

The Worldwide Approach to Vision Zero: Implementing Road Safety Strategies to Eliminate Traffic-Related Fatalities

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Published online: 28 April 2017
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Abstract

Purpose of Review This review describes the principle of Vision Zero in traffic safety and its adoption into the worldwide community. The Vision Zero policy seeks to reduce fatalities and serious injuries from road traffic accidents to zero. This review aims to show how this philosophy has affected policies and prevention strategies throughout the world.

Recent Findings The Vision Zero policy has been adopted throughout Europe as well as Australia. It has recently been adopted in the USA in many major cities with preliminary encouraging results.

Summary This article defines the Vision Zero model and demonstrates how multiple countries have implemented and adapted the vision. We review its origins in Sweden with its eventual adoption within Europe, the UK, and Australia and its recent acceptance by several cities within the USA. We reflect on shortcomings, challenges, and its future directions.

Keywords Vision Zero · Injury prevention · Vulnerable road users · Road safety · Traffic-related fatalities

Introduction

Traffic-related deaths and injuries are a major burden of disease worldwide. It often affects the young and healthy. No country is spared from this type of health problem. The World Health Organization (WHO) estimates road traffic injuries to be the ninth leading cause of death across all age groups globally at 1.25 million deaths per year and is predicted to rise to the seventh leading cause of death by 2030. It is the number 1 cause of death among those aged 15–29 years [1]. Road traffic injuries contribute to the largest portion of global injury mortality and surpass violence-related and war-related fatalities combined. It is estimated that 20 to 50 million people are seriously injured or disabled each year due to road traffic crashes [1]. Traffic injuries also affect countries in different economic ways with poorer countries having greater loss in disability-adjusted life years (DALY) and higher-income countries have a greater financial burden. The USA is ranked number 1 with the greatest financial loss in the world [2].

Vision Zero (VZ) is an evolution of road safety policy. It explores how the traffic environment can be altered to accommodate for predictable errors and prevent people from being subject to non-survivable physical forces. The goal of VZ is to have no fatalities or serious injuries within the transportation system. It is an ethical approach to road safety that calls for greater participation of multiple stakeholders such as road users, system designers, vehicle industries, public health professionals, and local governments. In this vision, road users are expected to demand safety from government and industry. The VZ philosophy shifts a larger responsibility of road safety to industry and system designers. System designers are encouraged to consider changes to infrastructure that result in safer driving practices and prevent harm to vulnerable road users. Vulnerable road users are defined as persons expected

This article is part of the Topical Collection on *Injury Prevention*

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to use streets or highways in conjunction with vehicles such as pedestrians, cyclists, and motorcyclists. VZ urges the vehicle industry to create safer cars and incentivize safer driving behaviors. Road safety stakeholders are pressured to alter the kinetic energy (*speed*) allowed within the system. The aim of VZ is to design safer infrastructure and vehicles and implement education and enforcement policies that prevent deaths within the transportation system [3]. The main emphasis for this philosophy accepts that humans will make mistakes, but challenges the traditional thinking that these events will unavoidably result in some major injuries or deaths.

Since its implementation and success in Sweden, VZ or analogous policies have spread throughout Europe and Australia. The principles of VZ have also been actively adopted by several cities across the USA [3]. This review concentrates on how VZ has been adopted and implemented throughout the world and explores the successes and challenges in meeting the goal of zero traffic-related deaths.

History

Road safety is not a new idea. Traffic-related injuries and fatalities became a major problem since the late nineteenth century [4]. One of the first recorded British laws restricted riding on foot paths and prohibited drinking while in charge of a carriage. In the early twentieth century, driver behavior became the focus of traffic safety. Drivers were encouraged to obey driving rules, signs, and signals and avoid alcohol intoxication while driving.

By 1922, the concept of the three Es: education, engineering, and enforcement was developed by a Kansas City insurance broker, but this was directed at safety practices within industry not the transportation system [4]. In the mid-1920s, a more formalized approach to traffic safety was introduced by US Secretary of Commerce Herbert Hoover. Although automobile manufacturers began to implement safety features such as brake lights and safety glass, they also maintained that accidents would be largely affected by regulation and law enforcement that focused on driver behavior and the driving environments [5]. In the 1930s, the USA required drivers to have formal driver's education, to take tests, and to be licensed. During the same time period, car marketing highlighted speed and horsepower. This remained a major marketing strategy until the 1960s. The industry suggested that higher speeds might be safer since motorists could escape dangerous situations more quickly [5]. In the 1950s, car crashes were deemed inevitable. Research in this era showed it was safer for drivers to be restrained, dashboards to be padded, and vehicle door latches to be stronger. It was not until 1968 that mandatory three-point restraints were installed in all new cars [5]. In the 1970s and 1980s, government policies focused on vehicle safety features that reduced rollovers and provided

restraint and airbag requirements. US government-sponsored safety campaigns managed to increase compliance with seat belts from 20 to 80% between the 1970s and the 1990s [5].

In 1988, the Volvo Traffic Safety award went to a group of international researchers who published on the global burden of traffic injuries and outlined strategies for accident prevention. The authors predicted the burden of injury would likely double in the year 2000 if new safety measures were not implemented. In that year, 500,000 people died worldwide and 15 million people were seriously injured from traffic collisions [6]. This publication was notable in its advocacy of tackling traffic safety as a public health problem in contrast to an isolated transportation issue. Since the advent of the vehicle, human error in judgment has been attributed to the result of traffic accidents and, in much of the world, this attitude persists [7]. Many current safety measures continue to focus on changing the behavior of individuals as opposed to evaluating the role of the transport system and its interaction with road users.

Operational Strategies of Vision Zero

A core component of VZ is the division of responsibility in providing traffic safety. Traffic safety should be shared with road users and system designers [7]. Street and vehicle design have shown to contribute to over half of all fatalities [7, 8]. The VZ policy emphasizes that speed is likely the most critical feature contributing to fatalities. The central ideas of VZ began as a Swedish policy initiative and are listed in Table 1. The operational strategies of VZ can be organized into four main points: political or governmental commitment, recognizing the contribution of vehicle speeds in their respective driving environments, vehicle designs and safety features, and encouraging the involvement of diverse community stakeholders who want to see a safer traffic system [10].

Government Commitment

The success of VZ has largely been attributed to how it was implemented in Sweden. Government and political commitment mobilized a diverse group of stakeholders to tackle safety in a completely different way. Fatalities in the road system were blamed on the system design as opposed to the road user. Government had a serious stake in road user outcome. The Swedish government laid out short- and long-term action plans. These plans engaged multiple stakeholders ranging from road engineers, public health safety analysis, education for the public on road user responsibilities, quality assurance in transport work, empowering the technology sector, and exploring forums for financing new roads and infrastructure [10].

Table 1 Central ideas of Vision Zero

1. Traffic injuries are preventable, not accidental.
2. Experts from all sectors including road users shared responsibility for road safety.
3. Transportation systems should be designed and accommodating to common road user's errors to prevent death or major injury.
4. Humans should not be subjected to kinetic forces that can fatally harm or seriously injure.
5. Traffic safety is a social equity issue.
6. Assistance from high-income to low-income countries should adjust for local conditions and needs.
7. Prevention strategies should take into consideration local practices and knowledge, not just professional guidelines^a.

^aBergh et al. [9]

Vehicle Speed

A key cornerstone for most traffic safety programs is having road users remain within speed limits. For VZ, the goal of reducing speeds is adjusted to all other road users within transport system. Safe travel speeds should be determined in respect to their environments. Road speeds are directly and proportionally related to the rise in transferred kinetic energy, which results in more injuries and death [9, 11]. Pedestrians struck at speeds between 15 and 20 mph are more likely to survive than those struck at speeds over 30 mph. In urban environments, the presence of intersections with vulnerable road users should be considered. For example, pedestrian crossings provide signal priority but do not, in and of themselves, protect pedestrians. The reduction of vehicle speeds at these locations determines the safety provided to pedestrians [11].

In rural or highway driving, roadsides and land separation are considered when adjusting for recommended vehicle speeds. Intersections with possible side impacts between cars should have speed limits no faster than 30 mph. Roads with possible frontal impacts should not have speeds faster than 45 mph. Common driver behavior patterns should be taken into consideration, such as car overtaking in the setting of highway driving and speeding. Highway designs can affect these behaviors. In fact, a major finding is that the widening of roads and highways contributes to fatalities because drivers increase their speed [9].

Design and Safety Features

The vehicle design and its safety features are known contributors to road user safety. Comprehensive fatality investigations have divided crashes into three groups: crashes of excessive force, excessive risk, and violation of system restrictions [10]. Crashes of excessive force can be mitigated by speed limits; air bags; vehicle technologies, such as intelligent speed

limiters; or possibly automated vehicles. Excessive risk involves either the lack of or non-use of personal protective devices such as seat belts or helmets. Countermeasures involve education or vehicle-initiated reminders. Those road users who violate the system restrictions are targeted by law enforcement or the installation of alcohol ignition locks [10].

Safety System Stakeholders

The final operational strategy of VZ calls for creating a system where safety responsibilities are shared with all stakeholders. Professionals that contribute directly or indirectly to road safety should be engaged in issues that confront road users. Speed, street design, vehicle marketing, and driver attentiveness can be altered by multitude of stakeholders. Safety culture should be so embedded in the transport system that market demand for these features encourages industry to meet them. The process needs to be demand driven and not solely regulatory based [10].

The Implementation of Vision Zero in Europe and Australasia

Swedish Origins

The Swedish origin story of VZ began with a multidisciplinary working group during the 1990s [12]. The group members came from diverse backgrounds ranging from public health and injury prevention to motor vehicle design and urban planning. The result of this collaboration became the central ideas of VZ. The Swedish Government conceded that there were critical structural shortcomings in design and function within the transport system that placed human lives at risk. This ultimately resulted in government policy initiatives with Swedish Parliament adopting the VZ and Traffic-Safe Society Bill [7].

Swedish VZ implementation focused on decreasing road speeds [12, 13]. A key component has been road designs that result in speed reduction. Many Swedish roads have incorporated median and side barriers [9, 11]. These obstacles contribute to greater separation between road users rather than space itself within the roadway. Pedestrians and cyclists have designated pathways separate from the major roadways, and barriers are put in place to separate road users. When vulnerable road users do have to interact with vehicles, speeds are reduced to below 20 mph [11].

Other roadway designs that help to reduce speed, head-on collisions, and overtaking accidents are the 2 + 1 roadway design (Fig. 1) [9]. This involves one continuous lane in each direction. There is an additional lane at an interval of 1–1.5 miles (1.5–2.5 km). All desired overtakings are performed in the two-lane sections. This design reduced the number of



Fig. 1 An example of a 2 + 1 road with cable barriers in Sweden (Wikipedia contributors. “2 + 1 road.” Wikipedia, The Free Encyclopedia. https://en.wikipedia.org/w/index.php?title=2%2B1_road&oldid=741622137. Accessed on November 7, 2016)

injured persons. Nevertheless, there were significantly more accidents where these design features were implemented, albeit less fatal [9]. After 10 years of VZ, Johansson reported that roads with median barriers and streets with speeds <18 mph had an 80% reduction in vehicular fatalities [11].

European Adoption of Vision Zero

Leah Shahum, a previous German Marshall Fund fellow and the current founder and director of the Vision Zero Network in the USA, studied the implementation of VZ in Germany and Sweden and the closely related *sustainable safety* model in the Netherlands [14]. Her findings point to the prioritization of managing speeds by road users, which is a key to success in their safety goals. The next priority was street design. The Netherlands has introduced more roundabouts in city streets. This design slows traffic at intersections. It places more physical separation between cars and bicycles where vehicle speeds are high or where there is increased traffic. In addition, all three countries have increased engineering efforts as opposed to education and enforcement [14]. Another interesting difference in this traffic safety approach appears to be the support of private industry. Automakers and insurance companies have invested in research and have implemented technologies that encourage speed reduction and even reward drivers for remaining within speed limits.

The UK has been actively integrating VZ policies. London has implemented the Safe Streets for London program. This action plan doubled funding for traffic safety and specifically focused on vulnerable road users—cyclists. The city goal is to have a 400% growth in cyclists from 2001 to 2026 [15]. Over the past 15 years, London’s prior safety efforts have significantly reduced serious injuries and fatalities involving

children by 70% [15]. Components of the safe street action plan involve improving intersections, implementing safer truck and van designs, and reducing speed limits to 20 mph. New technology is being evaluated to monitor individual vehicle speeds and alter driver and cyclists’ awareness with audible alerts.

Australasia

Australia and New Zealand adopted the Safe System Approach in 2003, which combines the most effective aspects of VZ and the Dutch Sustainable Safety policy [16]. Like Vision Zero, it encourages the involvement of a wide net of community stakeholders. The Australasian Safe System underscores four principles very similar to VZ (Table 2). A unique challenge to Australia is its large geographic area with relatively small population [16]. A high burden of traffic fatalities occurred in regions outside of metropolitan areas. The Safe System approach focused on the unique needs and challenges of geographic areas to reduce road user casualties. They identified high crash or high-risk locations and focused efforts on infrastructure design changes, such as roundabouts and barriers. Again, a key component to road safety in Australasia is speed reduction. Finally, the Safe System also supports better vehicle designs with implementation of technologies that make cars safer, as well as educational programs that target behavioral changes such as driver impairment, restraint use, and driver distractions.

Implementation of Vision Zero in the USA

It is estimated that traumatic injuries cost the USA up to \$600 billion dollars each year [17•]. In 1966, trauma was considered an epidemic by the US National Academy of Science, but 50 years later, federal funding and commitment remains lacking [17•, 18•]. In fact, US performance is dramatically worse than similar developed nations, including Great Britain, Canada, and Australia [18•]. In the 1970s, the USA had the best traffic safety record in the world, but currently, it ranks number 18. While it is true that driver fatalities have fallen by 40% in the USA, in the Netherlands, fatalities have decreased over 80% [18•]. Even more discouraging is the US performance in preventing fatalities that affect children and the elderly. Children in the USA are five times more likely to experience a fatality when compared to children in the UK [19•].

The momentum is changing in the USA, and the VZ movement is taking hold in many of the country’s largest cities. As of 2016, 16 cities throughout the country have adopted a VZ policy. In 2014, New York and San Francisco launched their versions of VZ. In 2015, the US Department of Transportation (USDOT) instituted a zero death initiative for traffic safety called toward zero deaths (TZD). In 2015, the Vision Zero

Table 2 The Australasian Safe System four principles

1. The limit of human performance
 - a. Limitations at intersections
 - b. Limitations of overtaking vehicles
 - c. Limitations of staying within lanes
 - d. Limitation of driver fatigue
2. Limits of human tolerance to violent forces
 - a. Design vehicles to protect humans to common crash types
 - b. Recognize the biomechanical limits of vulnerable road users in respect to vehicle types and speed zones
3. Safe road use
 - a. Emphasize shared responsibility
 - b. Road users must comply with laws on speed limits, driver impairment, and restraint use
4. Creating a forgiving road transport system
 - a. Objects interact within the laws of physics^a

^a Australasian College of Road Safety [16]

Network was launched to help cities develop and share best practices for all road users [20]. The Vision Zero Network currently includes Austin, TX; Boston, MA; Chicago, IL; Fort Lauderdale, FL; Los Angeles, CA; New York City, NY; Portland, OR; San Francisco, CA; San Antonio, TX; Washington, DC; Seattle, WA; and several cities throughout the San Francisco Bay area [20].

The USDOT has reported a decline in road traffic fatalities from 43,510 in 2005 to 35,092 in 2015. In an effort to further the decline, the USDOT established the *Roadway Safety Plan* to coordinate its actions and initiatives with the Federal Highway Administration (FHWA) and dedicated \$4.3 billion to enhance roadway safety and reduce transportation-related injuries and fatalities [21]. The FHWA Strategic Plan incorporates the idea of TZD [22]. The TZD approach incorporates the 4Es: education, enforcement, engineering, and emergency medical and trauma services in order to prevent *even one death* on the US transportation system [22].

Implementing VZ policies in the USA has not been without controversy. In New York City, a component of the VZ law was ruled, unconstitutional stating that the law puts the burden of proof on drivers and violates their presumption of innocence under the 5th and 14th amendments [23]. The Transit Workers Union in NYC has opposed some aspects of the law after six city bus drivers were arrested following vehicle crashes [23]. Regardless, VZ policies are being enacted throughout the country in multiple ways and are being tailored to community needs.

New York City

New York City's Vision Zero Action Plan reported 2015 as officially the safest year ever for New York City streets since

record keeping began in 1910 [24]. NYC reported a decrease in traffic-related deaths and a 27% decrease in pedestrian deaths. The NYC initiatives have included tougher sentencing for drivers, redesigning intersections, and reducing the speed limit citywide. Before implementation of the VZ policy, vehicles seriously injured or killed a New Yorker every 2 h. The primary causes of 70% of pedestrian fatalities involve speeding or failing to yield [25]. Signal timing strategies are thought to contribute substantially to the initial success of the NYC Vision Zero Action Plan (Table 3). Since implementing the action plan, the NYC DOT has completed 102 corridor and intersection safety projects, in addition to protected bike lanes and traffic calming treatments.

Seattle

Seattle is considered a relatively safe system in terms of traffic-related incidents. Nonetheless, the city adopted the VZ and is, in particular, applying the approach in certain high-risk corridors. Seattle attributes traffic collision to four causes: user inexperience, complex and/or confusing street design, inadvertent distraction, and high-risk behavior by road users [26]. Their basis for effective traffic safety has been identifying high collision locations. Focusing on collision locations has identified high yield areas to initiate safety programs that affect vulnerable road users and improve driver attention. A successful example of this type of implementation has been the Aurora Avenue Traffic Safety Corridor. Changes in street design, coupled with increased enforcement and education to raise awareness, were able to reduce collisions and injuries by 20%. This strategy will be executed in other high-risk locations throughout the city [26].

San Francisco

With major collaboration with the Department of Public Health, the emphasis for Vision Zero San Francisco has been a citywide effort to curb traffic injuries and deaths. Collision analysis identified that 70% of severe and fatal collisions occur on only 12% of San Francisco streets [27]. In addition, 60% of pedestrian collisions occur on 6% of streets. The top 3 causes of fatal collision in San Francisco include driver failure to yield to pedestrians (29%), driver speed (26%), and drivers running red lights (13%). Trucks are one of the most dangerous traffic elements for vulnerable road users. According to Vision Zero SF, large trucks or buses were involved in 4% of all collisions with vulnerable road users yet were responsible for 17% of all fatalities in the city from 2007 to 2011 [28]. Trucks are eight times more likely to result in death of the road user than collisions involving cars. Side impact crashes comprise a large percentage of fatal truck collisions with pedestrians and bicyclists. San Francisco has started specific

Table 3 New York pedestrian and traffic signal strategies

NYC signal strategies	Mode of action	Benefit
Leading Pedestrian Interval (LPI)	Signal to walk given 6–10 s prior to parallel movement of traffic	Pedestrians cross free from conflict with turning vehicles and establish presence in crosswalk
Barnes Dance	Pedestrians allowed to cross in any direction while all traffic is stopped	Crossings are free from conflict, but only phase pedestrians are allowed to cross
Split Phase	Signal to walk given while vehicles are prevented to turn thru crosswalk; dedicated turn lanes required	Crossings are free from conflict, and turning movement proceeds better
Split Pedestrian Crossings	Signal to walk allows pedestrians to walk across service road and then wait on the median and complete crossing when traffic in the main roadway is stopped	Eliminates the need to cross long distances in one interval
Recessed Crosswalks	The crosswalk is moved (recessed) 60 to 80 ft. Pedestrian separators are erected. A separate signal coordinates with intersection signal	Motorists can turn free from conflict, and pedestrians cross at the recessed crosswalk free from turning vehicles
Arterial Timing Patterns	Adjusting signal cycle lengths based on overall traffic flow patterns	Can provide more time for long pedestrian crossings or reduce the time need to wait for the signal to walk
Accessible Pedestrian Signals	Provide audible messages to walk or wait	Informs and assists the visually impaired
Leading Bus Interval	Installed for traffic operational needs and available intersection geometry	Can reduce traffic and adjust for mass transit needs
Split LPI	The key difference between Split LPI and LPI is that turning traffic is held, but parallel traffic is released concurrent with pedestrians	More efficient than an LPI but requires turning lane

^a [25]

training programs on trucks in urban environments and has evaluated the implementation of side guards for city truck fleets.

In the first 2 years of initiating the policy, Vision Zero SF has surpassed its goal of completing 24 priority projects in 24 months. In addition, it has promoted educational programs that support pedestrian right-of-way and specific training for large vehicle safety in urban driving. Specific enforcement initiatives include citations for cars within crosswalks and that double parking and block bicycle lanes or sidewalks. Finally, Vision Zero SF aims to affect city and state policies by reducing traffic speeds and installing automatic speed enforcement near at-risk populations, in particular children, the elderly, and people with disabilities.

WalkFirst was a San Francisco pedestrian initiative implemented before the adoption of VZ. This program helped inform the current VZ policy implementation in the city. WalkFirst acknowledged that pedestrians faced the brunt of fatalities within the city. The program helped identify 170 high priority locations where a majority of incidents occur [29]. Several pedestrian safety countermeasures have been considered with public input playing a role in prioritization of projects [30]. The public health co-chair for Vision Zero SF, Megan Wier, describes the efforts dedicated toward traffic safety as “night and day” in comparison to the last 10 years in the city. Although there has not been a drastic reduction of fatalities (average traffic fatalities in the city average around 30 people per year), the city has not shared the same upward

trend in traffic-related fatalities as the rest of the country, which has seen an overall 8% increase.

Conclusion

Vision Zero remains in its infancy in the USA, but the increased interest and energy being placed on traffic safety is encouraging. The next few years will be very telling for the future of VZ in the USA and whether the culture has finally shifted toward favoring the lives of vulnerable road users. The potential undoubtedly relies in the framing of these issues to the public and to local and state governments. The largest challenge to implementing an aggressive policy like VZ is the lack of federal resources and support, which certainly played a role in the success observed in Sweden.

The fundamentals of VZ challenge traditional thinking of blaming individuals for design flaws and, instead, shift the responsibility of safety to governments, city planners, system designers, industries, and public health initiatives. It acknowledges the vital role of speed in traffic-related injuries. The cultural shift and dialogue required for the success of VZ cannot be understated. The USA has 5000 deaths alone each year from pedestrian fatalities, and this is poorly reported in the media [31]. There remains division on topics that clearly benefit vulnerable road users, such as helmet use by bicyclists and motorcyclists [32]. Nonetheless, the increasing interest in VZ by growing numbers of US cities represents a renewed

interest in traffic safety and a commitment to addressing this problem in a new way.

Acknowledgements I would like to thank Megan Wier, MPH of the San Francisco Department of Public Health, and Arielle Fleisher, MPH of the San Francisco Municipal Transportation Agency, for their advice, thoughts, and expertise.

Compliance with Ethical Standards

Conflict of Interest The authors declare no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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