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What would a road safety policy fully consistent with safe system principles mean for road safety?

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ABSTRACT

If fully implemented, the Safe System principles as formulated by the International Transport Forum would lead to a considerably safer road transport system. The aims of this paper are: (1) To define operationally what full consistency with Safe System principles means; (2) To estimate the potential effects on traffic fatalities of full compliance with the Safe System principles. Operational definitions of full consistency with Safe System principles are proposed for speed limits, road design, road maintenance, vehicle safety and road user compliance with road traffic law. Estimates for Norway indicate that by complying perfectly with Safe System principles in all these areas, the number of fatalities could be reduced by 50–70 %. This is a conservative estimate. This shows that the Safe System principles are well justified scientifically: adhering to them would greatly improve road safety. However, currently road safety policy in many countries, including Norway, fails to realise these improvements in safety by not complying with the Safe System principles.

1. Background and research problem

The guidelines recommended by international organisations regarding road safety policy have developed considerably in recent years. The International Transport Forum (ITF) of the Organisation for Economic Co-operation and Development (OECD) recommends the Safe System approach to road safety policy. This approach to road safety policy rests on the following four principles (International Transport Forum (ITF), 2022):

1. People make mistakes that can lead to crashes. The transport system needs to accommodate human error and unpredictability.
2. The human body has a known, limited physical ability to tolerate crash forces before harm occurs. The impact forces resulting from a collision must therefore be limited to prevent fatal or serious injury.
3. Individuals have a responsibility to act with care and within traffic laws. A shared responsibility exists with those who design, build, manage and use roads and vehicles to prevent crashes resulting in serious injury or death and to provide effective post-crash care.
4. All parts of the system must be strengthened in combination to multiply their effects, and to ensure that road users are still protected if one part of the system fails.

These principles are very similar to the principles of Vision Zero, launched in Sweden in 1997 (see next section). Norway officially adopted Vision Zero as the basis for transport safety policy in 2001 and has subsequently developed an institutional framework for drafting and implementing national road safety action plans that are updated every fourth year (Elvik 2022). Progress in reducing the number of traffic fatalities has been considerably faster in Norway after the adoption of Vision Zero than it was before 2001 (Elvik and Nævestad 2023). Road safety policy has been more successful. There was a reduction of traffic fatalities in the Netherlands and Sweden after these countries adopted the Safe System approach and Vision Zero (Aarts 2023).

It is nevertheless relevant to ask if road safety policy is as successful as it could be if it was perfectly consistent with the Safe System principles. A recent study (Hesjevoll et al. 2022) identified fatal crashes in Norway that were "within system limits" and "outside system limits". These concepts refer to Vision Zero, according to which system designers aim to guarantee that nobody will be killed or serious injured in crashes that occur within system limits, i.e. at legal speeds, with sober road users who are protected by available protective systems, etc. However, the report found that 60 % of fatal crashes and 60 % of killed road users were within system limits. This finding suggests that system designers still have some way to go before the system has become so safe that nobody who complies with road traffic law gets killed. System designers are still not fulfilling their part of the "Vision Zero contract" between road users and system designers (see next section). This paper aims to

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estimate how much the number of traffic fatalities could be reduced if both system designers and road users complied perfectly with the Safe System principles. How to define perfect compliance with these principles is discussed in section 4 of the paper.

2. The vision zero contract between road users and system designers

Vision Zero offers a contract between system designers and road users. Briefly stated (Belin 2022), the contract states that if road users behave within system limits, system designers guarantee that they will not be killed or sustain permanent injury. The implementation of this contract rests on the following principles (Tingvall and Haworth 1999; Belin 2022):

1. The system designers have ultimate responsibility for the design, operation and use of the road transport system and thereby responsibility for the level of safety for the entire system.
2. Road users are responsible for following the rules for using the road transport system set by system designers.
3. If the road users fail to obey these rules due to lack of knowledge, acceptance or ability, or if injuries occur, the system designers are required to take necessary further steps to counteract people being killed or seriously injured.

A reasonable interpretation of the third principle is that if road users do not comply with the rules for safe use of the road transport system, system designers should implement enforcement in order to ensure compliance. Thus, the responsibility of system designers includes measures to ensure road user compliance with the rules for using the road transport system.

Within Vision Zero, guidelines for safe system design are based on biomechanical knowledge about the impacts humans can tolerate without sustaining lasting injury. To ensure that impact speeds in collisions are below the level where the probability of sustaining fatal or permanent injury starts to rise rapidly, the following speed limits are proposed (Tingvall and Haworth 1999, Aarts 2023):

1. On roads where collisions between motor vehicles and pedestrians or cyclists are possible, the speed limit should not be higher than 30 km/h.
2. On roads where side impacts between motor vehicles are possible, the speed limit should not be higher than 50 km/h.
3. On roads where frontal impacts between motor vehicles are possible, the speed limit should not be higher than 70 km/h.

To justify higher speed limits, roads must be reconstructed to eliminate the potential for the relevant types of accidents. As an example, there must be complete physical separation between motor vehicles and pedestrians or cyclists to allow for a higher speed limit than 30 km/h. Another example is that a median or a median barrier may prevent frontal crashes, allowing for a higher speed limit than 70 km/h. System designers, in this case road authorities, are responsible for introducing safe speed limits and for implementing the changes in road design needed to allow higher speed limits than 30, 50 or 70 km/h.

As long as higher speed limits are allowed and/or enforcement is insufficient to ensure compliance with the speed limits, policy is not fully consistent with Safe System principles.

3. Fatalities within and outside system limits

As mentioned above, a Norwegian study (Hesjevoll et al. 2022) found that 60 % of traffic fatalities occurred in crashes that were classified as being within system limits, i.e. they did not involve road user behaviour outside system limits. The remaining 40 % of fatalities occurred in crashes that were classified as involving road user behaviour outside safe system limits. Fig. 1 shows the most commonly found types of behaviour outside safe system limits and the overlap between them in fatal crashes that occurred in Norway between 2017 and 2020.

The most common violation was impaired driving, i.e. driving under the influence of alcohol and/or drugs. The second most common violation was not wearing a seat belt. The third most common was speeding, which only included speeds well above speed limits, i.e. in the range where the driving licence is suspended. Speed would then usually be at least some 40–50 km/h above the speed limit. Had less serious cases of speeding been included it would have contributed to a larger number of fatalities. Miscellaneous other violations, not belonging to the three largest, contributed to 34 fatalities.

The fact that these violations contributed to 40 % of fatalities is, ultimately, a failure of system designers to ensure sufficient enforcement of road traffic law.

4. Definition of perfect compliance with safe system principles

Full compliance with the Safe System principles can be defined in terms of the following criteria:

1. Safe speed limits (30, 50, 70 km/h) have been fully implemented.
2. On all roads that have a higher speed limit than 70 km/h, median barriers or a physical median have been installed to prevent head-on-collisions.
3. All roads fulfil standards set for design and maintenance. There are no deviations from design standards or maintenance standards. This criterion cannot be expected to be perfectly fulfilled at a given point in time, but there should be a plan to ensure reconstruction of roads to make them comply with design standards.
4. All cars are as safe as the safest cars available on the market. This is clearly a dynamic criterion, as the safety of cars improves over time and it takes time to renew the car fleet. It therefore cannot be expected to be perfectly fulfilled at a given point in time.
5. There is sufficient enforcement to ensure full compliance with road traffic law, either by means of police officers, automated enforcement devices (e.g. speed cameras, red light cameras) or vehicle technology (e. g. intelligent speed assistance, alcohol ignition interlocks).

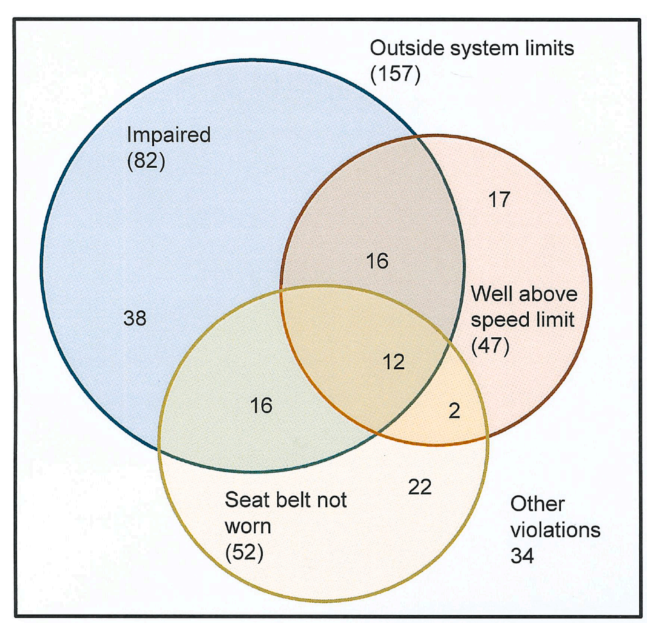

Fig. 1. Fatalities outside Vision Zero system limits. Based on Hesjevoll et al. 2022.

6. There are sufficient technical inspections to ensure that all vehicle-related defects associated with an increased crash risk are eliminated.

The next section evaluates how close current road safety policy in Norway is to perfect compliance with Safe System principles and how much the number of traffic fatalities could be reduced by ensuring perfect compliance with the Safe System principles.

5. Current compliance with safe system principles

5.1. Safe speed limits

Data collected for developing accident prediction models (Høye 2016) show that only 4 % of vehicle kilometres driven on roads with a speed limit of 30, 40 or 50 km/h are driven on roads with a speed limit of 30 km/h. Hence, the degree of compliance with safe speed limits in urban areas is 0.040 (degree of compliance is stated as a number between 0 and 1).

The current speed limit of 60 km/h should be reduced to 50 km/h (Elvik 2017). For this speed limit, compliance with safe speed limits is 0.0. Finally, only 28 % of vehicle kilometres on undivided roads with a speed limit of 70 km/h or above are driven on roads with a speed limit of 70 km/h. Compliance is therefore 0.280.

5.2. Safe road design

According to the Public Roads Administration (2018), about 3100 km of road are eligible for conversion to motorways or 2 + 1 roads with median barriers. By 2021 1180 km had been converted and 1920 km remained (compliance rate 1180/3100 = 0.381). However, the Public Roads Administration (2022) estimates that 53.5 % of vehicle kilometres on roads with a speed limit of 80 km/h or higher are driven on roads with a median or median barrier. Thus, roads that have been converted to motorways or 2 + 1 roads with a median barrier have a higher traffic volume than roads that remain to be converted.

A recent study of the safety of horizontal curves on rural two-lane roads in Norway (Elvik and Haugvik 2023) provides data on the compliance with geometric design standards for roads. It was found that 23.3 % of the curves had a smaller radius than the minimum permitted by current design standards (compliance rate 0.767). Spiral transition curves were too short in nearly all curves, resulting in a compliance with current design standards of just 0.065. The cross slope before curves was adequate in 69.6 % of the curves (compliance rate 0.696). Compliance with cross slope in curves was 0.631. Finally, there was variation in cross slope in most curves, resulting in a compliance rate of only 0.056.

A safe road design refers not just to the geometric design of a road, but also to its equipment. Road lighting has been included as an element of a safe road, as there are data in Norway about the share of traffic going on lit and unlit roads. According to Høye (2016) about 60 % of vehicle kilometres are driven on lit roads (compliance rate 0.604).

5.3. Safely maintained roads and traffic signs

The data analysed by Elvik and Haugvik (2023) show that rut depth exceeded maintenance limits in 2.2 % of the curves, meaning that compliance with maintenance standards was quite high, 0.978. An older study (Ragnøy et al. 1990) found that only 40 % of traffic signs were correctly placed and/or maintained (compliance rate 0.400).

5.4. Safe vehicles

The safety of vehicles is today not fully determined by national governments. Safety standards are generally set by international organisations. Besides, car manufacturers offer safety systems that are not mandatory according to official standards. As suggested above, perfect compliance with Safe System principles can be defined as having a car fleet which consists exclusively of the safest cars available on the market. These are, broadly speaking, the newest cars. According to Høye (2017) new cars are driven longer distances per year than older cars. Thus, cars that are up to one year old perform about 8 % of all kilometres of travel by car in Norway. Compliance rate with a perfectly safe car fleet is therefore set to 0.08.

In addition, no vehicle should have technical defects. Technical defects on heavy vehicles, in particular brake defects, are known to increase accident risk (Elvik 2023). Currently, about 70 % of heavy goods vehicles have good brakes. Technical inspections have been found to improve technical conditions and reduce the number of accidents. An increase in technical inspections is needed to improve the technical condition of heavy vehicles.

5.5. Safe road user behaviour

According to Elvik (2011) the fatality risk attributable to road user violations of road traffic law is 0.516, meaning that if these violations were eliminated, the number of fatalities could be reduced by nearly 52 %. More recent estimates (Elvik and Høye 2022) show that the risk attributable to speeding has been reduced from 2011 to 2022. A rough estimate of the current fatality risk attributable to violations of road traffic law is about 0.45. It is, ultimately, the responsibility of system designers, in this case enforcement agencies, to eliminate this risk by means of road traffic law enforcement.

5.6. Summary of compliance

Table 1 summarises the data presented above. It is noteworthy that compliance with safe speed limits is very low. Basically, these speed limits have not been introduced, but older speed limits retained.

It is possible to avoid introducing the speed limits of 30, 50 and 70 km/h. The way to avoid them is:

1. To ensure complete physical separation between motor vehicles and pedestrians or cyclists. If pedestrians and cyclists never interact with motor vehicles, there can be no collisions between them and motor vehicles.
2. To convert all junctions to grade-separated interchanges where side-impacts cannot occur.
3. To convert all roads where head-on collisions may occur to motorways with a median or to so-called 2 + 1 roads with a median barrier.

These changes are impossible to implement everywhere and will take long time and cost a lot to implement where it is possible to do so. Hence, the first step that should be taken in implementing the Safe System approach is to introduce safe speed limits. Changing the roads to allow for higher speed limits will take a long time and will not be possible everywhere.

The fact that widespread violations of road traffic law are tolerated is also inconsistent with the Safe System approach. In Norway, roughly 40 % of traffic is above current speed limits. Is it possible to obtain better compliance by increasing enforcement? Yes, analyses of data for 1980–2021 suggest that the risk attributable to road traffic law violations can be eliminated by increasing enforcement to ten times the current level. Such an increase is not outside enforcement levels that can be found in other countries. In the Netherlands, the mean risk of apprehension for speeding during the period 1995–2019 was 53.8 per million vehicle kilometres of travel. In Norway, it was just 4.7 during 2012–2013 (Elvik and Amundsen 2014). Thus, the risk of apprehension was 11 times higher in the Netherlands than in Norway.

Table 1
Current compliance with Safe System principles in Norway.

Element of Safe System	Consistent with Safe System	Unit of measurement	Part of system included	Current degree of compliance
Safe speed limits	Speed limit 30 km/h	Vehicle kilometres	National and county roads	0.233
	Speed limit 50 km/h	Vehicle kilometres	National and county roads	0.000
	Speed limit 70 km/h	Vehicle kilometres	National and county roads	0.281
Protective road design	Physical median or median barrier	Eligible roads in kilometres	National and county roads	0.381
Adherence to design standards	Horizontal curve radius	Share of horizontal curves	National and county roads	0.767
	Length of spiral transitions	Share of horizontal curves	National and county roads	0.065
	Cross slope in curve	Share of horizontal curves	National and county roads	0.631
	Variation of cross slope in curve	Share of horizontal curves	National and county roads	0.056
Safety equipment on roads	Road lighting	Vehicle kilometres	National and county roads	0.604
Adherence to maintenance standards	Maximum rut depth	Share of road length	National and county roads	0.978
	Condition of traffic signs	Correctly used and maintained	National and county roads	0.400
The safest possible car fleet	All cars as safe as safest model	Vehicle kilometres	All public roads	0.080
Road user compliance with law	Perfect compliance	Risk attributable to violations	All public roads	0.450
Technical condition of heavy vehicles	No defects	Share of vehicles	All public roads	0.702

6. Potential effects of fatalities of perfect compliance with safe system principles

This section estimates potential effects on traffic fatalities in Norway if road safety policy complied perfectly with Safe System principles.

6.1. Safe speed limits

The following changes in current speed limits in Norway are needed in order to make speed limits consistent with Safe System principles:

The speed limit of 40 km/h is reduced to 30 km/h
The speed limit of 50 km/h is reduced to 30 km/h
The speed limit of 60 km/h is reduced to 50 km/h
The speed limit of 80 km/h is reduced to 70 km/h on undivided roads
The speed limit of 90 km/h is reduced to 70 km/h on undivided roads
The speed limits of 100 and 100 km/h are retained, as these speed limits are only found on motorways.

Literature reviewed as part of the ongoing revision of the Handbook of Road Safety Measures (Elvik 2019A) has been used to estimate expected changes in speed associated with the changes in speed limits. The exponential model of the relationship between speed and the number of fatalities (Elvik 2019B) has been used to estimate changes in the number of fatalities resulting from the changes in speed.

Reducing the speed limit from 40 to 30 km/h was assumed to reduce the mean speed of traffic by 3.2 km/h. For the reduction from 50 to 30 km/h, mean speed was assumed to be reduced by 12.6 km/h; 60 to 50 km/h: 4.9 km/h; 80 to 70 km/h: 4.1 km/h and 90 to 70 km/h: 5.4 km/h. All these changes are reductions. For the speed limits of 80 and 90 km/h, the reductions of speed limit were assumed to apply to only 46.5 % of traffic, as 53.5 % already benefits from divided roads where higher speed limits can be allowed (see section 5.2).

If Safe speed limits were introduced, and speed reduced as assumed, the annual number of traffic fatalities would be reduced by about 20. This is a conservative estimate. It has not been assumed that the new speed limits would be perfectly complied with. If perfectly complied with, the number of fatalities could be reduced by more than 20. However, increasing compliance by means of more enforcement is treated as a separate measure. To avoid double counting, it was not assumed that the new speed limits would be fully complied with, as such an assumption would only be realistic in case there was increased enforcement.

6.2. Safe road design

There are several elements of current road design that are inconsistent with Safe System principles. As part of preparation of the National Transport Plan (NTP) for the 2025–2036 term, estimates were made of the potential reduction in the number of killed or seriously injured road users by converting roads to motorways or 2 + 1 road with a median barrier (Elvik and Høye 2022). The potential reduction of the annual number of killed or seriously injured road users was estimated to roughly 80. About 14 % of these were killed road users. Thus, the potential reduction in the number of fatalities was about 11.

The various inconsistencies with design standards found in horizontal curves (Elvik and Haugvik 2023) are more complex to deal with. The accident prediction models developed were based on the number of injury accidents, not the number of fatalities, which was too low to develop multivariate models. Hence, it has to be assumed that the estimated coefficients apply to fatalities, not just injury accidents.

Another complication is that the various elements of horizontal curves cannot be treated as independent. Thus, if radius is made larger, the curve becomes longer and the straight section ahead of the curve becomes shorter. To estimate the effects on safety of changing the design elements to make them consistent with current design standards, all design elements listed in Table 1 have to be included, so that their joint effects is correctly estimated.

The current mean values of these variables in the data set analysed by Elvik and Haugvik (2023) are: radius of curve: 261 m; length of curve: 98 m; length of spiral transition curve: 33 m; adequate cross slope in curve (dummy): 0.631; variation in cross slope in curve: 5.6 %. The ratio of the mean length of curves to mean radius (98/261) implies a deflection angle of 21.5 degrees.

The mean radius of curves that are sharper than minimum design standards is 83 m. The mean length of spiral transition curves that are shorter than design standards is 8 m. The minimum design values are, respectively, 125 m and 75 m. To estimate the effects on safety of complying with design standards, a section with the same length as the sum of mean values for curve length (98 m), spiral transition length (33

m) and straight section length (90 m) was assumed. This section was initially divided into curve 31 m, spiral transition 8 m and straight section 182 m. The number of accidents was predicted using these values. New values consistent with design standards were then inserted in the predictive equation.

Accident risk in curves fulfilling all design standards was found to be about 8 % lower than in curves not satisfying design standards. About 37 % of all fatalities occur in curves. Hence, a reduction of 8 % of 37 % is possible by complying perfectly with design standards. For the years 2020–2022, this means that the number of fatalities could be reduced by 3 per year. Adding this to the potential reduction by building motorways and 2 + 1 roads with a median barrier gives a total of 14.

Elvik and Høye (2018) estimated that the number of fatalities could be reduced by about 3 if all roads had road lighting. This brings the total potential reduction in the number of traffic fatalities by means of safer roads to 17.

6.3. Safely maintained roads and traffic signs

The potential safety gain by complying with standards for maximum rut depth are small. Using the coefficient estimated for curves, it can be estimated that curves complying with the standard have about 1 % fewer accidents than curves not complying with the standard, However, as 97.8 % of curves comply with the standard, we are talking about a difference of 1 % applied to 2.2 %. This becomes roughly 0.02 %, which is regarded as negligible.

Ragnøy, Vaa and Nilsen (1990) found that only 40 % of traffic signs were correct according to standards for their placement, use and technical condition. Little is known about how much incorrect traffic signs contribute to traffic fatalities. In 2021, traffic signs were listed as a contributing factor for 2 out of 76 fatal crashes studied in-depth that year (Ringen, 2022). This represents 2.6 % of fatal crashes. Considering the fact that the number of fatalities was abnormally low in 2021, this corresponds to about 3 fatalities in a more normal year.

6.4. Safe vehicles

New cars are today considerably safer than old cars, and a renewal of the car fleet has a considerable potential for improving safety (Høye 2019). According to Elvik and Høye (2018), the number of fatalities could be reduced by close to 21 % if all cars were as safe as the safest model found on the market today.

In addition, eliminating technical defects that increase the risk of crashes can reduce the number of fatalities. Previous studies of periodic motor vehicle inspection (Fosser 1992, Christensen and Elvik 2007) have not found any effects on the safety of light vehicles. For heavy vehicles, on the other hand, studies (Elvik 2002, 2023) have found that technical inspections reduce accidents. An increase in technical inspections of heavy vehicles sufficient to eliminate the risk attributable to technical defects would reduce the number of fatalities by about 4 per year.

6.5. Safe road user behaviour

In section 5.4, the risk attributable to road traffic law violations was estimated to 0.45, meaning that the number of fatalities can be reduced by 45 % by eliminating these violations. In principle, increasing enforcement to ten times the current level could bring about such a reduction. In practice, however, the police will always apply a certain tolerance margin for violations. As an example, small violations of speed limits are tolerated.

A conservative estimate is 40 % reduction of fatalities, which is identical to the share of fatalities classified as outside system limits by Hesjevoll et al. (2022).

6.6. Summary of potential effects on fatalities

Fig. 2 summarises the estimates presented above. The sum of the potential reductions in the number of traffic fatalities estimated for each component of a safe system is 103, which is clearly impossible, given that there were 97 fatalities in Norway (annual mean 2020–2022) in the baseline condition. To estimate the combined effect of all safe system components, a residual factor was estimated for each of them. The residual factor is the share of fatalities not prevented by a component. For safe speeds, for example, 20 fatalities are prevented and 97–20 = 77 are not prevented. The factor 77/97 = 0.794 is the residual factor for safe speeds. The optimistic estimate of the potential reduction was obtained by multiplying residual factors: 0.794 (speed) • 0.825 (roads) • 0.969 (maintenance) • 0.753 (vehicles) • 0.598 (behaviour) = 0.285. Multiplying 97 by 0.285 gives 27.7, which is rounded to 28 fatalities. This method was referred to as the common residuals method by Elvik (2009). The pessimistic estimate is based on what Elvik (2009) referred to as the dominant common residuals method. The common residuals estimate (0.285) is then raised to the value of the lowest residual = $0.285^{0.598} = 0.473$. 97 • 0.473 = 46. Neither of these methods has any theoretical justification but were simply found to fit different data sets well.

These estimates are likely to be underestimates, i.e. it is highly likely that the number of fatalities can be reduced even more.

In the first place, the estimates did not assume that Safe speed limits would be perfectly complied with. If, however, all motor vehicles had intelligent speed assistance (ISA), a mature technology which has been available for more than 30 years, there would be perfect compliance with these speed limits.

In the second place, estimates of the potential for reducing fatalities by improving the maintenance of roads and traffic signs included only rut depth and traffic signs. However, it is known that, for example, many roads have high pavement edge drop-offs, winter maintenance is not always performed according to required standards (Riksrevisjonen 2023), and road markings are in many cases poorly maintained. Correcting these defects would probably reduce the number of fatalities.

In the third place, future vehicles are likely to be safer than those currently on the market. The estimates in Fig. 2 are based on the best current technology and does not include any future driver support systems or automation systems that may further improve vehicle safety.

7. Discussion

Road safety policy in Norway has been very successful after 2000. The annual decline in the number of fatalities increased from 2.1 % in the period 1970–2000 to about 6 % in the period after 2000. The number of fatalities in 2021 was the lowest recorded since 1944. It was, however, an abnormally low number, perhaps due in part to lockdowns during the Covid-19 pandemic.

Road safety policy objectives in Norway are highly ambitious. The country aims for not more than 50 fatalities in 2030 and zero fatalities in 2050. The estimates presented in this paper show that it is possible to reduce the number of fatalities to 50. Some of the measures that are needed to bring down the number of fatalities to 50 or less are being implemented. However, most of the measures discussed in this paper are not being implemented.

The estimates of the potential for reducing the number of traffic fatalities by complying perfectly with Safe System principles presented in this paper show two main things:

1. The Safe System principles are scientifically well justified. Compliance with them would reduce the number of traffic fatalities by at least 50–70 %.
2. Current compliance with the Safe System principles is very incomplete. There is a huge potential for reducing traffic fatalities in Norway by complying more closely with Safe System principles.

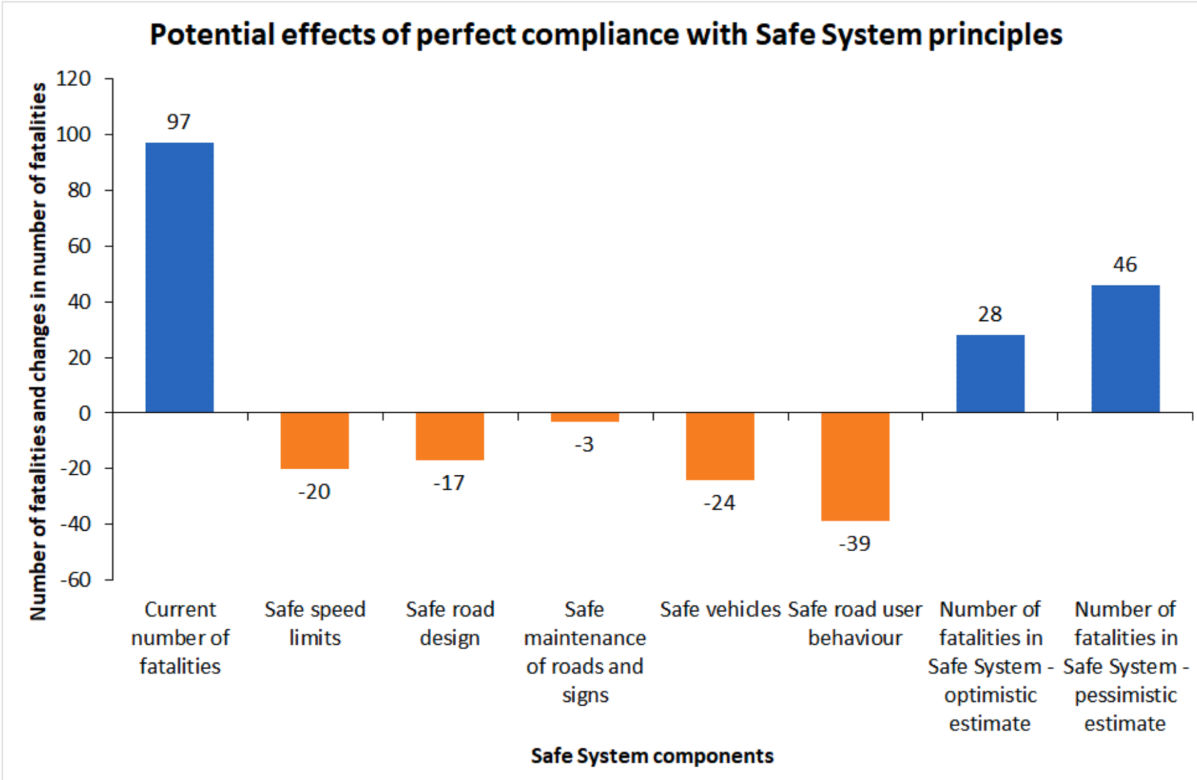

Fig. 2. Potential reduction of traffic fatalities by perfect compliance with Safe System principles.

These estimates are uncertain and should be interpreted as indicating an order of magnitude only. Data on the potential for improving safety by means of safer vehicles are uncertain. The same applies to the rough estimate of the potential associated with road user compliance with road traffic law. Very little is known about the combined effects of safety measures, and the two models used to estimate combined effects are based on a limited analysis.

Norway is not the only country that officially endorses the Safe System approach but fails to implement some of its key elements. Safe speed limits have not been fully implemented in any country. A speed limit of 30 km/h in urban areas is gradually becoming more common. A speed limit of 70 km/h on undivided rural roads is still uncommon. Norway has introduced this speed limit on a selective basis. It has been introduced on high-risk roads, but not as a general speed limit.

Since no country complies fully with the Safe System principles, there is likely to be a potential for reducing traffic fatalities in all countries. However, estimates similar to those reported in this paper would have to be made for each country in order to determine how large the potential for reducing traffic fatalities is.

The main question the analysis in this paper invites one to ask is: why have most of the components of the Safe System approach to road safety been so incompletely implemented? Answering this question is, of course, a research project on its own. This paper cannot answer it. Vision Zero is an appealing ideal. Indeed, it is probably the only ideal for transport safety that few would want to argue against. It is difficult to propose an "optimal" number of traffic fatalities other than zero.

Zero is, of course, a very demanding ideal. Yet, at least the broad outlines of a road system that would bring the number of fatalities close to zero are known. Road safety policy analyses as recently as in 2018 (Elvik and Høye 2018) concluded that it would be difficult to reduce the number of traffic fatalities in Norway to less than 50 per year. The estimates presented in this paper show that getting below 30 per year is theoretically possible. Is it also possible in practice? The answer to that question depends on how ready society is to take major steps forward in road safety. But, at the very least, safe speed limits can be introduced, and technology exists that can ensure perfect compliance with these speed limits, as well as eliminating impaired driving and the non-use of seat belts. The only relevant question to ask is why these steps have not been taken long ago.

8. Conclusions

The main conclusions of the analyses presented in this paper can be summarised as follows:

1. A road safety policy complying fully with Safe System principles would reduce the number of traffic fatalities by at least 50–70 %.
2. Norway does not have a road safety policy which complies fully with Safe System principles.
3. This is the case despite the fact that safety policy in Norway is based on a broad involvement of stakeholders and a formal commitment by each stakeholder to the implementation of road safety measures.

CRediT authorship contribution statement

Rune Elvik: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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