machines or even more.

The advancement of scientific technology is also pointing at development and improvement of methodologies for human problem-solving and education and training for enhancing problem-solving skills. The human nature, however, has not made much of a difference since the birth of humankind. Therefore, when the difficulty with performance requirement is over the limitations of human, or when the abilities of the performer are insufficient or inadequate, the odds for incidents or accidents to take place go up. The concept of human error comes with inadequate action by human from inabilities or inadequate responses that leave the given task incomplete.

7.2.2 Human Errors and Accidents

We all acknowledge that “anyone makes mistakes.” In fact, anyone can be “careless” and have “mind slips” at times, and as long we are human, we can never do away with them.

The advancement and complexity of scientific technologies now demand humans to perform well above their abilities, and there have been quite a number of cases where minor mistakes developed into unprecedented major accidents or troubles. Mistakes that humans make can qualitatively and quantitatively affect the society, and as they have caught our attention, the phrase “human error” now applies to such acts. At the same time, the idea that “we can prevent accidents and troubles if we eliminate human error” is gradually gaining grounds.

Since some time before, many companies post signs that read “Safety First.” Recently another sign “Eliminate Human Errors” often makes their ways next to them. Efforts to eliminate human errors have continuously been in practice since the 1980s, and much resource has been put into them. So far, however, there have been no case of successful human error elimination, and as we will discuss next, we will not succeed in the future, either.

Posting signs that say “Eliminate Human Errors” has the thinking behind that human errors are causes of incidents and accidents and that their elimination can prevent accidents. If, however, human “carelessness” or “slip of mind” is what a human error is, we can never eliminate them. The reason is because these phenomena are part of our specification as living organisms and they cannot change unless we change the specification for human. If we take the standpoint that human errors cause accidents, once we find a human error with one involved with an accident, investigation has identified the cause, and it stops right there. Since this cause cannot be eliminated, so is the accident.

As we clarified that “human error elimination” cannot prevent accidents, measures for accident prevention are shifting toward taking human error as a result, identifying the real cause in the background, and discussing accident prevention measures against it. The idea that human errors cause accidents, however, spread first, and many organizations still spend large efforts under the target of “human error elimination.”

7.2.3 Human Errors and Accident Prevention

We all acknowledge that “anyone makes mistakes.” In fact, anyone can be “careless” and have “mind slips” at times, and as long we are human, we can never do away with them.

Shinnosuke Usui, a researcher in Safety Ethology, stated “the same action would, depending on the range of system tolerance, result in a human error at times, but not at other times” (Usui 1995). He further claims that the phrase human error means “When the action taken is compared with the standards required for the external circumstances and situations and if it falls outside of tolerable range, it is named” human error and that “It does not mean some special action of an abnormal nature” (Usui 2000). An aero- and astro-medical scientist Isao Kuroda defined human error as “Human action against expectation that unintendedly resulted in something different from the target goal” (Kuroda 2001). Both views take human error as results, and we can summarize human error to mean “unintended different results,” “results outside of tolerable range,” or “unexpected results.”

Based on these ideas, we have to first analyze “what was the person’s intension or goal of action at the time,” “what was the tolerable range of action under the external circumstances or situations at the time,” and “how big was the gap between the expected results and results of the action taken,” and then we can determine what the human error was. Further, the countermeasure to make changes depends on which action is taken as human error which also depends on the point of time and level of concern throughout the series of actions.

Sidney Dekker stated that solving the problem of human error first takes understanding how the taken action systematically related to the external circumstances and expected results, and then it is important to understand, in the actor’s shoes, the local rationality inside the human judgments and actions (Dekker 2002). We need to think about local rationality when we want to understand human error, in finding the cause of an accident, and in attempting to prevent the accident. Further, with the understanding of human nature, we need to continually make efforts in gaining skills for judging the contents of the required problems, skills for judging if the posed difficulty is fair, and ability to accurately detect errors with the understanding of error patterns and enhance the overall system protection, expansion, and improvement.

7.3 History of Major Social Disasters and Their Countermeasures

7.3.1 History of Social Disasters and Accidents

Human exchanges material with the nature. The process involves (1) make actions to gain resources from the nature, (2) apply work to the gained resources to produce artificial objects, (3) consume resources and artificial objects to live, and (4) after completely consumed, return what is left of the resources and artificial objects by disposing them to the nature. This sequence of processes acquires resources and artificial objects needed to maintain life as "goods" and consume them. The sequence, however, often produces some unwanted "bads." Social disasters in the broad sense are, in a sense, "bads" produced in the process sequence of material exchange. For example, industrial bads are produced in processes (1) and (2), product and equipment accidents and accidents of infrastructures are bads in process (3), and environmental destructions are bads that can surface in all processes (1) through (4).

Industrial disasters affect the modern world in two forms: one contains the bads in the production zone, and the other spreads the bads to the surrounding regions and the whole society. The following descriptions review the history of their breakouts. Like for the case of accidents in mines, factories, or construction zones, when the damage is contained within the industrial zone, bodily damages are handled as industrial accidents. The history of coal and other mines tells us that major to minor accidents of explosions, fires, collapses, and flooding repeated. The postwar worst coal mine accident in Japan was the 1963 Mitsui Miike mine explosion that killed 458 and injured 555. This accident caused carbon monoxide poisoning to 839 and the majority suffered aftereffects. A number of large accidents followed this one.

Fires and explosions at factories made their marks also, like the 1892 Osaka Spinning Mill factory fire (85 deaths) and the 1905 Tokyo Artillery Arsenal factory explosion (26 deaths). After those, however, there have not been such factory accidents with many fatalities other than the exception of the 1970 Mitsubishi Heavy Industry Nagasaki Shipyard turbine explosion accident (a 50-ton turbine rotor broke apart killing 4 and leaving 64 injured). Industrial accidents in the manufacturing industry are mainly during the daily work, and the number of accidents has been declining since the peak around 1960. In recent years, however, the industry has to be cautious about accident that surfaced with some time delay. In some fields, a variety of chemical substances is present, and exposure to them without the knowledge of their danger can cause serious damages later. The problem of bile duct cancer with printing factory workers surfaced recently, and in the past were the problems of benzene poisoning and cancer-causing polyvinyl chloride. Health effects from asbestos have been known for quite some time; however, they have caught the general attention only recently.

Industrial disasters that affect the surrounding area and the society are caused either by accidents or in some cases the regular daily operation. A typical example of the former is the 1984 pesticide leakage from Union Carbide's plant in Bhopal, India. The toxic gas leaked out over a 5-mile area from the factory leaving 2000 dead and 300,000 injured the following day. The death toll continued to increase later in the devastated area, and health problems are still persistent as of today. Examples of the latter in Japan, on the other hand, are air or water pollution from smoke or wastewater disposal from factories. In the Meiji era (1868–1912), Ashio Copper Mine poisoning broke out, and smoke pollution from Hitachi Mining Company caused sickness. They were followed by itai-itai disease (cadmium poisoning), Minamata disease (organic mercury poisoning), Yokkaichi asthma (air pollution from petrochemical factory chimneys), and so on. Pollution in Japan was by then well known to the world as the negative side of economic growth.

Accidents and disasters caused by products have been growing in their magnitude of effects. The most prominent problem is automobile accidents. WHO announced the number of deaths caused by automobile accidents in 2013 was about 1,250,000 worldwide. The number of accumulated deaths caused by automobile accidents in Japan has reached 600,000, and the injured figure is close to 50 million. Railways and airplanes, much safer than automobiles, have also experienced their share of accidents. Once they take place, these accidents often turn into major disasters. Relatively recent ones are the 1998 Intercontinental Express (ICE) derailment (101 dead), the 2005 Japan Railway (JR) Fukuchiyama Line accident (107 dead), and so on. For airplane accidents, we have the 1977 collision of 2 Jumbo jets in Tenerife, Spain (583 dead), the 1985 Japan Airline crash (520 dead), and so on. Accidents involving ships and busses also result in large death tolls, like with the 2014 Sewol ferry disaster with victims including high school students on their school excursion (304 dead or missing) and the 2016 ski bus accident in Karuizawa (15 dead) that still have traces in our memories.

Accidents with facilities and infrastructures are also social disasters that break out while using artificial objects. They include accidents with escalators, elevators, and revolving doors, or accidents due to structural flaws in buildings. The 1995 Sampoong Department Store collapse in Seoul and the 2017 high-rise fire in London are such examples. Accidents with NPP are also facility disasters. As we saw with the 1986 Chernobyl NPP accident and the 2011 Fukushima Daiichi NPP accident, these accidents affect not just the area around it but also the entire world, and they require long-term actions against them. The ultimate disposition of radioactive waste takes tens of thousands of years, and no one can guarantee if the mankind has such capabilities (Beck 2002).

7.3.2 Overview at Major Measures Against Social Disaster

J. K. Mitchell categorizes accidents into "routine" ones and "surprising" ones. Specialists have already studied routine disasters, and principles and practices developed over the years can handle them. Surprising disasters, on the other hand, have huge effects over time and space, and without prior experience, even the specialists cannot predict them, and we need to study each one of them (Mitchell 1996).

Even for routine disasters that are easy to manage, their handling did not develop easily. People first thought that routine disasters were caused by technical problems. Their management then took improved technology and social handling. If we look at their history, however, we find that managers, reluctant to spend the cost on safety measures, often exposed workers to dangers.

Next, it was human error that caught the attention. Technical measures advanced and mechanical failures turned rare; however, with the magnitude of energy that humans control, minor mistakes caused huge disasters. The managing side had the idea that if they emphasized human error, they could avoid the cost of improving facilities and the work environment. Later studies of human factor, however, clarified that taking an error as the result, rather than the cause, and working countermeasures would better improve the safety. This finding led to implementing a countermeasure for each factor that could lead to an error, as we discussed in the former section.

Recently, organizational safety management has caught the attention. The 1986 space shuttle "Challenger" explosion and the Chernobyl NPP accident taught us that, in addition to human factor, we must also review the organization to eliminate accidents. James Reason explained that an active failure that pierces the weak points of multiple layers of defense leads to an accident with his Swiss cheese model (Reason 1997). He further named such accidents "organizational accidents" caused by organizational factors of people and technology and argued that organizational culture and management are responsible for their prevention.

As we saw above, we attribute causes of social disasters to technology, human factor, and organizations and their culture. By removing factors that lead to risk from each one of them, we have improved the technology, enhanced social regulation, implemented ways to prevent human error, and developed measures for safety management. As a result, the rate of accidents per operational quantity has drastically dropped. Erik Hollnagel, however, wrote that we would have to face and manage accidents that we cannot identify what their causes are. He argues that our measures so far are "Safety-I" and we will, in the future, need "Safety-II," that is, active safety management (Hollnagel 2014).

A typical example of applying the concept of Safety-II is the problem with Boeing 787. This model started commercial operations in 2011; however, due to its repeated damage and burn problems with batteries, it suspended operation in January of 2013. A thorough investigation has failed to identify the cause, still today; however, safety measures in case of batteries burning have been implemented, and the operation restarted in May of the same year. Some voice their anxiety that the decision does not follow the conventional Safety-I concept and the risk factor is not removed.

Ulrich Beck described in his *Risk Society* that an "industrial society at a stage where generation of wealth has turned into generation of risk" (Beck 1986). In the modern society, where what we thought were goods have turned into bads without us recognizing the change, we need to add Safety-II-type countermeasures that actively assure safety by identifying symptoms that can lead to failures and accidents through daily monitoring and managing of people or IoT like the way our computer software is continually revised.

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