
Part V

Vision Zero in Other Areas



Gerard I. J. M. Zwetsloot and Pete Kines

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Abstract

Unsafe and unhealthy working conditions contribute to more than 2.3 million deaths globally each year. Vision Zero (VZ) in workplaces presents the challenge to prevent all serious accidents and work-related sickness and disease. Companies and other organizations play a key role, in the development and implementation of VZ, and are supported by international organizations such as the International Labour Organization and the International Social Security Association (ISSA). VZ in workplaces has a long history and several roots, which explain the variety in its application. It is both conceptually and practically closely associated with the development of a broad prevention culture, focusing on the safety, health, and well-being of the workforce as an integrated part of business. VZ in workplaces has developed quickly since the Seoul Declaration (2008), whereby global occupational safety and health leaders and representatives of national governments expressed their will to create a worldwide culture of prevention. In particular, the ISSA launched a global VZ strategy and campaign in 2017, which now (in 2021) runs in more than 80 countries. VZ policies and strategies for both road traffic and workplaces are overlapping and can strengthen each other, as roads are an important place of work in many jobs. The implementation of VZ in workplaces should be regarded as a commitment strategy, based on genuine commitment of both top leaders and all personnel. It is important that VZ in workplaces is understood as a vision and a long-term ambition, not as a target. Proactive leading indicators are therefore more important for VZ than lagging indicators, such as accident frequencies.

Keywords

Golden rules · Innovating to zero · Occupational health · Occupational safety · Prevention culture · Proactive leading indicators · Safety ethics · Total quality · Vision Zero fund · Well-being · Work environment · Workplace · Work-related fatalities · Zero accidents · Vision Zero criticism

Introduction: The Global Challenges Concerning Safety and Health in Workplaces

The focus in this chapter is on how Vision Zero (VZ) is applied in organizations and workplaces. From a global perspective, safety and health in workplaces still needs a lot of improvement, and recent threats to the way we work in times of economic and social crises (e.g., during the COVID-19 pandemic) reinforce this need. According to the International Labour Organization (ILO 2019), more than 2.3 million people die globally from work-related accidents and diseases every year, and it is estimated that road traffic incidents account for approximately one-third of all work-related fatalities (EC 2020).

Roughly speaking, around 7,500 people die every day due to unsafe and unhealthy working conditions. Around 6,500 of them die from work-related diseases, and approximately 1,000 from fatal accidents (see Fig. 1), whereas the numbers for nonfatal accidents and diseases are much higher.

There are great differences in the frequencies of work-related accidents and diseases per region, country, and sector. Figure 2 shows the accident fatality rates per 100,000 persons in the labor force of various continental regions. In Europe, fatal accident frequencies are considerably lower than in, e.g., Asia and Africa, yet meaningful improvements are still needed and possible in Europe.

The high numbers of work-related accidents and diseases do not only mean a high human toll, but also considerable economic losses. According to the ILO, the global economic loss has been estimated at 4% of the Global Gross Domestic Product. This is because millions of productive workdays are lost, there is material damage, and production processes are interrupted. At the same time, there are huge associated



Fig. 1 Deaths per day due to unsafe and unhealthy working conditions (globally) (ILO 2019)

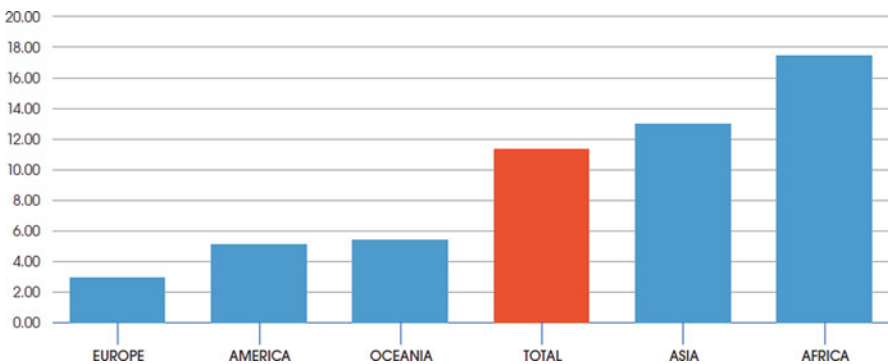


Fig. 2 Accident fatality rates per 100,000 persons in the labor force, 2014 (ILO 2019)



Fig. 3 The symbols of the United Nations Sustainable Development Goals no. 3, 8, 9, and 12, as relevant for Vision Zero in workplaces and road safety

costs for health care and worker's compensation. It is therefore not surprising that Decent Work and Economic Growth is one of the United Nations (UN) Sustainable Development Goals (SDG no. 8) for 2030 (UN 2015). SDG no. 3 – Good Health and Well-being – is also relevant to workplaces and road safety (e.g., SDG no. 3.6), as are SDG no. 9 – Industry, Innovation and Infrastructure, and SDG no. 12 – Responsible Consumption and Production (Fig. 3).

Vision Zero in Workplaces: Roots and Developments

Focus on safety in workplaces has a long tradition and is important in all parts of the world. Present practices with VZ in workplaces build, at least partly, on a range of historic experiences with accident prevention. In the remainder of this chapter, we follow the development of VZ in workplaces chronologically, paying attention at first to its main roots, and with examples of its relevance for road traffic safety.

The Origin of Accident Prevention (Early 1800s)

According to Eichendorf (2011), the roots of VZ for safety at work stem from E.I. DuPont who established a gunpowder mill near Wilmington (Delaware, USA) in 1802. Several severe accidents occurred, and on one occasion three wagonloads of gunpowder blew up, causing many fatalities and destroying many buildings in Wilmington. He realized that the disaster was not only a matter of bad luck. E.I. DuPont was one of the first to formulate safety rules, which he did back in 1811. He also realized that the lack of interest in safety of the managers contributed to the likelihood of accidents and disasters. He thus transferred responsibility to his managers, who were required to live on the site premises together with their families. In this way, he created a strong incentive for prevention. At that time, the understanding of safety and accident prevention was very limited, so DuPont's successes with accident prevention were limited. In the DuPont premises at Wilmington, 288 explosions took place during the period 1802–1921, causing the death of 228 people – including several members of the Dupont family (Hagley Museum

2020). However, E.I. DuPont's interest in safety formed the basis for the DuPont Company becoming a world leader in safety throughout the twentieth century.

Zero Defects (Since 1966)

In the 1960s, frontrunners in quality management were the defense and aerospace industries. In these industries, cooperation between various suppliers and industries in NATO countries implied a need to ensure that components, made in one country, matched perfectly with components from other countries and industries. To guarantee that products were "fit for purpose," quality management initially focused very strongly on "products meeting their specification" and inspection after production. Quality management gurus such as Edward Deming and Joseph Juran had clarified that in order to deliver quality products, organizations had to plan and control their production processes adequately, and they emphasized that quality had to be a top management priority.

The Total Quality philosophy enlarged the focus, from "products meeting their specification" and "being fit for purpose," to all aspects of production. In Total Quality Management (TQM, in Japan known as Total Quality Control, TQC), the general idea was that for delivering excellent quality, it was not sufficient to just control the production process, but that quality management also should comprise the quality of the organization and the quality of its personnel.

James Halpin was director of quality at Martin Company (now part of Lockheed-Martin), and responsible for the quality and performance of Martin's defense products, including missile systems, weapon systems, and communication systems. He was the first to develop a Zero Defects program. Under his guidance, hundreds of groups, also in related industries, developed, implemented, recognized, and sustained Zero Defects programs. In 1966, he published about the Zero Defects approach, to make it more widely available (Halpin 1966). In it, Halpin addressed the "double standard" workers may have: "If our 'everyworker' demands perfection from his mechanic, doctor, dentist, lawyer and all the rest, why doesn't he demand the same of himself in his own job?" (Halpin, p. 4). Zero Defects requires getting rid of this double standard: "The Zero Defects concept promotes a constant, conscious desire to do a job (any job) right the first time" (p. 5). Doing things right the first time eliminates the necessity of rework, reinspection, and retest and, in this way, saves a lot of costs.

Halpin saw the relationship between management and the individual employees as the key to achieving industrial excellence and described the Zero Defects program as "...a management technique beamed at getting the employee to think – getting him to think positively about each and every task" (p. 8). This could only be achieved by recognizing the importance of the dignity of the individual worker. Halpin also stated it was "...absolutely necessary that the unions be asked to join the ZD team" (p. 33). Though Halpin's program for Zero Defects was later criticized by other TQM experts for focusing too much on "creating a Total Quality Culture" and for "not paying sufficient attention to process controls," the impact of the Zero

Defects movement was great. The landing of the first man on the moon (1969) showed that with involvement of many stakeholders and a quest for prevention, it was possible to achieve unprecedented successes.

Zero Accidents (Since 1970)

When Zero Defects programs began to spread in industries, the path was paved for translating it to zero accident programs. Zero accident programs and campaigns were started in a number of countries and industries in the early 1970s. An example was the “Zero in Safety” or “Focus on Safety” campaign by the National Safety Council in the USA (US Department of Labor 1970). These early zero accident programs focused on promoting the state of the art in accident prevention; however, most of these campaigns lasted for only a few years.

Japan’s Zero Accident: Total Participation Campaign (Since 1973)

The zero accidents campaign of the Japan Industrial Safety and Health Association (JISHA), which was launched in 1973 with support of the (former) Ministry of Labor, demonstrated to be sustainable and is still running today. The campaign elaborated explicitly on activities, for quality control (QC), and also referred to the US National Safety Council campaign.

Similar to Halpin’s Zero Defects program, the Japanese Zero Accident campaign focuses strongly on participation of the workers, with the basic philosophy of respecting human life. They put a strong emphasis on Hazard Prediction training of workers (in Japanese KTY), and the technique of “pointing and calling.” Pointing and calling is a method whereby the workers collectively check the safety of the workplace and each other (e.g., use of personal protective equipment) before work is started. They point to (potential) hazards, and if it is OK, this is called out loudly by the workers. If is not OK, then measures are taken to rectify them. The method emphasizes that safety is a collective responsibility, and by using different senses (vision, sensing, hearing, and smelling), it is expected to have maximum impact on the workers’ awareness. In addition to this, meetings are held to discuss near-miss incidents.

The Japanese campaign is built around three basic principles (JISHA 2020): (1) a zero accident principle: achieving accident-free workplaces (including industrial accidents, occupational illness, and commuting accidents) by detecting, understanding, and solving all hazards (problems) in everybody’s daily life, as well as potential hazards existing in workplaces and work; (2) the principle of preemptive action, i.e., to prevent all accidents and industrial accidents by detecting, understanding, and solving all hazards (problems) in everybody’s daily life, as well as potential hazards existing in workplaces and work in order to create a brighter and more vigorous workplace with zero accidents and zero diseases as an ultimate goal; (3) participation, meaning managers, supervisors, staff, and workers making a concerted effort to

detect, understand, and solve potential hazards (problems) existing in workplaces and work. It requires the voluntary effort and commitment of all those involved in actions for problem-solving, and a positive attitude and engagement of top management, safety management, leadership by managers and supervisors, and the voluntary participation of every worker.

From Safety Culture to Prevention Culture (Since 1986)

One of the first references to the term occupational “safety culture” was made in the 1980s after disasters with: (1) the Chernobyl nuclear power plant in 1986 (INSAG 1986), (2) the space shuttle Challenger in 1986 (and Columbia in 2003 – CAIB 2003), and (3) the Piper Alpha oil production platform in 1988 (Cullen 1990). In the analyses, intangible factors such as information difficulties, violations, failure to recognize emerging danger, role ambiguity, management complacency, poor communication, and low prioritization of safety were mentioned (Cox and Flin 1998).

There is no generally accepted definition of safety culture, and there is no universally accepted method of assessment. Many definitions of safety culture can be found in the literature, with at least four issues underlying the variety of definitions (Table 1).

Each of the four “issues of debate” seems relevant for a more broad “prevention culture,” encompassing the prevention of injuries, illness, and disease, at the organizational level, wherein there is sufficient trust between management and workers, and wherein open communication is very important for the development of a

Table 1 Main issues in defining “safety culture” (Zwetsloot et al. 2020)

Issue of debate	Examples of definitions
Is safety culture an aspect of the broader organizational culture?	Safety culture is “a specific aspect of organizational culture regarding the organization’s shared beliefs, values, and attitudes that contribute to ensuring safe operations” (Morrow et al. 2014)
Should safety be defined normatively (i.e., as a positive concept)?	Safety culture is an “enduring characteristic of an organization reflected in its consistent way of dealing with critical safety issues” (Wiegmann et al. 2004)
Are deeper layers, such as values and implicit assumptions, the “heart” of a safety culture (or are practices most important)?	Safety culture are those aspects of the organizational culture which will impact on attitudes and behavior related to increasing or decreasing risk (Guldenmund 2000)
Are the interactions with safety management systems essential for safety culture?	Safety culture refers to the interaction between the requirements of the safety management system, how people make sense of them, based on their attitudes, values, and beliefs and what they actually do, as seen in decisions and behaviors (ERA 2018)

prevention culture. The concept of a prevention culture does not have to be normative by definition. However, prevention cultures can be well developed or less well developed, and for distinguishing between them a normative framework (e.g., Fig. 4) is always needed. While the direct impact of a prevention culture on safety and health stems from practices and behavior that can be directly observed, these factors are certainly partly determined by “deeper layers,” such as underlying values, attitudes, and implicit assumptions. Finally, while a safety and health management system represents the formal rules, the culture represents the informal rules. Formal and informal rules can strengthen each other, or conflict with each other. In the latter case, the culture tends to undermine formal safety management, while in the former culture and systems strengthen each other.

Prevention culture also has a business ethics dimension associated with corporate social responsibility (CSR). Avoiding “shifting consequences” (to others, to society, and to future generations), including the prevention of accidents and harm, is the key principle (Zwetsloot et al. 2013).

One popular and practical way of portraying safety culture in workplaces and organizations involves five levels of maturity or development in regard to companies’ approach to health, safety, and the environment (Parker et al. 2006). This is often portrayed as progressive steps of safety maturity, with gradually increasing trust and accountability, from a pathological to a generative culture (Fig. 4; Hudson 2007).

VZ in workplaces is a process, and most reflective of the proactive and generative strategy steps of the ladder (Fig. 4), and it is this that many VZ companies around the world attain to follow.

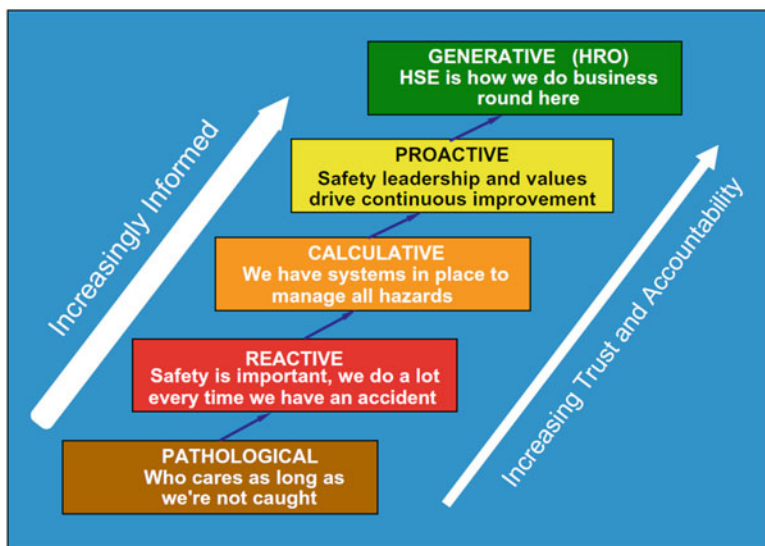


Fig. 4 The health, safety, and environment (HSE) culture ladder. (Source: Hudson 2007)

National Vision Zero Networks (Since 2003)

The Finnish Institute of Occupational Health and a group of Finnish companies started a Zero Accident Forum in 2003 with Professor Jorma Saari, who had picked up the zero “accidents” concept in Canada and the USA. The Finnish forum initially had 21 member companies in 2003 and, in 2021, counts more than 400 member organizations, representing various sizes and sectors. In 2019, the forum redefined itself as the Finnish Vision Zero Forum to reflect a broader application of the VZ concept to safety, health, and well-being. The management and staff of its member organization are committed to improving occupational safety and sharing good practices, in order to learn from each other, across industries and sectors, according to the following principles (Zwetsloot et al. 2017c):

- We commit ourselves to sharing information on best practices with other workplaces.
- We will improve our workplace safety in cooperation with our employees and management.
- Health and safety are an integral part of our workplace’s successful business operations.
- We commit ourselves to annually providing the Vision Zero Forum’s project team with information on occupational safety.

Similar VZ accident networks were started in the Netherlands in 2011, and in Germany in 2013.

Social Accident Insurance Policies (Since 2008)

In Germany, the national social accident insurance (DGUV) adopted the principles of VZ in 2008. They explicitly explicitly referred to these VZ principles as the basis for their strategy for accident prevention (at work, in schools, and on the road), as well as the prevention of occupational diseases and work-related illnesses (DGUV 2008). DGUV sees VZ as very closely related to the goal to achieve a comprehensive culture of prevention. According to Eichendorf (2011), there are four basic principles underlying VZ:

- Life is not negotiable.
- People make mistakes.
- Tolerance limits are the physical load limits of humans.
- People have a basic right to a safe working environment.

The DGUV regards VZ as a strategic and comprehensive approach. They also underline the ethical aspects of VZ, which implies that safety and health at work be regarded as human and societal values that provide direction to organizational and national preventive efforts. The DGUV also organized three international

occupational safety and health strategy conferences, whereby the second strategy conference (2011) focused on a Preventive Occupational Safety and Health Culture (2nd Strategy Conference 2011). In the conference, five pillars were regarded as essential for attaining such a culture of prevention:

1. Vision Zero: Reducing work accidents and occupational diseases
2. Raising awareness, developing competencies and capacity building
3. Cooperation between public health and occupational safety and health
4. Health and safety as an integral part of lifestyle
5. Integrating prevention into the social security system

VZ as pillar no. 1 was regarded as the basis for the other pillars, which prepares the foundation (the strategy) and forms the roof (the objective) for a culture of prevention. The pillar considered to be most relevant for a culture of prevention by the conference participants was pillar no. 2 – raising awareness.

National and International Policies for Vision Zero in Workplaces (Since 2008)

The relevance of VZ for national and international occupational safety and health policies is increasingly acknowledged, explicitly or implicitly, by an increasing number of governments and institutions. A key event for VZ and the development of a prevention culture was the signing of the Seoul Declaration on 29th June 2008, by 46 global occupational safety and health leaders, including 33 representatives of national governments at the occasion of the XVIII World Congress on Safety and Health at Work in Seoul (South Korea) (ILO, 2008). It elaborated on the ILO Convention No. 187 on the Promotional Framework for Occupational Safety and Health, wherein the concept of a culture for prevention was first introduced (ILO, 2006). It was a collaborative effort involving the ILO, the International Social Security Association (ISSA), and the Korea Occupational Safety and Health Agency (KOSHA), as well as representatives of national governments, social security providers, and professional organizations and associations representing employers and employees. They jointly expressed their will to create a worldwide culture of prevention. It broadened the term prevention culture beyond the workplace, by stating that “worker” health was the responsibility of society as a whole. By 2013, 379 institutions had signed the Seoul Declaration, demonstrating a shared will to establish a world-wide culture of prevention with human beings as it hearts (Eichendorf and Bollmann 2013). The Seoul declaration states that a prevention culture implies the right to a safe and healthy (working) environment, which is respected at all national levels. The signatories of the Seoul Declaration committed to actively participate in securing a safe and healthy working environment through a system of defined rights, responsibilities, and duties, whereby prevention was to be accorded the highest priority.

A “Prevention Culture” was defined as a culture in which society as a whole promotes high levels of safety and health at work. “A national preventative safety and health culture is one in which the right to a safe and healthy working environment is respected at all levels, where governments, employers and workers actively participate in securing a safe and healthy working environment through a system of defined rights, responsibilities and duties, and where the principle of prevention is accorded the highest priority.”

With the Seoul Declaration, the focus in prevention was widened from work safety to a broader health and safety prevention approach:

The steady increase in mental health issues and musculoskeletal diseases is an example, indicating that the borders between workers’ health and public health are dissolving and the links between work life and private life become more fluid. (Treichel 2013, p. 55)

In 2011, the Istanbul Declaration elaborated and built on the commitments of the Seoul Declaration and was signed by 33 countries (30 Ministers of Labor) (ILO, 2011). It recognized a healthy and safe working environment as a fundamental human right, as well as a societal responsibility. It was recognized that building and promoting a sustainable national preventive culture should be ensured through a system of defined rights, responsibilities, and duties. The countries that signed the declaration committed themselves to building sustainable national preventive cultures, and to taking the lead in promoting a preventive culture worldwide.

To foster a prevention culture, both prevention and promotion measures are needed that align with values, norms, actions, policies, customs, and beliefs. To help achieve such alignment, six seem essential (Schulze et al. 2013):

1. Reduce the tendency to compartmentalize work from the rest of life.
2. Understand the value of good jobs to a culture of prevention.
3. Integrate into educational systems a focus on career and job readiness that promotes skills for risk prevention.
4. Advance evolved notions of work, health, and prevention.
5. Advance a preventive approach to chronic (physical and mental) disease.
6. Identify the means to make both prevention and promotion integral parts of a culture of prevention and well-being.

The main drivers of societal change are the recognition of safety and health as important human and social values. Recognizing these values implies intrinsic motivation for promotion and prevention in the area of safety and health at work. Yes, there are rules and regulations:

But people live prevention because they believe in it, they are intrinsically motivated for it, they are convinced of the benefits, they have positive associations with prevention and finally, because they have successfully applied prevention principles at work and in their free time as part of their lifestyle. (Treichel 2013, p. 57)

The benefits of a prevention culture are: fewer health and safety problems and associated costs, and more productive employees; fewer quality and delivery problems, higher reliability, flexibility, and productivity in production and work processes; a better status in society and attractiveness in the labor market, greater profitability, and several social and economic benefits for society at large (Zwetsloot 2014).

In the USA, the National Institute of Occupational Health and Safety (NIOSH) defined a “Total Worker Health” trademarked strategy in 2011. Total Worker Health is defined as policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness prevention efforts to advance worker well-being. It focuses on four fundamental areas: safety first, well-being, leadership, and empowerment (NIOSH 2016). Another example is the Swedish government who explicitly referred to VZ in 2016 in their occupational safety and health strategy, which was focused on VZ for fatal accidents and other work-related injuries, sustainable working life, and a sound psychosocial work environment (Kristianssen et al. 2018).

Innovating to Zero (Since 2012)

A well-known business analyst and strategist, Sarwant Singh (2012), identified “innovating to zero” as one of the (ten) megatrends that was likely to greatly influence business, work, and life in the years to come. According to Singh, “innovating to zero” is a special kind of mega trend, as:

It is more a concept than a real happening. It implies the desire for perfection in our society: a ‘zero concept’ world with a vision of zero carbon emissions, zero crime rates, zero accidents, carbon-neutral cities. (Singh 2012, p. 46)

Although this seemingly perfect world sounds almost impossible, the point is that governments and companies today are moving towards this ‘picture perfect’ vision of eliminating errors, defects and other negative externalities, and along that very journey creating for themselves huge challenges and opportunities. (Ibid., p. 46)

Singh regards innovating to zero as a way of running and innovating one’s business.

It is not a trend that is incorporated by individuals or companies overnight. It is a gradual process, a journey that will create opportunities, demand investments, and yield long-term returns. The most remarkable feature of this Mega vision is that the ultimate opportunity lies not in attaining the actual goal itself, but in capitalising on the opportunities that would lead to it. Success in innovating to zero requires an innovation agenda that bravely talks of breakthroughs in the face of radical goals – goals that intend to create a better world, a zero concept world, which is free of unhelpful externalities and defects. It also needs a strong culture from people within that ecosystem. (Ibid., p. 59)

It is important to realize that VZ in workplaces and VZ for road safety, etc., are not unique concepts, but are all part of “a family of Vision Zeros” (Zwetsloot et al. 2013). Many leading companies have committed themselves to several applications

of VZ (quality, sustainability, safety, etc.). Initially, each of these visions was criticized for being unrealistic, or too expensive, yet in actual practice they triggered inspiring innovations and contributed to good business cases.

The Global Vision Zero Fund (Since 2015)

It was thanks to the good relationship of the DGUV with the German government that in June 2015, when the World Leaders of the G7 came together in the South of Germany, VZ was discussed at the global top level. VZ was agreed to be the leading concept for improving safety and health (G7 2015a). On that occasion, a “Vision Zero Fund” was established to promote prevention around the world, with the goal of seeing as few serious work-related accidents as possible, or none at all (ILO 2015a). The fund is implemented through the ILO (ILO 2015b), with the aim of supporting low-income-producing countries in improving occupational safety and health (G7 2015b).

Implementation of Vision Zero in 27 European Workplaces (2017)

The Partnership for European Research in Occupational Safety and Health (PEROSH) is a partnership of 14 occupational safety and health institutes in 13 - European countries. The PEROSH “Working Group on Safety Culture and Accident Prevention” generated a discussion paper entitled “The Case for Research into the Zero Accident Vision,” which was published in the journal *Safety Science* (Zwetsloot et al. 2013). In the paper, it was emphasized that many companies with a good safety reputation had adopted a zero accident vision (ZAV), while very little scientific research on VZ had been carried out. It referred to the success of the Finnish “Zero Accident Forum,” which had supported its member companies in realizing significant safety improvements over time. In the paper, a call was made to the safety research community to undertake empirical research to better understand and support safety strategies based on ZAV.

The next step for the PEROSH-working group was to initiate a multinational (seven countries) study involving 27 European-based companies that had adopted a ZAV. The research focused on their implementation of ZAV, and particularly on the roles of ZAV commitment, safety communication, safety culture, and safety learning (Zwetsloot et al. 2017b). It was a mixed method study involving a survey among managers and workers, as well as workshops at company and country level. A common characteristic of all the companies was the high commitment of their managers and workers to their ZAV, which often were embedded in the companies’ business strategies. This commitment was regarded by the researchers as the main driver for long-term safety improvements. Safety communication, safety culture, and safety learning (from incidents and good-practices) were also found to be relevant factors in ZAV implementation. It was concluded that ZAV is the basis for inspiring and innovative approaches to improve safety, as an integrated part of doing business.

The PEROSH research project also formed the inspiration for a second discussion paper, focusing on the innovative strategies of the companies committed to ZAV (Zwetsloot et al. 2017c). The researchers found that merely promoting traditional safety management or accident prevention will not necessarily lead to significant new improvements in safety. Six innovative perspectives associated with VZ were identified and presented:

1. A commitment strategy
2. Aiming for a culture of prevention
3. Mainstreaming VZ into the business processes
4. VZ as trigger for innovations in safety, health, and well-being
5. The combination of a strong ethical and rational basis
6. Networking and cocreation

Finally, the PEROSH research project also formed the basis for a third paper focusing on the broadening of VZ from accident prevention to the promotion of safety, health, and well-being (SHW) at work (Zwetsloot et al. 2017a). In the paper, the consequences of a genuine commitment to VZ for addressing SHW and their synergies are discussed, with special attention paid to the synergy between safety and well-being at work. One of the conclusions was that even with a strong focus on preventing accidents, health and well-being should also be addressed. The relevance of the above six innovative perspectives for SHW was further clarified (Table 2).

The ISSA's Global Strategy for Vision Zero (Since 2017)

The International Social Security Association (ISSA) launched a VZ strategy for workplaces in 2017 based on the assumption that all (serious) accidents, harm, and work-related ill-health are preventable (ISSA 2017). VZ in this context is the ambition and commitment to create and ensure safe and healthy work while preventing all (serious) accidents, harm, and work-related diseases. This requires a process of continual improvement, aiming at excellence in safety, health, and well-being (SHW). The ISSA global strategy is associated with a global VZ campaign, which (in 2021) is running in more than 80 countries, and where more than 11,000 organizations have associated themselves with the campaign and strategy.

VZ is not a target; it is a "Vision" and a process, a journey toward the ideal. VZ is something you do, not something you have. It is associated with ethical values, and it implies that work should help workers to maintain and improve their SHW, and develop their self-confidence, competences, and employability. Genuine commitment to VZ can initiate and sustain the process and social support necessary for the VZ process. Organizations, both large and small, can commit themselves to VZ independent of their performance in SHW.

A Vision is associated with a mindset, a mental image of what the future will or could be like. It requires attention to SHW in the design stage, in planning, procedures, and practices. The three aspects – "Safety, Health and Wellbeing" – are

Table 2 Vision Zero (VZ) for safety, health, and well-being – six innovative perspectives. (Elaborated on Zwetsloot et al. 2017a)

VZ theme	Traditional safety approach (accident prevention)	Zero accident vision (ZAV)	Zero harm for safety, health, and well-being (SHW)
Commitment strategy	Safety control strategy	Safety commitment strategy	SHW are a long-term commitment strategy
	Safety is a priority	Safety is a value	SHW are a value
	Safety (0 accidents) is an (unrealistic) goal	Safety is a process , a journey	SHW are a process , a journey
	Safety and health are in practice two distinct worlds	Safety and health are ethically and practically closely interconnected	SHW are ethically and practically closely interconnected
A way of doing business	Safety improvements stem from safety programs	Safety is an integrated part of doing business	SHW are an integrated part of doing business
	Safety is mainly a tactical and operational challenge	Safety is a strategic challenge	SHW are a strategic challenge
	Risk management	Safety leadership and business excellence	SHW leadership and business excellence
	Safety is perceived as a cost factor	Safety is perceived as an investment	SHW are perceived as long-term investments
	Safety is only relevant internally (and for the authorities)	Safety is also relevant for business partners and external stakeholders	SHW are also relevant for business partners and external stakeholders
Innovation	The workplace is more or less a static environment wherein safety management will lead to continuous improvement	The workplace is a dynamic environment wherein technological and social innovations are important for significant improvements in safety	The workplace is a dynamic environment wherein technological and social innovations are important for significant improvements in SHW
Prevention culture	Preventing accidents	Creating safety	Creating SHW at work
	Compliance – “We have to” (external motivation)	Participation – “We want to” (intrinsic motivation)	Participation – “We want to” (intrinsic motivation)
	Incidents are failures	Incidents are opportunities for learning	SHW events (incidents, cases) are opportunities for learning
	Safe behavior is desirable	Safe behavior is the norm	SHW promoting behavior is the norm
	Workers’ behavior (human error) is part of the problem	Workers are empowered to come up with solutions – they are part of the solution	Workers are empowered to come up with solutions – they are part of the solution

(continued)

Table 2 (continued)

VZ theme	Traditional safety approach (accident prevention)	Zero accident vision (ZAV)	Zero harm for safety, health, and well-being (SHW)
	Safety is designed or prescribed by experts	Safety is cocreated by experts and all members of the organization (having a questioning and learning approach)	SHW are cocreated by experts and all members of the organization (having a questioning and learning approach)
	Focus on management systems	Focus on culture and learning	Focus on culture and learning
	Safety culture is important	Safety culture and “ just ” culture are important	SHW promoting a “ just ” culture are important
	Focus on accident prevention	Focus on accident prevention and safety promotion	Focus on prevention and the promotion of SHW in work and life
Ethics and CSR	Safety management is always rational	Safety management is rational but also founded on ethics	SHW leadership is rational but also founded on ethics
	Safety is associated with prescriptions, paper work, and owned or placed upon only by a few leaders or workers	Safety is inspiring, “alive,” and “owned” by all members of the organization	SHW are inspiring, “alive,” and “owned” by all members of the organization
	Transactional leadership	Transformational leadership	Transformational leadership also paying attention to job demands and resources
	Safety policy implicitly based on values	Safety policy explicitly based on values	SHW policy explicitly based on values
Networking and cocreation	Safety improvement is triggered by internal processes (Plan, Do, Check, and Act)	Safety improvement is triggered also by learning from the experiences of others in and outside the organization	SHW improvement is triggered also by learning from the experiences of others in and outside the organization
	Benchmarking on lagging indicators (like injury rates)	Benchmarking on leading indicators and good practices	Benchmarking on leading indicators and good practices
	Safety improvement is triggered by best practices in the sector	Safety improvement is triggered by adopting and adapting good practices from other (ZAV) organizations and sectors	SHW improvements are triggered by adopting or adapting good practices from other (VZ) organizations and sectors

interacting and can strengthen each other – thus implying opportunities for synergy. As a result, the consequence of commitment to zero accidents is to create these synergies by simultaneously dealing seriously with health and well-being (Zwetsloot et al. 2017a). By focusing on not just safety, but also health and well-being, the VZ strategy builds on emerging initiatives in policies and practice to prevent, e.g., workplace stress, terror, violence, bullying, and harassment, as well as ergonomic issues such as heavy lifting and repetitive strain in the workplace.

The ISSA has developed a guide for organizations that want to implement or further develop VZ. The guide has been developed in close interaction with many organizations and practitioners and is structured around seven “Golden Rules” for VZ for SHW at work (ISSA 2017):

1. Take leadership – demonstrate commitment
2. Identify hazards – control risks
3. Define targets – develop programs
4. Ensure a safe and healthy system – be well organized
5. Ensure safety and health in machines, equipment, and workplaces
6. Improve qualifications – develop competence
7. Invest in people – motivate by participation

The guide for the 7 Golden Rules, which addresses employers and managers, can be downloaded from the ISSA website visionzero.global and is available in many languages, and there are also several sector-specific versions available. In addition, a “Seven Golden Rules ISSA” app can be downloaded (currently in English and Spanish), and it is also available via the website: www.sevengoldenrules.com.

Examples of the Implementation of Vision Zero in Workplaces

Although there are many organizations that have adopted VZ (Zero accidents, Zero harm, etc.), there are not yet many well-described case studies performed on the implementation of VZ. The two examples below illustrate some variety and potential.

Case 1 Implementation at the New Zealand Aluminium Smelter

Young (2014) described and analysed 25 years of experiences and interventions at the New Zealand Aluminium Smelters Limited (NZAS), which was named the safest aluminium smelter of its class in the world in 2007. A Zero Accident Vision was introduced in the company in 1990, using the slogan “Our Goal is Zero.” Young evaluated the activities and success factors of their sustained effort, one of which was the importance of recognizing innovations as opportunities for safety improvement. The most important success factors

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over the years were: (1) automation (thereby eliminating hazardous work); (2) transformational leadership (which enabled the application of resources toward goal-oriented interventions); (3) an ergonomic strategy focussing on the hierarchy of controls; and (4) a focus on environmental conditions, instead of trying to influence individual behaviour directly. There was an emphasis on eliminating hazards or risk scenarios and improving ergonomic system design, and as such, individual behaviour was generally regarded as less important.

Case 2 Implementation in a Large Steel and a Large Construction Company in the Netherlands

Twaalfhoven and Kortleven (2016) carried out empirical research in the largest steel company and the largest construction company in the Netherlands, both of whom were committed to zero accidents. In both companies, the attitude and behaviour of employees were seen as important for achieving zero accidents. In their research, Twaalfhoven and Kortleven focused on how the companies managed human errors and the use of sanctions. Both companies had a three-step approach for dealing with unsafe behaviour: Step 1, the behaviour of an employee is addressed by the supervising manager; he/she explains what behaviour is expected from the employee and why. When the undesirable behaviour persists, step 2 follows. The manager has to ensure that the employee fully understands what is expected and why and an official warning is given. If necessary, step 3 implies an intervention to ensure that the undesirable behaviour stops. The intervention may include additional training or allocating the employee to a different task. In the two organizations, employees were seen as individuals who intrinsically wanted to work safely. External factors were regarded as the prime causal factors of unsafe behaviour, which were regarded as the responsibility of management. They also found that sanctions were used more frequently toward employees from external contractors than toward their own personnel.

The ISSA's Proactive Leading Indicators for Vision Zero (Since 2020)

Many companies and organizations have been inspired by the ISSA VZ strategy, yet one of the challenges and traps that organizations fall into when implementing and evaluating the effects of VZ strategies is, as mentioned above, their sole reliance on measuring “reactive” (*after incidents have occurred*) and “lagging” indicators, such as accidents, fatalities, injuries, harm, sickness absence, and disease. So the question is: What else can they measure which will help them steer in the right direction, which can pinpoint areas for preventive and promotion action, and which can be used as “proactive” and “leading” indicators?

To support the ISSA VZ strategy and the seven Golden Rules, a set of 14 proactive leading indicators were developed in 2020 through an interactive and collaborative process involving researchers, organizations, and companies. There are two proactive leading indicators for each of the 7 Golden Rules as outlined in Table 3. There is also an ISSA Guide available for the use of the indicators, as well as a fact sheet for each of the indicators. The fact sheets comprise aims, key concepts, good practice, limitations, and options for measuring the indicator.

The guide provides three options for using the proactive leading indicators:

- Option 1: A Yes/No Checklist, focusing on the key activities for good processes in each facet of safety, health, and well-being.
- Option 2: A Frequency Estimation addresses the frequency with which key activities for good SHW processes are carried out in a systematic and consistent manner. The degree of systematic action and consistency can be estimated using, e.g., five broad semiquantitative categories: Always or almost always – Frequently – Occasionally – Rarely – Very rarely or never.
- Option 3: A Quantitative Measurement, wherein the key activities are quantitatively measured with either frequencies or percentages. The outcomes thereof can be used for benchmarking.

Vision Zero in Workplaces and Road Traffic

Workplace and road traffic safety are more closely related than is often realized. Roads are the workplace for: Truck, bus, and taxi drivers; emergency, health care, and law enforcement personnel; salespeople, mail, food, and package delivery; and road construction and service workers. Their health and well-being are central to strategies to ensure excellence in workplace and road traffic safety. In addition, for many people commuting to and from work is a daily routine, which is also relevant for both road and workplace safety. For a wide variety of professions and many people, workplace safety and road safety go hand in hand. Many jobs, professions, and workplaces are influenced by the VZ policy implementation in road traffic, from the construction and service of the roads, to commuting and transport of goods and people. It is estimated that up to one-third of all work-related fatalities occur in work-related motor vehicle crashes (EC 2020). VZ in workplaces is therefore relevant to all organizations that deal with traffic safety, most prominent with organizations involved in the construction and maintenance of road or rail infrastructure.

Workplace Vision Zero and Road Traffic Policies

Two of the fields where work-related fatalities and injuries occur most frequently are in the construction and use of roads. A recent study of roadway work zone fatalities in the USA revealed that 76% of fatalities involved “transportation events” (CDC 2020), such as when construction workers are struck by vehicles entering work

Table 3 Overview of the 14 proactive leading indicators for safety, health, and well-being at work (SHW) (ISSA 2020)

No.	ISSA Vision Zero Golden rule	No.	Proactive leading indicators	Aims
1	Take leadership – demonstrate commitment	1.1	Visible leadership commitment	Through visible leadership commitment and being exemplary role models, leaders demonstrate their commitment to SHW and actively promote and support SHW improvement processes and the development of a prevention culture
		1.2	Competent leadership	Committed and competent SHW leadership is essential to drive the development processes of VISION ZERO. Such leaders are intrinsically motivated to improve SHW and promote SHW as personal and organizational core values. Leaders then regard SHW as integrated parts of business processes, and support processes of continual improvement of SHW, while creating a strong prevention culture
2	Identify hazards – control risks	2.1	Evaluating risk management	Evaluation of the effectiveness of SHW risk management shows leadership focus and commitment to improving SHW and stimulates active participation and influence of workers. It allows leaders and workers to improve the effectiveness and sustainability of SHW promotion measures as an integrated part of business. In addition, it allows for organizational learning and continuous development
		2.2	Learning from unplanned events	Learning from unplanned events (incidents, events, and cases) is necessary to prevent similar undesirable events from reoccurring, and to create a culture of SHW prevention and learning. Adequate follow-up of reported unplanned events will increase reporting and learning
3	Define targets – develop programs	3.1	Workplace and job inductions	Integrating SHW in induction (onboarding) processes demonstrates that SHW are an integrated part of each job and each business process. SHW are an essential part of leaders and workers' new job in a workplace. It can be both a formal and informal way of welcoming new personnel to an organization, group, and/or job function and highlights SHW purpose, values, and goals

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Table 3 (continued)

No.	ISSA Vision Zero Golden rule	No.	Proactive leading indicators	Aims
		3.2	Evaluating targeted programs	Evaluating targeted programs (e.g., temporary campaigns) that integrate SHW in work processes helps to verify that they are implemented as intended, and that the improvement goals for SHW are met
4	Ensure a safe and healthy system be well organized	4.1	Prewrite briefings	Integrating SHW in prework briefings allows leaders and workers to identify context-specific hazards, risks, and prevention measures. This shows leadership focus and commitment to SHW, and a commitment to stimulating the active participation and influence of workers
		4.2	Planning and organization of work	Planning and organization of work are essential for the success of every organization and for ensuring SHW. This is because planning can make an organization competitive and efficient. Several issues need to be considered in effective planning and work organization in order to promote SHW. Good planning and work organization promote good morale and a healthy organizational culture
5	Ensure safety and health in machines, equipment, and workplaces	5.1	Innovation and change	Technological, organizational, and personnel changes occur frequently in organizations. Instead of assessing SHW risk after the changes, these changes should be considered proactively, and to utilize innovation to improve SHW right from the start in the design phase
		5.2	Procurement	The indicator aims to trigger the systematic use of procurement for SHW improvement. Procurement, particularly of hardware, can determine SHW risks for a long period, while procurement of services, such as maintenance, is often associated with increased SHW risks
6	Improve qualifications – develop competence	6.1	Initial training	Competence is key to ensuring good SHW. Being proactive requires training/qualifying leaders and workers in advance, before they start their job. It also shows that no job or task should be carried out without the relevant SHW competences, and that SHW are an integrated part of any job or profession

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Table 3 (continued)

No.	ISSA Vision Zero Golden rule	No.	Proactive leading indicators	Aims
		6.2	Refresher training	Developing SHW competence should be an aspect of continuous professional development. Refresher training ensures that leaders and workers' knowledge and skills on SHW remain up to date and include new SHW insights
7	Improve qualifications – develop competence	7.1	Suggestions for improvement	In the development of a prevention culture and the active involvement of workers, it is important that suggestions of workers for SHW improvements are welcomed and taken seriously. This will stimulate workers' active commitment to SHW and demonstrates their leaders' commitment to improving SHW
		7.2	Recognition and reward	Providing timely, proactive, and relevant recognition and reward for excellent SHW performance to both leaders and workers is essential for fostering a SHW culture that is based on trust, respect, participation, and cooperation

zones. Likewise, employees travelling the roads as part of their work or commuting also suffer fatalities, including crashing into roadway work zones. Designing, planning, training, and building safe work zones for construction workers are therefore crucial aspects of VZ strategies in this sector, focusing on proper work-zone layout, signage, high-visibility apparel, concrete barriers, speed-reducing measures, etc.

Companies have developed road traffic policies for their employees regarding their use of vehicles and the roads, which deal with a number of safety, health, and well-being issues that can be applied to a VZ strategy, including:

- Type of vehicle or mode of transport – truck, car, motorcycle, bicycle, scooter, etc.
- Vehicle exterior and interior design and configuration – mirrors and cameras, suspension seating (ergonomics), noise reduction, etc.
- Placement and securing of cargo – people, machines, tools, goods, etc.
- Planning tools – GPS-routing, global tracking of goods, etc.
- Behavior in traffic – speed limits, use of mobile phones, seat belts, helmets, alcohol, drugs, rest breaks, working hours, etc.
- Technical assistive devices – tail lift, forklift and crane for heavy lifting, etc.
- First-aid and fire training
- Vehicle inspection – check before each trip, etc.
- Vehicle maintenance – consistent with manufacturers' recommendations
- Incident reporting and investigation

- Travel management – weather, use of public transport, etc.
- Routine and nonroutine trips – knowledge of routes and locations, etc.

Case: Shell's Lifesaving Rules

More than 350 employees and contractors of Shell International were fatally injured worldwide in work-related incidents between 2000 and 2008. The company regarded the frequency of fatalities and serious accidents of people working for them (employees and contractors) as far too high. Shell analyzed the fatalities and serious accidents in their company (including accidents involving non-Shell employees working for them), and in response defined, introduced, and implemented 12 so-called Lifesaving Rules (Peuscher and Groeneweg 2012), which were in line with their safety strategy to pursue “Goal zero.” The Lifesaving Rules were not new rules but were selected as they target activities where failure to comply with the rules had a high potential for serious injury or death. The Lifesaving Rules have since 2008 been mandatory for everyone while on business or on Shell sites. Consciously breaking safety rules was already never acceptable, and in the case of Lifesaving Rules, the Shell philosophy is that it is totally unacceptable: Failure to comply with any Lifesaving Rule, or encouraging or tolerating rule-breaking, results in disciplinary action. Breaches in these situations mean that Shell applies the principle that: “If you choose to break these rules, you choose not to work for Shell.” All reported breaches are investigated thoroughly, fairly and on an individual basis in line with the established local policy and practice. Complying to the Lifesaving Rules is not only an individual responsibility, but it is also the responsibility of everyone to intervene in case someone else is breaking one of these rules. Four of the twelve Lifesaving Rules are explicitly aimed (fully or partly) at decreasing serious road accidents, e.g., involving trucks with Shell products (Table 4).

In the period 2008–2011, Shell's fatal incident rate dropped by 71%, while in other oil and gas companies the average decrease was 39%. In the same period, the Lost Time Injury rate at Shell dropped by 40%, while the average decrease in the sector was 21% (Peuscher & Groeneweg, 2012).

Pitfalls in the Implementation of Vision Zero in Workplaces

The research on the implementation of VZ in workplaces has also identified a number of pitfalls in the implementation process, one of more of which can seriously hinder successful implementation of VZ. The pitfalls do not imply serious challenges for the implementation, when the organizations fully understand VZ. However, when VZ is only used as a slogan, without real commitment to the long-term process, and without realizing that it should be based on genuine commitment of leaders and workers, implementation may fail to be successful (Table 5).

Table 4 Shell's Lifesaving rules that are also relevant for road safety

Lifesaving rule	Sign	Reason
While driving, do not use your phone and do not exceed speed limits		Speeding or using your phone while driving increases the risk of losing control of your vehicle
Wear your seat belt		A seatbelt protects you from injury in the event of an incident while driving and keeps you safe
Follow prescribed Journey Management Plan		A Journey Management Plan is a plan for you as a Driver that will help you to travel and arrive safely
No alcohol or drugs while working or driving		Using alcohol, illegal drugs, and misusing legal drugs or other substances will reduce your ability to do your job safely

Table 5 Pitfalls when considering Vision Zero in workplaces. (From Zwetsloot et al. 2017a)

Vision Zero used inappropriately	Vision Zero used appropriately
Applying Vision Zero as a target and making people accountable for realizing it (perhaps even strengthened by economic incentives)	It is a process that requires commitment from all leaders and workers in an organization
Focusing strongly on incident rates (and other lagging indicators)	Using leading indicators
Assuming that more safety rules, management systems, and behavioral control will help to go from good to excellent safety performance	Focus on leadership , being innovative, and promoting (collective and individual) learning
Assuming that one approach is able to improve different types of safety (e.g., process and personal safety)	Using a variety of approaches and adapting them where appropriate

Vision Zero Criticism and Response

VZ in workplaces is regularly criticized as being only based on simple slogans, leading to counterproductive results (Dekker et al. 2016; Dekker 2014; Long 2012). The main criticisms are that VZ: is unrealistic and naïve, denies the realities of risk, and is a fundamentalist ideology; in short, VZ is a dangerous idea (Long 2012), and VZ companies pursue safety through bureaucratic safety systems and bureaucratic accountability (Dekker 2014). According to the critics, VZ focuses on lagging indicators (such as injury rates) only, leading to underreporting of incidents, and is associated with trickery and fraud with

numbers. The critics also state that ZAV drives a safety culture characterized by skepticism, and cynicism. VZ would also drive a punitive mindset, while positive goals and targets are said to be much more effective than avoidance goals such as zero accidents (Long 2012).

The VZ criticism is more often based on anecdotal evidence than on empirical research. It does confirm the pitfalls in implementation. Rather than being fundamental criticism, the criticism mostly highlights failures in implementation and proceeds to generalize such cases to criticize VZ in general. It is also striking that the critics all stem from the safety area, and do not pay any attention to other members of the family of VZ, e.g., zero defects, zero downtime, etc.

Conclusion: Key Messages

1. Globally, more than 7,500 people die each day due to unsafe and unhealthy working conditions.
2. Vision Zero in organizations is applied to several areas, e.g., zero defects, zero downtime, and zero emissions, as well as on workplace strategies targeting worker safety, health, and well-being, and the prevention of workplace accidents and work-related diseases.
3. Vision Zero in workplaces has a long history. Its roots go back to the beginning of the nineteenth century when E.I. Dupont formulated the first industrial safety policy. It also builds on the Zero Defects approach for Total Quality Management developed in the 1960s.
4. The concept of Vision Zero in workplaces is closely related to the concept of creating a prevention culture.
5. For many professions, the road is an important workplace. Vision Zero for road traffic and workplaces are overlapping and can strengthen each other. This is most relevant for employees who use roads as part of their work, for commuters, and for the workers who build and maintain the roads.
6. The implementation of Vision Zero in workplaces should be regarded as a commitment strategy, as it is based on genuine commitment of top leaders as well as the personnel. It is associated with five other innovative perspectives: Safety, health, and well-being as way of doing business, using opportunities for innovation, the development of a prevention culture, as an ethical basis linked to corporate social responsibility, and networking.
7. It is important that Vision Zero in workplaces is understood as a vision and a long-term ambition, not as a target.
8. Proactive leading indicators, such as those reflecting ongoing processes for ensuring safety, health, and well-being, are more important for Vision Zero in workplaces than lagging indicators, such as accident frequencies.
9. Vision Zero in workplaces is relevant on many levels, from workplaces and organizations, to national and international policies.
10. In 2021, more than 80 countries and 11,000 organizations are participating in the ISSA's Vision Zero strategy and campaign.

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Anna-Lena Andersson and Kenneth Svensson

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Abstract

The Swedish Transport Administration (STA) work to reduce the number of suicides in the transport system. Fatalities, i.e., on roads, railways, and bridges, originate from either accidents or suicides, natural death excluded. Knowing the correct manner of death is needed to work with optimal prevention strategies. The aims are to separate fatalities due to suicides, follow the development, and implement measures for suicide prevention. Methods are developed for suicide classification and criteria for the selection in which suicides were suspected. Fatalities in level one and two of five were classified as suicides. Data from the STA's databases are used and so are data from the psychosocial investigations done by a trained investigator in the topic and with clinical experience from counselling at hospitals. 2129 persons died on the roads in Sweden, 10% (206 persons) were classified as suicides. 336 persons died after being hit by trains, 85% (284 persons) were suicides. 130 persons died by jumping from bridges.

The number of suicides increases with population density. Suicide in the transport system is a major problem; firstly personal tragedies, it is also a work environment problem for truck and train drivers and for the emergency staff. It generates delays and costs for passenger and cargo transport. By analyzing the results of countermeasures in the form of obstructive barriers, the physical environment can be improved and high-risk areas can be accentuated. Restricting access to the means of suicide is important in suicide prevention. Strategies for the STA include suicide prevention in the design of new roads, railways, and bridges, as well as by identifying and reducing existing high-risk locations. Sharing the results with other authorities and organizations and cooperation within suicide prevention missions are vital for the enhancement of the overall suicide prevention work in society.

Keywords

Suicides · Suicide classification · Transport-related · Transport system · Suicides on roads · Suicides on railways · Suicides on bridges · Jumping · Psychosocial examination · Countermeasures against suicides · Physical barriers · Suicide prevention · Multidisciplinary collaboration

Introduction

In September 2016, the Swedish government relaunched the Vision Zero initiative ([Renewed Commitment to Vision Zero](#)), which states that suicide in the transport system is a problem that also must be addressed within the traffic safety work. Preventive measures in order to reduce fatalities in road traffic, intentional or accidental, are in line with Vision Zero. The Swedish Transport Administration (STA) works actively to reduce the number of suicides in the transport system, i.e., in roads and railways, including suicide preventive measures on bridges.

Suicide is a major health problem and affects a large part of the population. In addition to the personal tragedies, suicide also affects professional working groups

and imposes costs on society. In Sweden, approximately 1200 persons per year die due to suicide by intentional self-harm and about 300 persons by undetermined intent ([The National Board of Health and Welfare](#)). Some suicide means can be more difficult to classify, if it has been with intention or if the person died unintentionally. Examples can be drowning oneself or drowning by accident, jumping from a high height or falling by accident, suicide by burning oneself to death or being burned to death by accident, and poisoning by purpose or unintentional overdose. Some people use the transport system to take their lives, and it can be hard to assess if the fatality was a suicide or an accident.

The Swedish Parliament decided in 1997 that Vision Zero should serve as the basis for traffic safety activities in Sweden. In 2010, the Swedish government decided that fatalities in road traffic due to suicides should be reported separately from fatalities due to accidents. Since then Sweden has been presenting statistics on suicides in road traffic separately from fatalities caused by accidents, using a specially developed method (Swedish Transport Administration [2017](#); Andersson and Sokolowski [2022](#)). Suicide accounts for a significant proportion (10%) of road traffic fatalities. Since the year 2015, the method was adjusted to classify the fatalities on railway, and a majority of them are due to suicidal actions (85–90%). It can be difficult to assess whether a fatality is due to suicide or accident. Reporting statistics about suicides is a complex task due the hidden cases. A method has been developed for classification of road traffic fatalities in order to determine if the fatality was caused by accident or suicide. This method has been adjusted for suicide classification for fatalities on railways.

Suicides in the Transport System

The Public Health Agency of Sweden is a national expert agency striving for better public health. In order to prevent suicide, broad collaboration is needed between the Swedish government and the Swedish Parliament, authorities, municipalities and county councils, universities and colleges, voluntary organizations, and organizations that support bereaved families (Public Health Agency of Sweden [2016](#)). The STA is one of the authorities that cooperate with the Agency. The national action program adopted by the Swedish Parliament in 2008 contains nine strategic areas of action to reduce the incidence of suicide. According to these nine actions, the Swedish Transport Administration works directly or indirectly with the strategies.

1. Promote good life opportunities for less privileged groups
2. Reduce alcohol consumption in the population and in groups at high risk for suicide
3. Reduce access to means and methods of suicide
4. View suicide as a psychological mistake
5. Improve medical, psychological, and psychosocial initiatives
6. Distribute knowledge about evidence-based methods for reducing suicide

7. Raise skill levels among staff and other key individuals in the care services
8. Perform “root cause” or event analyses after suicide
9. Support voluntary organizations

Promote Good Life Opportunities for Less Privileged Groups

Promoting good life opportunities by providing safe and secure traveling communications contributes to social sustainability.

Reduce Alcohol Consumption in the Population and in Groups at High Risk for Suicide

Demanding drivers not to be influenced of alcohol, e.g., by technical systems and behavioral impact, reinforces the second strategy. SMADIT (cooperation against alcohol and drugs in the traffic system) is a cooperation between different authorities with the aim to support persons who are reported for driving drunk or influenced of drugs (The Swedish Transport Administration 2012). The procedure is based on being able to offer help from the health care as quickly as possible, preferably within 24 h. The STA supports technical development for sober driving in vehicles and implementation of alcohol interlock devices. The STA also works on an information assignment to citizens, where sobriety is one of the areas, and cooperation with the police is another important area in the field.

Reduce Access to Means and Methods of Suicide

The third strategy is the action most often associated with the work of the STA. Restricting access to means of suicide is effective in preventing suicide, and suicide prevention measures on roads are beneficial for all road users. Collision at high speed against a solid object in the roadside area can be avoided by putting up guardrails or by removing the solid object. Rebuilding roads to the so-called 2+1 roads will reduce the number of fatal head-on collisions. Erecting fences or barriers along high-speed roads in urban areas will make it harder for pedestrians to carry on with a suicidal attempt and can prevent persons from being tempted to take a dangerous shortcut. Installing high fences on bridges and viaducts will increase the safety for all pedestrians and may prevent sabotage in the form of throwing down objects. The Swedish road and bridge design guidelines have been updated to make sure those suicide preventive measures are included in the design of new roads and bridges.

To reduce access to the railway system, different measures are to prevent people from intruding on the tracks at distances between stations on suicide- and accident-

prone routes. Measures such as barrier fences, intermediate fencing between tracks, anti-trespass panels, alarming cameras that monitor the track areas, and platform screen doors are examples of physical barriers. Other important actions are functioning communication between the STA and emergency services when someone is on or close to the tracks as well as designed environments, which promote safety and security.

View Suicide as a Psychological Mistake

Suicide can be seen as a psychological mistake or mental accident (Beskow 2008, 2010), where the deliberate self-destructive act can lead to death, as the individual experiences a situation that seems impossible to change. The “solution” to take one’s own life can be impulsive, and in those situations, protective barriers can prevent the act, by disturbing the impulse.

Improve Medical, Psychological, and Psychosocial Initiatives

On rare occasions, the STA can take the initiative to alarm the police, psychiatric care, and the municipality to report that a person is recurrently located in a risky place in the transport system. This action can be lifesaving as the psychiatric care and the responsible municipality can provide focused support to the person in an ongoing crisis.

Distribute Knowledge About Evidence-Based Methods for Reducing Suicide

Sharing the results from the suicide classification in the transport system to other authorities and organizations with suicide prevention missions is vital for enhancement of the overall suicide prevention work in society.

Raise Skill Levels Among Staff and Other Key Individuals in the Care Services

By analyzing the results from the systematic suicide classification, countermeasures in the form of obstructive barriers in the physical environment can be improved, and high-risk areas can be accentuated. The facts of the psychosocial contexts and patterns of transport-related suicides are important to share with other stakeholders. The exchange of information from the STA to responsible authorities is also a part of the total activity against suicides.

Perform “Root Cause” or Event Analyses After Suicide

Methods have been developed for suicide classification of fatalities on the roads (Swedish Transport Administration 2017; Andersson and Sokolowski 2022) and the railways. Criteria for the selection of fatalities in which suicides were suspected were compiled, and a classification scale with five levels was defined. Fatalities in level one and two were classified as suicides. Data from the STA’s databases (Trafikverket 2012) have been used together with data from psychosocial investigations performed by a trained investigator and with clinical expertise through counselling at hospitals. The suicide classification method will be described below.

Support Voluntary Organizations

Different research grants are given to nonprofit organizations with the aim, e.g., to reduce alcohol consumption in society and to work in the field of traffic safety, where reducing suicide is a part.

Suicide Classification Methodology and Psychosocial Factors

Not all fatalities in road traffic are accidents, some are suicides. Since 2010 Sweden has been presenting suicides in road traffic separately from fatalities caused by accidents. To undertake this, a method has been developed for the classification of road traffic fatalities (Swedish Transport Administration 2017; Andersson and Sokolowski 2022) based on whether the fatality was caused by accident or suicide. It can be difficult to assess whether a fatality is due to one or the other. Reporting statistics about suicides is a complex task and the choice of method can make a substantial difference. Data showing that the fatality was an accident are as relevant as data speaking for a suicidal act.

Vision Zero is the ethical standpoint that no one should be killed or suffer lifelong injury in road traffic. The Swedish Parliament decided in 1997 that Vision Zero should serve as the basis for traffic safety activities in Sweden. In 2008 the Swedish Parliament also stated in a new health policy that no person should end up in such situation that suicide is seen as the only way out. In connection with the introduction of Vision Zero, in-depth studies were carried out on all fatal accidents in road traffic in Sweden by investigators at the STA. The in-depth studies (Trafikverket 2012) are stored in a database at STA. In each case information on the vehicle, the road and event, and the road user are collected.

Already in 2001, a group of well-informed scientists wrote about the problem that statistics about road traffic fatalities contained at least three groups: “accidental” fatalities, suicides, and natural deaths. They also requested criteria for the classification of manner of death in “borderline” cases (Ahlm et al. 2001). According to Värnik et al. (2010), there is an underestimation of suicides, due to shortage of necessary information for determining the manner of death.

The work with the classification method has been carried out in cooperation between the STA, the Swedish Transport Agency, the National Board of Forensic Medicine, and Suicide Prevention Western Sweden. This method was developed to be used for road traffic, but with suitable modification, it can also be used for other modes of suicide. Since 2015 a revised method has been used to classify suicides on the Swedish railway system.

The study about suicide classification method (Andersson and Sokolowski 2022) has been approved by the Central Ethical Review Board in Gothenburg.

Criteria to Undergo the Classification Process

Criteria for selecting fatalities, which were to undergo the classification process because of a significant suspicion of suicide, were determined and are shown in Table 1. The criteria were influenced by a list developed by the European Rail Agency (ERA 2004) of factors that may indicate that a death is a deliberately act. That list is based on the so-called Ovenstone criteria (Ovenstone 1973). Criteria for cases that were to undergo the classification process in 2012 included the traffic event; the vehicle; together with a knowledge of psychosocial factors, such as prior suicide attempts; indirect suicidal communication and knowledge of ongoing depression, and so forth.

Classification Scale

A classification scale was developed and is shown in Table 2. The scale for assessing suicidal diagnosis by Lönnqvist (1977) influenced the assessment tool (Lönnqvist 1977). The classification harmonizes with the National Board of Forensic Medicine for assessment of the manner of death, but only a five-point scale is used, instead of a nine-point scale (Rättsmedicinalverket 2014).

Table 1 Criteria for selecting fatalities, which might be suicides and are to undergo the classification process

Criteria
1. Farewell message, oral or written, where intention is clearly communicated and where the traffic event supports a suicide
2. A traffic event that indicates a suicide in combination with knowledge of
a) Recent known suicide attempts
b) Recent indirect suicidal communication
c) Communication about committing suicide or having no reason to live
d) Ongoing prolonged depression or mental illness
e) Previous severe emotional or stressful life event
3. A traffic event that strongly indicates a suicide

Table 2 Classification scale for fatalities in the road traffic system

Grade	The result of the examination
1	Shows that manner of death was suicide Requires farewell letter or equivalent
2	Strongly supports that the manner of death was suicide Almost certain suicide, but the intention is judged primarily on the basis of evidence in the surroundings
3	Cannot determine whether the manner of death was suicide or the result of an accident The information is not sufficient to determine whether an event was a suicide or accident
4	Strongly supports that the manner of death was accidental Almost certainly an accident
5	Shows that the death was accidental way Surely accident

Data Collection and Psychosocial Examination

The investigators from STA and the police collected the primary data at the scene of the fatality. The investigator at STA gathered important documents such as the autopsy report, photos, information from the police, press clippings and details of the technical investigation of the car, and information about the road environment. The material was registered in the STA's database, the so-called in-depth client.

When the STA's investigators suspected that the fatality was due to a suicide, they reported this to the psychosocial investigator, who from the year 2012 conducted an expanded psychosocial data collection. The psychosocial investigator also attended the monthly review of the previous month's fatal accidents in road traffic to detect suspicious cases. Reports from the police, written and oral, information from relatives, and witnesses of the accident scene, as well as information from autopsy reports, were used. When possible, medical case records were collected as primary data. The psychosocial investigation was conducted by an investigator with education in behavioral and medical sciences and with experience from counselling at hospitals and trauma care. The psychosocial investigation (Andersson and Sokolowski 2022) is a working routine similar to, but not the same as, a "psychological autopsy" (Cavanagh et al. 2003). The most common reason to conduct a psychological autopsy is to determine the mental state of someone who is already deceased to determine the cause or nature of death, whether it be by natural causes, suicide, homicide, or an accident.

The review of the deceased was performed regarding data about socioeconomic background factors, as well as data about the life situation earlier and at the time of the traffic event. The review could include marital status, education, gainful employment and working situation, health, economy, residence, alcohol, and drug or medicine abuse.

Information such as suicide notes, previous suicide attempts, suicidal communication, recent suicide threats, long-term mental illness, use of psychopharmacologic

drugs, or neuropsychiatric diagnoses were noted. Other important information was triggering factors as separations or recently revealed “socially unacceptable behavior.”

Expert Group

An expert group of five experienced professionals with knowledge in forensic medicine, behavioral and medical science, counselling, and traffic safety classified the suspected suicides using the classification scale in Table 2. During the first years, complex cases were discussed in a special referee group. The expert group and referee persons contributed over time to more comparable assessments. The cases classified as suicides were reported to the Swedish government agency for transport policy analysis, Transport Analysis, which compiles and publishes the official statistics on road traffic injuries. In 2013 Transport Analysis approved the method with data from the STA’s database and the psychosocial investigations for delivery of the official Swedish statistics of suicides in road traffic.

Data on Suicides in Road Traffic 2010–2018

During 2010 and 2011, no psychosocial investigations were done, since these started in 2012. Results of the distribution of suicides and accidents in road traffic during 2010–2018 are shown in Table 3. The validation of the method is reported in a manuscript (Andersson and Sokolowski 2022) comparing results when the suicide classifications are conducted, without and with psychosocial investigations as a ground.

Data on Suicides on Railway 2010–2018

During 2015 and 2018, the suicide classifications were made using the adjusted method from road traffic for the fatalities on railway (Table 4).

Table 3 The official statistics for fatalities in road traffic, 2010–2018

Fatalities in road traffic	2010	2011	2012	2013	2014	2015	2016	2017	2018
Suicides	16	23	36	28	25	23	31	29	35
Accidents	266	319	286	260	270	259	270	253	324
Total	282	342	322	288	295	282	301	282	359
Percentages of suicides %	5,7	6,7	11,2	9,7	8,5	8,2	10,3	10,3	9,7

— Without psychosocial examinations, 2010-2011

— With psychosocial examinations, 2012-2018

Table 4 The official statistics for fatalities on railway, 2010–2018

Fatalities on railway	2010	2011	2012	2013	2014	2015	2016	2017	2018
Suicides	66	57	84	93	78	87	68	50	79
Accidents	45	25	15	18	25	16	13	14	9
Total	111	82	99	111	103	103	81	64	88
Percentages of suicides %	59	70	85	84	76	84	84	78	90

- Before the adjusted suicide classification started, 2010-2014
- After the adjusted suicide classification were used, 2015-2018

Data on Suicides by Jumping from Bridges 2010–2017

Earlier there has not been any collected or reliable data in Sweden about how many people take their own lives by jumping from bridges. In collaboration with the National Board of Forensic Medicine, data from 2010 to 2017 was collected (Riesenfeld 2020). In total 130 people died in this way during 2010–2017, distributed on 61 different bridges, whereof 8 bridges had 3 to 20 suicides, and the rest of them, 1 or 2 each. Physical barriers have been installed on some of the bridges during this time and positive effects have been noted. Analysis of the data has started and the effects of erecting fences will be studied. The most affected places are the bridges in or near urban areas with large populations. During the observation period, 2010–2017, no reduction in total was noted in Sweden, but the survey showed fewer suicides by jumping from bridges than expected. Riesenfeld (2020) points out that to make the data collection more effective, it is important to have high quality of documentation from different authorities and a simpler coding method for the certificate of cause of death. The National Board of Forensic Medicine and STA will further develop the suicide classification method.

How Do We Address the Problem of Suicides in the Transport System?

Suicides are a major health problem which affects a large part of the population. According to the World Health Organization (WHO), nearly one million people take their own lives in the world every year. Suicides in the transport system cause personal tragedies and loss for relatives and affect the working environment for truck and train drivers, as well as for operational and service personnel. Suicides cause delays of goods and passengers and impose costs for society.

Suicide is the result of complex interactions between genetic, individual, and social factors. The most effective way of approaching this complex topic is through interdisciplinary research (WHO Library Cataloguing in Publication Data 2010).

The same principle should be used when assessing the manners of death in the transport system. The combination of different competences in the classification group has been successful. The safety analysts take into account the road, bridge, or railway environment and the factors concerning the vehicles or trains. The forensic doctor interprets the autopsy report and contributes medical knowledge. The psychosocial investigator has competence in behavioral, psychological, and clinical sciences and from practice counselling patients, as well as next of kin to persons who died because of suicides. The ordinary road user data like gender, age, influence, etc. are not enough; it has to be complemented with additional complete psychosocial information.

Suicide Prevention in the Society

Suicide prevention provided by the health-care system should contain early diagnosis and customized treatment, which is individualized to the person suffering from mental illness. The level of knowledge in the government, municipalities, and authorities about suicides must be increased. Another important task is to restrict means and methods of suicide.

Strategies for the STA comprise suicide prevention in the design of new roads and by identifying and reducing existing high-risk locations. Key preventing strategies include building intrusion protection and middle separation as well as clearing the side region of the roads to protect people from taking their lives in road traffic.

Besides roads and bridges, people use the railway system for suicidal acts. To prevent suicides on the railways the systematic work with creating barriers between people and tracks is important. The number of suicides increases with population density. Building barrier fence, intermediate fencing between tracks, anti-trespass panels, alarming cameras that monitor the track areas, and platform screen doors is vital.

Designing an environment that promotes safety, which makes people feel secure, can reduce suicidal thoughts. Other important actions are functioning communication between the STA and emergency services. This is important in situations when someone is near or on the railway tracks and needs to be taken care of by the police or emergency units. The STA can order the train to stop or run at reduced speed, so that the rescue staff can manage to help the suicidal person. Rapid alert chains and cooperation between the STA and the emergency services also guarantee a safe working environment for the staff. Suicide prevention is a multidisciplinary commitment, and collaboration with emergency services and highlighting good examples of alert chains and cooperation are crucial.

Other measures that can be used against suicides in the transport system are analyzing the suicide events with a uniform method and discussing the psychosocial contexts and patterns with responsible authorities. Strategies against suicide should be developed continuously based on the best research knowledge available and the cooperation of all stakeholders in the community. According to the WHO, suicide

prevention programs should be multidimensional (WHO Library Cataloguing in Publication Data 2010).

Conclusions for the Future

There are several important pre-crash factors determining whether an injurious or fatal event occurs in the transport system (Andersson 2003). There are material factors, such as the condition of the road, vehicle status, the weather, etc., and there are psychosocial factors, such as mental illness, abuse, socioeconomic problems, etc. An accident or a suicide often depends on a combination of factors, the latter especially in case of a suicide. To improve prevention, knowledge regarding the importance of psychosocial factors is required and should be a part of the work.

Good-quality data are needed for the analysis of the incidence and patterns of suicides in the transport system. A uniform method of suicide classification for all modes of transport should be used. Nevertheless, the method must be adjusted to the different challenges and circumstances of roads, bridges, and railways. The systematic suicide classification methods and the analysis concerning suicides should be used in the prevention work in the transport system. They should also be used in collaboration with other organizations and authorities. The countermeasures against suicide should be intermodal for the systems of roads, bridges, and railways. Suicide-preventive measures are important variables in the design of new roads, railways, bridges, platforms, etc. Already existing exposed places and stretches can be located and remedied.

Many countermeasures against suicides require the same types of mind-sets regardless of means of suicides. By working with countermeasures and in collaboration with other responsible authorities to reduce the total incidence of suicides in the society, the transport-related suicides can decrease.

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Vision Zero in Suicide Prevention and Suicide Preventive Methods

37

Danuta Wasserman, I. Tadić, and C. Bec

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Abstract

According to the World Health Organization (WHO), suicide is a global public health issue, and countries need to be working toward a comprehensive and holistic response to prevent suicide and suicidal behaviors. Vision Zero for

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suicide is an aspiring goal that aims to lower suicide occurrence through a combined action of public health and healthcare sectors. Vision Zero for suicide has a multilevel and multidisciplinary approach that intends to provide a systemic change in society to facilitate and put suicide prevention on the agenda. This chapter explores the origins of Vision Zero for suicide by first presenting theoretical models that influenced suicidal behavior preventive programs. Then, Vision Zero for suicide goals, advantages, challenges, and examples of implementation in some countries will be presented. Further, evidence-based suicide prevention programs in existing public health and healthcare settings will be described as they support the Vision Zero aims. Vision Zero is an ambitious goal, but one that is worth aspiring to achieve, as the potential outcomes for suicide prevention implementation and research are very worthwhile.

Keywords

Vision Zero · Suicide · Suicide attempts · Suicidal behavior · Suicide prevention · Healthcare approach · Public health approach · Evidence-based · Multilevel interventions · Strategies · Mental health

Introduction

Suicide is a significant public health issue with over 800,000 people worldwide dying by suicide each year (WHO 2016). At least 20 times as many attempt suicide. These figures have increased globally in the last decade by 4% (Brodsky et al. 2018). Suicide impacts every age group. Despite various national suicide prevention strategies which have been established to address this problem in countries around the world, suicide is the third leading cause of death globally in adolescents aged 15–19 years after road injuries and interpersonal violence (WHO 2018). A 10-year systematic review compiling almost 1,800 studies (Zalsman et al. 2016) highlighted that increasing and coordinating the application of evidence-based suicide prevention strategies is crucial. Zalsman et al. (2016) also emphasized the importance of implementing suicide prevention programs both across public health and mental healthcare systems. Vision Zero for suicide with a multilevel and multidisciplinary approach to drive evidence-based suicide prevention has been introduced in some countries. Suicide prevention relies on suicidal behavior research to implement the most accurate evidence-based programs. Knowledge about suicidal behavior, risk, and protective factors is paramount to ensure good practice in implementation. Therefore first, we provide an overview of models for suicide prevention; second, we present Vision Zero; third, we offer reflections on the advantages and challenges in the implementation process in some countries; and last, we describe public health and healthcare prevention programs which are recommended to be used in obtaining Vision Zero for suicide.

Models for Suicide Prevention

Suicide prevention strategies have been continually studied and developed over time. Understanding the complexity of suicidal behaviors and their multifactorial dimension is important when establishing effective suicide prevention strategies. Various theories – or models – explain the suicidal process and which factors lead an individual to develop suicidal behavior (Sisask and Kølves 2018). Models and understanding their evolution, as well as theoretical influences, are crucial, when designing suicide prevention programs (Cramer and Kapusta 2017).

Below is a summary of important models which have influenced and continue to influence suicide prevention programs today.

Sociological Theory

Emile Durkheim, in his sociological investigation of suicide, stated that suicide is the result of society's strength or weakness of control over the individual (Durkheim 1897). Suicide is thought to be a result of an interaction between low and high levels of social regulation and moral integration. Social integration describes bonds with other members in society, while moral regulations are the adherence to existing norms in society. According to his theory, suicide occurs “when the level of social integration is too high (leading to altruistic suicide) or too low (leading to egoistic suicide) and when the level of social regulation is too high (leading to fatalistic suicide) or too low (leading to anomic suicide)” (Lester 1999). This contributed to the understanding of societal and community influences on suicidality. But the theory failed to consider individual variations in suicidal behavior (Mäkinen 2009).

Hopelessness Theory

The hopelessness theory by Beck highlights the notion of hopelessness as a psychological factor that has a central role in suicide (Beck et al. 1985). Hopelessness is defined as the fatalistic expectation of an individual. Nothing the individual wants or wishes for will happen, and there is nothing one can do to change it. Since the development of the model, research has shown that hopelessness is an important predictor of future suicidal behavior (Wolfe et al. 2019). However, this theory does not account for other factors contributing to suicidal behavior (Aish and Wasserman 2001).

Psychache Theory

Schneidman defined psychache as intense psychological pain. He emphasized that psychache is a necessary condition for suicide to occur and that this pain can overpower any other protective factor (Schneidman 1998). Schneidman further asserts that the only solution to stop the psychache is suicide.

Escape Theory of Suicide

The escape theory of suicide highlights the role of failure, disappointment, and setback (Baumeister 1990). Suicide is thus viewed as an escape from existential problems. Feelings of failure are a necessary but insufficient condition to attempt suicide. In addition to feelings of failure, the six-step process when considering suicide includes escape motivation, self-blame, depression, cognitive deconstruction, and disinhibition (Tang et al. 2013).

Emotional Dysregulation Theory

According to Linehan, emotional dysregulation is a process relating to the incapacity to adjust to and manage emotions. Emotion dysregulation is a risk factor predictive of suicidal behavior (Ammerman et al. 2015). This model was originally geared toward borderline personality disorder and was used to develop dialectical behavioral therapy (Hogan and Grumet 2016). There is strong evidence supporting this model.

Stress-Diathesis Model

This model takes into consideration that suicidal behavior is influenced by both individual biological/psychological predisposition (diathesis) as well as the surrounding environment (environmental stressors) (Mann 2003; Wasserman 2001). Although suicidal behavior is heterogeneous and varies between individuals, this model provides an explanation as to why some commit suicide and why others do not. The causes of suicidal behavior are complex with many interacting contributing factors (Sokolowski et al. 2015). Many factors can lead toward a predisposition for suicide diathesis such as genetic makeup, exposure to psychological stress, and adverse environmental conditions, especially in the developmental stages of childhood and adolescence (Mann 2003; Wasserman 2001). There are strong associations between suicide and inequity, social exclusion and socioeconomic deprivation which are all causes of stress.

Interpersonal-Psychological Theory of Suicide

This theory considers suicide to be the interaction between two states: (a) *Thwarted belongingness* is feeling that one does not have connections with others; (b) *perceived burdensomeness* is feeling that one is a burden for those around them. *Acquired capability* described as diminished fear of pain and death due to repetitive experiences with painful and fear-evoking life events leads individuals to getting used to self-harm, suicidal behavior as response to risk (Ribeiro and Joiner 2009). The strength of this theory is that, contrary to previous theories, it differentiates between suicidal ideation and suicidal behavior (Van Orden et al. 2010). The interpersonal-psychological theory of suicidal behavior still has some unanswered gaps, such as the threshold for acquired

capacity to lead to suicide attempts and death by suicide. However, evidence-based research shows the potential of this theory, for understanding pathways to suicide from risks for suicidal behavior (Barzilay et al. 2015).

World Health Organization (WHO) Socioecological Model

The WHO report *Preventing suicide: A global imperative* (2014) offered evidence-based recommendations and actionable steps to improve suicide prevention, as well as to support countries within public health strategies. The WHO used a socioecological model, built on risk and protective factors identification of socioecological contexts, to help build resilient suicide prevention.

This theory assumes that the cause of suicidality is multifactorial, and that the accumulation of risk factors increases suicide as a potential outcome. Risk factors are grouped into the following categories: systemic (society and health system), community, relationship, and individual. Suicide prevention needs to address these risk factors while strengthening protective factors through effective suicide prevention programs.

The aforementioned models highlight that suicidal behaviors are multifactorial; thus, to reduce them, there is a need for a joint effort from public health and healthcare strategies which are described later in this chapter. Vision Zero for suicide is influenced by the theoretical models and uses multidisciplinary and multileveled approaches to combat suicidal behaviors.

Vision Zero for Suicide

Definition of Vision Zero for Suicide

Vision Zero for suicide is an approach emerging in the last two decades that aspires to bring suicide prevalence as close as possible to zero. It assumes that no one should end up in a situation where suicide is the only option. Considering that suicidal behaviors, as previously explained, stem from biological but also social, environmental, and cultural factors, Vision Zero initiatives look to bring resources together in a multiphased plan that uses evidence-based knowledge to cause a system change (Kristianssen et al. 2018). Vision Zero can be implemented through policies on nation-, region-, or organization-based levels. Vision Zero is more than an approach guiding suicide prevention initiatives; it is an aspirational goal bringing healthcare and public health sectors together to decrease suicide rates.

When countries or regions implement Vision Zero policies, initiatives need to first involve programs not only at the public health level (policy-makers, politicians, research centers, and advocacy groups) but also at the community level (community-based organizations, NGOs, and minorities advocates), and then at the healthcare level. Developing a Vision Zero approach thus needs a multidisciplinary effort from fields such as political, policy, economics, public health, psychiatry, psychology, sociology, anthropology, education, and religion. Even when Vision Zero is implemented in

smaller settings, such as in a hospital, the different departments need to work together to organize procedures and communication that involve all staff members.

Advantages and Challenges of Vision Zero for Suicide

Advantages of Vision Zero for Suicide

Vision Zero provides a general goal to focus and gather resources (funding, research, monitoring, and evaluation). Implementing Vision Zero as a suicide prevention approach, rather than a mental health policy in general, provides a platform to allocate more funding focused primarily on suicide prevention. Similarly, this gives incentives as well as financial means and frameworks to organizations to commit to strategies and goals for suicide prevention and to pool resources to tackle suicide. Thus responsibility for suicide prevention will be shared with multidisciplinary approaches that have proven to be successful in many instances (Brooks et al. 2019; Kim et al. 2019).

Vision Zero also aims to decrease stigma about suicide by putting into practice a systemic approach and improved communication around suicide. Vision Zero strategies have been described as shifting the focus of policies from suicidal individuals and those bereaved by suicide to combating social determinants of suicide and improving protective factors (Swedish Legislation of 2007 translated by Kristianssen et al. 2018). This shift puts a stop to the blaming of suicidal individuals, their families, and medical practitioners to build a general understanding that suicide is due to the entire failure of the system. Tackling stigma is additionally linked to improved communication. Communication increases understanding of suicide, mental health disorders as well as bringing into light the work of public health and healthcare services to combat suicide. An additional perk of raising awareness with safe and positive messaging is that it promotes and increases help-seeking behaviors (Sisask and K lves 2018).

Vision Zero for suicide contributes to a broader understanding of suicidal behaviors and preventive measures, by giving more resources and opportunities (due to the increased number of programs) to accumulate evidence-based information. This has enabled researchers to better understand not only the course of mental disorders, the impact of risk factors, but also which protective factors work best to prevent suicides from happening. Initial organizations and healthcare systems that have started a Vision Zero initiative, such as the Henry Ford Health System in the United States, have inspired further programs. Similarly, the *Lex Maria* legislation in Sweden recommends investigations of all suicides that occur in relation to healthcare practices to learn from medical errors.

Challenges of Vision Zero for Suicide

The main challenge to Vision Zero for suicide is that this approach is interpreted differently and at different scales depending on the countries (this is further illustrated in section Vision Zero in the world). This has led to some criticisms which are addressed below.

For example, Karlsson et al. (2018) interviewed Swedish psychiatrists to identify their arguments for and against Vision Zero. They found that most participants,

although being able to list some advantages, considered Vision Zero to be unachievable and leading to incentive-oriented practices toward patients with mental disorders and could lead to increased involuntary admissions. Similar arguments highlighted that this approach would take the focus away from learning to live with mental disorders to only preventing death by all means.

First, the findings of the Swedish study might be an artifact of the researcher's methodology which allowed respondents to themselves define Vision Zero for suicide rather than using the official parliamentary document describing the different strategies that should be implemented. Second, in Sweden, a study by Roos af Hjelmsäter et al. (2019) describing the results of healthcare provider examination after suicides evaluated that the state of healthcare, the treatment given to patients, and suicide risk assessments were deficient. These deficiencies occur at the organizational microlevel, and the authors called for sustainable improvement of healthcare (Roos Af Hjelmsäter et al. 2019). This is exactly what Vision Zero aims for. The goal of Vision Zero is to implement system responsibilities and healthcare practice improvements that would provide resources for public health and healthcare programs to tackle suicidal behavior and stigma. Thus, Vision Zero initiatives raise awareness of the magnitude of mental disorders in society and call for providing financial resources to tackle suicide.

Funding for an initiative of this capacity can be considered as a challenge. In national health policy, practice change in addition to training is costly at every scale, from a public health policy scale to a hospital department scale. Taking the Henry Ford Health System as an example, data showed that even though initial loans were required at the beginning of the initiative, the impact of Vision Zero reduced the cost from the burden of suicide in recent years (Hampton et al. 2010; Coffey 2015).

There has also been a debate on whether aiming for zero suicide would hinder ongoing discussion about euthanasia and physician-assisted suicide (Holm and Sahlin 2009). The authors consider that having a goal of zero suicide would make it difficult to enable euthanasia (2009). Although others would argue that physician-assisted suicide and suicide decided independently by an individual are different and thus should not impact the target number of Vision Zero policies.

In summary, Vision Zero for suicide drives suicide prevention policies through a multidisciplinary approach by directing awareness, training, and resources toward a concrete goal of having zero suicide. It teaches and empowers individuals in all of society – not just suicide survivors, victims, and medical practitioners – as well as removing guilt and responsibility by proving that suicide prevention needs the support of the entire system to be effective (Mokkenstorm et al. 2018a). Vision Zero is also a support and provider of evidence-based research which improve suicide prevention programs.

Vision Zero in the World

Vision Zero for suicide approaches has been implemented at different scales, i.e., national, regional, and organizational levels. Initiatives share common approaches, such as using evidence-based information to raise awareness, support and guide

individuals, families, medical workers, and in some cases public health practitioners. Approaches are systematic and aimed at improving suicide prevention at multiple levels and often through a healthcare approach.

Vision Zero in Sweden

Sweden has a national countrywide approach to Vision Zero. In 2008, the Swedish Parliament launched the *National Action Programme for Suicide Prevention* which presented Vision Zero for suicide approach. Many of the documents were inspired from Vision Zero for road traffic that Sweden successfully implemented by aiming to reduce the road toll to zero (Kristianssen et al. 2018). Vision Zero aims to implement a systematic approach based on preventive measures with the aim that no one should be in a situation where suicide is the only solution (Karlsson et al. 2018; Kristianssen et al. 2018). Vision Zero targets individuals using healthcare services, and also the wider populations to encourage stakeholders to create supportive environments.

The plan is based on nine main areas of action (Folkhalsomyndigheten 2016):

- Promote good life opportunities for less privileged groups.
- Reduce alcohol consumption in the population and in groups at high risk for suicide.
- Reduce access to means and methods of suicide.
- View suicide as a psychological mistake.
- Improve medical, psychological, and psychosocial initiatives.
- Distribute knowledge about evidence-based methods for reducing suicide.
- Raise skill levels among staff and other key individuals in the care services.
- Perform “root cause” or event analyses after suicide.
- Support voluntary organizations.

As mentioned previously, Sweden has a legislation entitled the *Lex Maria* about the healthcare system’s responsibility to investigate incidents to improve patient safety (Karlsson et al. 2018). Vision Zero emphasized (2008) the current usage of this legislation and recommended that if a suicide occurs due to a medical error in the healthcare setting, the case should be evaluated under the *Lex Maria* legislation. This would then allow these suicides happening in healthcare setting and during outpatient procedures to be further studied for future prevention (Hadlaczký et al. 2012). However, *Lex Maria* application to suicides happening within a short time after a healthcare contact was mandatory until 2017 and is presently only implemented based solely on the healthcare provider’s decision.

Vision Zero in the United States

Several Vision Zero initiatives are implemented in healthcare systems in the United States. In 2000, the first United States national suicide strategy was launched, and in 2010, the National Action Alliance for Suicide Prevention was created. National Action Alliance for Suicide Prevention (NAASP), a public-private partnership, identified healthcare systems as paramount for suicide prevention and launched several task forces focusing on a comprehensive system approach to detect and

manage suicide in the healthcare setting (Labouliere et al. 2018). To reach the aspirational Vision Zero goal, the National Institute of Mental Health and NAASP committed to reduce suicide by 20%, a first step in the joint effort to prioritize research and resources to lower suicide in the United States (Gordon et al. 2020). The implementation of Zero Suicide practices is recommended by both national governmental offices such as the United States Office of the Surgeon General (2012), and countrywide nonprofit organizations such as the Joint Commission, a United States healthcare accreditation program (2016). Initial data from studying Zero Suicide initiatives in the United States show that these initiatives are effective and should be replicated more widely (Hogan and Grumet 2016; Brodsky et al. 2018).

One example of large-scale prevention program under Zero Suicide in the United States is the Perfect Depression Care program at the Department of Psychiatry at the Henry Ford Health System, launched in 2002 in Detroit, Michigan (Hogan and Grumet 2016). The program focused on evidence-based approaches to improve healthcare chain of care: effectiveness, safety, patient-centered, timeliness, efficiency, and equity among patients (Hampton 2010). One of the key approaches to minimize suicide has been to increase screening of patients that enter the healthcare system for suicide (Coffey 2015). Another component is to tackle concerns from primary care physicians when it came to treating suicide, such as providing guidelines on how to deal with potentially suicidal patients and direct access to knowledgeable psychiatrists (Coffey 2015). The system has been deemed a huge success, with a 75% reduction in suicide rates in the first 4 years of implementation, and has been sustained each year since 2001 (Hampton 2010; Covington and Hogan 2019).

Vision Zero in the United Kingdom

The United Kingdom has also embraced the Vision Zero approach for healthcare practice. The United Kingdom government launched across the National Health Service (NHS) a zero-suicide ambition in January 2018 targeting mental health patients in care and aiming to expand to all mental health patients (Department of Health 2019). This led to two international conferences on zero-suicide where some of the programs launched by the NHS were presented (Henden 2017).

The Mersey Care NHS Foundation Trust, for example, aims toward zero suicides inspired by the Henry Ford Hospital system in the United States. The core strategy lies in quality improvement, universal staff training, and support for victims of suicide. Mersey Care established several public campaigns to tackle stigma and funded digital innovations to improve health outcomes. The program is also being scientifically evaluated, and future results will direct both subsequent improvements of the system and adaptations of their approach to other systems (IIMHL 2016). Additionally, the NHS trust launched the Zero Suicide Alliance which is supported by and partnered with many organizations. The alliance plans to both raise awareness and promote accessible training in suicide prevention. According to them, if the general public learns to identify signs of suicidal behavior and how to direct the individual to services and care, then everyone can be empowered to help prevent suicide (Zero Suicide Alliance 2020).

Vision Zero in Other Countries

In several countries, most of the Vision Zero projects target healthcare settings and follow the example of implementation of the United States framework titled Zero Suicide. In the Netherlands, mental healthcare institutions were targeted by the Dutch National Prevention Strategy to investigate and assess the practice and variation of suicide prevention strategies. The study highlighted that several institutions gathered together under the name SUPRANET Care and publicly announced pursuing a Zero Suicide aim (Mokkenstorm et al. 2018b). Additionally, the New South Wales (NSW) state in Australia launched an initiative called Zero Suicides In Care to create a blame-free working environment in addition to several other initiatives such as postvention service for people bereaved by suicide, resilience building in local communities, or gatekeeper training (NSW Ministry of Health 2019). This NSW program combines both public health and healthcare initiatives which demonstrate that the objective of Vision Zero for suicide needs a consensus of actors to be reached.

Toward a Vision Zero for Suicide Label?

The above-mentioned examples on Vision Zero for suicide initiatives show that most of the existing implementations of Vision Zero revolve around healthcare prevention in hospital settings. This can be explained by the influential Zero Suicide organization and its framework used worldwide (in the United Kingdom, Netherlands, Australia, and more) after proving successful in the United States. This even led to the international declaration for better healthcare signed by Australia, Canada, China, Denmark, French Polynesia, Hong Kong, Japan, Malaysia, the Netherlands, New Zealand, Taiwan, the United Kingdom, and the United States (IIMHL 2016). This declaration provides a strong action plan implementable in any organization wanting to reach zero suicide in healthcare. Healthcare-setting improvements are a crucial interpretation of the systemic approach to improve suicide care in the medical system. However, the general aim of Vision Zero for suicide calls for more implementation in the public health system.

There are many suicide prevention programs, presented in the next section, built on evidence-based approaches that reduce suicide in societies worldwide. These interventions involve multidisciplinary actors and not only target at-risk groups but also target society as a whole, in addition to often being implemented at different levels (Zalsman et al. 2016). This resonates with the Vision Zero aim described earlier, but they are not labeled as such.

An example of what can be called international aspirational label is the Sustainable Development Goals (SDGs), a high-level concept to enable coordination between governments and international organizations and place emphasis on partnerships in implementation (Nilsson et al. 2018). Although criticized about their indicators, top-down approach, and feasibility, the SDGs, once adapted locally and taken as a general guideline for development institutions to create policies and attribute funding to local initiative, are impactful. Judging by the number of projects and papers

published in relation to the SDGs, the use of the SDGs as a label stamped on papers, funding proposals, media communication, and policies improves society's awareness and increases communication about a much-needed field of intervention.

Like the SDGs, Vision Zero for suicide could be an overarching label by which programs and organizations can identify themselves with the aspirational goal of zero suicide, even though their strategies and scales of operation may differ. This would improve the visibility of such projects, would create a strong link between international programs, and would create a research consensus among multi-disciplinary actors, as well as provide a clear funding platform to catalyze efforts from governments and funding bodies.

What Does the Evidence Say about Suicide Prevention

Evidence-based suicide prevention programs are often organized around the conceptual framework called the Universal, Selective, and Indicated model (USI) (Wasserman and Durkee 2009). This framework is used internationally, especially by the WHO for its suicide prevention activities (Cerulli et al. 2019; World Health Organization 2014; Wasserman 2019).

These three strategies are aimed at target populations. Universal prevention is aimed at general population. Examples of strategies could be increasing access to mental health care, restricting access to means of suicide, or encouraging responsible reporting of suicidal behaviors. Selective prevention is aimed at groups who have an above-average risk to develop disease or risk behavior (for example, immigrants, substance users, or children coming from at-risk families). A selective strategy would focus on community support and strengthening protective factors, such as building strong personal relationships or teaching positive coping strategies. Indicated prevention is directed at persons who have already experienced symptoms of a disorder. These strategies target specific risk groups, such as individuals with mental health disorders and substance use, individuals who are bereaved by suicide, or individuals who have experienced some form of trauma or use.

Suicide prevention requires a multiphased and multilevel approach, drawing strategies from both the healthcare and public health perspectives (Hegerl et al. 2009; Zalsman et al. 2016). Preventive intervention strategies can be implemented according to the healthcare approach and the public health approach which are complementary of each other (Wahlbeck et al. 2017; Wasserman and Durkee 2009; Wasserman 2019; Zalsman et al. 2016, 2017). The public health perspective focuses on population-based initiatives and aims to decrease risk factors and strengthen protective factors (Wasserman and Durkee 2009). The healthcare perspective targets patients, relatives, and healthcare professionals, as well as different healthcare settings and fields. A comprehensive overview of all evidence-based strategies is published in *Suicide: an Unnecessary Death* (Wasserman 2016) and *Oxford Textbook of Suicidology and Suicide Prevention: a Global Perspective* (Wasserman 2009, 2020) presently updated. A summary of the evidence-based strategies is presented below.

Public Health Approaches

Public health prevention strategies target the general public and draw resources from governmental bodies as well as nongovernmental organizations. These strategies with strong scientific evidence include increase in public awareness, restriction of access to lethal means, and school-based universal prevention. Strategies that need more research are gatekeeper training, media guidelines, internet-based interventions, helplines, and indigenous preventive programs.

Increase Public Awareness

Public information campaigns are aimed at the whole population to promote health and prevent suicide. Public information campaigns disseminate knowledge about mental health, about the treatable aspects of suicidal behavior and depression, and about the importance of communication about these issues. Information campaigns also provide crucial information on helpline numbers and who to contact. Many Vision Zero for suicide initiatives described earlier, such as the NSW one in Australia, have programs including the raising awareness approach. The NSW Australian initiative aims to build resilience to support the suicide prevention of local communities including people with lived experience, health organization, and others to raise awareness (NSW Ministry of Health 2019). Awareness campaigns can be shared through several media platforms such as television, newspapers, radio, YouTube, advertising posters, social media, brochures, websites, etc., in order to increase public awareness (Barker et al. 2017; Kreuze et al. 2017; Zalsman et al. 2016). Campaigns that were part of a larger multicomponent approach, with other public health interventions, produced better and more lasting results than campaigns implemented without complementary interventions.

Restrictive Access to Lethal Means

Limiting the availability of means by which a person can commit suicide is supported by strong evidence in many studies in suicide prevention. A means restriction is a preventive approach adapted to different lethal means and several environmental and cultural contexts. The restricting access to lethal means' methods that have the strongest evidence of efficacy is: limiting access to medication, restricting firearms, and limiting pesticide access; barriers implementation; and control of carbon and gas, preventing hanging, and alcohol restriction (Värnik et al. 2007; Barker et al. 2017; Das et al. 2016; Dodd et al. 2016; Gunnell et al. 2017; Pirkis et al. 2015; Riblet et al. 2017).

The theoretical standpoint for this approach is that the longer it takes and the more difficult it is for a person to access means to commit suicide, the more time there is for the person to be interrupted by others or to change their mind (Zalsman et al. 2016). For the same reason, these restrictions have a greater chance of decreasing the mortality rate in impulsive suicide attempts compared to the planned ones.

Medication

Self-poisoning via medication is often a lethal mean of suicide (Ho et al. 2016; Sinyor et al. 2019). Restricting access to medication (analgesics, barbiturates,

opiates, and caffeine tablets) is linked to a reduction in the number of deaths by suicide. Methods for restricting access to medication include restricting and monitoring prescriptions, prescribing alternative medication, taking precautions against forgery, recalling unused drugs, and creating blister packs (reducing the size of the packaging of drugs) (Zalsman et al. 2016; Hawton et al. 2018).

Firearms

Firearms are a fatal mean of suicide in countries where they are easily accessible. Restrictions of domestic firearm availability with control legislation have mostly positive results. Regulations of firearms have also resulted in a decrease of suicide by firearms in Norway, Switzerland, Israel, New Zealand, and Australia (Zalsman et al. 2016).

Pesticides

In low-income and middle-income countries, pesticides are a common means of suicide (Eddleston and Gunnell 2020). Therefore, governmental actions aim to remove dangerous pesticides from agriculture practice (WHO 2019). Measures to restrict pesticides include reducing their toxicity, controlling sales of pesticides, raising awareness toward safe management and storage practices, and improving healthcare practices of pesticide overdoses (Mann et al. 2005). Such policies to control toxic pesticides have shown to be successful in suicide reductions in Sri Lanka, India, and Western Samoa (Gunnell et al. 2017; Zalsman et al. 2016).

Barriers

Suicide by jumping plays an important role in urban societies (Hemmer et al. 2017). Barriers to jumping sites, as well as railways and subways, have strong evidence in reducing suicides (Zalsman et al. 2016). For bridges, installing high altitude barriers or safety nets has proven effective, with little evidence of substitution to other jumping sites (Perron et al. 2013). For subways, restricting access to railways, installing platform doors, creating “suicide pits” (areas with suspended rails resulting in trains passing above a person fallen on the rails without risk of hurting them), and increasing surveillance systems can prevent suicide (Ratnayake et al. 2007).

Control of Carbon Monoxide: Charcoal and Gas

Detoxification of domestic gas and restricting the purchase of charcoal are effective in preventing suicide (Zalsman et al. 2016). Suicide by poisoning from car exhausts decreased due to the push for cleaner air, leading to the introduction of catalytic converters and suicide with domestic gas decreased due to its detoxification (Mann et al. 2005). Charcoal burning has been a suicide method especially carried out in Asia (Wong et al. 2009; Yip et al. 2010). Limited access to charcoal for the general population was highlighted as an effective way of preventing charcoal-burning suicide (Yip et al. 2010).

Hangings

Only a small amount of evidence exists regarding prevention of hangings (Zalsman et al. 2016). Controlled environments and institutions, such as psychiatric hospitals and prisons, can enforce the implementation of hanging prevention because of the supervision occurring there. Proposed implementations are safe clothing that cannot be used as means of suicide, windows adjustment, and installation of antisuicide shower heads (Reisch et al. 2019).

Alcohol

Alcohol generally increases impulsiveness and aggression which can lead to premature or rash decisions in a crisis. In addition, alcohol use is particularly common in many cases of suicide among men (Gvion and Apter 2011). Drinking habits are embedded in the culture as well in society. In some societies where alcohol consumption is not culturally acceptable, restrictions may not have the same effects as in countries where alcohol consumption is pervasive. Some examples of legislations and policies aimed at reducing alcohol consumption of the population are increased taxes, ban on alcohol imports, decreased availability of alcohol through alcohol license sale restrictions, and zero-tolerance when driving (Xuan et al. 2016).

Several examples of significant decrease of suicide rates due to alcohol reduction include the prohibition in the United States in 1910–1920 (Wasserman I 1992), price increases in Denmark in 1911–1924, and restriction of sales in Sweden starting in the first part of the twentieth century (Norström 1988). However, one of the best-studied examples of alcohol restriction on suicide rates can be found during 1984–1990 in the former Union of Soviet Socialist Republics (USSR), during the time of the *perestroika* (Wasserman et al. 1994).

Perestroika was a period of major political change, which developed into a time of increased freedom. Policies limiting the sale of alcohol were administered, which resulted in an attitude that also encouraged the restrictive consumption of alcohol in the population. It was also around this time that the USSR national archives were opened, making them available for research to study topics such as societal factors that may affect suicide rates (Wasserman and Värnik 1998). Studies of the archives showed differences of suicide within the country. The Slavic (25.6 per 100,000) and Baltic (28) region had higher suicide numbers than the Caucasian states (3.5); this is understood to be due to the cultural differences between these populations (Wasserman et al. 1998a, b). Even so, after the introduction of the *perestroika* movement, all states witnessed a fall in suicide rates, with a decrease among men approximatively by 40% for suicides from 1984–1988, in comparison with the decrease by 3% in 22 European countries at the same time (Wasserman and Värnik 1998). Further, a study that examined the alcohol levels, at the time of death in suicide victims before, during, and after the launch of the antialcohol movement during *perestroika*, confirmed that the use of alcohol consumption was a common precursor to suicide and that strong alcohol restrictions were accompanied particularly by a decrease in suicide mortality among persons of both sexes who screened positively for alcohol (Värnik et al. 2007).

School-Based Universal Suicide-Prevention

Suicide is the second leading cause of death among young people of age 15–29 years, globally (WHO 2016). School-based suicide-prevention programs can be used as an important tool to support vulnerable people and provide them with education on how to effectively cope with stress and mental health issues. In general, research shows that school-based interventions are effective concerning increased knowledge and changes in attitude (Zalsman et al. 2016). Moreover, evidence shows that some school-based mental health and suicide awareness programs are followed by a reduction in suicide attempts and ideation. The three universal school programs with the strongest evidence which are briefly described are Good Behavior Game, Signs of Suicide, and Youth Aware of Mental Health studied in the Saving and Empowering Young Lives in Europe (SEYLE) study (Zalsman et al. 2016).

The Good Behavior Game (GBG) was developed in 1969 in the United States and is designed as team-based behavior management to control aggressive and disruptive behaviors in the classroom setting. With the design of the game, the pupils are being taught two important skills: learn what maladaptive behavior is, and how to be part of a social setting and work toward common goals (Wilcox et al. 2008). The GBG program, although not primarily developed as a suicide prevention program, was successfully linked to lower suicidal behavior from childhood to young adulthood. This is believed to be related to the decrease in aggressive and disruptive behavior, as both these behaviors are correlated to suicidality (Newcomer et al. 2017). The program has primarily been linked to a long-term impact in lowering alcohol and substance use.

Signs of Suicide (SOS) is a school-based universal intervention aimed at secondary school pupils and was successful in reducing self-reported suicide attempts. The program was designed in relation to the theoretical standpoint that suicide is the outcome of mental illness and not solely a response to life stressors and emotional distress (Aseltine et al. 2004). The program aims to communicate knowledge of the warning signs of suicide risk and what to do if they are discovered by others or oneself. The intervention, however, was not followed up after 3 months and was limited by follow-up dropout (Schilling et al. 2016).

Saving and Empowering Young Lives in Europe (SEYLE) project was implemented in 11 European countries with Sweden as a scientific coordinating center. Its goal was to study the mental health of 15-year-old school-based youth and to evaluate three different school-based suicide-prevention programs compared to a control group (Wasserman et al. 2010). The project included three programs: *QPR* (Question, Persuade, and Refer), *ProfScreen* (the Screening by Professionals), and *YAM* (Youth Aware of Mental Health). Of the three SEYLE programs, *YAM* was the most effective in reducing the number of suicide attempts and suicidal ideation (Wasserman et al. 2015).

- The *QPR* program is designed by Paul Quinnett to train teachers and other school staff to act as gatekeepers (Quinnett 2007). The goal was for staff to learn how to identify risk and suicidal behavior in students and to motivate them to help

students seek professional help if in crisis. Teachers also distributed contact information of local healthcare services to students who seemed to be at risk (Wasserman et al. 2015).

- The ProfScreen program screens and identifies at-risk students through the SEYLE baseline questionnaire. This enabled referral to clinical services if needed (Kaess et al. 2014).
- The YAM program is a 5-hour universal intervention targeting all students in the classroom. This program consists of interactive role-play workshops teaching skills to cope with dilemmas in life, stress, anxiety, depression, and suicidal behavior. A booklet regarding these topics with contact information to local healthcare services is also provided (Wasserman et al. 2010).

The YAM program decreased by 50% severe suicide ideation with plans and suicide attempts. This program was unique in that it not only provided knowledge on how to cope with stressful life events but also gave the students the chance to verbalize a variety of different issues concerning mental health and suicidal behavior (Wasserman et al. 2018). Additionally, it was also effective in diminishing impulsiveness as a coping strategy (Kahn et al. 2020). The YAM program is currently being culturally adapted and implemented in Australia, England, India, Norway, the United States, and Sweden. The cultural adaptation is pursued by the local researchers in collaboration with the founders of the YAM program. The adaptation is based on a back-and-forth translation of the materials, linguistic adjustments, and on the results of qualitative research using focus groups with young people, instructors, and facilitators. This procedure feeds in the program materials and aims to ensure the fidelity of the original YAM program, quality insurance, and outcome improvement for the schools (Lindow et al. 2019).

Gatekeepers

Gatekeeper training aims to increase knowledge of suicide prevention as well as the response and identification of at-risk individuals for people with a high chance of being in contact with at-risk population. They may be from the general population, or specific professionals (e.g., teachers, police officers). The training activities are focusing on warning signs, risk factors for suicide-related acts, and how to assist or refer a person in need to appropriate assistance. Quinnett with the QPR program highlighted that in addition to such activities, training should also aim to enhance mental health literacy and decrease stigma (Quinnett 2007). Examples of existing training activities include 113 Suicide Prevention, a Dutch gatekeeper training (Terpstra et al. 2018) and Mental Health First Aid (MHFA) training launched in Australia and adapted worldwide (Kitchener and Jorm 2002; Hadlaczky et al. 2014; Jorm et al. 2019).

Media Guideline

Media reporting of suicide-related events may have negative consequences if done incorrectly. The WHO published guidelines on how suicide should and should not be reported (WHO 2017). For example, Guidelines suggest avoiding sensational descriptions of suicide as well as not providing information about the means of suicide, location, or suicide notes, and to avoid the inclusion of pictures. Media

outlets should focus on educating the population about suicide (facts and myths), and their reporting should always include visible contact information to crisis helplines for people in need. Implementing such guidelines for media has a strong positive impact on the population (Torok et al. 2017). Additionally, media reporting may have a protective factor on the general population due to an emphasis on coping with suicide.

Internet Initiatives for Suicide Prevention

The Internet can be seen as a source providing counseling and psychological help that is accessible for everyone (Gilat and Shahar 2007; Lester 2008). Internet and Internet-based applications (on smartphones and computers) are increasingly utilized for suicide preventive programs (Perry et al. 2016). Internet-based information has several advantages regarding the low-cost of building Internet prevention and accessible nature of such media (Perry et al. 2016). It nonetheless is challenged by the uncontrolled nature of the Internet, the mental health impact on users, and the fact that only a few programs are systematically evaluated (Hökby et al. 2016; Larsen et al. 2016; Zalsman et al. 2016). The Internet is all-encompassing, but research has highlighted that search engines should, and can, improve their algorithms with a more positive and tailored approach to suicide prevention (Arendt and Scherr 2016).

The Suicide Prevention through Internet and Media-Based Mental Health Promotion (SUPREME) project was aimed to develop, share, and evaluate a web-based intervention on adolescent mental health and suicide prevention. The website was designed to increase knowledge and awareness of mental health and to offer direct professional support to users. The research had strong evidence that all mental health-related outcomes declined. The study revealed that participatory designs are paramount for Internet-based interventions to meet the preferences of the users (Carli 2016).

Another example of initiative implementing Internet initiative to pursue the Vision Zero for suicide aim is the Netherlands consortium of organizations called SUPRANET which launched 113Online program to empower and improve suicide prevention action network (IIMHL 2016).

Helplines

Telephone-based helplines for suicidal people are available in many countries. The aim of these helplines is for the suicidal, or otherwise concerned, person to feel heard, talk about their problems, and be encouraged to find constructive solutions to their problems and to, ultimately, continue being alive. Since many suicidal people avoid seeking formal help, this may be the only opportunity for some to talk to someone. Crisis centers have been involved in national strategies to tackle suicide (Gould et al. 2012; Gould et al. 2016). Challenges exist to gather evidence on the effectiveness of helplines, as these services are anonymous and there are no possibilities to follow-up with the user (Nelson et al. 2017; Zalsman et al. 2016).

Indigenous Suicide Prevention

Indigenous communities have a significantly higher rate of suicide than other communities (Pollock et al. 2018). Indigenous suicide prevention programs are

unique because they need to be culturally responsive to be efficient (Wexler and Gone 2012; Charlier et al. 2017; Allen et al. 2019). Most culturally responsive programs are multilevel, multidisciplinary, and include projects on community prevention, gatekeeper training, school-based programs, media, helplines, primary care providers training, etc. (Kirmayer et al. 2009; Wexler et al. 2015). All public health and healthcare initiatives described in this section can be adapted for indigenous populations. Challenges for indigenous suicide prevention, as highlighted by some systematic research (Clifford et al. 2013; Harlow et al. 2014), are that usual suicide program designs (randomized-control trials with large population), and their evaluations do not fit the needed approach for indigenous communities (holistic approach, community-level factors, suicide considered as a social issue, etc.) (Wexler et al. 2015; Hatcher 2016; Allen et al. 2019). However, some programs on quasi-experimental designs (based on strengths-based assessment and community-level variables) have seen an increase of protective factors and reduction of suicidal behavior (Kirmayer et al. 1999; Allen et al. 2009; Allen et al., 2019). Indigenous suicide prevention programs, in addition to following a similar holistic approach as Vision Zero, highlight the strengths of community-based prevention programs.

Healthcare Approach

Healthcare approach aims to improve healthcare services, early diagnosis, and identification and treatment of suicidal behavior, as well as training healthcare staff toward better practice and follow-up for suicidal patients. These prevention strategies target patients, families, and others affected by suicide in addition to healthcare setting (Wasserman 2004; Wasserman and Durkee 2009). The initiatives with the strongest evidence are treatment of depression and chain of care. Others with mixed-result evidences are education of primary care physicians and screening in primary care (Zalsman et al. 2016).

Treatment of Depression

Psychiatric disorders are a major risk factor for suicidal behavior; therefore, their treatments are essential to suicide prevention (Zalsman et al. 2016). Improvement in depression screening and recognition by general practitioners, as well as depression campaigns, have strong evidence on suicide prevention (van der Feltz-Cornelis et al. 2011; Hegerl 2016). Various medications and psychotherapies are effective and recommended in suicide prevention (Zalsman et al. 2016).

Chain of Care

The chain of care revolves around the idea that care must be consistent and coherent at every level during the screening, diagnosis, treatment, and follow-up of a patient. It is particularly important for serious mental illnesses and suicidal behavior, which usually require longer treatment and follow-up. The chain of care needs structural (internal communication and information sharing) and follow-up improvement.

Some interventions consist of phone-based patient follow-up (Noh et al. 2016) or crisis-coping cards (Wang et al. 2016). Crisis-coping cards have shown positive results in reducing suicidal behavior and severity of suicide risk (Wang et al. 2016). Evidence for chain of care is quite heterogeneous (Zalsman et al. 2016). In the United Kingdom, the NHS launched a plan for Zero Suicide which includes engaging staff through the creation of a Safe from Suicide Team comprising representatives from local services. This team monitors and ensures the implementation of the program through all services to strengthen the chain of care regarding suicide prevention (Public Health England 2016).

Education of Primary Care Physicians

Zalsman et al. (2016) highlighted that the training of primary care physicians is effective in preventing suicide. For example, studies have shown that primary caregivers face several challenges when working with mentally ill patients (i.e., lack of training on suicide management, competing health issues, and brief and inconsistent visits) (Jerant et al. 2019). As such, programs and guidelines need to support primary caregivers on how to talk about suicide and develop contact with suicide specialists and psychiatrists (Hogan and Grumet 2016).

Screening in Primary Care

In order to prevent suicides, screening must be combined with an effective response for those individuals who screen positively for suicide risk. Considering the cost of screening, and the insufficient evidence of its benefits in primary care populations, it is judged not to be the most effective strategy for suicide prevention (Zalsman et al. 2016). In the United States, the Henry Ford Health System to implement their Zero Suicide program first assessed and screened every patient going through the Behavioral Health Service. This first step enabled the prioritization of care and contributed to the improved communication between services by creating a targeted profile of patient accessible through shared records (Hampton 2010).

Conclusion

Like all Vision Zero policies, Vision Zero for Suicide should be seen as an aspirational goal bringing together several sectors at all levels of society. But in order to succeed, it must be ambitious. It aims to not only diminish the stigma around mental health and suicide but to also bring about systematic changes. Working toward this goal for zero suicide enables multiscale and multidisciplinary suicide prevention interventions as a label for stakeholders to rally together and pool resources. Despite criticisms, successful programs worldwide guide future Vision Zero implementations for suicide.

To achieve the goal of Vision Zero for suicide, evidence-based suicide prevention strategies need to be widely implemented, in both public health and healthcare settings. Substantial financial support is a prerequisite for the success of Vision Zero. These strategies need to be catered to the respective contextual environments and regularly evaluated to improve their quality and effectiveness.

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Abstract

Since 2010, Sweden has a Vision Zero policy on fire safety: no one should die or be seriously injured as a result of fire. Compared to the traffic safety model, however, the preconditions for successful implementation appear more immature and less convincing in the fire area. The purpose of this chapter is to illustrate, using the Vision Zero policy on fire safety as an example, how a Vision Zero initiative in a new area, where the conditions for governance may differ significantly from the area of inspiration, can be dealt with as a dynamic process to gradually establish credibility and effectiveness.

Globally, fire is a significant cause of death and injury. The general trend is toward a slow decline, especially among middle-income and high-income

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countries. The decline may be due to successful fire safety efforts, but also to other conditions affecting it indirectly. Both risk-increasing and risk-reducing factors determine fire safety. Risk increasing factors include an ageing population, an increasing diversity of possible ignition sources, and a change in the composition and amount of combustible materials present in our homes. The risk-reducing factors include generally favorable socioeconomic and technological developments, including concrete societal actions directed against fire risks such as the promotion of smoke detectors and sprinkler systems.

Fire safety is one of the oldest documented examples of societal risk management. City planning and construction were early influenced by fire safety considerations, while in contrast, the legal responsibility for residential fire safety has largely remained a private and individual matter. The situation is similar to the one that for long prevailed in the traffic sector, that is, the primary responsibility rests with the system's users, not with its designers.

The launch of the Vision Zero on fire safety in 2010 represented a clear boost in ambition. Along with the vision, a strategy intended to guide the work toward the visionary goal was also presented. The strategy included four items: information, technical solutions, local collaboration, and evaluation/research. Several actions were taken in line with the strategy, including a significant research effort and the development of a set of indicators to monitor progress.

Ten years later, the research effort has brought new knowledge that puts previous perceptions into partly new light. The notion that survival depends on the individual's personal capacities is strengthened. Adverse outcomes such as death and serious injury appear mainly linked to specific vulnerabilities of certain groups for medical and social reasons. Most fires are handled by the residents themselves without injuries and without assistance from Rescue Services; on the other hand, even minor fires can be fatal for vulnerable residents. This turns the problem framing toward social aspects rather than technical, since broad groups of residents lack the capacities needed, conflicting with the prevailing view that the individual should bear the primary responsibility.

Other findings relate to the proven inefficiency of certain measures for groups at elevated risk and the need for re-thinking and innovations to meet the challenges ahead. This includes extended inter-sectoral collaboration on a broader spectrum of residential risks besides fire, threatening the same groups for similar social and medical reasons.

This updated state of knowledge is now being used as a basis for renewing current national fire safety strategies. With reference to general principles of systems control, this chapter will discuss obstacles and challenges to establish a more robust and systematic national control of the fire problem in line with the Vision Zero policy. The appropriateness of launching Vision Zero policies in fields that are not yet ripe for systematic governance is also discussed. It is concluded that a Vision Zero initiative can still be meaningful and successfully pursued, provided that limitations in the ability to influence crucial elements in the system are openly identified and systematically addressed in a process in

which strategical and policy developments interact with research and innovation.

Keywords

Vision zero · Fire safety · Systems approach

Introduction

Since 2010, Sweden has a Vision Zero policy on fire safety: no one should die or be seriously injured as a result of fire. Compared to the Vision Zero on road traffic safety, the Vision Zero on fire safety can be said to be less well known and less systematized in its implementation. It was launched as one among several Vision Zero policies in different areas where politicians and decision-makers became inspired by the Vision Zero on traffic safety and advocated similar approaches to meet other societal problems. Unlike the Vision Zero on traffic safety, where scientific and strategic progress can be said to have paved the way for the breakthrough and acceptance of a new paradigm (Belin et al. 2012), the Vision Zero on fire safety is still based on fragmentary scientific and strategic evidence. Rather, the Vision Zero on fire safety appears as an expression of decision-makers' desire to manifest will and determination before there is a clear picture of how the vision can be realized. Other Vision Zero policies have been established on similar grounds, which raise questions regarding the challenges involved in launching Vision Zero policies in new areas before they can be said to be scientifically and strategically mature for such a radical approach. The purpose of this chapter is to highlight these challenges, using the fire area as an example. More specifically, we wish to demonstrate how a long-term Vision Zero initiative in a new area where essential preconditions for adequate governance are still lacking can be dealt with as a dynamic and iterative process where such insufficient preconditions are systematically tackled along with more detailed solutions.

The chapter is structured as follows: first, we give a brief background on fire as a societal problem from Swedish and international perspectives, and how it has historically been managed. This is followed by a presentation of how the Swedish Vision Zero policy on fire evolved to the formal initiative that was presented in 2010. An essential part of the strategy associated with the policy was to initiate research in areas that were assessed to be of particular importance for the further implementation of the policy. The richer state of knowledge resulting from this research effort is summarized briefly, as well as its implications for the continued Vision Zero work. Emphasis is placed on achievements that can be judged of importance for a broader understanding of the nature of the fire safety problem, and how these achievements can be assumed to influence future strategic work. The chapter concludes with a discussion on the challenges a Vision Zero initiative can encounter when transferred to a new field where the preconditions for societal control may differ considerably, as compared to the traffic safety model.

Background

Globally, fire is a significant cause of death and injury. A total of about 120,000 people are estimated to die each year in fire (Ritchie and Roser 2018). Most of these deaths occur in low- and middle-income countries.

Reliable comparisons of the number of fire-related deaths between countries are largely lacking. In the EU, fires are estimated to be responsible for 2% of all fatal injuries (EuroSafe 2014). A report based on data from the International Association of Fire and Rescue Services shows steadily declining trends in countries such as Estonia, Germany, the United Kingdom, Latvia, Russia, and the United States since 2002 (Winberg 2016). Similar trends are shown in a Swedish study based on WHO data (Moniruzzaman and Andersson 2018). The latter research suggests socioeconomic development is the determinant that most clearly explains the differences between countries.

Sweden has documented a steady decline in fire mortality of about 60% from 1950s levels (Jonsson et al. 2016). Similar developments are observed in many comparable countries. Why this has happened remains largely unclear, but for Sweden, it is noted that the decrease has been most significant in children and younger ages. This has contributed to assumptions that expanded childcare and improved medical burn care may be important factors besides fire safety measures. Further, an ongoing shift in the medical cause of fire deaths, from burns toward intoxication, is observed, possibly due to changes in interior materials in Swedish homes. A vast majority of all fire deaths occur in residential settings.

Fire is a risk that accompanies people of all times, and fire safety is one of the oldest documented forms of societal risk management. For several centuries, many cities were ravaged by devastating urban fires (Garrioch 2019). As urbanization took off in the nineteenth century, Swedish cities grew rapidly, and a large number of them were hit by widespread fires (Bankoff et al. 2012; Schmaltz 1992). In 1874, the first Swedish national building and fire charter was adopted (Kongl Maj:t 1874). Rules on building height, firewalls, chimney-sweeping, and physical separation between buildings were introduced. Blocks with spacing between them replaced the previously clustered style of city planning. These measures proved effective; extensive urban fires ceased in the twentieth century and became limited to more finite block fires. This positive development continued, and the major fire problem then became fires in individual buildings. During the 1950s and 1960s, the concept of “fire cell” was introduced. A fire cell is a defined part of a building within which a fire can be confined for a given minimum period without spreading to other parts of the structure. This is achieved practically by requiring fire-resistant properties of the fire cell limiting surfaces – walls, ceilings, floors, doors, etc. This measure has been proven successful as well and has contributed to a deep reduction in fully developed fires in buildings. Most fires in apartment buildings are now limited to the fire cell where the fire started. The same applies to fatal fires; in a majority of residential fires with a deadly outcome, the fire is confined to the fire cell of origin (e.g., an apartment) or even to the single room of origin.

Besides regulations on construction and city planning, which impose certain obligations on industries, property owners, and municipalities, there is a strong tradition of responsibility of the individual in fire safety. According to the current Swedish legislation applicable to fire safety – The Civil Protection Act (Swedish Parliament 2003) – “the individual,” whether human or legal, has a primary responsibility to protect life, property, and the environment and not to cause fires or other accidents. In the first place, it is the individual who should take measures to prevent accidents and limit the consequences of accidents that may yet occur. The individual – for example, a resident of a single-family house or an apartment – is therefore assumed to have both the knowledge and ability to prevent a fire. The individual is also expected to have the skills and equipment (e.g., smoke detectors) needed to be able to act properly if a fire nevertheless should occur.

The fire safety framework described above has largely grown through evolution. The legislation is developed reactively, usually adjusted only in the aftermath of major and devastating fire events (Ewen 2018). Fire research gained momentum in the second half of the twentieth century but remain mostly technology oriented. An exception is research on evacuation, where behavioral knowledge and related methodology play a significant role.

Another aspect that might, in part, explain the lack of proactivity and adaptation to the social aspects of fire prevention is to look within the rescue service’s deeply ingrained culture. Most people choosing this career are focused on operational firefighting. Prevention tends to be regarded as an alternative or second-hand task. The strong internal professional culture, organized after military-type hierarchical models, with male dominance and a technical focus, probably makes it even harder to take on board knowledge and practices from non-fire science related areas such as public health or social care.

The Swedish Vision Zero Initiative

The first initiative toward a long-term strategical approach to reducing deaths and injuries in fires was taken by the then national authority having jurisdiction, the Swedish Rescue Services Agency, concurrently with the launch of the Vision Zero of road traffic in the late 1990s. At this time, it was primarily the ethical component of Vision Zero – it is hardly possible for a safety authority to argue for an ultimate visionary state other than zero – that was the motive. In 1997, the Swedish Rescue Services Agency submitted a fire prevention program to the government, proposing that “*The risks of fires should be continuously reduced. The numbers of deaths and injuries, as well as cases of serious damage to irreplaceable environment and property assets, should decline towards zero*” (SRV 1997). Partly as a result of this initiative, a systematic collection of facts about fatal fires and fire fatalities began at the Swedish Rescue Services Agency.

The current Swedish Vision Zero policy on fire safety was formally proclaimed by the succeeding nationally responsible sector authority, the Swedish Civil

Contingencies Agency (MSB¹), in 2010. It was developed in response to a government initiative in which the Swedish government called for a national strategy on how fire protection can be strengthened by providing support to individuals (MSB 2010).

The initiative was motivated by an impression of slow progress and the recent occurrence of some high-profile fires with multiple fatal outcomes among immigrants. A supplementing strategy, intended to guide the work toward zero deaths and serious injuries, was formulated in four points:

Knowledge and communication

Technical solutions

Local collaboration

Evaluation and research

“Knowledge and communication” aimed at easily accessible and coordinated information for different target groups, such as those with special needs. Basic fire safety knowledge was judged essential to be included in schools and vocational training, as well as in training courses for newly arrived immigrants.

“Technical solutions” addressed technical innovations and the development of so-called forgiving systems that allow individuals to make mistakes without being seriously harmed or killed. Smoke detectors and extinguishing equipment in homes were particularly highlighted, as was the need to spread knowledge of other solutions. This point also underlined the need for strengthened fire safety in nursing homes.

“Local collaboration” addressed the importance of collaboration across sectoral boundaries to identify groups and individuals in need of special efforts and to reach out to property owners and insurance companies.

“Evaluation and research” was added as a final point to support future strategic development by bringing new knowledge. Among other things, a focused research effort on residential fires was proposed.

In support of Vision Zero for fire safety, a collaboration group and a campaign were launched (MSB 2020a). Further activities included the editing of a guide on “individualized fire safety,” aimed at providing knowledge to, and guiding professional fire safety efforts toward, particularly vulnerable groups (MSB 2013a). In addition, an initiative on planned home visits was undertaken in 2016 (MSB 2020b). The latter activity was primarily inspired by the extensive home visiting activity in the UK, which is cited as an explanation of the substantial decline in death rates in fires there (Arch and Thurston 2013).

¹MSB replaced the Swedish Rescue Services Agency in 2009, as a result of the Southeast Asian tsunami disaster in 2004, when more than 500 Swedes lost their lives. The intention was to create a broader national agency on crisis management and preparedness. MSB is the Swedish government’s expert authority on fire safety and is responsible under the government for advice and support to the country’s municipal rescue services and issues regulations and general advice to individuals and other actors.

Inspired by monitoring and follow-up routines employed in the traffic area in Sweden (Trafikverket 2020), nine indicators for fire safety were also developed (MSB 2013b). Four indicators related to outcomes (number of fatalities and serious injuries in fire per year, number of fully developed residential or fireplace-related fires per year, and societal costs of residential fires per year). The remaining indicators intended to reflect the implementation of fire prevention measures taken by society and individuals (presence of functioning smoke detectors, presence of extinguishing equipment, the proportion of municipalities with developed cooperation in the prevention of residential fires, knowledge of how to act in the event of a fire, awareness of fire risks in the housing environment). All indicators were intended to be regularly monitored, primarily through Rescue Services response records and complementary surveys.

Among these points, the proposed research effort has come to play a particularly important role in further strategic development for Vision Zero, as was envisaged when the proposal was presented in 2010. In 2013, three major research projects on residential fires were supported by MSB, all of them finalized and reported in 2017/18. The projects focused on different aspects related to fire safety, such as death and injury, social patterns, and technical solutions.

The Updated Status of Knowledge; What Is New, and What Are the Implications?

The aforementioned research has shed new light on residential fires in general, on contributing circumstances to deaths and serious injuries, and on the effectiveness of measures considered important for prevention. The research has also increased the awareness of remaining critical knowledge gaps, which consequently need to be addressed in further research efforts.

Residential Fires and How They Are Managed

In 2010, the state of knowledge was mainly based on data from Rescue Services call-out records collected through MSB. There was an awareness that these data might be skewed by underreporting, but in the absence of better data, generalized conclusions were nevertheless drawn on causes and consequences. In 2020, there is now a more complete picture of the total incidence of fire in Swedish homes based on complementary sources, leading to new insights and increased awareness of remaining uncertainties, such as:

There is more clarity on the fact that fires are frequent occurrences in Swedish homes, and that most fires are handled by the residents themselves. The total incidence of residential fires is estimated to be about four times the number to which the Rescue Services are deployed. Residential fires rarely lead to death or serious injury. This reinforces the image that fire outcomes primarily depend on the residents' own capacities.

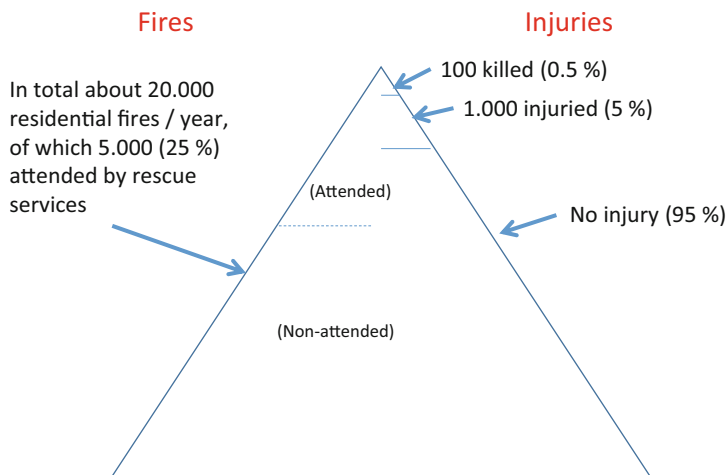


Fig. 1 Proportions between injury outcomes and rescue service attendance in case of residential fires in Sweden (derived from Jonsson 2018a, b)

The interest in creating an overall picture of the property damage caused by the large number of residential fires has increased.

The possibility of drawing conclusions about the causes of residential fires is surrounded by greater uncertainty, as most fires never come to the attention of the Rescue Services and thus are not subject to expert analysis. This also affects the state of knowledge regarding the relative danger of different fire causes, as current data collection does not capture information on the fires that residents handle themselves.

The updated knowledge status is summarized in Fig. 1.

Killed and Injured

One of the more important research efforts on fire fatalities, their circumstances, and the possibilities to assess the true number of fire-related deaths was carried out by Jonsson et al. (2015), by matching data derived from three separate sources. These were the National Board of Health and Welfare's cause of death register, the National Board of Forensic Medicine's register of autopsies, and MSB's fatal fire register. Through this matching, a validated and richer aggregate data set was created. From this work, it was possible to conclude that none of the registers alone gave complete coverage of fire fatalities and that the actual number of deaths was systematically underestimated by 20–25% in MSB's fatal fire register (Jonsson et al. 2015).

The understanding of fire-related deaths has thus developed considerably from 2010 to 2020. Data capturing from multiple sources is now secured, meaning that the previous under-reporting is under control. The statistics are now far more reliable. The importance of medical and social vulnerability among victims emerges more clearly. In the rare cases when a residential fire leads to death (<1%), the cause is

usually the inability of the affected individuals to act appropriately in the acute situation, for example, for age reasons or because of illness, disability, or intoxication. There is no clear relation between the magnitude of the fire and the severity of the outcome in terms of death or injury. The majority of fatal fires are limited in size, with the victim most often found in the room of fire origin. Even very limited fires can be deadly for those who cannot help themselves, an insight that shifts the framing of the problem from a previously technically dominated perspective toward a more social one, including housing policy for people with special needs. Smoking, in combination with alcohol consumption, still appears to be a central problem among groups at risk. More in-depth analysis, however, reveals complementary scenarios, such as clothing fires, where influence of alcohol is rare. Medicines can also contribute to reduced alertness and ability in the aging population where prescribed drug consumption often is high (Sessing et al. 2017).

For the seriously injured, the knowledge is still very limited, but data from the national burn clinics, where the most seriously injured are treated, indicate a similar social profile as among deaths (Gustavsson and Nilsen 2018). The average age is slightly lower than among fatalities; on the other hand, a heavier social burden is indicated. In contrast, those with milder injuries and those who escape unharmed do not appear to differ significantly from the population average.

Although the Swedish Vision Zero on fire safety encompasses all types of fires, the policy has in practice been restricted to unintentional residential fires. While a clear majority (about 70%) of all fire deaths in Sweden result from such fires, a considerable proportion also relates to non-residential and intentional fires. For instance, around 10% result from post-crash fires in vehicles, and about 13% relate to intentional fires, mostly suicide (Jonsson et al. 2017). More study of this group is needed; currently no central measures to counteract these deaths or injuries appear to have been implemented, although some local Rescue Services in recent years have activated themselves in the field of suicide prevention (MSB 2009). It is important that future strategical developments also incorporate considerations on non-residential and intentional fires.

The toxicity of fire gases is the most critical factor from a survival point of view (Stec and Hull 2016). The majority of fatalities now die from poisoning (Purser 2010). In addition, toxicity contributes by incapacitating the victim before death occurs. The incapacitation process is comparatively less well studied in the published literature. Given that fire gases usually contain a mixture of very potent toxic gases such as cyanide and carbon monoxide, it is, however, reasonable to assume rapid impacts in those who cannot immediately escape the room of origin.

Fatalities and property losses from fires represent separate problems and should be understood from separate points of view. Deaths are caused by medical impacts on living organisms by the fire's by-products: gases and heat. Property damage, such as structural damage to buildings, is mainly caused directly by the oxidation process of the fire itself. Some property damage also results from smoke or extinguishing materials such as water. Costlier property damage is often caused by larger fires, while most fatal fires are limited in size. Deaths usually occur in the initial phase of the fire, while property damage culminates later as the fire grows in intensity. Thus, measures to prevent lives will also reduce the risk of property damage.

Effectiveness of Measures

In 2010, smoke detectors were highlighted as the single most important measure to improve safety. Ten years later, there is an increased awareness of the limitations of the effectiveness of smoke detectors in relation to vulnerable risk groups, with accompanying requirements for complementary individual and needs-adapted measures (Runefors 2020a). These include technical equipment such as detector-activated sprinkler systems, but also social initiatives such as the provision of adapted housing for those with special needs, meeting higher safety standards. The latter, in turn, raises a broader perspective on fire safety, including more factors and actors than originally considered.

Smoking is a leading source of ignition as regards fatal fires. Therefore, there were considerable expectations for the so-called self-extinguishing cigarettes as introduced in both the USA and the EU around 2010. The cigarettes were designed to stop glowing when left without active smoking. However, studies have shown that the cigarettes do not seem to fulfill this criterion in practice (Bonander et al. 2015), and that the testing method poorly reproduces real situations (Larsson and Bergstrand 2015).

A particular problem is the extensive introduction of various types of artificial materials in buildings, including dwellings, since the 1950s. Different plastic materials with the potential to emit highly toxic gases are present in many interior products and finishes (Seo and Son 2015). Energetic petroleum-based polyurethane foam has largely replaced natural materials in furniture upholstery. The above developments have led to the presence of significantly more flammable material in larger volumes inside an average dwelling. This has significantly shortened the time until very high temperatures (flash-over) are reached and also leads to a faster release of combustion gases with very high toxicity (Kerber 2012; Blomqvist 2005). The problem has been understood for a long time, and early attempts were made to counteract this by the addition of flame retardants. However, these agents, usually bromine compounds, have serious environmental and health effects and are in many countries banned or on the verge of being phased out (Chivas et al. 2009). Research to find environmentally acceptable alternative solutions are underway (Brandforsk 2019).

The Rescue Services annually rescue a number of people who would otherwise have died (Runefors 2020b). However, the ability to save more lives is strongly limited by their response time (Jaldell 2017). In practice, few can be reached as quickly as would be needed for rescue operations to be considered a reliable safeguard for those who cannot help themselves in case of a fire at home. Swedish standards for fire protection in dwellings still presuppose that residents can evacuate on their own (Boverket 2019). Yet those rescued by Rescue Services are, on average, younger, more often cohabiting, and more commonly found in spaces other than the room of origin as compared to those who die (Runefors 2020a, b). The gender balance is also more even. Those rescued generally seem more capable than those who die, perhaps by being able to move to a safer space while awaiting assistance. Trials with complementary semi-professional or volunteer response resources, which may arrive at the scene earlier than the Rescue Services, show some potential to increase the ability to rescue and thereby increase survival (Sund and Jaldell 2018).

Knowledge Gaps and Innovation Needs

Besides generating new knowledge that can be directly utilized in prevention work, research also helps to increase awareness on remaining knowledge gaps. As the research front moves forward, new issues are identified whose importance may earlier not have been fully understood.

For example, since most residential fires remain unattended by the Rescue Services, there is still insufficient knowledge about the total incidence of fire in Swedish homes, typical patterns and details of unattended fires, and how these fires are normally handled. It emerges now more clearly that death and serious injury from fire are among the exceptions, while the typical situation is that most fires are controlled by the residents themselves without serious consequences. This underlines the need for a wider comprehension of residential fires to better understand under which specific and exceptional circumstances a fire leads to serious consequences. In-depth studies and learning processes on fires with fatal or seriously outcomes need to focus more intensely on such specific conditions.

Further knowledge is also needed on the conditions that facilitate the successful rescuing of people who would otherwise die in life-threatening fire situations. The abovementioned circumstances, as indicated by Runefors (Runefors 2020a, b) and Sund and Jaldell (2018), need to be explored in more detail.

Those who incur serious injuries remain to be studied with the same depth and breadth as those who die. Some similarities are already indicated between the two groups. However, the fact that people in this group survived suggests that there may be significant differences as well, carrying potential information on protective factors critical for survival.

The knowledge is still sparse on the physiological effects of toxic fire gases. This knowledge is crucial for the understanding of the time available for rescuing helpless persons left in the room of origin, as well as the mechanisms and speed of incapacitation of the victim.

The contribution of pre-hospital and hospital care to reducing mortality and injury severity associated with fire needs to be further studied. Proper care of a seriously injured person at the fire scene and during transportation, such as adequate antidote treatment and breathing support, as well as the quality of the subsequent specialist care, is often crucial for survival and successful restoration. In contrast, incorrect pre-hospital diagnosis and treatment can further aggravate the harm.

The role and measures of the Rescue Services should be studied in a broader context. The social dimension of the residential fire problem calls for more extensive involvement from other societal actors to take the preventative work forward. At the same time, studies show that Rescue Services can make very cost-effective efforts outside their core area, for example, in cases of sudden cardiac arrest. The vulnerable target group identified here is surrounded by several other parallel risk and insecurity issues at home, all of them originating from similar vulnerability circumstances linked to age, ill-health, and disability. The time seems ripe to seriously explore broader models of cooperation around the wider risk spectrum shared across sectors.

Trends and Implications

In 2010, an aging population, combined with an increasing proportion of elderly remaining living at home, was assumed to pose the risk of a significant increase in the number of people dying in fire. Also, social and economic factors were judged to contribute to the risk of death, which called for actions targeting particularly vulnerable groups. Alcohol and drug prevention was also considered an essential part of fire safety work. These judgments remain in 2020 with increased weight. In addition, the knowledge of ethnicity as a possible contributing factor was in 2010 seen as necessary to strengthen. This assessment no longer seems as relevant, as additional studies do not support the assumption that an immigrant background is a significant risk factor for fire mortality. On the other hand, there has been rapid technology development that was not really predicted in 2010, but which in 2020 appears worrying from a fire safety point of view. Digitalization has led to a sharp increase in rechargeable electrical products in living environments. An increase in fire problems can also be foreseen due to the transition to a fossil-free society. This development is expected to lead to increased multi-dwelling construction in wooden materials, a sharp increase in rechargeable electric vehicles, local electricity production via solar cells and storage in lithium-ion batteries with a high energy content (Andersson et al. 2019).

Finally, the new state of knowledge brings new policy implications that need further study and development. These include housing policy, social services, home-based health care, and how society generally should provide safe, secure, and attractive housing for a growing elderly population, and other groups with limited abilities in the event of fire. What is the potential for initiatives such as changes in housing policy, a broadened content in social needs assessments, and home visits? What support in the form of amended legislation, directives, and resource allocation is needed to promote a more extensive and intensified development of societal fire safety? Preventative and Vision Zero approaches from adjacent areas suggest a need for a broader systemic approach to housing risks, in line with the principles adopted in traffic and occupational safety, where responsibility for safe conditions is seen to rest with several actors in cooperation.

Continued Strategic Development Work

The richer state of knowledge gained from research has created incentives for renewed strategic initiatives based on science rather than traditional experiential learning. First up was the Swedish Fire Protection Association (SFPA), a nonprofit organization working for “A fire safer Sweden.” SFPA is supported by a number of stakeholders in the field of fire safety, such as the insurance industry, and works with standard development, knowledge dissemination, and advocacy in the fire field. A parallel strategic update has been initiated by MSB. This work is ongoing at the time of writing, which means that we here limit ourselves to summarizing what we

perceive as broader achievements and considerations that generally influence both processes.

One such insight concerns the need for a more comprehensive “systems” approach to the problem of residential fires, as indicated above. It is becoming increasingly clear that the risk of being killed or seriously injured in fire is due to several interlocking factors, which in turn link back to the responsibilities of many different actors. Another overall insight concerns the need for a systematized collaborative approach across sectors regarding all these factors and actors toward the Vision Zero targets.

An interesting model for describing and analyzing the possibilities of controlling a system, in this case reviewing the potential of a Vision Zero strategy, is the so-called GMOC model. GMOC is an acronym that stands for Goal, Model, Observability, and Controllability. According to general control theory (Kalman 1959), four criteria represent prerequisites for controlling any system. Although control theory is mainly focused on automated systems, GMOC has found applications in fields such as human decision-making and human-machine interaction (Tschirner 2015).

The four criteria include:

G: The need for an objective – the Goal criterion

M: The need for a model of the system – the Model criterion

O: Possibilities to determine the current states of the system – the Observability criterion

C: Opportunities to influence these states – the Controllability criterion

The goal criterion is about defining what is to be achieved; in this case, fewer deaths and serious injuries from fire. The goal should be directed toward the adverse end outcome (e.g., deaths and serious injuries) instead of focusing on single upstreams exposures or determinants (e.g., fire occurrence). There are many examples of the latter kind of policies that prove ineffective because they are based on simplistic and sometimes erroneous notions on cause-effect relations, such as zero tolerance on drug use to prevent drug-related mortality, to mention one.

The model criterion relates to the need for a commonly shared view of what the “system” looks like, who designs it, what it is aimed for, the relationship between inputs and outputs, and why, in certain circumstances, it also entails risks for its users. In this case, it is reasonable to consider housing as a system. The primary purpose of housing is to provide shelter and security for its users. Unfortunately, however, housing is also the arena where most injuries occur. It is necessary for the sake of prevention to identify significant circumstances contributing to these injuries and subject them to intervention with the involvement of those actors which directly or indirectly determine the related risks.

The observability criterion means that relevant system states and dynamics can be monitored over time by valid measures and indicators. If the goal is to reduce the number of deaths and serious injuries, monitoring procedures for these variables must be ensured to identify actual states and to follow and evaluate progress in the

preventive work. The same applies to different determinants of need to influence, for example, smoking and alcohol habits, the presence of smoke detectors, the proportion of single residents, the proportion of residents with disabilities, etc.

The controllability criterion refers to the need for a preventative “toolbox,” that is, access to evidence-based methods with credible ability to influence the outcomes targeted for change. If adequate tools are lacking, it does not matter how well a system is defined, and its mechanisms and determinants are modeled and understood. There is still no ability to influence the outcome of interest.

To the controllability criterion, we wish to add an aspect highlighted in the literature on “governance” on how to develop systematic societal control of broad and complex problems affecting several societal sectors (Hedlund and Montin 2008). It is not enough that control is technically possible; there must also be a governing system in place that ensures policy implementation. To a large extent, this is about providing policymakers and stakeholders at different levels of the system with the necessary information and ensuring their mandates and resources. Communication and feedback vital for a proactive safety control include objectives, priorities, actual status in relation to objectives, and awareness among involved actors of the potential safety effects of their decisions. A proactive governance strategy should aim at defining the boundaries of safe performance, making these boundaries visible to decision-makers, and counteracting pressures that drive decisions toward the boundaries (Rasmussen and Svedung 2007).

Table 1 represents an attempt to review the current fire safety work by employing the GMOC model’s criteria. As can be seen, a great deal of work remains to be done before even elementary system control possibilities can be said to be in place concerning the prevention of deaths and serious injuries from fire.

Table 1 Illustration of prerequisites for systems control and actual status regarding fatal and serious injuries from residential fires

Criteria	Fatalities	Serious injuries
Vision/goal	Established by MSB at agency level	Ditto
Observability/ status monitoring	Ongoing data collection and analysis with good quality	Inclusion criteria and monitoring routines are still lacking
Model	Good problem comprehension on groups at risk, injury mechanisms, and significant risk- and protective factors from recent research The broader system including related actors remains to be modeled	Weak problem comprehension due to lack of research. Injury etiology largely unknown
Controllability/ governance	Major limitations: Lack of effective measures Lack of governing system Obsolete legislation Lack of political support	Ditto

The preconditions for a well-founded prevention strategy are undoubtedly better regarding fatalities, with adequate status monitoring and a growing understanding of relevant mechanisms and determinants (the model criterion). However, there is still reason for skepticism on effectiveness and success when it comes to the possibility of influencing the problem. The main obstacle is the lack of a politically supported governance system across sector boundaries, as many of the determinants, such as medical and social, lie outside the mandate of the expert authority itself (MSB).

In the case of non-fatally injured persons, primarily those seriously injured as are explicitly addressed in the vision zero policy on fire safety, the basic conditions for systems control are still largely lacking. There is no regular monitoring routine in place, leaving the knowledge-base for this group relatively unclear, including related determinants and potentially effective countermeasures. The lack of a national cross-sectoral governance system characterizes this category as well.

The same applies even more to property damage. However, as this aspect of the problem falls outside the objective of the Vision Zero policy on fire, it is not further commented on here.

This presents several fundamental challenges for the continued Vision Zero work on fire safety.

The provision of basic statistics and the use thereof need to be significantly developed, especially concerning serious injuries. Major determinants of deaths and serious injuries from fire should be monitored and followed up on a regular basis as well.

The modeling work needs to be intensified. Actors having an impact on housing safety need to be identified on a broader scale and assigned roles and responsibilities in the collective fire safety work. It is also crucial that the injuring process itself (corresponding to the impact from crash violence in traffic) is modeled to increase the understanding of the time interval for action that is available to a person left in the room of origin in the event of a fire. This knowledge is crucial for proper system measures aimed at improving the individual's chance to self-evacuate and the potential success of external rescue operations.

The "toolbox" needs further improvements with new and innovative methods of fire prevention, such as detection, alarming, extinguishing, evacuation, and rescuing. Not least, new forms of housing need to be considered for those who, despite supportive efforts in regular homes, are at risk of acute danger in the event of a trivial fire incident.

Societal governance in the fire safety area needs to be fundamentally upgraded. Like the traffic safety model, the Vision Zero policy for fire safety needs clear support from the top political level, mandating a national body to coordinate the work across sectors, and an obligation for other sectors concerned to participate in the work. The legislation needs to be reformed, supporting such a broadening of the fire safety work, including its approach to liability.

All these steps need to be underpinned by continued knowledge development and innovation. Research and prevention need increasingly to take the medical and social dimensions of the problem into account.

Conclusions and Future Work

Each risk area is unique in terms of context, typical sequences of events, and possible consequences. Therefore, it is not possible to merely copy models and measures from one area to another. On the other hand, there are often parallels allowing some generic lessons to be transferred, not least in terms of general procedures and approaches in safety work. Here, with the fire area as an example, we wish to discuss some more universal lessons learned on Vision Zero work in areas where essential conditions for systematic societal governance may remain weak. In such situations, we claim, the focus must be on establishing these conditions.

Fire and traffic share the feature that both areas entail injuries and deaths. In traffic, it is mainly the crash violence that harms and kills, while in the case of fire, the corresponding mechanisms are the exposure to heat and combustion gases. It has taken decades of research and development in the field of traffic to reach consensus on the crucial importance of controlling crash violence as a core strategy to improve road safety. In parallel, there is a persistent narrative on the role of human error. Crash violence is determined by the design of the traffic environment, vehicles, regulations, etc., that is, conditions determined by actors other than road users. The parallel focus on the responsibility of the road user thus tends to become an excuse for dangerously designed traffic environments and vehicles. The Vision Zero in road traffic can be said to represent the visible result of a paradigm shift in which policy-makers have decided to partly reverse the division of responsibilities: “responsibility for road safety is shared between those who design and those who use the transport system. The ultimate responsibility for safety rests with the designers” (Swedish Government 1997). Underlying this statement on the overall responsibility of system designers is a judgment that to err is human and that the transport system, therefore, needs to be designed in a way that compensates as far as possible for simple mistakes that anyone can make. The traditional idea of the individual’s primary responsibility can thus be said to be abandoned in the current theory and practice of road safety work, even though this view is still apparent in legislation and law enforcement practices.

For the Swedish fire safety work, the Vision Zero policy on traffic and its indicator-based follow-up system has undoubtedly served as a source of inspiration since the late 1990s. There has been a genuine interest in establishing something similar. However, the analysis of the core contents of the Vision Zero philosophy in the fire area has remained relatively superficial, and the fire sector has not yet been able to take the full step toward a corresponding paradigm shift. The thinking has to a large extent remained inside the existing legal framework and the extensive work done in the field of road safety to identify and involve system designers does not seem to have been fully understood and replicated in fire safety.

There is a persistent narrative on the responsibility of the individual in fire safety as well. This view is reinforced by the fact that fires, in addition to having different injury causes (heat and toxicity), also differ from road accidents in terms of the time available for action while the accident happens. Traffic accidents usually cause instant harm, while hardly anyone is injured at the onset of a fire. A fire takes time

to escalate, which means that the individual responsibility is seen as twofold; to ensure that fire does not occur, but also to extinguish or evacuate before the fire becomes critical. Rescue Services' response times are usually not short enough to guarantee safety for residents, which means that fire safety in ordinary homes is considered to rest on the premise that residents themselves are able to act appropriately in the event of a fire (Boverket 2019).

Thus, compared to the traffic area, the broader systems approach is still lacking in the fire area. Consequently, the Swedish vision zero initiative on fire safety cannot be described as a mark of a scientific and practical paradigm shift similar to that in traffic. The situation is therefore reversed in fire safety, leaving a flavor of wishful thinking. Instead of an emerging knowledge base forcing a new groundbreaking policy, the new policy comes first while the scientific foundation has to be constructed afterwards. The reversed approach may seem irrational, but can also be seen as a challenge and an incentive for further research, innovation, and policy development. It is this opportunity we wish to highlight here.

Another difference lies in the prevailing traditional intra-professional culture in the fire area, in contrast to the broader and more cross-sectoral approach of the transport area. Traditional exertion of authority, which characterizes fire safety, mainly consists of regulation and enforcement. The regulations issued, based on existing legislation, usually imply incremental improvements, reflecting traditional mental models of liability, of fire causation, and of measures to be taken. The rules tend to define minimum levels only, following the natural logic of formal rule-based processes. Unless such a process is complemented by initiatives relying on other drivers than compliance and also exploit, for example, the innovative powers of industry, there are reasons to be pessimistic about the potential for more significant changes in trends.

Again, the fire area here should be able to find inspiration from the traffic area's Vision Zero work. Several innovative solutions have been implemented in the road infrastructure, but the major leap in improvement is undoubtedly to be found in technological developments in the automotive sector. These achievements are not a priori driven by legislation, but by consumer demands and competition. Airbags and other safety systems are now standard equipment in every new car. But, for those buying a new villa, often at a cost that exceeds a car's manifold, few or no safety systems against fire or other accidents are included in the standard delivery.

The GMOC model presented above with its four criteria can serve as a theoretical framework for understanding what needs to be in place for a Vision Zero initiative to appear meaningful and practicable. The basics for controlling dynamic systems have been known since the steam engine's introduction in transportation and industry (Maxwell 1868). This theoretical framework has been further developed over time and led to applications in high-tech areas such as aviation, nuclear power production, and space expeditions. Those are areas where high values are at stake, and where all related risks, therefore must be meticulously controlled. These applications are all characterized by interactions between human, technological, and organizational components, so-called sociotechnical systems (Rasmussen and Svedung 2007). The principles have been subsequently disseminated to broader areas of risk

management already in the 1970s and 1980s, first to the field of occupational health and safety, with its industrially dominated culture and understanding on issues like organization, reliability, process control, and quality assurance, and then further to areas such as product safety and patient safety. In these areas, risks are commonly understood as the result of an interaction between people, technology, physical environment, and organization where all components contribute and where weaknesses in one element, for example, the human part, can be compensated by other parts of the system. The notion that risks can be systematically controlled is fundamental. The Vision Zero policy in traffic safety was the result of a breakthrough for a systems control approach to traffic safety as well. It became increasingly clear that accidents are not just to blame on road users. Infrastructure, vehicle standards, regulations, etc. play fundamental roles in addition to human behavior. Therefore, road safety also more clearly emerged as controllable by society. The scientific achievements came first, and the policy innovation Vision Zero was prompted as the logical result. The goal criterion could be formulated based on confidence in the possibilities of long-term systems control. The model criterion was already met through a thorough conceptualization of the interaction between road users, traffic environment, vehicle technology, regulations, and monitoring, combined with an in-depth understanding of the crucial importance of crash violence in the severity of outcomes in the event of an accident. Observability was enhanced by improved data collection on outcomes and major determinants (indicators). With broad top-level political support and supervision, better conditions for controllability were created and further strengthened through systematic feedback to the various system sub-designers and other actors involved.

The fire area differs considerably from the aforementioned situation. A Vision Zero policy was launched without a corresponding scientific underpinning that preceded the Vision Zero on traffic. Through the GMOC model, it is possible to identify that more development is needed to establish a controllable system on fire safety, and it is these needs that ongoing strategy work now aims to meet. The goal criterion (no one should die or be seriously injured) remains fanciful as long as data capture on deaths and seriously injured, and evidence of prevalent types of societal interventions, is not secured. Hence, there is still a lack of credibility in both the long-term vision and the milestones set. The model criterion is the weakest point. Housing is a system that is still waiting for its modeling. It should be seen as a socio-technical system in the same way as working life and transportation, with a spectrum of associated risks, including fire. Risk levels in housing are, to a large extent, determined by system designers such as property owners, the construction industry, social services, regulatory designers, licensees, and manufacturers and suppliers of installations and movables. As far as fire is concerned, it is evident that significant responsibilities fall on these different system designers, especially as it is becoming increasingly clear that a growing proportion of residents lack the skills to ensure their fire safety themselves (Nilson et al. 2019). Also, there is a need for more elaborated modeling of the dynamic process of deaths and injuries in case of fire (corresponding to traffic crash violence), and how this process can be affected by different types of interventions. In particular, the time aspect is critical for the dimensioning of rescue

functions for residents lacking the ability to evacuate on their own. The observability criterion is linked to the measurement of the variables one wants to modify (numbers of deaths and serious injuries), occurrences and characteristics of residential fires, as well as significant determinants of the problem, such as proportions of elderly people and single residents and disabled people. Finally, the controllability criterion is linked to the possibilities of influencing the problem. The Vision Zero in fire safety is still only adopted formally by the national fire safety agency itself, MSB, not by the parliament or government. MSB has no mandate over other sectors concerned, meaning that the conditions for proper governance of fire safety across sectors are still very limited.

The establishment and acceptance of a vision zero initiative addressing a cross-sectoral problem area must most probably be made at a top policy level to ensure adequate conditions for governance and controllability.

All in all, the Vision Zero initiative on fire safety appears still immature and based on fragmented evidence. Therefore, the ongoing strategy work should be largely focused on creating better conditions for effective governance. The strategy linked to the launch of Vision Zero on fire safety in 2010 reflected the status of knowledge and experience at that time. One crucial insight is the significant knowledge gaps on residential fires, in particular that related to deaths and injuries. An essential component of the strategy was, therefore, to initiate further research. Ten years later, there is now a richer knowledge base in several respects, both in terms of causes and countermeasures, but also on the need for a more comprehensive system approach and a strengthened societal governance approach. These new insights now constitute inputs to the ongoing strategy work described above, forming the next generation of strategy. An essential component of the new strategy, as in the previous version, will be to continue to identify remaining knowledge gaps that need to be addressed in upcoming research and innovation for future generations of strategies. In this way, a Vision Zero initiative can be described as an iterative process where knowledge acquisition and strategy development interact and strategies are continuously refined based on “best practice and knowledge” available at each time. From this view, the “reverse approach” rather appears as a reasonable and rational way of dealing with inspiring role models in parallel fields by formulating challenges for one’s own area that accelerates a development that would otherwise have taken much longer.

In light of the above, the main lessons can be concluded as follows:

- Establishing Vision Zero initiatives in new areas where fundamental prerequisites for systematic control and governance are lacking may still appear valuable provided that the Vision Zero approach is used as a challenge to systematically establish the missing preconditions. The GMOC model is a valuable tool in this work.
- Knowledge gaps should never be accepted as an excuse for the lack of strategies. Strategies always need to be developed and updated based on the best knowledge and experience available. On the other hand, these gaps must be subjected to new research and innovation so that what today may seem utopian will tomorrow appear possible, realistic, and affordable. In this way, vision zero work can be

- seen as a planned and controlled dynamic process in which strategy and action programming interact with research, development, and innovation.
- Governance takes place in a political context where the scientific rationale often has to be balanced against many other considerations. Vision Zero initiatives must, therefore, enjoy broad political support from a level that is respected among all sectors affected by the vision. The body appointed to lead the work needs strong top-level political support to ensure sustained participation from other actors.
 - Governance and cooperation between different actors need to be orchestrated based on a shared understanding of the nature of the problem, its determinants, and the roles and responsibilities of all actors involved. A systems approach is the key to this.

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Mark Rosenberg, Emaline Laney, and Claes Tingvall

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Abstract

The eradication of smallpox – the first and so far only human disease to be eradicated – generated a tremendous amount of excitement and attention to the idea of disease eradication and elimination. In the twentieth century alone, smallpox had claimed the lives of more than 300,000,000 people (Sneed A, Scientific American, <https://www.scientificamerican.com/article/who-remember-smallpox/>, 2014). The last natural case occurred in 1977, almost 200 years after the smallpox vaccine was discovered, and in 1979 the World Health Organization declared that the disease had been eradicated (WHO, Smallpox, World Health Organization. World Health Organization. <https://www.who.int/csr/disease/smallpox/en/>, 2019c). Most importantly, it demonstrated that eradication was possible; that through the use of science, we could change our future for the better in ways that we had not even dared to think about previously. This achievement also helped to focus attention on clear definitions of disease eradication and elimination. Since then, these definitions have been continuously evolving. In 1993, the International Task Force for Disease Eradication (ITFDE I) defined disease control, elimination, and eradication. With that, they evaluated over 90 potential infectious disease candidates and concluded that six were eradicable. Subsequently in 1997, the Dahlem Workshop focused on the science of eradication and defined a range of public health approaches to infectious diseases from control, to elimination of disease, elimination of infections, eradication, and extinction. Three years later, the second International Task Force for Disease Eradication (ITFDE II) convened in 2000 to review the progress over the past decade.

Inspired by these efforts, we reviewed our own experience and interviewed leaders of several disease eradication and elimination campaigns to identify lessons learned from a variety of disease elimination campaigns including smallpox, polio, Guinea worm, and onchocerciasis. Our aim was to identify lessons that might be applied to road traffic injuries. We identified 12 lessons from these infectious disease campaigns: (1) this is a cause and effect world; (2) know the truth; (3) coalitions are absolutely essential and absolutely hard; (4) avoid certainty (the Achilles heel of science); (5) measure frequently and build in continuous improvement; (6) respect the culture and work *with* the people you are trying to help; (7) the best decisions are based on the best science, but the best results, on the best management; (8) the best solutions move us closer to global health equity; (9) do not underestimate the time, resources, or tenacity it will take succeed; (10) eradication does not always require a vaccine or a cure; (11) start in the most difficult places first; and (12) you don't begin at the end. These concepts from infectious disease campaigns have broader public health applications, and we discuss some of the implications for reducing road traffic injuries.

Keywords

Disease elimination · Disease eradication · Campaigns · Surveillance · Coalitions · Health equity · Continuous improvement · Certainty · Tenacity · Cause and effect · Smallpox lessons

Introduction

The linkage of two visions has changed the world: the eradication of smallpox and the elimination of road traffic deaths, better known as “Vision Zero.” The strategy that ultimately led to the eradication of smallpox was proven effective in 1966, when Dr. William Foege was a medical missionary and faced a smallpox outbreak in Biafra, Nigeria, on the eve of civil war. The conventional response at the time was to vaccinate everyone, but this was impossible due to a vaccine shortage. He directed his team to map the spread of the disease and to vaccinate people only in villages where smallpox had already appeared and in the neighboring areas, forming a protective ring. This novel and efficient “surveillance and containment” strategy worked. Six months after the first case had appeared, no new cases were reported in eastern Nigeria. Working in relative isolation, Foege’s team developed the strategy that would eventually lead to global eradication.

In 1973, Dr. Foege, the then director of the Smallpox Eradication Program at the US Centers for Disease Control and Prevention, responded to a plea from the World Health Organization to assist them in India. For years, the Indian government, with the assistance of many outside organizations, tried to control smallpox through mass immunization. But the country’s size and enormous population, as well as the difficulty of reaching people in remote areas, had frustrated their efforts.

Working directly with government leaders, Dr. Foege helped develop a sense of urgency for addressing the disease and mobilized funding support from industries that had been affected by smallpox. He helped convince India leaders to shift from the unsuccessful mass vaccination approach to a containment strategy and then skillfully guided the surveillance and containment efforts. He knew success depended on motivating thousands of highly dispersed workers to map the incidence of the disease in more than 700,000 villages and to quickly contain the threat (Rosenberg et al. 2010). Putting his own life at risk, he carried millions of rupees in his briefcase to ensure that health workers received their salaries and stayed on the job and rode the trains across the country to keep morale among workers high until its clear eradication would be achieved.

Although the CDC encouraged Dr. Foege to stay until no new cases were reported, he purposely left India before the country was free of smallpox so the credit would not go to him. He felt that Indian officials and public health workers deserved the credit for the remarkable work they had done, and the recognition would motivate them to continue to work hard in the public interest. India went from 87,000 cases of smallpox in 1973 – more than any other country – to no cases at all in the spring of 1975 (Rosenberg et al. 2010).

This success led global health experts to believe they might achieve something that had never been achieved before: the actual eradication of a disease from every single country on the planet. In 1979, through the efforts of healthcare workers and experts across the world, the WHO did, in fact, declare smallpox eradicated (WHO 2019c). A disease that had killed millions of people had been driven from the face of the earth. This extraordinary success in smallpox eradication generated optimism and enthusiasm for eradication efforts for polio and Guinea worm. Both campaigns have made great strides, and these diseases are within reach of eradication today.

The success of smallpox eradication elicited inspiration beyond the infectious disease realm of public health. It inspired the Swedish Transport Administration to dare to declare that road traffic deaths could be completely eliminated. More than 30 years ago, the Swedish Transport Administration had to decide whether to aim for a 10% decrease in road traffic deaths or to do something bolder – something that would mobilize the energy, enthusiasm, and resources of the road safety sector, as well as public support and political will. The agency proposed the bold aim to eliminate all road traffic deaths in Sweden, to aim for Vision Zero (Ministry of Transport and Communications 1997). They saw that road traffic deaths are not a fact of life, nor are they the price we must pay for mobility in the modern world. Vision Zero's goal of no deaths on the road, combined with the dedicated leadership of Sweden, showed the world that this is not only a goal for which we should aim but also one that is possible through evidence-based interventions.

The Swedish Transport Administration helped to develop the Vision Zero policy, the goal of which was a road transport system free of death and serious injury resulting from road crashes. Designing safer roads was key to protecting road users from human error. One of their advances, for example, included substituting roundabouts for red lights at intersections, bringing the death rate down by 90% at these intersections (Robinson et al. 2000; WSDOT 2020). Vision Zero was subsequently presented in 1995 and adopted by the Swedish Parliament in 1997 (Ministry of Transport and Communications 1997; Larsson et al. 2010), sparking a movement of similar legislation in cities and countries around the world. In addition to the push behind the radical target of elimination rather than just a small risk reduction, Dr. Tingvall was essential in translating policy into practice, engaging stakeholders from private, public, and governmental sectors to work together.

Success in both safety and health can be represented by the idea of zero, whether that zero stands for zero deaths from disease or crashes or zero illnesses or injuries or collisions. We believe that there are important lessons to be learned from the history of infectious disease eradication and elimination efforts, lessons that might be applied to the field of road safety and beyond. With this in mind, we interviewed a number of disease eradication experts to hear what they thought were the most important lessons from the campaigns that they had worked on. We interviewed Drs. Walt Dowdle, Eric Ottesen, William Foege, and Don Hopkins. They shared with us lessons and stories of extraordinary work, extraordinary workers, and extraordinary numbers. We also added some of the most important lessons we had learned from our experience working with coalitions to address disease elimination and eradication campaigns. This chapter aims to share some of these lessons with the hope that these lessons can be applied, not only to future disease elimination campaigns but to the pursuit of reducing road traffic fatalities to zero, to making Vision Zero a reality.

Part I: Clarifying the Definitions of Disease Control, Elimination, and Eradication

The first and so far only human disease to be eradicated is smallpox (WHO 2019c). When this occurred in 1979, not a lot of attention had been given to strict definitions of disease eradication and elimination. Since then these definitions have been continuously evolving.

The International Task Force for Disease Eradication (ITFDE I) came together in 1993 to define these three previously ambiguous words: eradication, elimination, and control (Cochi and Dowdle 2011). They evaluated over ninety potential infectious diseases and six were concluded to be *eradicable*: dracunculiasis (Guinea worm), poliomyelitis, lymphatic filariasis, mumps, rubella, and taeniasis/cysticercosis. Further seven conditions – including one noninfectious disease – were considered *eliminable*: hepatitis B, iodine deficiency disorders, neonatal tetanus, onchocerciasis, rabies, trachoma, and yaws (Centers for Disease Control 1993).

After much reflection and discussion, they defined eradication to be the worldwide achievement of obviating the need for further control measures. In contrast, elimination involves control of the manifestations of a disease such that the disease is no longer considered “a public health problem” within a specific region. Yet, this is a fairly vague term that may not be useful to those working on the problem.

In 1997, the Dahlem Workshop on the Eradication of Infectious Disease convened to further consider the biological and epidemiological factors of infectious diseases that are susceptible to eradication (Cochi and Dowdle 2011). The principal change to the previous set of definitions was the clearer distinction between the types of elimination and the addition of extinction. The definitions are (Cochi and Dowdle 2011):

Control – the reduction of disease incidence, prevalence, morbidity, and mortality to acceptable levels

Elimination of disease – the reduction to zero incidences of disease in a defined geographic area

Elimination of infection – the reduction to zero incidences of infection caused by a specific agent in a defined geographic area

Eradication – the permanent reduction to zero worldwide incidences of infection caused by a specific agent

Extinction – achieved once the specific agent no longer exists in nature or the laboratory

Over time, attitudes toward the feasibility and relevance of extinction of pathogens changed. Reasons for the shift in attitudes include the thought that in post-eradication, certain pathogens would inadvertently become potential bioterror agents if routine immunization and surveillance were discontinued. This is supported by the inability to account for all stocks and specimens containing pathogens, as well as the

sophistication of modern genomics and molecular biology techniques which now allow for in vitro synthesis of infective agents (e.g., poliovirus) (Cochi and Dowdle 2011).

A second International Task Force for Disease Eradication (ITFDE II) was constituted in November 2000 to assess the progress over the past decade and to review the potential eradicability of the previously selected infectious diseases (Cochi and Dowdle 2011). While the definitions remained unchanged, measles was added to the list of possible diseases for eradication. The most recent meeting evaluating the definition and disease considered to be eradicable or eliminable took place in Frankfurt in August 2010 (Cochi and Dowdle 2011).

Aside from the official set of eradication and elimination definitions, some find other renditions to be clearer. Walt Dowdle, for example, finds:

the terms national, regional, and global eradication [to be] much more powerful and meaningful than ‘elimination’. Moving from national to regional to global eradication is a logical and defensible progression. Moving from “elimination” to “eradication” means crossing a huge, but artificial, barrier. (Dowdle, W. Interview by Mark Rosenberg, 2014)

Similarly, Dr. Foege suggested the use of global eradication, national eradication, and personal eradication (Foege, W. Interview by Mark Rosenberg, 2014). Clarity is necessary, yet it remains important not to become fixated to the point of inaction.

Part II: Twelve Lessons from Infectious Disease Campaigns

These 12 lessons were gleaned from our own experience and from conversations with leaders involved in past and current eradication and elimination campaigns. The lessons are not meant to be prescriptive. In fact, many – if not most – of the lessons learned became more apparent in retrospect than they were at the time the campaigns were initiated. As Walt Dowdle pointed out, “you never know until you get there” (Dowdle, W. Interview by Mark Rosenberg, 2014).

Lesson 1: This Is a Cause and Effect World

If We Understand the Causes, We Have a Chance to Change the Effects

We can use science to understand the causes, and if we understand the causes, we can intervene to improve the outcomes. Using the scientific method means that we look at the evidence and that we assess the evidence and use it to answer four basic questions:

1. What is the problem?
2. What are the causes?
3. What works to prevent this?
4. How do we do it or implement it?

Seeing that disease eradication is even possible helped us to set new targets that we had never before dared to declare. Knowing that this is a cause and effect world also helps us appreciate the idea of agency. Diseases do not disappear by chance. Disease eradication does not happen by chance. None of these things *just* happen – they happen because someone has set an objective saying we *want* it to happen. They happened because time, energy, and lifework are dedicated to achieving the goal.

A belief in cause and effect also brings about activism and optimism. Thus, if we understand the science, it is cause for optimism because it means we *can* change things in this world and change them for the better. For the first time, eradication meant that we can aim for and hope to achieve reductions in disease levels that we rarely thought possible before.

Science – both biological science and social science – can help us understand the conditions that are necessary for a disease to be eradicable. The conditions are different for elimination but those, too, can be defined. The ITFDE identified three groups of factors that determine the conditions and possible success of a disease eradication or elimination program (Hopkins 2013):

1. **Scientific feasibility** – The factors affecting scientific feasibility include epidemiological vulnerability of the disease; availability of effective and practical interventions; the lack of an animal reservoir for the disease; and demonstrating successful elimination of the disease in a particular area. Other factors include the cost-effectiveness of eradication versus elimination or control programs; benefits of eradication in terms of reducing morbidity and mortality compared to other health interventions; the ability to coordinate with other health programs; and the potential effects of control programs on the health system.

For smallpox this meant that there was a proven effective vaccine with an easy means of administering it. Although vaccine standards were not initially in place when the final push toward eradication was begun, they were subsequently developed; infected individuals were easily detected because of their multiple blisters, fever, and malaise; people who were immune were visibly marked by multiple scars left by the disease or a single scar at the site of their vaccination. There were also no latent infections beyond a 2-week incubation period and no animal reservoir, and the virus could not survive in the environment.

2. **Political will/popular support** – Societal and political commitment is essential, as well as the capacity for financial, managerial, and technical support. Disease eradication programs should not bypass or compromise existing health systems and attempts should be made to expand benefits to health services beyond the limited impact of eradicating the target disease. The government must commit support with a willingness to sustain the effort until the campaign has been successful.
3. **Sufficient resources** – Eradication, elimination, and disease control campaigns require resources. As such, ensuring sufficient resources lined up or a plan to get the resources necessary for the job is key. Mobilization of adequate resources may require clarifying the perceived burden of the disease, not only including the number of deaths but also the number of persons affected and how they are

affected during the acute and subsequent phases; this includes but is not limited to the long-term disabilities, stigma, and mental health impact. It is rare that the true burden of a disease is accurately perceived. This total burden of disease suggests the benefits expected to accrue from eradication. The distribution of the costs and potential benefits among the population is relevant to both rich and poor countries.

It is also valuable to quantify the expected cost of eradication, especially in relation to the perceived burden of the disease. There may also be a synergy of eradication efforts with other interventions that should be noted. And finally, the accumulation of costs and benefits over a relevant time period should be taken into account. In the case of smallpox eradication, the smallpox vaccine was inexpensive and donated free of charge to the program by the Russians (Henderson 2009; Hotez 2017). It could be administered in a single dose that seemed to produce protection from the disease.

Lesson 2: Know the Truth

Knowing the truth first requires us to understand the problem. This is the lesson of the saying sometimes – but without proof – attributed to Albert Einstein: “If I had only one hour to save the world, I would spend fifty-five minutes defining the problem, and only five minutes finding the solution” (Einstein quote). For Foege, knowing the truth means knowing “the state of things—in the real world, honestly. You need to know your enemy. In the case of smallpox, you needed to know the disease and where the virus was. You needed to be able to pinpoint its positions at any one time”. Organizations have resources, cache, and networks that can be used to address many types of public health programs. For public health, this means surveillance. As Foege shared, “Surveillance is intelligence gathering and it should be complete, accurate, and honest” (Foege, W. Interview by Mark Rosenberg, 2014). Our experience with smallpox and polio eradication efforts furthered our understanding of surveillance – both as to how crucial it is and how it should be done. In turn, strengthening our surveillance systems allowed us to identify, understand, and define new strategies against diseases that not been adequately controlled in the past.

Continuous Reassessment Has Collateral Benefits

Surveillance systems, in addition to requiring continuous evaluation and improvement, also require indefinite replacement in order to detect the possibility of future disease recurrence. This requires ongoing data collection, analysis, and response. This has the additional benefit of creating a system that may have the additional ability to detect other infectious and noninfectious problems. For example, the surveillance system established by the polio program became the major source of surveillance for the Guinea worm eradication campaign (WHO 2014), and this same system was later used in efforts to control Ebola.

The Closer You Get to Elimination, the Closer You Have to Look; the Closer You Look, the More You See

The story of polio eradication also taught us that what we surveil, even for the same disease, constantly changes. For example, when the polio vaccine was first developed and deployed, public health personnel thought that since the disease produced by polio was an acute flaccid paralysis (AFP), it would be easy to count the cases of polio by looking for cases of AFP. The effectiveness of vaccination campaigns could then be monitored by looking for all cases of AFP and seeing if the number of these cases was going up or going down. While there were other causes of AFP – usually due to other types of viral infections – these were rare in comparison to the cases of AFP due to poliovirus. As such, the overall number of cases of AFP was indeed a good indicator for tracking the success of the polio vaccination programs. However, once a large number of children had been vaccinated in a particular area and the number of cases of AFP caused by the poliovirus was markedly decreased, the percentage of acute flaccid paralysis due to the other previously “rare” viruses became significant. At this point, AFP was no longer a useful indicator of infection by poliovirus. Here a new lesson became clear: *the closer you get to elimination, the closer you have to look.*

Scientists now had to look for evidence of poliovirus infection by testing each case of AFP for evidence of infection. As scientists looked more closely, they found significant numbers of persons infected with the poliovirus, but without AFP. The prevalence of asymptomatic carriers meant that surveillance now had to be looking for the virus itself. That, too, was not enough, as it also turned out that the virus is excreted in feces and could survive in sewage. Now environmental sampling of sewage was needed to know that the poliovirus was not lurking in a given area where individuals could be infected. Another lesson gave rise: *the closer you look, the more you see.*

It turned out that not only did the poliovirus live in sewage, or in contaminated fecal samples that might be stored in a laboratory, but some types of live viruses used in vaccines could actually mutate and revert to virulent viruses that could actually cause the disease – creating a new subset of now-monitored disease, vaccine-derived poliovirus cases. This ultimately led to changes in the formulation of the vaccines, with the hope that if only killed viruses were used in the vaccine, they would no longer be capable of mutating and causing disease. More experience keeps leading to new insights and improved strategies. The endgame of this eradication campaign gets more and more complicated and difficult as we get closer to eradication and learn more and more about the virus and vaccines.

Surveillance Is Useful for Tracking More Than Just the Number of Cases

In the case of vaccinating populations against smallpox or treating large populations with drugs to treat and prevent the neglected tropical diseases, it also became clear that surveillance was necessary at many different stages. Initially, surveillance was focused on searching for cases. But after that it was necessary to do surveillance to track the population that had been vaccinated or treated. Surveillance also provided

the epidemiologic data to define risk groups, to assess the effectiveness of vaccine or preventive treatments, to monitor adverse events, and to assess the effectiveness of different treatments and interventions.

Be Open and Honest with Your Data Even When That Might Be Risky

It is important to know the truth even when there is a risk that it might endanger your campaign. Information collected has also been used to undermine a public health campaign. When Dr. Foege first arrived in India to help oversee the smallpox eradication efforts, he saw that mass vaccination, the traditional smallpox strategy, was not working. Despite the best efforts of the Indian government, they could not vaccinate everyone and could therefore not achieve complete coverage of the population. There would always be susceptibles and enough of them to keep the disease going. Foege switched the strategy to one that would (1) focus on places where there were active outbreaks of smallpox and (2) vaccinate everyone in those areas. They would contain the population of towns and villages where there was active smallpox and not let anyone leave until everyone had been vaccinated. If anyone had been exposed to smallpox and then left, they would go find them, bring them back, and vaccinate that person and all of their contacts. People would be “contained” in these areas for 30 days until either they became sick and recovered or died or until they had been vaccinated and became immune. This was called the “containment strategy” (Foege 2011). Applying this containment strategy also meant that active and thorough surveillance was needed to identify every town or village with an active case of smallpox. For it was in these places that the containment strategy would have to be applied. But after only several months of applying the containment strategy, the Minister of Health (MoH) for the Indian state of Bihar went to Dr. Foege and wanted to stop the containment approach (ibid.). This would have to be stopped, the minister declared. This alarmed Foege who then asked the minister “why?” The minister replied that when Dr. Foege had arrived, when the containment program began, there were 85,000 known cases. Now, he said, the improved surveillance showed there were 125,000 cases (ibid.). “Clearly,” the MoH said, “your strategy is making the problem worse and you will have to stop it” (ibid.). Fortunately, they were allowed 30 more days to turn the problem around, and in that time the containment strategy was working, and the numbers started heading down.

Establish a Very Clear Goal and a Mechanism to Certify That You Have Reached It

Surveillance is also needed to confirm that an eradication or elimination goal has been achieved. This demands precise definitions and clarification of the program goals and a degree of rigor. An important mechanism for certifying that the elimination or eradication goal has been reached is the appointment of an independent commission that is able to collect credible and accurate information and can then certify that the goal has been achieved.

To date, 156 cases of wild poliovirus were reported in 2019, 128 of which were within Pakistan and the remaining 28 within Afghanistan. Nigeria, the third and only remaining polio-endemic country – in addition to Pakistan and Afghanistan – has the

Nearly there

Polio eradication by country

■ Endemic ■ Polio-free (not certified) ■ Polio-free (WHO certified) ■ No data

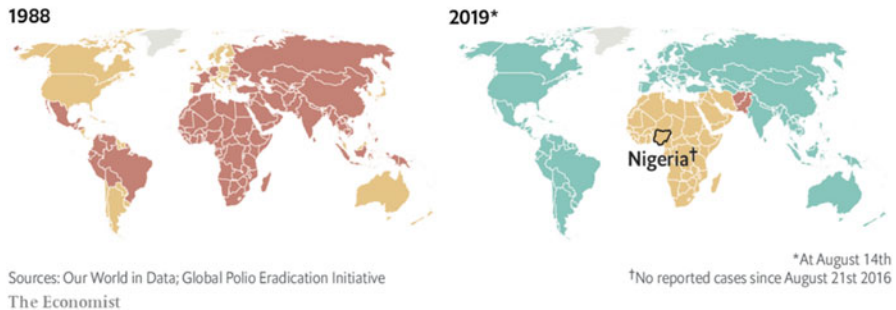


Fig. 1 Economist (updated August 21, 2019)

possibility of being certified polio-free in 2020. While circulating vaccine-derived poliovirus remains to be a challenge, with 249 cases reported in 2019, it is estimated that over 1.5 million lives have been saved and 16 million cases of paralysis averted since the onset of the polio eradication initiative in 1988 (Global Polio Eradication Initiative 2020) (Fig. 1).

Lesson 3: Coalitions Are Absolutely Essential and Absolutely Hard

The possibility of eradication rests on the ability to bring multiple stakeholders together; in effect, the ability to form a coalition. Indeed, solving any large-scale global health problem today requires effective coalitions. And effective coalitions require the following: (1) a clear, overriding common goal; (2) a strategy for achieving that goal; (3) a structure for the coalition; (4) defined membership; and (5) effective management of both meetings and programs. Without these, coalitions will fail. In fact, most coalitions do fail to achieve their goals. A coalition is like a marriage: it is very easy to get into it but very hard to make it work. Obstacles (and opportunities) occur at every level: global, multinational agencies, regions, countries, and communities. And these obstacles to effective collaboration abound. James Austin, Harvard Business School Professor Emeritus, characterized them as the seven C's and we have added the eighth C, conflict (Austin 2000):

Culture – All of the elimination and eradication campaigns had to deal with geographic, social, and ethnic differences in culture, including North-South differences and a multitude of different languages. In addition, in the culture of global health, there was an antibusiness bias and distrust of the private sector. Business and global health also operated on different time scales: public health traditionally used decades to measure progress, while business wanted it

measured in terms of calendar quarters. The nonprofit culture of global health also doesn't like measurements because it is doing good (rather than well). There are diverse cultures at all levels.

Conflicting goals – Inadequate attention to clarifying the overriding, shared goal at the beginning of a coalition is the most common reason for the failure of a coalition.

Confusion – The confusion that arises when coalitions fail to take time to adequately diagnose and define the problem often leads to confusion about roles, responsibility, structure, and about what the problem really is.

Control – The members of most coalitions don't want to give up control. Member organizations want control, even if individual members of the coalition are willing to give it up. For these members, they reason that even if they are not going to get resources by joining the coalition, they can at least get control.

Capabilities – Coalition members want to be seen as good at everything, often reluctant to admit that others might do it better; if you don't know your own capabilities and don't want to know your weaknesses (much less admit them), then you struggle to be seen as omnipotent, and this becomes a barrier.

Competition – Competition can become a difficult obstacle when members continue to focus on "me" rather than "us." The goal for them then becomes who is the best, who has the most, and who is the biggest. There is competition for credit, power, and funding.

Costs – In many cases, we are not realistic about what things cost, limiting our thinking to what we can do with the scarce resources we have rather than define the resources we actually need; or we focus on the costs of collaboration but not the benefits.

Conflict – Shared goals are what can help to transcend politics and even bring warring sides of a conflict together. During elimination campaigns for vaccine-preventable diseases, in several countries which had ongoing civil wars, the opposing sides agreed to a truce on days that were designated as vaccination days to allow complete coverage of the entire population by vaccination teams. Partnerships are even more vital when working in areas of conflict. Insecurity remains a substantial obstacle to current efforts on polio eradication and the control of Ebola.

The critical elements of a successful coalition are simple and clear, and we can't overstate their importance.

Clear, Overriding, and Common Goal

Getting the members of a coalition to agree upon a shared goal is the most important determinant of whether a coalition will succeed. Elimination and eradication of a problem represents a clear goal that is easy to understand and measurable. These are also goals that can inspire organizations to join the effort and become active members of a coalition. When the WHO adopted elimination goals for many of the neglected tropical diseases, this stimulated new donors and new program delivery institutions to join these efforts as active participants in these campaigns.

Strategy for Reaching the Goal

Coalitions need to have a strategy for reaching their goals. It took almost 200 years after the development of smallpox vaccination, for the delivery strategy to change from mass vaccination to containment of outbreaks and vaccination only of persons exposed to active cases.

Structure

No one would suggest that an important organization could function without a structure or organizational chart. But people sometimes fall into the trap of thinking that a coalition can function without a structure. They don't realize that a coalition made up of several different organizations is *more* complex than its member organizations. It is the sum of complicated parts. The structure need not be formal and elaborate, but it needs to assign to individuals the roles that are critical to keep it functioning. And as opposed to many corporate or bureaucratic organizations where all decision-making may be concentrated in one chief executive officer, in coalitions the most effective leadership is often shared leadership, where different leadership functions – such as strategy implementation, financial accounting, advocacy, and dispute resolution – are delegated to different coalition members. The successful leader, and especially the successful public sector leader, is one who can persuade these various people able to lead these various functions to join in harmony to support a worthy goal. This requires that the players be empowered and be given credit for their contributions. This requires, in turn, that the leader or leaders involved be more orchestra leaders, intent on the results, than themselves trumpet players. Such leadership is facilitated when the goal to be attained is easily understood, when progress is easily measurable, and when the goal itself is narrow (Henderson 1999).

Defined Membership

It is important to get the right people working together. You need people who are problem-solvers looking for problems to solve. The coalition leader, too, must have the right set of leadership skills. This includes both visionary leadership and operational leadership from the person who can make things work (Foege 2011).

For several disease eradication campaigns, people and organizations came together across governmental, private, public, civil society sectors, between countries, and between international entities. Coalitions must also include the political leaders. Don Hopkins, who, for many years, led The Carter Center's efforts to eradicate Guinea worm, noted that this was a lesson learned from smallpox eradication; however, Jim Grant, a former director of UNICEF, pushed it further in his efforts to expand childhood immunizations through the Task Force for Child Survival. Hopkins shared “we pushed as far as we possibly could in Guinea Worm eradication. We have involved not just President Carter, but General Yakobu Gown and then General AT Toure, now president of Mali” (Hopkins, D. Interview by Mark Rosenberg, 2014). In India alone, smallpox eradication required mobilization of more than 250,000 workers and staff and contributions from many different countries (Foege 2011). Eradication on a global level required the participation of more

than 150 different countries and highly skilled leadership at all levels, from the WHO down to regional, national, state, and local levels (Rosenberg et al. 2010).

Multi-sectoral collaboration can be particularly challenging. Each sector may think that this problem it is not their responsibility. For example, in trachoma elimination, clean water is needed but if the water sector thinks that this is a problem that belongs to the health sector, they may not prioritize the bringing of safe water to trachoma-affected communities. Or the education officials may not think it is important to teach children the importance of using latrines and wearing shoes to protect against soil-transmitted worms. The members of a coalition will all have their own “day jobs” and may be too busy dealing with their own set of crises to spend time working toward the coalition’s goal.

Management of Meetings and Programs

Coalitions pose their own management challenges that go beyond the need for effective management of meetings and programs. Global or regional coalitions that are addressing large-scale public health problems often require that people come together, transcending politics. Most of the work on smallpox eradication took place during the cold war, and it was a global collaboration, with Russia making the offer to supply vaccine (Hotez 2017). Russia supplied the early vaccine – millions of dollars’ worth – for the Global Eradication Program (Henderson 2009; Hotez 2017). Bilateral aid donations have also been very important in other disease elimination programs. The USAID has donated hundreds of millions of dollars for NTD elimination programs; the DFID and the UK have donated millions of pounds for trachoma elimination (Solomon et al. 2016). When working on an underfunded problem in an underfunded area, the problem may be that no coalition member is eager to control it or be responsible or accountable.

Lesson 4: Avoid Certainty (the Achilles Heel of Science)

A Great Many Things Are Subject to Change as We Learn More About Them

The CDC published a guideline for disease elimination and eradication campaigns that required that potential eradication campaigns be almost certain that eradication is possible before committing to the campaign. While it is important to highlight the feasibility and overall benefit of a campaign, Dr. Foege counters that “if we had waited until we knew that we could eradicate smallpox, we never would have been able to do it” (Foege, W. Interview by Mark Rosenberg, 2014). Even if we know what to do, there is so much uncertainty, so much we do not know. The physicist Richard Feynman said that certainty is the Achilles heel of science (Foege 2013). It is quite clear now that we did not know how to eradicate polio when the WHO first committed to doing it. Now we are not certain it can be done. But it is better to try and then learn that it cannot be done, than to prematurely think that something cannot be done and create the self-fulfilling prophecy that it will not be done. As Don Hopkins asserts, “there is no getting around it. The only proof that you *can* eradicate

something is that you *have* eradicated it. . . CDC is right to want to reduce the risks that you can, but eradication is always risky business” (Hopkins, D. Interview by Mark Rosenberg, 2014).

Stay open to revisiting and revising your goal. Participation in a successful eradication campaign can also be effective in improving the morale and performance of workers in public health, although this potential benefit can also sometimes be derived from a control program. An eradication campaign requires complete surveillance, rigorous administration, and operational research to a degree that may not be necessary in a control program because the standard of success in an eradication program is unambiguous and uncompromising. Another requirement of an eradication campaign may be funding to support measures to eliminate a minor focus of disease from a country where the disease has limited impact and does not constitute a national priority. But don’t be afraid to change your goal if you learn new information or it appears that for reasons you had not foreseen, eradication or elimination would not be possible.

The potential negative effects of an eradication campaign, especially an unsuccessful one, must also be weighed. It is important to take into account the economic burden and consequences as well as the potential negative impact on broader public health programs. The possible effects of competition for scarce resources and the political implications of a campaign that fails are among the factors that should also be considered (Henderson 1999). Campaigns that succeed may also have unexpected consequences. After the successful conclusion of the smallpox campaign, “support for any new eradication effort seemed especially unlikely since the smallpox eradication programme was then being critically maligned by traditional international health planners. To them, the smallpox campaign epitomized the worst of what they characterized as anachronistic, authoritarian, ‘topdown’ programmes which they saw as anathema to the new ‘health for all’ primary health care initiative” (Henderson 2009).

Lesson 5: Measure Frequently and Build in Continuous Improvement

Don Hopkins designed and oversaw the campaign to eradicate Guinea worm and believes that it is important to “pick a handful of indices for the most important outcomes and processes that people implementing the programs can use to track their own progress or lack thereof (Hopkins, D. Interview by Mark Rosenberg, 2014). This handful of indices can focus attention on the interventions that are most important, and they can foster friendly competition. Besides showing progress, these data are useful for motivating people and for advocacy” (ibid.).

During the course of the campaign, the overarching goal – eradication of Guinea worm disease – remained constant, but the strategy and tactics would change based on what they learned. When the campaign to eradicate Guinea worm began in 1986, an estimated 3.5 million human cases were occurring each year spanning across 21 countries (CDC 2011; The Carter Center 2019). By 2019, only 49 human cases were reported, 43 of which were within Chad, 4 in South Sudan, and the remaining

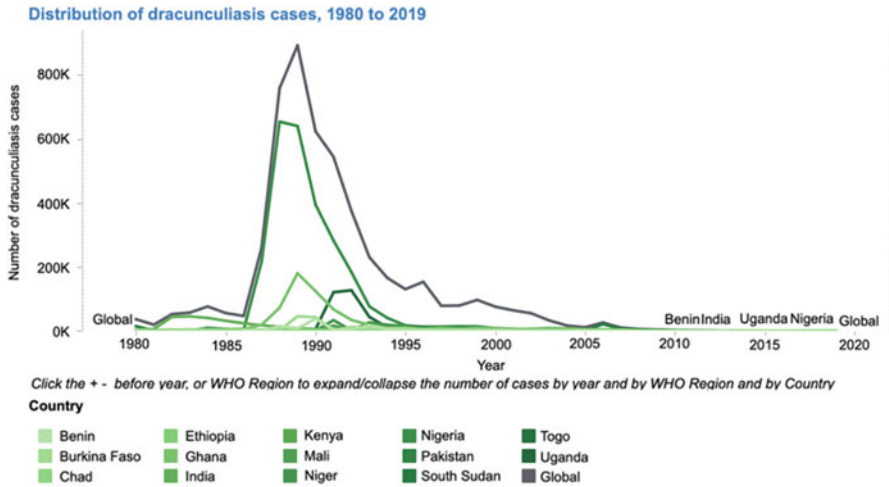


Fig. 2 (WHO 2019a)

1 in Angola (The Carter Center 2019). This was a remarkable 99.9% reduction in human cases since The Carter Center began their Guinea worm eradication campaign in 1986 (ibid.) (Fig. 2).

But after 30 years of campaigns to control Guinea worm, and just when it appeared that eradication was in sight, it was discovered that dogs could also be hosts for the Guinea worm. Dogs had previously been overlooked as reservoirs for the parasite, and it was clear that a major change in strategy and tactics would be required. The strategy for eradicating smallpox also changed as the program progressed.

Lymphatic filariasis (LF) is another one of the neglected tropical diseases, a group of deforming and debilitating diseases collectively known as the NTDs. These are diseases that for a long time were neglected because they infected “neglected people” living in poor tropical and subtropical countries. The NTDs include onchocerciasis, trachoma, intestinal parasites of children, schistosomiasis, and lymphatic filariasis. For LF, also known as elephantiasis, changes in the strategy for eliminating it also occurred as new treatments, and new diagnostic tests were developed. The main strategy for eliminating LF is treatment of those infected by mass drug administration with the goal of preventing further transmission. Using this approach, the Global Program to Eliminate LF has mobilized treatment numbers that have never been seen before [Ottesen]; since the start of the program in 2000, 7.7 billion treatments have been delivered throughout 68 countries with a target population of 910 million people (WHO 2019b). But an even broader and more effective strategy became feasible when new diagnostic tests and new treatments became available.

As we look at the history of efforts to control NTDs, we noticed a larger pattern, a meta-cycle, that we think is worth pointing out. These are very roughly stages in the evolution of the battle against these diseases. Different stages required different strategies that needed to be modified, extended, and continuously improved as more

players and resources joined the battle. Our short and greatly oversimplified history of the battle against NTDs has 8 phases:

1. **Creation** – The modern history of global health institutions began in 1945 when the WHO was born, along with UNICEF and the World Bank. It was thought that the WHO would be *the* organization to deal with global health, the World Bank would deal with poverty, and UNICEF would take care of the health of children. It was thought that these organizations would each have a clear and well-defined role, but that was not to be. Overlapping mandates often resulted in fierce competition. Defining a role for each organization and getting them to collaborate effectively in the disease elimination programs was not automatic and not easy. As noted above (Lesson 3) coalitions would be needed to facilitate effective partnerships.
2. **Donation** – Another NTD, onchocerciasis, *or river blindness*, was endemic to 31 countries within Africa and several in Latin America. Then Merck developed and tested a human version of the drug, avermectin, and they were faced with an interesting dilemma. They had a drug so good it could inhibit the microfilaria of onchocerciasis for an entire year with a single dose. But the population in need included some of the poorest people in the world. This was not a promising commercial endeavor. In October 1987, Roy Vagelos, the Merck CEO, decided to donate the drug, all that was needed for as long as it was needed. Thirty-three years later, more than 1 billion avermectin treatments have been provided free by Merck. Millions have been spared the loss of sight and even more spared the burden of itching. A coalition of partners has now made huge advancements in the reduction of onchocerciasis worldwide through mass drug administration. The disease is diminishing to the point where it has been possible to contemplate a new strategy aimed not just at control, but at elimination, first in Latin America and eventually even in the most infected regions of Africa. The Mectizan Donation Program brought Merck a very high return on this investment in terms of disease and disability prevention, employee morale, and positive company name recognition. This, in turn, has inspired other pharmaceutical companies to follow suit. And now it is not just Merck but GSK donating albendazole for control of soil-transmitted helminths (STH) and LF; J&J donating mebendazole for STH; Merck Serono donating praziquantel for schistosomiasis; Eisai donating DEC; Pfizer donating Zithromax for trachoma; Novartis for malaria and leprosy; and more. And funds are being donated for implementation by the USAID and DFID and Geneva Global and more. And for operational research, by the Bill and Melinda Gates Foundation (BMGF) and more. These donations, are rewriting history.
3. **Multiplication** – Increased donations of money and drugs led to more participation by private sector, nongovernmental (NGOs), governmental, and multilateral organizations working to eliminate NTDs.
4. **Fragmentation** – As more organizations from civil society and the private sector entered the battle against NTDs, they created a changed landscape with no focal point. Competition – for countries to work in, for resources to work with, and for credit – rather than collaboration characterized this stage. Countries were faced

with a shortage of healthcare workers, generally lacking critical skills, especially in the areas of management and finance. While this may have been a more democratic approach to global health, it also led to a change in the authority and perception of the WHO. There was a dispersion of strategy and governance and a culture of diplomacy with little accountability. This lack of coordination imposed a huge burden on the minister of health who had to deal with many multilateral, philanthropic, bilateral, nonprofit, and corporate organizations. A multiplicity of donors acting on their own contributed to the burden.

5. **Aspiration** – To make the challenge even tougher, the donations and multiplication of interested players raised hope and led the WHO to set some aspirational goals: to eliminate some of the NTDs and control others.
6. **Collaboration/integration/convergence** – It became clear that things had gotten out of control. Bringing people together from different organizations and different cultures with different needs and expectations is challenging and takes strong, but sensitive, leadership. Collaboration takes time and attention, and these are scarce resources that are often not well-managed. Participants will not commit these resources unless they see that the collaboration is worth it. Because people believe collaboration should be easy and natural, they are naïve about what it takes to collaborate successfully, and they often don't put in the time and attention needed. In the beginning of the worldwide effort to control NTDs, many donors and implementers set up parallel programs for NTD control that were not centered in country governments. That was a mistake (Fig. 3).

The impact of multiplication and fragmentation can be devastating

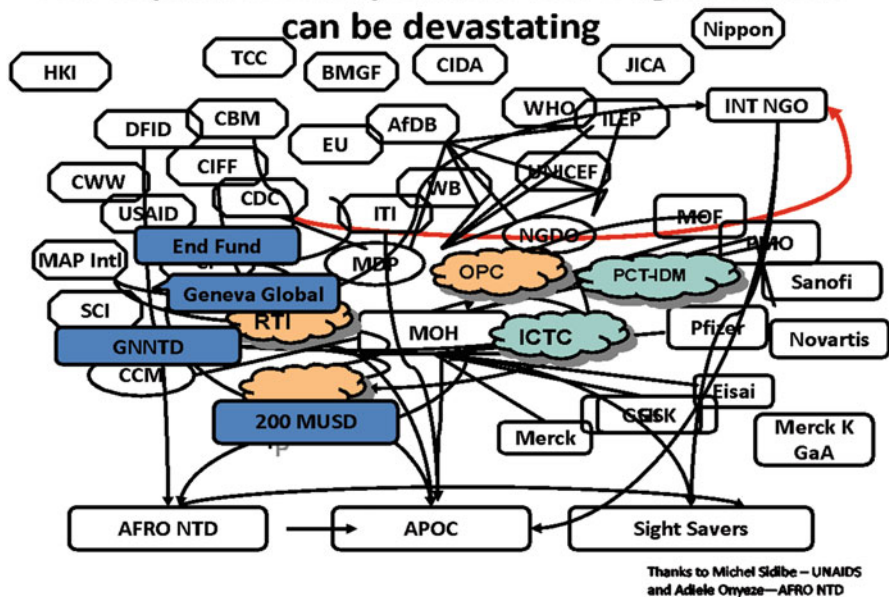


Fig. 3 Based on personal communication from Michel Sidebe and Adiele Onyze

7. **Capacitation** – Later, each country developed their own NTD master plan, and it became clear that the capacity to control NTDs must reside within country health systems. NGO and donor implementers can work alongside – not in the place of – country programs. Countries coming together will strengthen the countries’ voice and role.
8. **Elimination** – Having built the capacity to achieve elimination, states, countries, regions, and continents can certify that they reached their goal. But post-elimination plans need to be put in place. These plans should be open to continuously assessing your strategy and your progress because your world will keep on changing.

Lesson 6: Respect the Culture and Work with the People You Are Trying to Help

“If we are to succeed,” Foege noted, “it will be because in everything we do, behind every decision we make, we see the faces” (Foege, W. Interview by Mark Rosenberg, 2014). Seeing the faces means we need to remember exactly who are the people we are trying to help. We need to understand both the individuals and communities that we work with. This means respecting diversity and including those who are different from ourselves. It also means we need to understand what the theologian Dietrich Bonhoeffer called “the view from below,” the view of those who suffer from the problem and those who suffer most. Bonhoeffer said:

There remains an experience of incomparable value. We have for once learned to see the great events of world history from below, from the perspective of the outcasts, the suspects, the maltreated — in short, from the perspective of those who suffer. Mere waiting and looking on is not Christian behavior. Christians are called to compassion and to action. (Bonhoeffer 2015, p. 16)

Global health, by definition, crosses boundaries and involves the participation of citizens of multiple countries, multiple cultures, multiple languages, and many diverse people. We, coming from one culture, need to work together with partners whose knowledge and cultures complement our own. We must be respectful and collaborative if we want to be successful. When global health began in the nineteenth century, it was very much a missionary-fueled movement, where people largely from the Global North traveled to the Global South to improve the health of the people there. The missionaries did things to improve their health, and they also tried to convert people to their own religion. They did things TO the people. In the next phase of global health, it was fueled by philanthropy, and people from the Global North did things FOR the people. Today it is clear that we need to do things WITH the people we want to help. And this means we need to understand and appreciate the local culture. It is also important to recognize lingering effects of colonialism.

That said, while “respecting the culture” is important, we must go beyond to empower: realizing that every elimination intervention is, in fact, a concomitant and

essential opportunity to strengthen health systems, bring and create parity, and build cross-cultural exchanges with bidirectional (and equal) shared learning and receiving. Middle- and high-income countries stand to learn a tremendous amount from low-income countries because poverty often drives innovation and discovery (Hiatt et al. 2016).

Lesson 7: The Best Decisions Are Based on the Best Science, but the Best Results Are Based on the Best Management

The importance of good management is often undervalued, but it is absolutely essential to the success of any elimination or eradication program. The ability to actually reach your goal, to get to the “last mile,” and to deliver the results you are aiming for depends on good management. The importance of strong management with meticulous supervision cannot be overemphasized. It is not enough to just train people and send them forth to do good. It is imperative to encourage them and to ensure that they get supplies, constructive mentoring, and constructive supervision in order to keep them on target. It is also important to supplement what they have learned with training and re-training sessions (Hopkins, D. Interview by Mark Rosenberg, 2014).

Good management also means that we understand how decisions will be made. Graham Allison, a professor of political science at Harvard’s Kennedy School of Government, gave us a powerful way to understand the issues by saying we have to look at three models or levels of thinking to understand how decisions will be made (Allison 1969). The **rational model** views actions as the rational deliberation of a single solitary and strategic actor who chooses actions that are most likely to achieve a goal. This model leads us to ask what are the costs and benefits of an elimination or eradication campaign? What are the most cost-effective strategies for achieving our goal? The **organizational model** sees output as a function of “routine” rather than of “choice” and leads us to ask: How do the organizations operate that make the policy and lead the implementation? The WHO passed a resolution to eradicate polio in 1988, but essentially nothing happened for 10 years. To understand why nothing happened, a good manager has to understand the organizational dynamics. In 1988 when they passed the WHO polio resolution, the program was going so well in Latin America that they almost shamed the WHO into doing something about it. Haftan Mahler, the WHO Director General at the time, really pushed this. But the WHO staff fought it because they did not know where the money would come from, and without that it would not be possible. In addition, the WHO had signed onto the Declaration of Alma Ata, which had a goal of “healthcare for all,” and many staff said “no more vertical programs.” These staff felt that to provide primary care for all, the WHO would have to emphasize programs that addressed *all* of the most basic healthcare needs, i.e., horizontal programs. When polio came up, they had already agreed there would be no more programs that focused on a single disease like smallpox, no more vertical programs. All of these organizational factors contributed to the WHO missing their 2000 polio eradication target by more than 20 years. The

individual model sees policy as the outcome of individuals in positions who can pull strings depending on who they know. It leads us to ask: Who are the key players, how are they connected, and what strings can they pull and what levers can they push? At the WHO, the Director General, Dr. Mahler, had signed on to the Alma Ata agreement but he personally strongly supported the polio eradication campaign. And that made a very important difference.

Lesson 8: The Best Solutions Move Us Closer to Global Health Equity

Eradication is a step toward global health equity and social justice. Smallpox eradication did this. Before smallpox was eradicated, the rich countries were already rid of the disease, but the disease still percolated along among the world's poorest and most vulnerable citizens. Millions living in poverty remained vulnerable. For other global health problems as well, frequently those who continue to suffer from the diseases or public health issues that we can eradicate and eliminate are those with the fewest resources and those who are the least well-off. This is global health delivery in the pursuit of social justice, a noble calling.

The campaigns to eliminate the “neglected tropical diseases” are another good example. NTDs are widespread, disabling, and devastating diseases, and elimination means people like us will be able to see, learn, walk, and support our families. We are concerned with the suffering of others. But they are diseases of poverty, so the developed world does not see the people, bear witness to their lives, and understand their problems. Advocacy and resource mobilization for HIV/AIDS was extremely effective because the advocates were highly influential individuals affected with HIV/AIDS who lived in the USA. NTDs are diseases of neglected people who live out of our sight. As long as the high-income countries only track diseases that represent threats to their own health (like MDRTB, SARS, and influenza), they will not focus on the NTDs because they do not spread in rich countries with cooler climates and good sanitation. Therefore, we need to work even harder together to make our case, mobilize the resources we need to implement our master plans, and reach our ambitious elimination goals.

Finally, in designing and implementing disease elimination and eradication programs, it is important to achieve clarity about our values and what our goal really is. Is it to protect the most poor and vulnerable or is it to protect ourselves? The philosopher Martin Buber described two types of relationships, which can be the drivers for disease elimination and eradication campaigns. We can be concerned with others primarily as they affect us and our own security and well-being, seeing ourselves as “I” and others as “It” (Buber 1958). Or, we can view others as important in their own right and recognize that their well-being affects us because we are interconnected, and their suffering diminishes us. This latter view leads to what Buber called “I and Thou” relationships (ibid.). Our current global health security priorities are driven by “I-It” considerations: we need to protect ourselves here by controlling this disease over there. The WHO’s International Health Regulations primarily require reporting of diseases that represent cross-border threats, for

example, Ebola virus or multidrug-resistant tuberculosis. While “I-It” surveillance serves an important public health function, “I-Thou” campaigns are needed if we are to reduce health disparities, monitor progress toward global health equity, or address the complex social determinants of health in the twenty-first century. Indeed, if we value consequential compassion, I and Thou values must play a role in designing our elimination and eradication campaigns.

Lesson 9: Do Not Underestimate the Time, Resources, Tenacity, and Focus It Will Take to Succeed

Elimination and eradication campaigns always take longer than people initially thought. Looking at the extended time it has taken to eradicate Guinea worm, Don Hopkins emphasized that it is important to focus and stay focused. With respect to Guinea worm, Hopkins said he never imagined it would take this long, as he shared:

To me it was such a logical thing with just obvious benefits and an obvious no-brainer, and I didn't anticipate how much work it would take to mobilize the countries and the international agencies. That to me is the biggest surprise of all. . . . It took wearing them down, working with those groups willing to work. There were a lot of people willing to work, but results came not from standing there and butting your head against the wall of those unwilling to move but going with those who were willing to move. I thought that the results would convince the others to come along. That also took longer than I would have liked. (Hopkins, D. Interview by Mark Rosenberg, 2014)

Costs as well have been much greater than anyone had dreamed in regard to the polio campaign. Simply because the personnel needs have been quite high in the countries that require assistance for adequate surveillance and immunization coverage, also the costs for supplies – including new types of vaccine and antiviral agents that came to be required – have been greater than anticipated.

There is always a decline in coverage and interest when any country has reached its initial elimination target. When coverage is reduced in countries that have become polio-free, they are at a great risk of becoming reinfected, and that contributes to the high cost. The lack of participation in the campaign of Nigeria for several years led to virtually all of the susceptibles becoming reinfected, in very large numbers. They had not had any polio in that area for 10 years, so they kept doing the same thing, surveillance, for years, and then slowly stopped paying attention. But there were groups that were difficult to reach, and they had gone un-immunized. In other neighboring countries, endemic transmission has been cleared only to find that the virus from Nigeria has entered the country (Dowdle, W. Interview by Mark Rosenberg, 2014).

The deliberate spread of disinformation about polio case workers has generated violence against them. This slowed the polio campaigns in Nigeria and has led to the murder of some case workers in Pakistan.

Measles is a prime example of how important the social will and public trust are and what happens when that trust is lost and resistance to the elimination campaigns

gets crystallized and spread. Biomedical science only gets you so far; effective implementation in the face of human complexity can continue to be a tremendous challenge. Today, *measles* remains a leading cause of death for children worldwide. The WHO has made significant improvements to decrease that number by vaccinating over one billion children in high-risk countries since 2000, hoping to achieve measles elimination in at least five of the WHO regions by 2020. But in recent years, low vaccination rates in many areas of the USA and Europe have led to a resurgence of cases. Resistance to vaccination by groups opposed to vaccinations – given the name of “the anti-vaxxers” – has resulted in large outbreaks in several cities in North America (Benecke and DeYoung 2019).

Sometimes a variety of factors have contributed to the undermining of public trust. 1986 saw one of the biggest bovine spongiform encephalopathy (BSE) (i.e., mad cow disease) outbreaks in the UK (WHO 2010). The rise in cattle deaths led to the speculation of a circulating disease. It took time for scientists to identify the pathway of infection and etiological agent, which was later discovered to be a prion. In the meantime, lack of certainty led officials, the very people on whom the public depended, to deny any risk to human beings. In fact, in 1990, John Gummer, the presiding Minister of Agriculture, not only stated the threat BSE posed to humans was “so remote as for all practical purposes to be ignored,” he also tried to publicly feed his daughter a hamburger to assuage public concerns (*The Guardian* 2000). Sir Donald Acheson, Chief Medical Officer at the time, followed, stating on TV that there was “no risk associated with eating British beef” (ibid.). It would be another 5 years until a ban was placed on “mechanically recovered meat” (ibid.). Between 1986 and 2004, it is thought that Creutzfeldt-Jakob disease, the human BSE variant, contributed to 152 deaths in the UK (WHO 2010).

Soon after, in 1998, Andrew Wakefield published a paper in the *Lancet*, claiming a link between vaccine and autism (Rao and Andrade 2011). The wavering credibility and authority of science and health officials from the preceding years of BSE in the UK created the perfect storm for Wakefield’s claim to prevail even though his work was quickly discredited.

Today there are similar problems where the truth is not welcomed. Climate change, tobacco, and gun violence, all reinforce the importance of human factors in campaigns directed at disease elimination and eradication.

Lesson 10: Eradication Does Not Always Require a Vaccine or a Cure

If successful, Guinea worm (dracunculiasis) would be the first parasitic disease to be eradicated, and the first disease to be eradicated without a vaccine or even without a curative treatment. Guinea worm disease is spread when an individual drinks water that is contaminated by tiny water fleas that carry the Guinea worm larvae. By treating unsafe drinking water with a chemical that kills the water fleas and always filtering drinking water from possibly unsafe sources, the disease can be prevented. When an individual is infected with the larvae, they mature after about 1 year in the subcutaneous tissues of the legs or arms, reaching a length of 70–80 cm. After the

worms emerge, if that person enters a lake, pond, or well, the emergent worm can liberate larvae into the water which can then contaminate additional water fleas.

Before the recent development of an effective Ebola vaccine, some Ebola outbreaks were also eliminated without a vaccine or cure. But the idea of eradication extends well beyond infectious diseases; it is applicable to general public health eradication or elimination campaigns, such as women who die in childbirth, or deaths due to smoking, or medical errors. In this case, environmental, educational, and engineering interventions are powerful tools. It is usually not the discovery of a single magic bullet that turns the tide, but successful elimination usually depends on incremental improvements over time, as new parts of the problem are understood and new solutions are discovered. This requires a sustained commitment to research and continuous improvement.

Lesson 11: Start in the Most Difficult Places First

Don Hopkins, the architect and long-time manager of the Guinea worm eradication program, told us that:

The most difficult places will take the longest and will be the hardest, and that time cannot be bought back. It might seem better to go after the low hanging fruit first, but it's just the reverse: it's better to face the harder problems and solve them and then pick up the low hanging fruit later. Ideally, it would be done simultaneously—but that is usually not how the world works. (Hopkins, D. Interview by Mark Rosenberg, 2014)

Eliminating the problem in the most difficult places will often require the development, testing, and delivery of new and innovative approaches. These will take time, so better to get this work started earlier. In addition, there is often a limited amount of time during which the public will pay attention to an elimination or eradication campaign, but it may be possible to sustain that interest for a longer time if you can show that you are making progress even in the most difficult to reach places. If you start on only the low-hanging fruit initially, then it may be more difficult to sustain interest – of the public, of your funders, and of your staff – when you are trying to push through to the end.

Sometimes the most difficult place is not a particular geographic locale, but it is the most difficult part of the strategy, made difficult because of intense disagreement. Sometimes the decision is made to defer working out an agreement because two sides may seem just too far apart, and a discussion could threaten the survival of the coalition. But that is usually a mistake. We have found it is better to try to resolve these basic differences directly. The conversations needed to resolve these differences can be very difficult, but they are important. Frances Kissling has given very helpful advice:

Have the courage to be vulnerable in front of those we passionately disagree with. Ask what is it in your own position that gives you trouble? What is it in the position of the other that you are attracted to? . . . When people who disagree with each other come together with a goal

of gaining a better understanding of why the other believes what they do, good things come of that. . .It is very hard for all of us in these situations to acknowledge, for example, that we just don't have the answers to this problem. (Kissling 2011)

Lesson 12: You Don't Begin at the End

Be wary, Walt Dowdle said, of prematurely closing our minds thinking that we know what eradication is when we have only seen it done once (Dowdle, W. Interview by Mark Rosenberg, 2014). Smallpox has been seen as an example of eradication, but the problem is that it has been seen as the *only* example.

Smallpox was not the first disease eradication program. The Rockefeller Foundation began campaigns to eradicate hookworm in 1907 and yellow fever in 1915. Both these campaigns against diseases of humans failed: the hookworm campaign because mass treatment of affected populations with anthelmintic therapy reduced the severity of individual infections but rarely eliminated them and thus did not prevent rapid reinfection (Nuwer 2016) and the campaign against yellow fever because of the previously unknown, inaccessible cycle of disease among nonhuman primates living in forests (Soper 1963). Acceptance of the concept of eradication declined during the late 1920s and early 1930s, after the futility of the eradication of hookworm and yellow fever was recognized.

Humility and an open mind are needed because when you begin, and at almost every stage before the last mile, you can't be sure what will work and when you will succeed. The CDC's guideline requires that potential eradication campaigns must be almost certain that eradication is possible before committing to the campaign. But as Don Hopkins noted earlier, "The only proof that you *can* eradicate something is that you *have* eradicated it" (Hopkins, D. Interview by Mark Rosenberg, 2014). And there is no way to know that at the beginning. You will not know it until the end.

The Lessons from Disease Eradication and Elimination Apply to Road Traffic Safety

We believe that all of these lessons are relevant to the elimination of road traffic injuries and can be useful in the development and the application of Vision Zero.

1. This is a cause and effect world
2. Know the truth
3. Coalitions are absolutely essential and absolutely hard
4. Avoid certainty, the Achilles heel of science
5. Measure frequently and build in continuous improvement
6. Respect the culture and work *with* the people you are trying to help
7. The best decisions are based on the best science, but the best results on the best management
8. The best solutions move us closer to global health equity

9. Do not underestimate the time, resources, or tenacity it will take to succeed
10. Eradication does not always require a vaccine or a cure
11. Start in the most difficult places first
12. You don't begin at the end

These lessons are not as much about the behavior of infectious agents as they are about how to understand problems, develop strategies, and successfully apply those strategies to solve those problems.

Claes Tingvall has been a pioneer in applying the idea of elimination to road traffic injuries and in spearheading the development of a standard for the management of road traffic safety systems; he has focused our attention on the importance of good management (ISO 2012). He has pointed out that there are interventions – such as traffic circles – that have been so effective that they have been called “vaccines for roads” (Rosenberg 2007). The biggest changes have been in road design, infrastructure designed to reduce the number of crashes by widening and straightening roads. Recent efforts to reduce road traffic injuries have aimed not just to decrease the number of crashes but to decrease the number of fatalities and serious injuries. The body has crash tolerance limits; they should not be exceeded. As soon as the driver loses control, the infrastructure should take over to mitigate the seriousness of the crash, for example, by clearing trees and boulders from the sides of roads and installing side barriers; it is kinetic energy control.

As Vision Zero is adopted by more and more governmental and non-governmental organizations, the value of applying elimination to road traffic injuries is proving its worth. Barriers and roundabouts and design for pedestrians have become increasingly important in improving road safety. The idea of a “shared space” between pedestrians and vehicles was trialed successfully in Gothenburg and other cities, as long as the environment is redesigned for slow traffic. Two-lane roads – the real killers – were also adapted into roads with two lanes in one direction and one lane in the opposite direction, the 2+1 system. But the real trick was to install a crash barrier between the lanes, saving approximately 50 to 60 fatalities per year.

Conclusion

The lessons above highlight the importance of partnership, leadership, strategic planning, as well as compassion, focus, determination, and, above all, perseverance. The thoughts shared from these disease eradication and elimination experts go beyond disease. Compassion moves us to seek to eliminate suffering as much as is humanly possible. We understand the perspective of those “down below,” in the words of Dietrich Bonhoeffer, and we know that those who continue to suffer from the diseases or public health issues that we can eradicate and eliminate are

those with the fewest resources and those who are the least well-off. This is global health delivery in the pursuit of social justice, a noble calling.

Every eradication or elimination campaign, however, will learn much more as it progresses. It is important to capitalize on this opportunity for continuous improvement by creating, from the beginning, a strong research component, including a research agenda, and strong links between the research community and the operational challenges facing the implementers.

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Zero-Waste: A New Sustainability Paradigm for Addressing the Global Waste Problem

40

Atiq Zaman

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Abstract

There is a growing interest in addressing global waste problems by applying innovative ideas and philosophies such as zero-waste and circular economy. As a new sustainability paradigm, zero-waste challenges the common assumption of waste as a valueless and unavoidable by-product created at the end of the product's life phase. Instead, it acknowledges that waste is a "misallocated resource" or "resource in transition"; produced during the intermediate phases of production

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and consumption activities. Waste should be recirculated to production and consumption processes. Therefore, zero waste means no “waste” would be wasted under the circular economy system. This chapter presents various examples of zero-waste practices derived from family, community, business, and city levels. In addition, zero-waste implementation strategies and actions are also discussed in the chapter. Despite its potential, the visionary zero-waste goals cannot be achieved without responsible global stewardship and active citizens’ role.

Keywords

Zero-waste · Consumerism · Sustainable design · Waste diversion · Value hill · Circular economy

Introduction

With a growing interest and raising awareness of sustainability, waste has become one of the focal points of sustainable urban development. Yet, it is still one of the least priority areas for allocating budget and necessary infrastructure in many countries around the world. Millions of people’s livelihoods in various parts of the world depend on collecting and recycling waste. According to the World Bank’s report, around USD 205 billion was spent on waste management worldwide in 2010, and it is predicted that the cost will increase to USD 375 billion by 2025 (World Bank 2012).

Despite technological advancement and engineering solutions, one-third of the global waste is managed in environmentally unsafe manners such as littering, open dumping, open burning and unsanitary landfill, etc. (Kaza et al. 2018). Globally, around 85% of the collected waste is sent to landfills, including uncontrolled landfills and open dumping, and only 15% of the collected waste is recycled (Zaman 2016). To date, the landfill is the leading waste management option because of the low management cost (Hoorweg and Bhada-Tata 2012). Although the actual environmental cost of landfill is significantly higher, unfortunately, the traditional market-driven economic system often ignores the environmental costs of the pollution caused by landfills (Eriksson et al. 2005).

Plastic waste pollution is a major environmental concern since 79% of all plastics we generate are ended up in some form in the environment through land or water. These plastics will continue to pollute the environment for hundreds of years as plastics’ decomposition rate is generally prolonged. It was estimated that the emissions from plastics in 2015 were equivalent to nearly 1.8 billion metric tons of carbon dioxide (CO₂), and it will reach 17% of the global carbon budget by 2050 (Zheng and Suh 2019). The recent discovery of the Great Pacific Garbage Patch illustrates the level of long-term pollution and damage occurring in our marine environment.

Urbanization and overconsuming lifestyle trends are the key challenges related to sustainable waste management (Zaman and Ahsan 2019). Cities expand horizontally

and vertically to accommodate many people every year (Ahsan and Zaman 2014). According to the UN report, the global urban population has increased by a factor of five, from 0.7 billion in 1950 to 3.9 billion in 2014, and it is expected to increase by another 60 percent by 2050 (UN-DESA 2014). At the same time, global consumption of natural resources could almost triple to 140 billion tons a year, as predicted by the United Nations (SMH 2011). A study indicates that, even with a more aggressive sustainability growth scenario and a drastic waste reduction in intensity by 30%, the global “waste peak” will occur after 2075 (Hoornweg et al. 2014). This indicates that even with our best intention and efforts, the waste generation will continue to increase until the end of this century.

Therefore, a paradigm shift is urgently needed to address the ever-growing global challenges. China was once seen as a global hub for receiving and treating a significant amount of waste from different parts of the world. Since the China Waste Ban (24 different categories) in 2018, countries worldwide are experiencing significant challenges to manage waste locally. Innovative ideas and solutions are urgently needed to overcome the current waste crisis. This book chapter presents a critical analysis of the emerging concept of “zero-waste” as a new sustainability paradigm for addressing the global waste management system’s core problems.

The Anatomy of Zero-Waste

The term “waste” is commonly referred to as the valueless by-product that emerges at the end of life phase, and the substance needs to be disposed of or incinerated for proper management. The concept of zero-waste directly challenges the common assumption of waste as a valueless and unavoidable by-product created at the end of the product’s life phase. Zero-waste acknowledges that waste is a “misallocated resource” or “resource in transition” which is produced during the intermediate phases of production and consumption activities, and thus, it should be recirculated to production and consumption processes through reuse, recycling, reassemble, resell, redesign, or reprocess (Zaman and Ahsan 2019). Zero-waste does not see “waste” as a substance that must be disposed of or incinerated but considers waste as a resource that should be used repeatedly (Glavic and Lukman 2007).

The Zero Waste International Alliance (2018) defines zero-waste as “the conservation of all resources through responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health.” This implies that zero-waste as a concept is a target for transforming waste management systems towards a “circular economy,” where extraction, production, and consumption become increasingly waste-free. Zero-waste doesn’t mean that we would not create any “waste” in the transition of resource extraction, production, and consumption. Rather, it means no “waste” would be wasted under the circular economy system.

Zero-waste is a vision, a target, and an aspiration to progress towards sustainable management of waste. The underpinning principle of zero-waste is retaining the

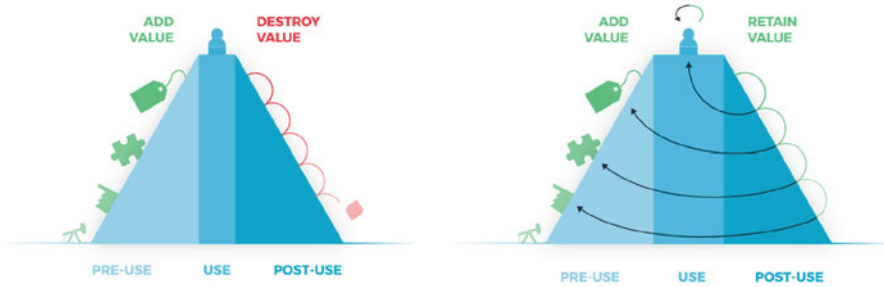


Fig. 1 The value hill as a business strategy tool. (Credit: Achterberg et al. 2016)

value of products instead of depleting the value of the resources. The value retaining strategy proposed by Achterberg et al. (2016) is presented in Fig. 1.

According to the value hill concept, value is added while the product moves “uphill,” and circular strategies keep the product at its highest value (top of the hill) for as long as possible. The circular design is one of the fundamental principles to apply during the pre-use or the design, production, and distribution phase of a product. “Tophill” is about the optimal use of resources-circular design, and sustainable consumption would be a useful tool. “Downhill” is about value recovery, which involves the post-use phase of a product. Instead of disposal of end-of-life products to landfill, the resource would be recovered during the post-use phase at the optimum level possible (uphill to downhill).

The Development of Zero-Waste Concepts

The term “zero-waste” was coined by Palmer (2004) in 1973. Since the late 1990s, the concept has attracted much public attention. Many cities around the world, such as Adelaide (Australia), Dubai (UAE), Milan (Italy), San Francisco (USA), Tokyo (Japan), Vancouver (Canada), Wales (UK), and so on, are working towards zero-waste cities. Besides, several organizations such as Adidas, Ethique, Procter & Gamble, Subaru, Unilever, etc. have adopted the concept of zero-waste by setting zero-waste disposal targets. The Australian Capital Territory (ACT) Government released the “No Waste By 2010 – Waste Management Strategy for Canberra” in 1995, which was the first initiative that a government anywhere in the world had set such a challenging goal for waste management (Connett 2013, p. 303; Snow and Dickinson 2003, p. 5). Unfortunately, the “No Waste Bill” and the zero-waste targets were unsuccessful as the proposed implementation time (5 years) seemed to be unrealistic.

The zero-waste movement in New Zealand was started by establishing the Zero Waste New Zealand Trust in 1997 (Zaman and Ahsan 2019). The Trust voiced a goal of creating “a closed-loop materials economy; where products are made to be reused, repaired and recycled, an economy that minimises and ultimately eliminates waste”

(Tennant-Wood 2003). In 2000, Del Norte County, California, took on the first comprehensive zero-waste plan in the USA. In 2001, the California Integrated Waste Management Board adopted zero-waste goals as strategic waste management plans (Connett 2013, p. 307). Table 1 summarizes the key milestones and events about zero-waste development.

The Enigma of Consumerism, Environmental Degradation, and Zero-Waste

Apparently, continuous technological innovation, easy access to goods and credit, low prices, online shopping, and ongoing cycles of advertising and marketing cycles all reinforce the way of life called “consumerism” (Aspin 2012, pp. 8–10). This is usually defined as a “way of life and state of mind” where activities associated with consumption become a means for establishing social position and expressing individual identity (Smart 2010, pp. 7–10). The core of our modern world’s economic system is founded on the principle of consumerism of the mass population. Let us explore what we mean by consumerism and why it is essential and related to zero-waste.

In the pre-modern consumerism era, the consumption of luxurious goods and services was only available to affluent people. However, consumerism is not limited to wealthy people anymore; it is for everybody. Initial signs of consumerism include high demand for sugar in the late Middle Ages (one of the early mass consumer goods); household furnishings (beds, cloths instead of straw mattress) in the early sixteenth century; and tea and fashionable clothing at the end of the seventeenth century (Stearns 2006). According to Stearns (2006), although there was an explosion of shops and new marketing methods in the eighteenth century, which played a significant role in consumerism, it was a shopkeeper and his methods that anchored the first iteration of a consumer society (p. 16).

Shopping become an important cultural activity among the “elite” people in the eighteenth century, and the industrial revolution brought more variety in the clothes and household items and not only for the affluent elite but also for the ordinary people in the Americas and Europe (Crocker 2017; White 2009). After the post-world wars era, consumerism was mainly driven by “economic consumerism” to stimulate economic growth and ensure a good living standard (Crocker 2017, p. 10). The global economic growth model is founded on a linear material flow, i.e., “take-make-disposal” approach, whether the “planned obsolescence” is the primary principle for repetitive shopping of “waste ready” products. Planned obsolescence, i.e., designing a product for a limited useful life, is one of the biggest drivers to make products more affordable for mass people and somewhat influence economic development. Along the way, various marketing strategies and approaches such as “big is better” or “buy now pay later” were inherent in our modern consumer culture. In the 1950s, plastics appeared to be the “magical” material to produce “waste ready” single-used products. It would be challenging to find a product nowadays that doesn’t use plastics in the product’s supply chain (Zaman and Ahsan 2019).

Table 1 The key milestones and events on zero-waste development (Zaman and Ahsan 2019)

Year	Country	Milestones/events
1970s	USA	The term “zero-waste” was coined by Paul Palmer
1986	USA	The National Coalition against Mass Burn Incineration was formed
1988	USA	Seattle introduced the pay-as-you-throw (PAYT) system
1989	USA	The California Integrated Waste Management Act was passed to achieve 25% waste diversion from landfills by 1995 and 50% by 2000
1990	Sweden	Thomas Lindquist introduced the “extended producer responsibility”
1995	Australia	Canberra passed the “No Waste by 2010” bill
1997	New Zealand, USA	The Zero Waste New Zealand Trust was established The California Resource Recovery Association (CRRA) organized a conference on zero-waste
1998	USA	Zero-waste was included as guiding principles in North Carolina, Seattle, Washington, and Washington, DC
1999	USA	The CRAA organized zero-waste conferences in San Francisco
2000	USA	The Global Alliance for Incinerator Alternatives was formed
2001	USA	GrassRoots Recycling Network published “A Citizen’s Agenda for Zero Waste”
2001	Australia	Towards Zero Waste Action Plans, WA vision for Waste 2020
2002	New Zealand, USA	The book <i>Cradle-to-Cradle</i> was published Zero Waste International Alliance was established The first zero-waste summit was held in New Zealand
2004	Australia, USA	ZWIA gives a working definition of zero-waste GRRN adopts zero-waste business principles Zero Waste SA was established in South Australia
2008	USA	The Sierra Club adopted a zero-waste producer responsibility policy
2012	USA	The documentary film <i>Trashed</i> premiered at the Cannes Film Festival The Zero Waste Business Council was established in the USA
2017	USA	Zero Waste Development and Expansion Act of 2017
2018	China	From 1 January 2018, China banned importing 24 categories of solid waste. China stopped importing plastic for recycling by setting the acceptable contamination level at 0.05 per cent – compared to the up to 10 percent it previously accepted
2018	Global (C40, UK)	Twenty-three global cities and regions advance towards zero-waste. This commitment will avoid the disposal of at least 87 million tons of waste by 2030
2018	Australia	The Australian governments set 100% packaging targets, i.e., Australian all packaging be recyclable, compostable, or reusable by 2025
2019	Australia	The Australian governments has banned waste export to overseas countries
2019	Singapore	Singapore has designated 2019 as the year towards zero-waste
2020	N/A	Apple’s all established final assembly sites are Zero Waste certified
2021	Italy	ABB Smart Power’s manufacturing in Frosinone, Italy has achieved the zero waste to landfill goal — 14 years ahead of the European Union’s Circular Economy Package target

People are obsessed with changing or upgrading their “almost new” gadgets because there is a newer and a little more “fancier” version available. However, both would perform similar or identical functionality. People find “pleasure” in consumption and try to establish a social identity in a diminished social value system. On the contrary, economic growth doesn’t always ensure a similar level of human subjective well-being as promised to deliver. The current overconsumption trends are mainly driven by technological innovation, fashion, deferral pricing, corporations, branding, and marketing strategies (Crocker 2013; Princen et al. 2002; Slade 2006). Over time, these influential factors contribute to product obsolescence and repetitive consumption practices, which are the core cause of generating excessive waste and depleting natural resources.

Clothing is an excellent example of how consumer culture significantly impacts the environment. Like America and Europe, Australia’s obsession with new clothes and “fast fashion” textiles is hurting the environment significantly like America and Europe. Australia’s obsession with new clothes and “fast fashion” textiles seriously hurts the environment (Pepper 2017). A T-shirt retails in America often travels over 10,000 miles, and most of the distance (88%) travels during the production (mainly in Asia) and distribution phases (Xing et al. 2016). As consumers, very few of us truly realize how our consumption choice, even for a single T-shirt, impacts people’s livelihood and the environment in the distant parts of the world.

On average, Australians dispose 6000 kilograms of fashion and textile waste every 10 minutes. Only 15% of it is sold again locally in opportunity shops, and the rest 85% ends up in landfills (Wynne 2017). The moment we throw our clothes and consumer goods into the waste bins, it becomes somebody else’s problem. The realization of the impacts from waste through greenhouse gas and leachate contamination in landfills is not easy and fun to do.

Given various contexts, how does zero-waste tackle these challenges? The zero-waste concept recognizes that the current linear economic model which is based on consumer culture is not sustainable. Thus, an alternative economic model such as a circular economy model is necessary, which will ensure “custodian citizen” to promote sustainable consumption, material circularity, and conserve the natural environment. Since zero-waste identifies waste as materials in transition, it favors the repetitive use of resources instead of burning and burying forever. The following sections present the zero-waste practices worldwide from an individual level to a city level.

Zero-Waste Practices Around the World

Zero-Waste Family

We have seen several occasions where people or a family live without producing a notable amount of “waste.” Although most cases are published through social media and blog, they can be regarded as aspirations that people are trying to achieve after

realizing how our way of life is depleting the environment. Some families in California (Johnson 2013), Phoenix (Mlynek 2018) in the USA, and Tasmania in Australia and many other places in the world are trying to live without creating any waste. In all these families, one thing is common: they have embraced the zero-waste challenge and are working towards the aspirational zero-waste goals. Bea Johnson and her family, living in Mill Valley, California, USA, is one of the most renowned zero-waste practitioners in social media who has adopted the zero-waste lifestyle since 2008. After living a decade on the zero-waste lifestyle, the outcome is extraordinary concerning well-being, and she states, “We not only feel happier, but we also lead more meaningful lives based on experiences instead of stuff” (Zero Waste Home 2018).

Zero-waste practices in families worldwide give a mixed message (needs to be vegan, sacrificing lifestyle, etc.) because the practitioners maintain different enthusiasm levels considering the practicality under the current system. Zero-waste requires transforming our existing system concerning product design and shopping system, which is not entirely equipped to achieve zero-waste goals. Thus, under the current situation, zero-waste practices could mean differently to families. Moving towards zero-waste lifestyles requires individual or family commitments and the necessary supporting infrastructure, for example, packaging-free bulk grocery shops. In recent years, packaging-free zero-waste shops are growing in numbers in many cities.

The most common practices that the zero-waste families are conducting are:

- Focusing on needs instead of desire when it comes to consumption and shopping
- Avoid shopping single-used goods (bottled water, bags, utensils, etc.)
- Avoid shopping goods with unnecessary packaging and buy bulk with reusable/refillable bottles/jars and from local growers
- Reuse non-compostable items such as jars, bottles, cloths, etc. as much as possible
- Mindful about what to buy and how it would contribute to waste generation and seek alternatives
- Recycle whatever cannot be reused
- Composting all organic materials in the household

Considering only municipal solid waste, achieving zero waste goals would be tough and challenging to achieve zero-waste goals, even though several families have shown how they live by creating only a jarful of waste in a year instead of three different bins full of waste every week. However, it is also essential to acknowledge that they achieved that because of their extreme dedication and desire to change their lifestyle, which may not be valid for mass people. It is also expected that almost all notable zero-waste families live in stand-alone houses with gardening and composting facilities. It may not be possible to maintain the same outcome if one lives in an apartment block without any composting facility. This affirms that systemic changes in personal, social, and infrastructural are needed to achieve the zero-waste goals.

Kamikatsu, Japan: A Zero-Waste Community

Kamikatsu Community

Kamikatsu is a small town in Japan located in Katsuura District. Kamikatsu is hilly and dominated by a range of mountains higher than 1000 meters above sea level. A total of 1556 people (in 2018) live in 788 households with a higher ratio of female than male (1:1.1) (Kamikatsu 2018). Over half (50.3) of the population is over 65 years old, and one-quarter of the population is over 85 years old (Suzuki, 2018). There is no formal door-to-door waste collection system from the local authority; thus, the local community is responsible for collecting and managing their waste.

Although waste was predominantly managed through open burning, the restriction of open burning and the mandate for recycling in the early 1990s forced the local community to sort recyclable from non-recyclable. Even the waste-to-energy plant was shut down due to a high level of dioxin pollution and to meet Japan's pollution reduction target, encouraging the community to look for an alternative solution to manage waste more sustainably. In 2003, Kamikatsu considered zero-waste as part of its waste management policy, aiming to be a 100% zero-waste town by 2020 (Sakano 2017).

Kamikatsu Zero-Waste Declaration

Kamikatsu was one of the first towns in Japan to declare the zero-waste goal in 2003. The aspects of Kamikatsu Zero Waste Declaration are (ZWA 2018):

- Kamikatsu will strive to foster ecologically conscience individuals.
- Kamikatsu shall promote waste recycling and reusable resources to the best of its ability for eliminating waste incineration and landfill by 2020.
- Residents of Kamikatsu shall join hands with people around the world for ensuring a sustainable global environment (Table 2).

Zero-Waste Practices at the Kamikatsu Community

Zero Waste Academy (ZWA) is a local organization working towards achieving zero-waste goals by changing people's mindsets, actions, and social systems to make zero-waste Kamikatsu (Sakano 2017). Under the zero-waste strategies, 100% of all organic waste is composted at home either with the traditional home composting method or an electric composting machine. The local government subsidizes the composting devices' cost as this will help reduce organic waste volume. Each household and store are responsible for washing, sorting, and delivering their trash to the recycling center (Hibigaya Waste Station) (Fig. 2).

Household waste sorting is one of the biggest challenges to recovering materials from waste. In many countries and cities in Europe and North Americas, waste is

Table 2 The key waste management milestones at Kamikatsu. (Adapted from ZWA (2018) with permission)

Year	Options	Brief descriptions
Before 1990s	Informal disposal/open burning	The absence of formal waste collection leads to open burning and informal disposal of household waste
1991–1995	Open incineration with alternative options	Subsidies for the household composter, formation of the Kamikatsu Recycle Town Plan, along with open incineration
1997	9 segregation categories	Commenced separate collection of wastes under the National Recycling Act (clear, brown, and other colored glass bottles, aluminum cans, steel cans, spray cans, milk cartons, incineration waste, bulk waste)
1998–2000	22 segregation categories	Concern about dioxin pollution from the incineration and increasing the sorting categories from 9 to 22
2001–2015	34 waste categories	Shut down small incinerators and increase sorting categories from 22 to 34 to improve recycling efficiency. Volunteer group “Recycle Kamikatsu” helped transport waste from households to the collection center
2016–2017	45 segregation categories	Renewed the Resource Segregation Guidebook for residents Established the Zero Waste Accreditation system

Fig. 2 Sorting options for various resource types at the waste station. (Courtesy: Akira Sakano, Zero Waste Academy, Japan)



sorted into several categories: paper, plastics, metals, glass, electronic waste, organic waste, etc., depending on the local management infrastructure's availability. Local people at Kamikatsu sorted waste into 45 different categories (Sturmer 2018). There are 13 main categories, and under each category, there are several subcategories to sort waste based on their characteristics. For example, cans are subcategorized as aluminum, steel, and spraying cans; glass bottles are subcategorized as clear, brown, other, and returnable glass bottles. These subcategories require a higher level of knowledge and understating of waste sorting and recycling issues to recycle correctly. Table 3 shows the waste categories at Kamikatsu.

Table 3 Waste sorting categories at Kamikatsu

Number	Main waste sorting categories	Waste sorting subcategories	Potential use
1	Reusable	Reusable items	Second-hand shop
2	Organic	Organic waste	Home composting
3	Metals	Aluminum cans Steel cans Spray cans Metal cans Scrap metals	Aluminum products Steel products Metal products Metal products Metal products
4	Papers	Newspaper flyers Cardboards Magazine scrap paper Paper cups Paper carton with aluminum Hard paper core Shredded papers Other papers	Newspaper Cardboards Recycled paper Recycled paper Recycled paper Cardboards Recycled paper Refuse paper and plastic fuel (RPF)
5	Cloths	Biodegradable cloths Other cloths	Second-hand shops RPF
6	Firewood/fuel	Chopsticks wood Master oil	RPF Compost fodder
7	Plastics	Clean plastic packaging Dirt plastic packaging (squeeze pack) Styrofoam trays (white) Styrofoam PET bottles PET bottle caps	Plastic products, RPF RPF Styrofoam trays RPF Cloths Plastic products/RPF
8	Glass	Clear glass bottle Brown glass bottles Other colored bottles Reusable glass bottles	Clear glass bottles Brown glass bottles Glass bottles Reuse
9	Mixed product	Other glass, potteries Mirrors, thermometer Light bulb, fluorescent tubes Dry batteries Discarded batteries Lighters	Based course material Mercury & glass wool Mercury & glass wool Metal products Lead Metal products
10	Bulk products	Large metal products Bulk wooden product Beddings, mattress, etc. Large/bulk PVC/rubber products	Metals RPF RPF Incineration
11	Mixed items	PVC, leather products, etc. Diapers and sanitary napkins	Incineration Incineration
12	Shells	Shells	Landfill
13	Home appliances	Discarded tires Specific home appliances	RPF Recycled by each producer/brand

All individuals in the community are responsible for taking their waste to the recycling center. A significant proportion of the community is very elderly people, and an intermitted waste collection system is offered once every two months. The local community needs to sort their non-organic waste into 45 different categories. Still, they also need to meet the recycling requirement, such as properly sorting, cleaned, and dried, which is also true for the residents outside of Kamikatsu. If waste is not properly cleaned and separated, it is not picked up (Sturmer 2018). After 15 years of implementation of the zero-waste practices in Kamikatsu, the town currently recycles around 80% of its waste, and the remaining 20% that can't now be processed – things like nappies and certain types of plastics – gets sent off to be incinerated (Garfield 2018; Sturmer 2018).

At the beginning of the zero-waste program, the community found the zero-waste practices were challenging and time-consuming. A survey in 2008 showed that around 40% of residents were still unhappy about at least one aspect of the zero-waste policy, which is washing each recyclable item before sending it to the recycling center (McCurry 2008), which has become a norm after a decade-long practice. According to Akira Sakano, Chair, the Board of Directors of the Zero Waste Academy, the sheer inconvenience of the process can act as a deterrent to excess consumption in the first place. The detailed categorization can make people start thinking about what they should buy, how much, and when, i.e., beginning of the problem (Garfield 2018).

Zero-Waste Business

Adidas: Zero-Waste Sporting Project

As part of its sustainability initiative, Adidas has partnered with “Parley for the Oceans” – an organization working for the ocean’s ecosystem. Adidas launched a zero-waste sporting project called “Sport Infinity” in 2015 with a plan for a new breed of sporting goods that will never be thrown away. The Sports Infinity project has the potential to be recycled endlessly and combined into new products through a closed-loop supply chain of sports products (Adidas-Group 2015).

Adidas-Parley’s AIR approach is to avoid (A) through reducing and replacing materials with sustainable ones, intercept (I) through retrieving and recycling problematic materials such as plastic waste from the ocean, and redesign (R) through creating a new industry standard (Parley 2018). In 2016, around 740 tons of plastic pollution were collected by the partnership organization “Parley for the Oceans” from the Maldives, Indian Ocean, to turn plastic waste into yarn (Parley 2018) (Fig. 3).

The recycled plastic yarn is used to produce shoes and t-shirts, and the target was to produce one million shoes using ocean plastic (McCarthy 2018). Each pair of sneakers takes 11 plastic bottles to make, which could mean that Adidas will recycle 55 million plastic bottles in 2018 if they hit their projected sales. Adidas wants to make all products from recycled plastic by 2024 (WMC 2018). Adidas has started to produce shoes made from reclaimed and recycled ocean trash (Borchardt 2017).



Fig. 3 Converting ocean plastic into yarn. (Parley (2018), with permission)

The Zero-Waste Stores to Phase -Out Unnecessary Packaging

In recent years, zero-waste stores have been opened up aiming to minimize the environmental impact by phasing out unnecessary packaging (Moss 2019). Plastics waste seems to be one of the biggest environmental changes for humanity due to its adverse pollution to the environment. However, unnecessary packaging is a common practice that can be easily avoided through zero-waste thinking. Over 36% of all plastics are used for packaging (Geyer et al. 2017); therefore, reducing and phasing out unnecessary plastics packaging through zero-waste make more sense than the traditional business model. Understandably, people who would like to implement zero-waste practice in everyday life need the necessary support infrastructure, such as zero-waste stores within their close proximity. The zero-waste shops offer consumers reusable containers and refill the required products ranging from oil and shampoo to cereals. A significant proportion of packing waste can be avoided through these alternative shopping practices. Another benefit of buying unpackaged items from the zero-waste store is that one can buy the amount the person or the family needs, which may not always be the case for prepacked supermarket stores. As a result, a significant proportion of foods and groceries are wasted in households due to over-shopping. Figure 4 shows an example of unnecessary packaging (left) and a zero-waste shop.

Zero-Waste City: The Case Study of San Francisco, USA

Waste Management in San Francisco

San Francisco is one of the world's leading cities that has considered zero-waste as its core waste management manifesto. In the UN-HABITAT (2010) study of solid waste management in the world's cities, San Francisco has been identified as one of



Fig. 4 The examples of unnecessary packaging (left) and zero-waste shop (right). (Sources: Flickr Creative Commons)

the most resourceful cities in waste management services. However, San Francisco has a long history in waste collection systems, from informal waste recycling in the early twentieth century to today's modern collection systems. Homeless and jobless poor people mostly drove informal recycling in the early 1930s as a means of survival. This was also seen in the last global economic crisis in 2008–2012. San Francisco has successfully transformed its waste management system by integrating informal waste recycling activities with formal waste management systems.

The composition of MSW waste in San Francisco includes organic (34%), paper (24%), plastic (11%), glass (3%), metal (4%), and miscellaneous (24%). Household hazardous waste is included in municipal waste, and, therefore, hazardous waste is also managed by the local waste management authority. A total of 508,323 tons of MSW (609 kg per person per year) was generated in 2008, making San Francisco one of the world's highest waste-generating cities. MSW is primarily managed by recycling (52%) and composting (20%), and the remainder of the waste (28%) is managed by landfills. The landfill waste in San Francisco has consisted of 31% organics, 23% paper, 23% C&D, and 23% other inert (SF Environment 2019), which indicates that with a proper system, the recycling rate can be improved further.

Over time, San Francisco has adopted various policies and strategies around waste management and zero-waste. In regard to waste services, San Francisco predominantly depends on a single service provider. Recology collects waste from households and public waste bins and transports it to the central material recovery facility (MRF). Figure 5 shows the schematic waste management systems in San Francisco.

Regulatory Policies and Zero-Waste Strategies

San Francisco has an effective and successful implementation of waste management policies and strategies. The notable policy can be outlined back to the Scavengers

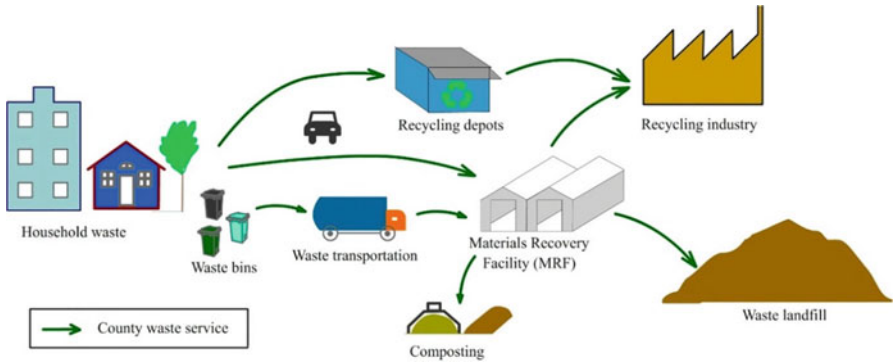


Fig. 5 The material flow of waste management systems in San Francisco

Protective Union’s formation in 1879 (Perry 1978, p. 19). Since the nineteenth century, San Francisco has been visionary and supportive of environmentally friendly solutions. Thus, in 1987 the community opposed incinerator as a solution, instead enforcing community recycling and curbside collection systems. In 1988, San Francisco set a 32% reduction in the city’s waste stream by 1992 and 43% by 2002 (US-EPA 1993).

The sustainable waste management strategy in San Francisco started in 2005 when the city initiated the UN Urban Environmental Accords, which include zero-waste, manufacturer responsibility, and consumer responsibility under the Waste Reduction Accord (City of Berkley 2005). San Francisco has adopted a range of regulatory policies to ensure maximum resource recovery from waste by integrating many stakeholders’ involvement, including local businesses, local governments, and communities.

The first zero-waste strategy was adopted in 2005 under the Urban Environmental Accords to achieve a waste-free city by 2020. As a result, San Francisco achieved an 80% diversion rate (residential and commercial) and 61% diversion rate (equivalent to Germany’s 62%) of municipal solid waste in 2012 (MacBride 2013). Undoubtedly, achieving zero-waste in the future is an ambitious target. It involves product manufacturers and consumers to ensure that all discarded materials are diverted from landfill. Realizing the challenges of zero-waste, San Francisco updated the zero-waste goal at the Global Climate Action Summit, in September 2018, to these two pledges:

- Reduce municipal solid waste generation by 15% by 2030 (reducing recycling, composting, and trash)
- Reduce disposal to landfill and incineration by 50% by 2030 (reducing what goes in the black trash bins)

Table 4 shows the critical milestones of municipal waste management policies and strategies in San Francisco

Table 4 Key milestones of municipal waste management systems in San Francisco

Year	Milestones in WMS	Goal and focus
1879	Scavengers Protective Union	The union protects the scavengers' right and promotes recycling
1932	Refuse Collection and Disposal Initiative Ordinance	Waste collected only by license holder: waste service provider (Recology)
1970	Community recycling center	Community recycling centers promote recycling activities within the city and involve local people
1981	Curbside waste collection	Collect recyclables from the community by the systematic curbside collection system
1987	Suspension of Incineration Plant	Incinerator for waste management deferred due to environmental pollution
1988	Waste Diversion Targets	Visionary diversion targets for higher recycling and less landfill
2003	Extended Producer Responsibility Resolution	Ensure producers' responsibility on the end-of-life product
2004	Fantastic Three Program	Promote higher sorting efficiency and recycling rate
2004	Green Building Ordinance	Requires city construction to manage waste and provide adequate recycling storage space in buildings
2005	Urban Environmental Accords	Visionary zero-waste strategy, producer, and consumer responsibility
2006	C&D Debris Recovery Ordinance	Requires C&D projects to use city-registered transporters and processing facilities to increase debris recovery
2006	Food Waste Reduction Ordinance (extended in 2016)	Requires restaurants and food vendors to not use Styrofoam food service ware and instead use foodware that is recyclable or compostable
2007	Plastic Bag Reduction Ordinance	Requires the use of compostable plastic, recyclable paper, and/or reusable checkout bags by supermarkets and drugstores
2010	Mandatory Recycling and Composting Ordinance	Everyone is required to separate and put their recycling, composting, and trash in the right place
2010	The Alameda County Landfill Ban	Alameda does not receive any contaminated recyclables to promote recycling and zero-waste
2012	Extended Bag Reduction Ordinance	Reduction of single-use plastic bags and promotion of reusable shopping bags
2014	Bottled water legislation	Restricted sale or distribution of drinking water in plastic bottles of 21 ounces or less on city property
2018, 2019	Plastics, Toxics, and Litter Reduction Ordinance	The Single-Use Foodware Plastics, Toxics, and Litter Reduction Ordinance aims to: Reduce plastic pollution by prohibiting the distribution of plastic straws, among other foodware accessories, and providing allowed accessories only upon request Eliminate toxic fluorinated chemicals from foodware products
2019	Zero-waste events	The event producers in San Francisco must do at least one of the following:

(continued)

Table 4 (continued)

Year	Milestones in WMS	Goal and focus
		Provide, lend, or sell reusable beverage cups to event attendees Promote or incentivize attendees to bring their own reusable beverage cup
2020	Compostable foodware requirements	Starting 1 January 2020, straws made of natural fiber or paper and all other compostable foodware sold in San Francisco must be certified by the Biodegradable Products Institute (BPI). Examples of compostable foodware include: Grease-resistant paper Paper plates To-go containers and straws made of paper or other natural fiber

One of the critical zero-waste drivers for San Francisco is the city’s strong commitment to the precautionary principle and visionary strategies. Various regulatory policies and strategies have shaped the current waste management performance, such as Refuse Collection and Disposal Initiative Ordinance, curbside collection, Fantastic Three Program, landfill ban, food and plastic waste reduction, and so on. The zero-waste challenge in San Francisco is reflected in the solid waste systems support for reducing consumption, maximizing diversion, and encouraging reuse, repair, and green purchasing. Banning troublesome goods such as plastic bags and superfluous packaging and promoting alternatives such as recyclable or compostable takeout food packaging and reusable transport packaging are the most prominent initiatives for achieving zero-waste goals in San Francisco (UN-HABITAT 2010).

Implementation of the Zero-Waste Strategies

Based on the discussion presented above of various waste management challenges and by analyzing the current zero-waste practices in family, business, and urban scale, this chapter proposes several zero-waste strategies and exemplary action plans which could be useful to implement zero-waste principles. The listed strategic elements presented in the below table were identified in the author’s previous study (Zaman 2017) through a perception survey of the waste experts. Table 5 summarizes the guiding principles as the zero-waste framework elements (in no particular order). Four selected groups of stakeholders (national and state governments, local government, community and family, and industry) are analyzed based on their relevance and importance (low, medium, and high) of the action plans in Table 5.

Table 5 presents overarching zero-waste strategies in the context of the relevance for various stakeholders. It is apparent from Table 5 that the local governments seem to be the most relevant, followed by industry and local community and individuals. It is important to acknowledge that the proposed strategic elements and action plans are

Table 5 The strategic elements for the zero-waste and the relevance for stakeholders

Phases	Strategic elements	Action plan	Example	National/ state	LGA	Community/ individual	Industry
Waste prevention and reduction	Effective public awareness and education on plastic waste	Inclusion of waste education program at the school curriculum	Primary school	H	M	M	NA
		Organize promotional awareness program on plastic waste avoidance and reduction	Plastics hackathon	H	H	H	H
	Zero plastic waste program	Hands-on training and knowledge-sharing program	Crafts and design	L	M	M	M
		Sustainable packaging and consumption practices	Avoid unnecessary packaging	H	M	H	H
	Sustainable and responsible living	Citizen initiatives through responsible shopping and consumption behavior	Buy loose items	NA	NA	H	M
		Promote local farmers market	Pop-up shops	L	M	H	M
	Shared-ownership of product & service	Collaborative consumption	Borrow/resell	L	L	M	L
		Owning services than products	Renting instead of owning	H	H	H	H
	Zero plastic waste products	The designing for reuse	Cradle-to-cradle product	M	NA	NA	H
		Alternative use of plastic waste	Storage container	NA	L	M	NA
	Extended producer responsibility	Mandatory take-back scheme for producers	Swap	M	L	L	H
		Container deposit scheme	Return	H	H	H	H
	Extend the life of post-consumer items	Resell and repair	Gumtree/eBay	NA	NA	M	L
		Men's shed or community resource center	Men's shed	NA	H	M	NA

Waste management and treatment	Appropriate waste infrastructure (centralized and decentralized)	Promote complete recycling market	H	H	M	H	Green procurement	H	H	M	H
		Mandatory 3 bin	NA	H	NA	FOGO	NA	H	NA	NA	NA
		Plastic sorting infrastructure	M	M	NA	Optical/density sensor	M	M	NA	NA	M
		Take-back points	NA	H	M	Reverse vending	NA	H	M	M	H
		Community, precinct-based drop-off points	NA	H	M	Drop-off point	NA	H	M	M	NA
		Social business for plastics recycling	L	L	L	SMEs	L	L	L	L	M
		Reuse, repair, and recycle through community participation	NA	L	M	Community business	NA	L	M	M	NA
		Improved policy	H	NA	NA	100% packaging	H	NA	NA	NA	H
		Polluters pay principles	L	H	M	PAYT scheme	L	H	M	M	NA
		Incentives for green initiatives	H	H	L	Green procurement	H	H	L	L	M
Monitoring and assessment	Restrictions on WTE technology	Interim use of WTE	H	M	NA	Temporary use	H	M	NA	NA	
		A 100% plastic waste diversion from landfill	H	H	H	100% diversion	H	H	H	H	
		Refund, landfill levy, etc.	H	H	H	10c/levy	H	H	H	H	
		A mandatory online data collection system	H	H	M	Online platform	H	H	M	M	
		Zero plastic waste research collaboration	H	M	L	National/international collaboration	H	M	L	L	
		Research on zero plastic waste	H	M	L	National/international collaboration	H	M	L	L	
		Standardized data collection systems	H	H	M	Online platform	H	H	M	M	
		Economic incentive	H	H	H	10c/levy	H	H	H	H	
		Landfill ban for plastic waste	H	H	H	A 100% plastic waste diversion from landfill	H	H	H	H	
		Restrictions on WTE technology	H	M	NA	Temporary use	H	M	NA	NA	

Fig. 6 Steps in the zero-waste action plan (Zaman 2017)



contextual and may not be applicable to all countries, especially in both developed and developing countries. Thus, the development and application of zero-waste strategies need an explicit consideration of the locality's local needs and priority areas. The strategic elements should be implemented by following both short-term (i.e., 5–10 years) and long-term (i.e., over 10 years) action plans. Cities that consider zero-waste practices worldwide indicate that achieving a 60–80% waste diversion from landfills is achievable within a short period of time. San Francisco (USA), for example, diverted 80% of the waste from landfills in 7 years (2005–2012), and Novara (Italy) achieved a 70% diversion rate within 18 months when the zero-waste program was initiated (Connett 2010). However, diverting the remaining 30%–20% of waste from landfills is the biggest challenge because of inappropriate design and poor recycling practices. Therefore, appropriate product design and responsible consumption and recycling behavior are crucial for achieving a 100% waste diversion rate.

Three steps (clockwise) of implementing action plans are presented in Fig. 6, which are (i) pre-assessment or evaluation of waste management system for benchmarking, (ii) implementing zero-waste programs, and (iii) post-evaluation of the waste management performance against benchmarking study.

Conclusion

The vision for zero-waste and zero-waste cities is not only a new sustainability paradigm for addressing the global waste problem, but at the same time, it is also very challenging to achieve. Zero-waste requires a long-term commitment and active

participation from all relevant stakeholders including producers, consumers, and regulatory bodies. Similar to climate change issues, the skeptic would have different views on the zero-waste agenda. However, implementing zero-waste practices seems beneficial not only for the environmental aspects and for creating new business and economic momentum. Already global 23 cities (C40 Cities 2020) pledge to advance towards zero-waste cities by:

- Reducing the municipal solid waste generation per capita by at least 15% by 2030 compared to 2015
- Reducing the amount of municipal solid waste disposed to landfill and incineration by at least 50% by 2030 compared to 2015 and increasing the diversion rate away from landfill and incineration to at least 70% by 2030

The change is inevitable as the pollution from waste is significantly damaging to the environment. Education and awareness are the first aspects of working towards zero-waste. The second crucial aspect is the industrial transformation of product design and manufacturing. In recent years an influx of global initiatives has been observed mainly to tackle plastic packaging waste. Andrew Forrest (mining giant in Australia and the founder of Munderoo Foundation) has committed to USD 300 million and several big companies to end worldwide plastic waste (Munderoo Foundation 2019). Similar initiatives and commitments are needed from the world-leading manufacturers and retail brands. Finally, global citizens' role is also an essential aspect because zero-waste is not about managing the waste, but mainly about not creating it in the first place during the consumption process. Therefore, without responsible global stewardship, the visionary zero-waste goals can never be achieved.

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