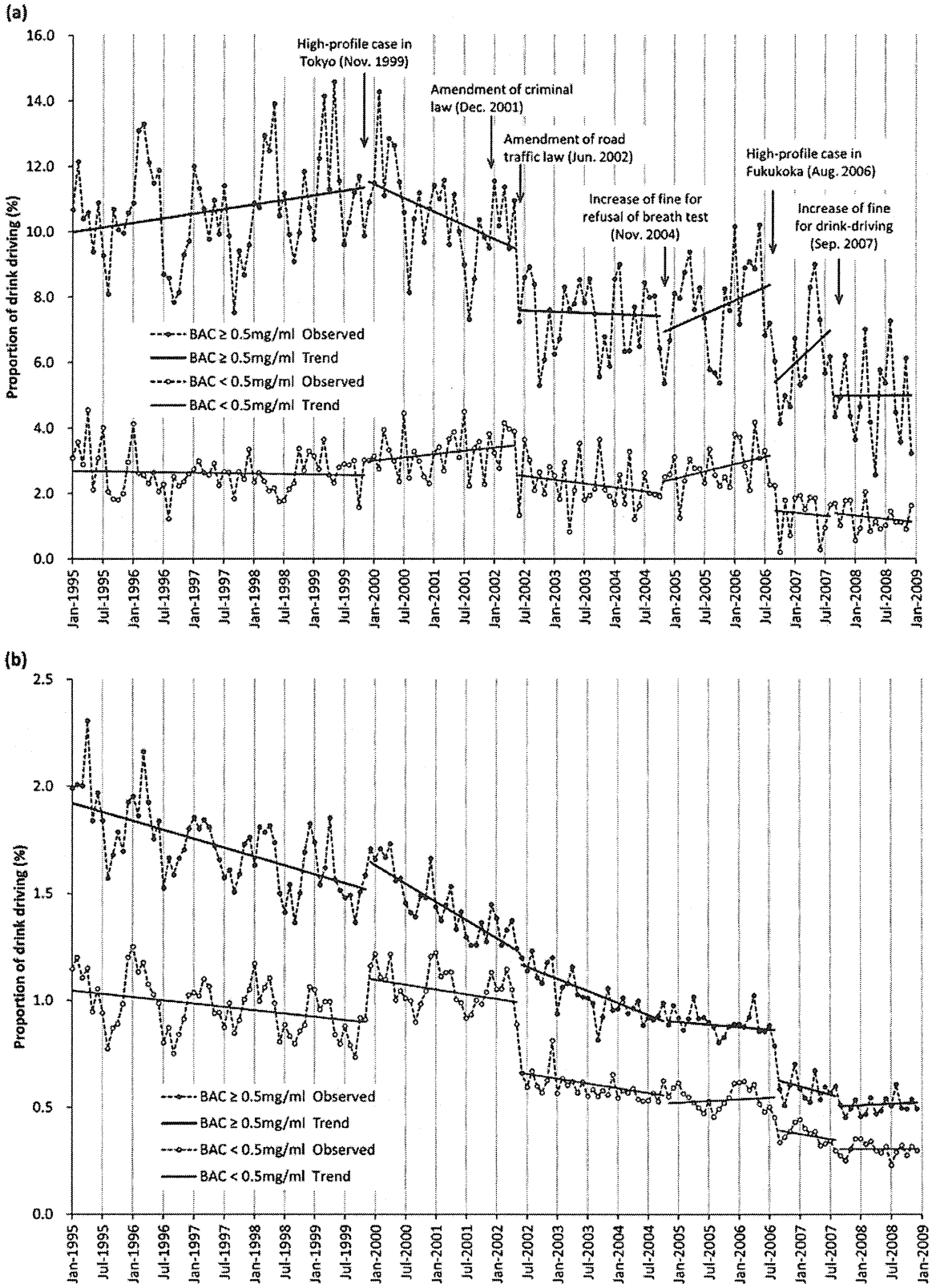

Figure 1 Proportions of motor vehicle crashes involving drink-driving in Japan between 1995 and 2008. (A) Trends in fatal crashes involving drink-driving by blood alcohol concentration (BAC) (≥0.5 or <0.5). (B) Trends in all injury crashes involving drink-driving by BAC (≥0.5 or <0.5).

Table 2 Time-series analyses of fatal crashes and all crashes involving injuries by blood alcohol concentration (BAC)

	BAC ≥0.5 mg/ml		BAC <0.5 mg/ml		Untested but detected	
	β (95% CI)	p Value	β (95% CI)	p Value	β (95% CI)	p Value
Fatal crashes						
Time	0.023 (0.003 to 0.044)	0.027	−0.002 (−0.010 to 0.006)	0.589	−0.011 (−0.019 to −0.003)	0.010
E1 Crash in Nov 1999	0.245 (−0.961 to 1.451)	0.691	0.418 (−0.065 to 0.902)	0.092	−0.098 (−0.579 to 0.382)	0.689
E2 Law amendment in Jun 2002	−1.901 (−3.278 to −0.525)	0.008	−0.888 (−1.445 to −0.331)	0.002	0.069 (−0.484 to 0.622)	0.807
E3 Law amendment in Nov 2004	−0.547 (−2.046 to 0.952)	0.475	0.338 (−0.273 to 0.949)	0.280	0.104 (−0.502 to 0.711)	0.737
E4 Crash in Aug 2006	−3.113 (−5.025 to −1.200)	0.002	−1.666 (−2.471 to −0.861)	<0.001	−1.109 (−1.901 to −0.316)	0.007
E5 Law amendment in Sep 2007	−1.991 (−3.932 to −0.050)	0.046	0.113 (−0.711 to 0.937)	0.789	−0.251 (−1.059 to 0.556)	0.543
Trend change after E1	−0.093 (−0.153 to −0.033)	0.003	0.019 (−0.005 to 0.042)	0.125	0.029 (0.005 to 0.053)	0.018
Trend change after E2	0.063 (−0.019 to 0.145)	0.131	−0.036 (−0.069 to −0.004)	0.029	−0.055 (−0.087 to −0.023)	<0.001
Trend change after E3	0.074 (−0.034 to 0.181)	0.180	0.057 (0.014 to 0.100)	0.009	0.038 (−0.005 to 0.080)	0.083
Trend change after E4	0.075 (−0.162 to 0.312)	0.537	−0.053 (−0.150 to 0.043)	0.281	0.028 (−0.068 to 0.124)	0.568
Trend change after E5	−0.141 (−0.405 to 0.122)	0.295	−0.001 (−0.108 to 0.106)	0.984	−0.029 (−0.135 to 0.076)	0.586
R^2	0.786		0.525		0.620	
All crashes involving injuries						
Time	−0.007 (−0.009 to −0.005)	<0.001	−0.003 (−0.004 to −0.001)	<0.001	−0.001 (−0.002 to 0.0004)	0.261
E1 Crash in Nov 1999	0.140 (0.048 to 0.232)	0.003	0.204 (0.136 to 0.273)	<0.001	0.164 (0.114 to 0.214)	<0.001
E2 Law amendment in Jun 2002	−0.059 (−0.163 to 0.045)	0.271	−0.325 (−0.402 to −0.248)	<0.001	−0.076 (−0.130 to −0.021)	0.007
E3 Law amendment in Nov 2004	0.001 (−0.112 to 0.114)	0.984	−0.038 (−0.122 to 0.046)	0.376	−0.010 (−0.067 to 0.046)	0.718
E4 Crash in Aug 2006	−0.229 (−0.370 to −0.088)	0.002	−0.151 (−0.256 to −0.047)	0.005	−0.072 (−0.137 to −0.006)	0.034
E5 Law amendment in Sep 2007	−0.049 (−0.192 to 0.094)	0.504	−0.042 (−0.147 to 0.063)	0.435	−0.011 (−0.076 to 0.055)	0.751
Trend change after E1	−0.007 (−0.012 to −0.003)	0.002	−0.001 (−0.005 to 0.002)	0.516	0.001 (−0.002 to 0.004)	0.417
Trend change after E2	0.005 (−0.001 to 0.011)	0.132	0.000 (−0.005 to 0.005)	0.973	−0.004 (−0.008 to −0.001)	0.026
Trend change after E3	0.007 (−0.001 to 0.016)	0.086	0.005 (−0.001 to 0.011)	0.112	0.003 (−0.002 to 0.007)	0.299
Trend change after E4	−0.005 (−0.022 to 0.013)	0.620	−0.005 (−0.019 to 0.008)	0.432	0.002 (−0.007 to 0.012)	0.671
Trend change after E5	0.008 (−0.012 to 0.028)	0.455	0.004 (−0.011 to 0.019)	0.597	−0.002 (−0.013 to 0.009)	0.768
R^2	0.972		0.964		0.906	

The intercepts, sine and cosine functions for seasonality, and autoregressive terms are omitted.

the times of the collisions. This supported our hypothesis that the media coverage of the high-profile cases stimulated social norm changes leading to changes in driver behaviour before the law amendments were made, although we did not directly investigate the impact of the quantity and quality of the media coverage on the alcohol-related crashes. Alternative theories had a limited capacity to explain our findings as using proportions in the model controlled for factors influencing crash occurrence in general, and factors selectively influencing drink-driving and alcohol-related crashes could not explain the observed abrupt changes.

Police-enforcement activities, which could have had an influence, did not abruptly increase after the high-profile crashes, with the exception of periodic crackdown campaigns (such as the 1-week nationwide crackdown in September 2006).[26] Indeed, such short-term crackdown campaigns, which are frequently run during the year-end party season, have had no reported impact. Although the number of breath tests performed and the number of checkpoints installed were not known, the number of drivers charged for drink-driving, which is an output of the enforcement activities, did not increase after the crashes but rather continuously declined after 2000 (Nakahara *et al*, unpublished data); this suggests that there was a change in driver behaviour before the deterrent effects of enforcement emerged as an increase in the number of arrests.

The gradual reduction in alcohol consumption seen in Japan since the mid-1990s, which must have influenced the long-term trends of drink-driving and alcohol-related crashes, could not explain the abrupt changes.[27] The reduced alcohol consumption might have been a response to the increasing intolerance to drink-driving after the high-profile crashes, and to the introduction of severe penalties for drink-driving, rather than an independent change. Recent expansion of the market for non-alcoholic beer suggests that people still enjoy the taste but want to refrain from drinking alcohol when they have to drive.[28]

Other factors could have had a gradual influence on the occurrence of alcohol-related crashes. For example, increases in the provision of chauffeur services, which dispatch an employee to drive a client's car, and streamlining of the public transportation system, particularly in cities with a high dependence on private vehicles, could have helped to reduce drink-driving.[23 29 30] Such changes, however, would not bring about abrupt changes.

The under-reporting of drink-driving in the police data did not appear to distort the results, particularly for fatal crashes, for the following reasons. First, the abrupt increase in the proportion of drink-driving crashes among all crashes involving injuries in 1999 suggested a reduction in the under-reporting of drink-driving among minor crashes due to improved police investigation; no such changes were observed for fatal crashes, suggesting that the methods had already been sufficiently stringent before 1999. Among all crashes, the proportion involving drivers with a BAC ≥0.5 showed a significant slope decrease after 1999, despite the level increase, suggesting that the declining trend started after the crash.

Second, the proportions of untested cases and those without information on alcohol consumption were considerably reduced over time, suggesting improvements in the accuracy of police reporting. Among fatal crashes, the proportion of untested drivers showed a temporary slope increase in 1999, but the decline among those with a BAC ≥0.5 overrode this, indicating a net decline in alcohol-related crashes. Although the increased fine for test refusal introduced in 2004 was expected to reduce untested cases or those without information, and to increase those with test results, a slope decrease among those untested or

without information was not observed, but a slope increase was observed only among those with a BAC <0.5 in fatal crashes. This suggested a net increasing trend in alcohol-related crashes during this period, probably owing to the waning effects of the previous changes to social norms and the effects of law amendments.

Contrasting changes occurred after the two high-profile crashes in the analysis: a slope change after the 1999 crash and a level change after the 2006 crash. The former might have reflected the start of changes that accelerated the declining trends through the escalation and diffusion of media campaigns and debates in response to several events, including calls for more severe punishments for drink-driving and criminal law amendments. The increased severity of the punishment for dangerous driving resulting in death introduced by the new criminal law might have sent the message that causing such crashes was intolerable, although the direct deterrent effect was questionable because of the limited application of the penalty.

In contrast, the level decline observed after the crash in 2006 probably reflected the more fierce debate and more rapid launch of a publicity campaign than occurred after the cases in 1999. The offender was a local government employee and, as a consequence, many such employers decided to dismiss any staff members who were charged with drink-driving regardless of whether they had caused a crash; this was announced by some immediately after the event,[31] sending a message to the public that drink-driving itself is a serious crime. This might have further increased societal intolerance to drink-driving. An opinion poll in October 2006 indicated that 73% of those surveyed supported more severe penalties for drink-driving.[32] A news article reported that a taxi company introduced breath-testing for drivers immediately after the crash, in response to such changes.[31]

The successful reduction of drink-driving and the resulting crashes in Japan can be attributed to the various combined effects of legislative and societal changes. The decline in crashes after 2002 was more obvious than that after 1999; this was probably because pre-legislative changes played a supporting role and enhanced the effects of the law amendments. Introducing more severe penalties alone could not have achieved the long-lasting effects, as illustrated by the experience in the late 1970s.[13] Conversely, more severe penalties might have prompted further societal changes by showing the increasing intolerance to drink-driving. The decline seen in 2007 was smaller than that observed after the previous crash, suggesting that more severe penalties can be 'a symbolic outcome rather than the catalyst of the changes', as Hingson *et al* stated, particularly when they are fiercely debated.[22]

What is already known on this subject

- Penalties for drink-driving were strengthened twice in the 2000s in Japan after high-profile crashes.
- How the media coverage of such high-profile cases influences drink-driving has not been well studied.

What this study adds

- Before the implementation of more severe penalties for drink-driving, alcohol-related crashes started to decline, reflecting changes in social norms following debates after high-profile collisions.
- Media coverage of high-profile cases might have played a role in changing social norms by triggering debates.

CONCLUSIONS

Our findings suggested that media coverage of high-profile cases preceding law amendments played a role in agenda-setting and changing social norms, leading to pre-legislative changes in driver behaviour. Media coverage could also accelerate the effects of legislation, and might have even larger impacts than changes to the law. There is a need to study the content and quantity of media coverage, to determine how it changes over time and to what extent it contributes to behaviour changes, in order to reproduce Japan's success in other countries. Nonetheless, our findings indicate that media effects should be fully utilised in combination with legislation in order to reduce drink-driving.

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Competing interests None.

Contributors SN conceived the ideas of this study, analysed the data, and prepared the manuscript. MI contributed to the analyses, preparing and critically revising the manuscript.

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Review

Population strategies and high-risk-individual strategies for road safety in Japan

Shinji Nakahara[a,*], Masao Ichikawa[b], Akio Kimura[c]

[a] Department of Preventive Medicine, St. Marianna University School of Medicine, 2-16-1 Sugao, Miyamae-ku, Kawasaki 216-8511, Japan
[b] Graduate School of Comprehensive Human Sciences, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8575, Japan
[c] Department of Emergency Medicine and Critical Care, National Center for Global Health and Medicine, Hospital, 1-21-1 Toyama, Shinjuku-ku, Tokyo 162-8655, Japan

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ABSTRACT

Objectives: We examined road safety policies and trends in road traffic injuries (RTIs) in Japan between 1970 and 2008 from the viewpoints of population and high-risk-individual approaches to see what lessons can be learned from the example of a country that experienced a decline in RTIs following comprehensive road safety policies.
Methods: We reviewed research papers and policy documents, obtained from relevant ministries, decade by decade. We obtained data on RTIs from police and from vital statistics.
Results: Japan started the Fundamental Traffic Safety Program to combat the increase in RTIs, and succeeded in reducing both RTI mortality and morbidity rates in the 1970s by implementing vast road safety improvements, using population approaches with a particular focus on protecting the most vulnerable population groups at that time. However, RTIs increased again in the 1980s because of increasing traffic volume. In the 1990s and 2000s, safety policies targeted at high-risk driving behaviors succeeded in reducing RTI mortality rates but failed to change morbidity rates.
Conclusions: To achieve a safer road environment, more emphasis is required on population approaches that reduce risk among the whole population, with a balance between population and high-risk-individual approaches.

Contents

* Corresponding author. Tel.: +81 44 977 8111; fax: +81 44 977 8356.
E-mail addresses: snakahara@marianna-u.ac.jp (S. Nakahara), akimura@imcj.hosp.go.jp (A. Kimura).

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1. Introduction

Road traffic injuries (RTIs) are the leading cause of death and disease burden worldwide [1,2]. Because of rapid motorization and inadequate safety measures, RTIs are greatly increasing in low- and middle-income countries (LMICs) and are predicted to be the fourth leading cause of disease burden in LMICs by 2030 unless effective measures are implemented [3]. Some international responses to this growing health problem include the "World Report on Road Traffic Injury Prevention," which guides countries to implement comprehensive prevention measures, and the "Global Status Report on Road Safety," which provides information to assist with national policy formulation and to measure global road safety progress [2,4]. Beyond these efforts, we can also obtain in-depth practical information by investigating the history of high-income countries (HICs), which have already experienced a rapid increase and subsequent decline in RTIs. This information would benefit LMICs in efficiently tackling their problem of sharply-increasing RTIs.

Japan has had some conflicting experiences in addressing RTIs, with both success and failure. It has been one of the most successful countries in reducing RTI deaths; its RTI crude mortality rate in 2008 was 4.7 per 100,000 population, comparable to the best rates among European countries (3.8 in Iceland, 4.1 in the Netherlands, 4.3 in Sweden, 4.3 in the United Kingdom, and 4.3 in Switzerland) [5]. In contrast, Japan showed one of the highest RTI morbidity rates (744 per 100,000 population) among HICs [6]. Exploring past countermeasures and their effects, while considering changing traffic situations, could shed light on the reasons for the coexisting success and failure.

Some countermeasures in Japan are targeted at high-risk individuals or situations (e.g., risky driving and "hotspots" such as intersections with extremely high collision rates) [7–9]. However, as Rose [10] pointed out, preventive measures targeted at "high-risk groups" cannot yield significant changes among the whole population when the high-risk group accounts for a small fraction. In contrast, with a "population" approach designed to control the causes that affect the whole population, although each individual's risk reduction is small, it may yield larger changes as a whole [10]. Although these two approaches have seen concerted efforts related to road safety in Japan, the balance between them might have varied over time, with more attention paid to high-risk-individual approaches.

In this study, we examined road safety policies along with trends in RTIs in Japan between 1970, when RTI deaths reached a peak, and 2008, when RTI deaths reached almost a third of that peak. We examined research papers and policy documents decade by decade to discuss how population and high-risk-individual approaches affected RTI prevention.

2. Materials and methods

We obtained police data on the number of vehicle collisions, and associated deaths (within 24 h of the collision) and injuries; population data from the Ministry of Internal Affairs and Communications; traffic volume data from the Ministry of Land, Infrastructure, Transport and Tourism (MLITT); and vital statistics data from the Ministry of Health, Labour and Welfare (MHLW). We reviewed the First to Eighth Fundamental Traffic Safety Programs (FTSPs), which were the most fundamental documents in the development of Japan's road safety policies, the Police White Paper 1973–2009, and the White Paper on Traffic Safety 1970–2009. Based on the information in the FTSPs, we searched for policy documents on road safety and traffic related issues (transportation, health promotion, and environmental protection) on the websites of related ministries (MLITT, MHLW, National Police Agency, and the Ministry of the Environment). We searched for published research on road safety in Japan, using PubMed and Ichushi (a database on Japanese biomedical science articles); our searched key words included Japan; road traffic; and [injury OR crash OR collision] (this study was not a systematic review). We also hand-searched the IATSS Review (1990–2009), a Japanese journal on road safety.

3. Results

3.1. Trends of RTIs in Japan

In the 1950s and 60s, RTIs increased because of rapid economic development and motorization, and reached a peak in 1970 (Fig. 1). To tackle this growing issue, the Japanese government introduced the Traffic Safety Policies Act in 1970, and implemented comprehensive measures. Consequently, in the early 1970s, both mortalities and morbidities declined considerably, in all age groups and for all modes of transport (Figs. 2–4). However, the declining trend exhibited a slowdown in the late 1970s. In the 1980s, the trends in both fatal and non-fatal RTIs began to rise again; however, mortality and morbidity rates per vehicle kilometers traveled (VKT) were constant (Fig. 1). This suggests that the increasing trend of RTIs mainly resulted from the increase in traffic volume, which might have canceled out the effect of countermeasures taken in the 1970s. The pedestrian morbidity rate, which declined evenly in all age groups during the 1970s, thereafter showed a decline only among preschool-age children (Fig. 4). In the 1990s, RTI morbidity and mortality trend discrepancies began to appear: the number of deaths as well as deaths per VKT started to decline, whereas injuries continued to increase,

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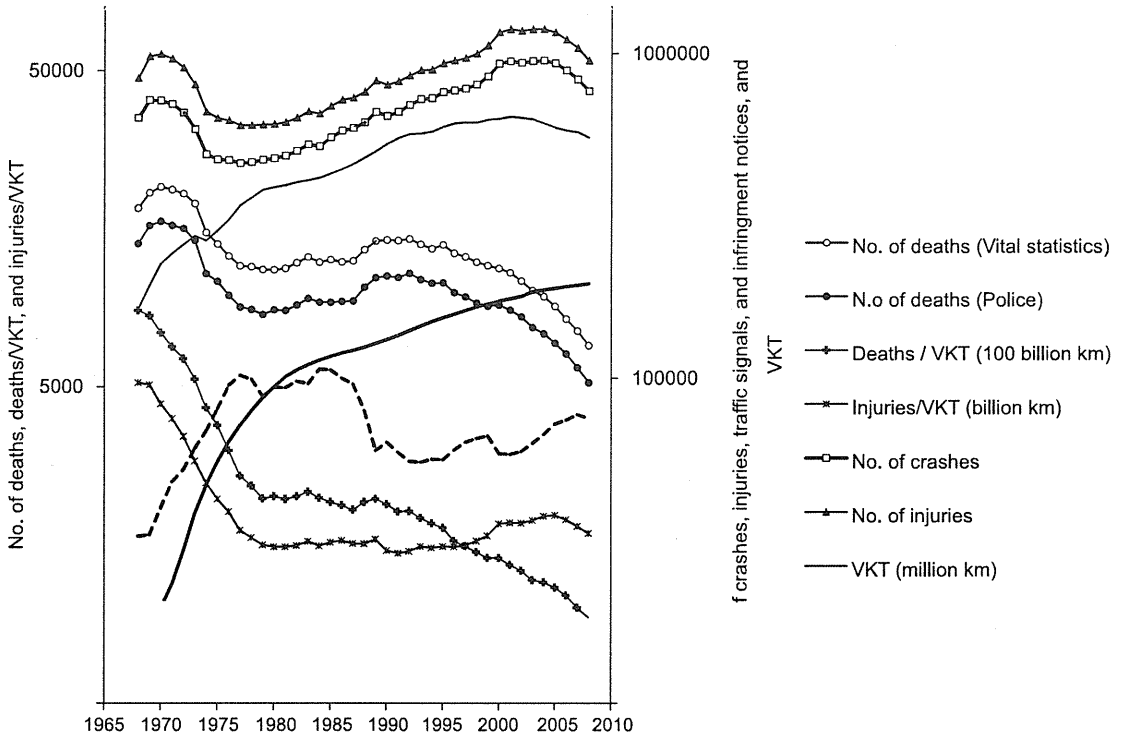

Fig. 1. Number of collisions, deaths, injuries, vehicle km traveled, deaths and injuries per vehicle km traveled: trends from 1968 to 2008.

with morbidity per VKT remaining mostly constant while sometimes increasing. The mortality rate among youths aged 15–24 showed a steeper decline than in the older groups; the economic recession and increasing unemployment rate in this period might have influenced RTIs among youths [11,12]. These trend discrepancies were mostly sustained through the 2000s. Injuries per VKT showed an increasing trend in the early 2000s and a slight decrease in the later part of the decade, though the number of RTIs stopped increasing and began to decrease, as a result of reduced traffic volume due to the depressed economy and increased gasoline prices [12,13]. In contrast, the number of deaths as well as deaths per VKT continued to decline.

3.2. Policies in the 1970s

In 1970, the Japanese government, under the Traffic Safety Policies Act, established the Central Traffic Safety Policy Council, consisting of related ministers with the Prime Minister being the chairperson, to promote collaboration among ministries and agencies. The First Fundamental Traffic Safety Program (FTSP) was also begun in 1971, which was a 5-year program to implement comprehensive countermeasures [14].

Given that pedestrians accounted for a third of all RTI deaths, the First FTSP emphasized pedestrian protection with a focus on children, who were at higher risk for pedestrian injuries, with a target of reducing pedestrian deaths to less than 4000 by 1975 [14]. The First FTSP, in the same way as the subsequent FTSPs, called for comprehensive strategies, including improvement of the traffic environment through road safety installations, managing traffic through traffic regulations, improvement of vehicle safety standards, improvement of the working conditions of commercial drivers, increasing safe play areas for children, providing safety education to children as well as drivers, improving the trauma care system, and improving financial compensation to victims.

Among the measures implemented during this period of time, some noteworthy features were sizable investments in road safety installations, and strengthened enforcement: for example, the number of installed traffic signals more than quadrupled in the 1970s while traffic volume only doubled, and the quantity of infringement notices issued saw an increase of 91% from 1970 to 1975 (Fig. 1) [9,15]. One study reported that the doubled frequency of police patrolling reduced the collision rate by 30% [16]. These measures, though mainly targeted at high-risk individuals and situations, such as child pedestrians and arterial roads with heavy traffic, benefited all road users because of their extensive coverage of almost all arterial roads (where the majority of RTIs occurred) rather than targeting a few "hotspots" (Table 1), resulting in considerable declining trends of RTIs in the early 1970s.

In the late 1970s, the sharp increase in road safety installations and enforcement activities leveled off, resulting in a similar slowdown in the declining trend of RTIs. The sizable investment in road safety of the early 1970s, reflecting the required response to the urgent situation of the time, could not be maintained partly because of the country's economic difficulties [9].

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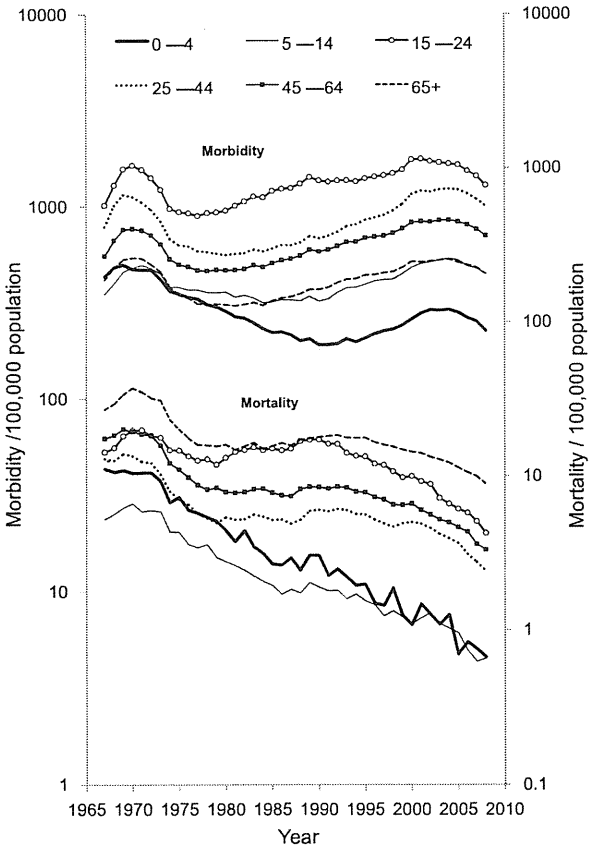

Fig. 2. Mortality and morbidity rates per population by age group: trends from 1967 to 2008.

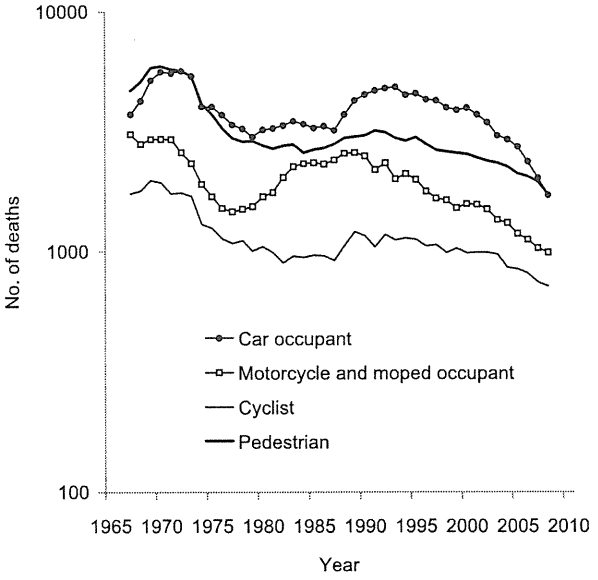

Fig. 3. Number of deaths by mode of transportation: trends from 1967 to 2008. Motorcycles include mopeds.

However, the considerable decline in RTIs in the 1970s occurred mainly in the targeted arterial roads, whereas local roads in residential areas had been overlooked because of their relatively infrequent collisions; the collision rate on main roads decreased by 65% whereas that on local roads decreased by only 15% (Table 1). Consequently, the share of local roads in the RTI occurrence increased to account for about half, despite their low collision rates per road length, because local roads make up the large majority of the country's road network.

Measures were then proposed in an attempt to target local roads. The Second FTSP, starting in 1976, described traffic-calming proposals to reduce traffic flow and speed in residential areas; however, the proposals concentrated on a few designated areas with high collision rates that account for a small fraction of residential areas in Japan. (To illustrate, the number of designated residential areas

Table 1
Number of collisions and collision rates per road length by road category.

	Arterial roads[a]	Prefectural roads	Local roads[b]
1970			
No. of collisions	374,266 (52.5%)	109,068 (15.3%)	229,207 (32.2%)
Road length (km)	61,906 (6.1%)	92,730 (9.1%)	859,953 (84.8%)
Collision rate per km	6.0	1.2	0.27
1980			
No. of collisions	184,296 (39.0%)	70,021 (14.8%)	218,029 (46.2%)
Road length (km)	86,697 (7.8%)	86,930 (7.8%)	939,760 (84.4%)
Collision rate per km	2.1	0.81	0.23
1990			
No. of collisions	268,513 (42.5%)	76,028 (12.0%)	287,020 (45.4%)
Road length (km)	101,950 (9.1%)	78,428 (7.0%)	934,319 (83.8%)
Collision rate per km	2.6	1.0	0.31
2000			
No. of collisions	382,109 (42.2%)	97,601 (10.8%)	426,625 (47.1%)
Road length (km)	117,832 (10.1%)	70,745 (6.1%)	977,764 (83.8%)
Collision rate per km	3.2	1.4	0.44
2008			
No. of collisions	300,843 (41.0%)	79,435 (10.8%)	354,178 (48.2%)
Road length (km)	119,875 (10.0%)	71,415 (5.9%)	1,009,599 (84.1%)
Collision rate per km	2.5	1.1	0.35

[a] Main roads include national roads, national expressways, and principal prefectural roads.
[b] Local roads are maintained by municipalities (cities, towns, and villages).

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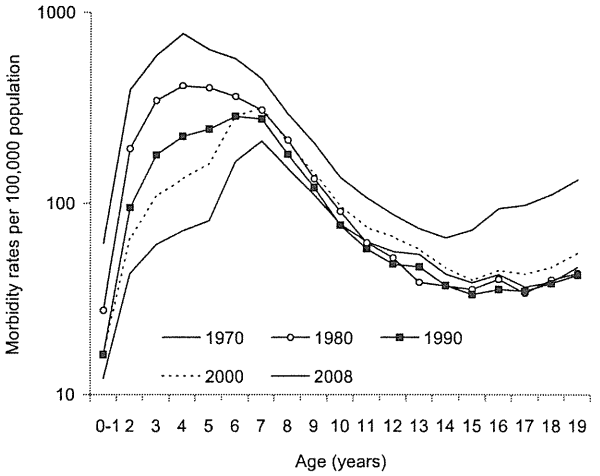

Fig. 4. Changing patterns in pedestrian morbidity rates by age.

increased from 1942 in 1975 to 6872 in 1980 [7,17].) This was, however, still insufficient in dealing with collisions on local roads.

Another promising intervention in residential areas to reduce child pedestrian injuries was the Urban Park Construction Plan, started in 1972, which almost doubled the total area of urban parks over 10 years [7]. An ecological study using prefectural data showed that the increase in public parks was significantly associated with a decrease in the road traffic mortality rate among preschool-age children [18].

Meanwhile, safety education was implemented in schools and preschools in an attempt to teach pedestrian skills so children could protect themselves [14,17]. This intervention is still ongoing. However, its effectiveness in injury reduction is still unclear; several studies in Japan and a systematic review have indicated that education can change children's behaviors as pedestrians, but they did not prove injury reduction to be an intervention effect [19–21].

3.3. Policies in the 1980s

Reflecting the success in the 1970s, the Third FTSP, starting in 1981, mostly followed the policies prescribed in the previous FTSPs, which focused on the protection of pedestrians, cyclists, children, and the elderly [22]. It also introduced the concept of "Community Roads," a traffic-calming proposal to reduce vehicle speed and flow in residential roads; however, such measures were not widely put into practice as mentioned above.

In the late 1980s, however, responding to the reversing trends, the government shifted its emphasis toward strategies that protect high-risk individuals, while adjusting the main objective from that of decreasing pedestrian deaths to that of decreasing vehicle (car and motorcycle) occupant deaths. More focus was placed on mortality reduction, since the FTSPs specified a concrete numerical goal of mortality reduction but not one of morbidity or collision reduction. The Fourth FTSP explicitly indicated motorcyclists and moped riders as a focused target group, in response to a rapid increase of mortality among moped drivers [23]; despite the penalty for non-use of helmets among motorcycle riders that had been introduced in 1975, helmet use among moped drivers was not compulsory [15]. Mopeds accounted for approximately 80% of the total number of motorcycles in this time period [15].

Seatbelt use became compulsory in September 1985, and a penalty was introduced in November 1986. Seatbelt use then increased considerably, from 26.7% in 1984 to 96.5% among non-highway drivers in 1987. However, the mortality reduction among car occupants was smaller than expected (Fig. 3) [7,24]. Some researchers explain this using a risk compensation theory, describing how people tend to drive more aggressively when belted because of the perceived protection from the seatbelt. However, the data fit better with a selective recruitment theory, which explains how drivers who are unlikely to adopt safe behaviors are at high risk of causing a serious collision, suggesting that to obtain significant benefit from the seatbelt legislation, almost all vehicle occupants on the road should be wearing a seatbelt [24–26]. Unfortunately, enforcement of seatbelt usage was not stringent enough in the 1980s because of a debate over whether such legislation violates individual freedoms, resulting in a reduction in seatbelt-wearing among non-highway drivers to 76.8% in 1990 [9,15]. Likewise, further helmet legislation introduced in July 1986, which imposed a penalty for non-use of helmets among moped drivers, increased their helmet usage from 63.9% in April 1986 to 97.5% in August 1986, but it did not have a considerable impact on the number of motorcyclist deaths (Fig. 3) [27].

Vast road safety installations in the 1970s successfully reduced the risk of pedestrian injuries among the whole population, mainly on arterial roads. Thereafter, however, environmental risk factors did not change, particularly in residential areas where the majority of pedestrian injuries would occur. Meanwhile, behavioral factors among preschool-age children might have changed; parents became less likely to allow preschool-age children to play outside alone, knowing the risk of child pedestrian injuries, although the independent mobility of school-age children was then a social norm [28]. This may explain why only children showed a constant decline in pedestrian morbidity rate (Fig. 4).

3.4. Policies in the 1990s

Responding to the increasing number of deaths, which exceeded 10,000 in 1988, a benchmark number for policymakers, the Fifth FTSP for 1991–1995 thus narrowed its focus to dangerous driving behaviors with a high risk of fatal collisions, such as speeding and drunk driving, stating that such driving behaviors must be strictly regulated "with a special emphasis" [29]. Furthermore, the Fifth FTSP specifically targeted elderly people and young drivers, given the markedly increased RTI deaths among them. Thus, the emphasis on high-risk-individual strategies was more apparent in the 1990s than in the 1980s.

As reflections of these policies, the number of infringement notices issued for extreme speeding of more than 30 km/h over the speed limit and for traffic signal violations increased by 31.7% and 44.9%, respectively, during

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the 1990s [11], whereas the number of people charged with drunk driving did not change. Consequently, fatal collisions due to speeding declined in the 1990s faster than those due to driving under the influence of alcohol (DUI) [30]. Fatal collisions due to speeding accounted for 23.2% of the total in 1990, and this was reduced to 16.3% in 2000 and 8.5% in 2006 [31–33]. The reduction in fatal collisions due to speeding among young drivers was greater than that among the other age groups [34]; youths aged 16–24 accounted for 28.1% of RTI deaths in 1990 and 17.2% in 2000 [15].

A novice driver's license system was implemented in 1990 to improve driving ability among young drivers. Newly-licensed drivers who commit a certain number of violations are required to attend a one-day paid training course, or to pass a reexamination for licensing, or their licenses are revoked. This system is different from graduated driver licensing for teen drivers, which gradually allows novice drivers to drive in more complicated situations [35]. The Japanese system successfully removed from the roads many intransigently dangerous young drivers who had repeatedly violated traffic regulations; 4171 novice drivers had their licenses revoked in 2006 [33].

Enforcement of seatbelt usage was strengthened in the early 1990s. The number of people penalized for seatbelt non-usage was 555,847 in 1989, and this increased to a peak of 4,195,524 in 1995. The Sixth FTSP stressed the need for stronger enforcement of seatbelt legislation. Consequently, the proportion of belted drivers increased to 83.7% in 1995, and to 88.8% in 2000 [36].

Meanwhile, improved trauma care including a better ambulance system also contributed to the declining trend in RTI mortality. In 1992, following the example of the US paramedic system, the Japanese government instituted the use of emergency medical technicians, who perform various resuscitation techniques under the guidance of physicians before a patient reaches the hospital [37].

In contrast, environmental measures aimed at reducing collisions and injuries had not been applied widely enough to yield substantial injury reduction, although the FTSPs did include such measures. For example, the Sixth FTSP introduced "Community Zones," which is a comprehensive traffic-calming proposal combining road measures that reduce vehicle speed using speed hump and chicanes, and zone measures that restrict through-traffic in designated residential areas, to achieve safe and comfortable environments for pedestrians and cyclists. However, only around 100 such areas were designated per year [11]. The Sixth FTSP also prescribed safety modifications to road environments, particularly at intersections. However, only a limited number of "hotspots" with high collision rates were selected for this program; safety modifications had been completed in 1665 locations by 1999 [38,39]. Although this program was expected to reduce collisions in these designated locations by about 30%, collisions occurring in these areas had accounted for only 1.4% of all collisions in Japan [39].

3.5. Policies in the 2000s

Noteworthy achievements in the 2000s were a successful reduction of alcohol-related crashes and policy changes that placed more emphasis on population approaches (e.g., numerical targets of morbidity reduction and measures to reduce traffic volume). An accelerated reduction in collisions involving DUI was achieved, following two major law amendments [30,40–42]. One of these was the new criminal law enacted in December 2001, which prescribed up to 15 years imprisonment (a maximum term of 20 years in combination with other offences) for extremely dangerous driving causing death, including heavily drunk driving [8]. Before this amendment, the maximum penalty was 5 years imprisonment. The other was an amendment to the Road Traffic Law in June 2002: the maximum fine for DUI was increased from 50,000 yen to 300,000 yen (it was increased again in September 2007 to 500,000 yen) [8]. At the same time, the legal punishable blood alcohol level was reduced from 0.5 mg/ml to 0.3 mg/ml.

However, we cannot ignore the effects of changes in social norms that might have influenced these amendments to traffic laws, or social norms might have been influenced by the passage of the amendments. It appears that behavioral changes among drivers may have begun before the abovementioned amendments. The number of drivers charged with DUI, which had been relatively constant at around 340,000 in a year in the previous decade, declined by 24% in 2000, and thereafter continued to decline to as low as 50,000 in 2008 [30,32]. A media campaign against drunk driving was started in 1999 and stimulated a negative public opinion toward drunk driving, which resulted in 34,000 signatures on a petition calling for severe punishment for DUI causing death [42]. The transportation situation has also changed in response to these changing norms; chauffer services, in which a dispatched driver can drive impaired individuals home in their own car, became readily available at a reasonable cost [43].

The most drastic policy change in this period has been that road safety policies began to include the reduction of morbidity and collisions as their explicit target. The Social Infrastructure Key Improvement Plan (SIKIP), introduced in 2003, placed greater emphasis than the previous such plans on safety in residential areas, where less-serious collisions are likely to occur [38,39]. The Eighth FTSP, starting in 2006, is the first to indicate a numerical target of morbidity reduction, emphasizing the protection of vulnerable road users [44]. However, the actual implementation of morbidity reduction did not change overnight; as yet, only a limited number of high-risk locations are selected for environmental modifications. The SIKIP selected about 800 residential areas, as well as about 400 hotspots in arterial roads, for comprehensive traffic-calming measures to improve the road safety environment.

Another change is the attempt to shift people's mobility choices from private vehicles to public transportation so as to reduce traffic volume, referred to as "transportation demand management." The Sixth FTSP briefly introduced this topic, while the Seventh and Eighth FTSPs described it more substantially, indicating various examples of development and improvement of public transportation systems [36,44,45]. However, the FTSPs did not explicitly describe these measures as a means to reduce the risk of traffic injuries, but as a means of achieving smooth transportation flow. Facilitating public transportation use has been

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promoted from the viewpoint of sustainable development, environmental protection, equitable transport access particularly in rural areas, and physical activity promotion to prevent cardiovascular disease [46–50]. In addition to interventions targeting the supply aspect of public transportation, strategies were proposed to facilitate behavioral changes related to the demand side (among users) through marketing techniques such as the "Mobility Management" initiative [51]. These measures, though they are yet to be thoroughly evaluated, have the potential to reduce injuries by greatly decreasing traffic volume.

Furthermore, vehicle design improvements to protect occupants and even vulnerable collision counterparts (pedestrians and cyclists), as well as standardized trauma care, also contributed to the reduction of deaths per VKT in this time period. Regulations that necessitate vehicle crashworthiness tests for occupant protection were introduced in the 1990s, as were tests for pedestrian protection (in a collision with a vehicle) in the early 2000s [52,53]; such measures take effect gradually, since newly designed vehicles do not immediately replace older ones. Attempts to standardize hospital and pre-hospital trauma care based on published guidelines began in the early 2000s, and may also have had a gradual effect [54].

4. Discussion

This paper evaluates road safety measures in Japan, from the viewpoints of population or high-risk-individual approaches. We assume that the population approach can stimulate a small risk reduction in individuals in the great majority of the population, resulting in a larger amount of risk reduction than the high-risk-individual approach aiming at greater risk reduction among a small group. In reality, however, most measures have both characteristics, and both may be necessary in some cases, while the extent of the coverage likely also matters. For instance, traffic-calming measures in residential areas, a population approach targeting all residents of those areas, cannot achieve significant collision reduction if covering only a few high-risk locations. Seatbelt legislation covering the whole vehicle-occupant population aims for small reduction of risk in individual occupants (individuals' collision risk is very small), but to achieve the expected mortality reduction, measures may be required to address those occupants who do not obey the legislation but who account for the majority of collision casualties.

Conversely, high-risk-individual approaches succeeded by extending their coverage. Heavy investment in the 1970s in road safety installations on arterial roads with higher collision rates was a high-risk-individual approach by nature; however, its extensive coverage benefited the whole population, leading to a considerable reduction in morbidity as well as mortality. The measures against DUI in the 2000s were high-risk-individual approaches; however, they would not have succeeded without changes in social norms and transportation systems that influenced the whole population and supported behavior change. Previous attempts to strengthen DUI law enforcement, lacking such cooperative social changes, had failed [55]. In contrast, improvements in "hotspot" environments in the 1990s and 2000s reduced collisions in those areas but did not make a difference for Japan's collision rate as a whole, owing to the small number of targeted areas.

Until recently, Japanese road safety policies tended toward high-risk approaches with limited coverage by prioritizing individuals and locations at higher risk of serious collisions, except in the early 1970s, probably for two reasons. First, the FTSPs (First to Seventh) indicated numerical targets for mortality reduction but not morbidity or collision reduction, which pushed the policies to emphasize high-risk-individual approaches. Second, economic constraints did not allow wider program coverage, requiring prioritization of high-risk individuals and locations. Heavy investment in road safety installations in large areas, which were possible in the 1970s because of the economic growth of that period, may have since been difficult given the declining economic situation in Japan.

There have been some indications of future change. The Eighth FTSP indicated morbidity reduction as a numerical target and the SIKIP began programs to reduce collisions (mainly non-fatal ones) in residential areas [39,44]. More importantly, there are growing movements that attempt to reduce traffic volume through wider use of public transportation, which has the potential to reduce vehicle collisions and injuries, influencing the whole population. Since this requires that people accept less convenient mobility options, public perceptions as well as the transportation system should change. Safety reasons alone cannot bring about such changes, and more impending issues related to sustainable development and aging societies (e.g., global warming, equitable rural development and cardiovascular disease) encourage radical changes. Therefore, these attempts should be coordinated to achieve the maximum effect.

5. Conclusions

Population and high-risk-individual strategies should be balanced in road safety policies. Although high-risk approaches contribute to mortality reduction, it appears that the Japanese government has not paid enough attention to population approaches. If the goal of having the safest roads in the world is to be achieved, as was declared by former Prime Minister Koizumi, policies should be shifted in such a way as to target those at lower risk who account for the majority of casualties [56].

Police and traffic engineers are inclined to modify "flaws" in behaviors and designs (high-risk individuals and situations), whereas epidemiologists address injury patterns and population risks [57]. Environmentalists and sociologists may see environmental and societal factors related to road safety issues. To integrate these perspectives, various forms of expertise including public health, environmentalism, and sociology should be incorporated into road safety policy formulation. However, the Ministry of Health, Labour and Welfare is currently only contributing to improving trauma care, and the Ministry of Environment is not involved at all. By incorporating multidisciplinary knowledge, greater momentum can be achieved with promising strategies to reduce population risk, thus generating well balanced and effective policies.

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Conflicts of interest

None

Ethical considerations

Human subjects were not used.

Contributions

SN conceived of the idea for this work, conducted the literature search, reviewed and interpreted the literature, and wrote the manuscript. MI and AK contributed to the interpretation, drafting and revision of the manuscript.

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**日本の道路安全と外傷予防に関する経験を活用した
途上国の外傷予防に関する研究**

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研究代表者　中原慎二
聖マリアンナ医科大学予防医学教室
〒216-8511　川崎市宮前区菅生 2-16-1
TEL：044-977-8111
FAX：044-977-8356