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Review

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

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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,

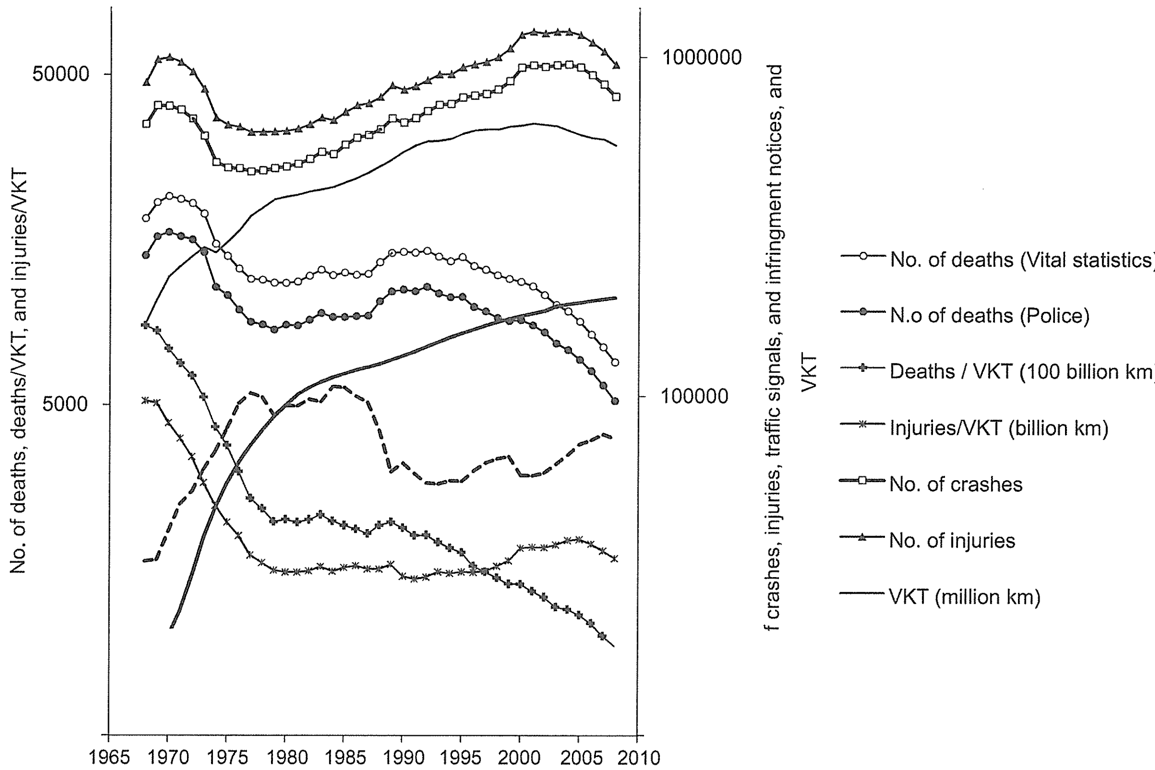

Fig. 1. Number of collisions, deaths, injuries, vehicle km traveled, deaths and injuries per vehicle km traveled: trends from 1968 to 2008.

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].

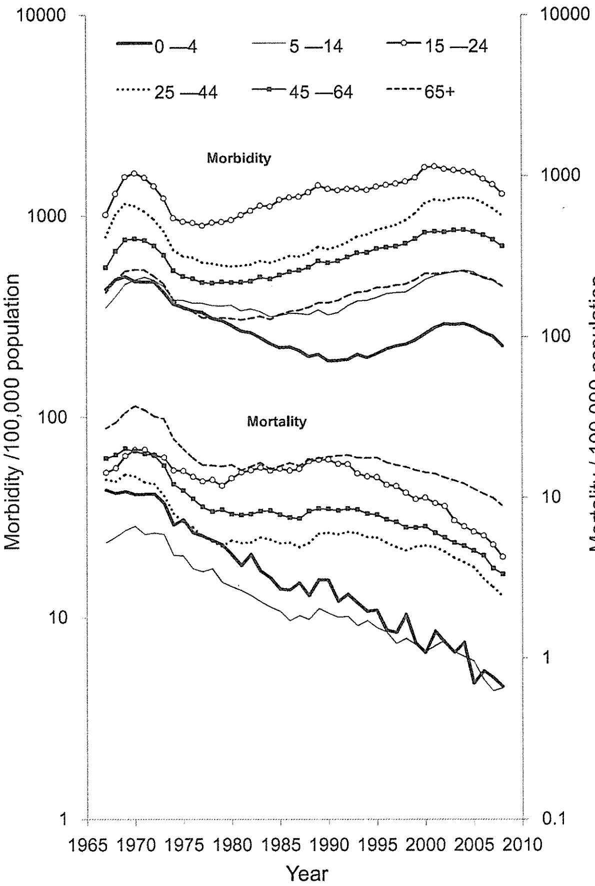

Fig. 2. Mortality and morbidity rates per population by age group: trends from 1967 to 2008.

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.

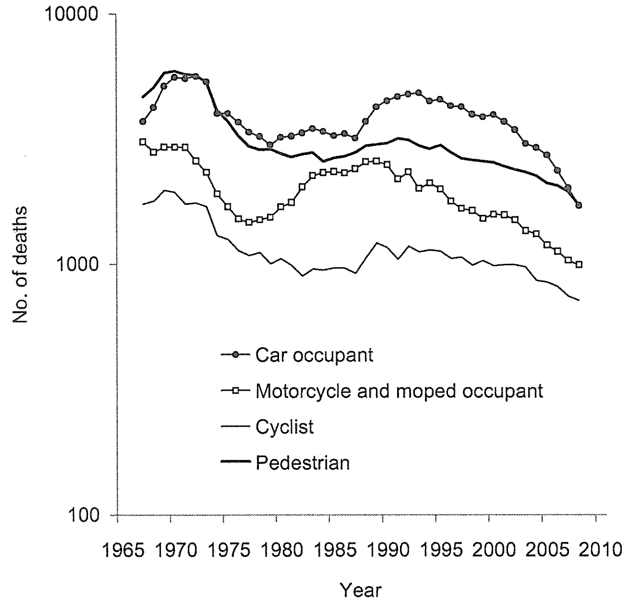

Fig. 3. Number of deaths by mode of transportation: trends from 1967 to 2008. Motorcycles include mopeds.

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).

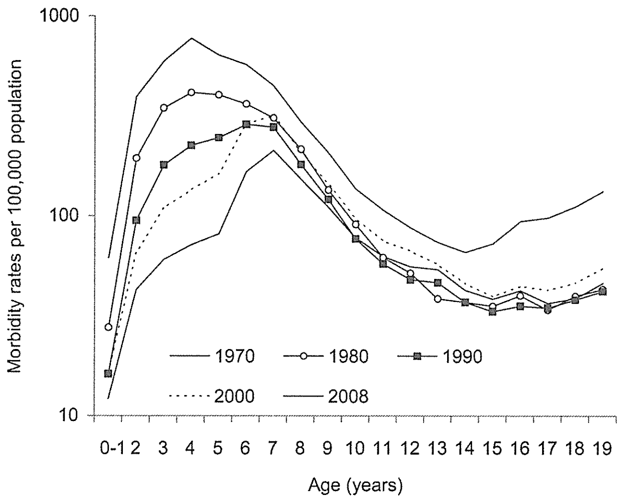

Fig. 4. Changing patterns in pedestrian morbidity rates by age.

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 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 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.

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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Lessons learnt from the recent tsunami in Japan: necessity of epidemiological evidence to strengthen community-based preparation and emergency response plans

Shinji Nakahara

A massive tsunami following an earthquake of magnitude 9.0 hit the northeastern part of Japan on 11 March 2011, causing catastrophic damage in coastal areas of the country. The death toll may have exceeded 20 000, with most deaths having been caused by drowning. As of 4 September, the National Police Agency has confirmed 15 763 deaths and has reported 4282 persons as missing.[1–3] This tragedy implies a partial failure of Japan's long-term efforts on preparation and emergency response plans for its frequent earthquakes and tsunamis. Having frequently sustained devastating tsunami damage in the past, the severely damaged areas, particularly the Sanriku coast in the northern part of the affected region, were well equipped with extensive coastal defences and sophisticated tsunami warning systems.[4 5] These technology-oriented measures, however, could not provide effective protection against this once-in-a-millennium tsunami.

This failure propelled Japanese authorities to recognise their over-reliance on technical solutions in their current approaches to disaster mitigation and to make a shift to more balanced solutions, which assume technological limitations and put greater emphasis on evacuation and land use.[4 6 7] The alternative approaches aim to promote community-based efforts in developing detailed evacuation plans and in targeting aspects of residents' behaviour. Epidemiological data, such as geographical and demographic risk distribution, should be used to guide such measures. The health sector and injury control experts should contribute in this regard by collecting and analysing epidemiological data. However, currently in northeastern Japan, preventing post-disaster health problems is a more pressing issue.

Before the 2011 tsunami, Japan's disaster countermeasures had made continual progress by reducing risk factors when weaknesses became apparent during natural disasters. However, the tsunami on 11 March 2011 exposed major limitations in Japan's emergency response plan for tsunamis. This paper provides an overview of Japan's experience in developing disaster preparation plans—an experience founded on lessons learnt in the past. It discusses what brought about the flaws revealed recently and what we can do to reduce casualties in any future disasters, with a focus on community-based actions founded on a better understanding of epidemiological evidence.

JAPAN'S EXPERIENCE OF EARTHQUAKES AND COUNTERMEASURES

Japan has experienced severe damage from frequent earthquakes, either directly from tremors or indirectly from tsunamis; lessons learnt from the damage have guided the subsequent development and improvement of countermeasures. The Great Kanto Earthquake on 1 September 1923 claimed approximately 105 000 lives in the Kanto area (mainly Tokyo, Kanagawa and the Chiba Prefecture). Of the total deaths, about 92 000 (87%) were caused by fire and about 11 000 (11%) were caused by collapsing houses.[8 9] Many fires broke out after the tremor because the earthquake occurred at 11:58, when many people were preparing lunch using charcoal stoves and more than 100 000 houses, mainly built of wood, collapsed. Unfortunately, a strong wind of more than 15 metres per second that afternoon assisted the rapid spreading of the fires. After the Great Kanto Earthquake, various measures were brought into effect to reduce fire-related casualties caused by earthquakes: better urban planning was introduced, with wider roads and larger green areas to prevent fire from spreading in city centres; charcoal stoves were replaced with safer gas cooking stoves; and the quake-resistance and fire-resistance of buildings were improved.[8 10 11]

In the Great Hanshin–Awaji Earthquake of 17 January 1995, in contrast, the leading causes of death were asphyxia/compression (77%), head/neck injuries (5%) and other traumatic injuries (4%), which were mainly caused by collapsing buildings or falling furniture. Fire accounted for 9% of the deaths; many of the fire victims were unable to escape from collapsed buildings.[12 13] Since the earthquake occurred at 05:46, when most people were asleep, the great majority of casualties occurred indoors. The lower proportion of deaths due to fire may have resulted of the fact that relatively few people were cooking at the time, in addition to the effects of the measures introduced after the Great Kanto Earthquake. Also, there were no strong winds that day.

Although efforts to improve quake and fire resistance in buildings were made for quite some time, those improvements were insufficient at the time of the Great Hanshin–Awaji Earthquake. The Japanese government introduced a building code in 1950 and tightened quake-resistance standards in 1981, however, there was still a large number of old buildings that had been constructed before 1981, and these accounted for the majority of collapsed structures in the earthquake.[14] To facilitate the renovation of old buildings after the earthquake, the government introduced the Act for Promotion of Renovation for Earthquake-Resistant Structures in 1995, which stipulates mandatory renovation of buildings for public use. However, renovations of private residences, which this law does not address, have still been executed insufficiently.[14]

The Sanriku area has frequently sustained earthquake damage, mainly as a result of tsunamis. The most severe one was the Meiji Sanriku Earthquake on 15 June 1896. Although the tremor itself was relatively weak in inhabited areas, it was followed by a huge tsunami, with

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a greatest run-up height of 38.2 metres, causing over 22 000 deaths.[5 15] On 3 March 1933, another earthquake struck the same region, followed by a tsunami with a maximum run-up height of 23.0 metres, resulting in about 3000 deaths. The strong tremors prompted the residents to evacuate the area, thereby minimising human casualties. Subsequent countermeasures to mitigate the impact of tsunamis have included a tsunami warning system, which was used first in this area in 1941 and was expanded to the whole country in 1952, the construction of breakwaters and seawalls, and relocating residential areas to higher grounds.[5 16] In 1958, the Sanriku town of Taro constructed a huge 10 metres high and 2.5 kilometres long seawall, which was nicknamed the Great Wall. These measures were based on geographical risk distribution and targeted areas that had been severely affected in past disasters.

On 24 May 1960, an earthquake off the Chilean coast caused a tsunami in the Sanriku area, thus revealing a weakness in the warning system which did not cover such distant events. The tsunami resulted in severe damage and 142 deaths, due in part to the lack of palpable tremor warning signs.[5 16] In contrast, Taro's Great Wall offered local protection from this tsunami, while other areas with smaller structures sustained great damage. The government consequently initiated a 5-year plan to develop seawalls and breakwaters in the Sanriku area, and expanded the tsunami warning system to cover distant events.

Consequently, the Sanriku coastline became a showcase of Japan's advanced technology in civil engineering—for example, the world's deepest tsunami breakwater at Kamaishi Bay in the Iwate Prefecture. Since the completion of the 5-year plan in 1966, the gigantic coastal defences successfully protected the areas from frequent tsunamis until 11 March 2011. This temporary success, possibly coupled with the extensive defences' reassuring appearance, may have provided residents with a false sense of safety against tsunamis[4] and deterred them from evacuating promptly. Several surveys reported that, in recent earthquakes, most residents in these areas did not evacuate even when tsunami warnings were issued.[17 18]

Although the Japanese government—as stated in its 1998[19] guidelines on enhancing tsunami countermeasures—has endorsed comprehensive countermeasures, including evacuation planning, land use and protection works, its approach was greatly biased towards technology-oriented measures. This is partly because of the relative success of coastal defences and also because of the long and difficult process of obtaining a consensus among residents in order to modify land use. Although municipal governments were obliged to designate and manage evacuation sites, the educational and behavioural aspects of evacuation were left to the local communities. The degree of community-based activities such as safety education and evacuation drills varied greatly across communities, depending on the perceptions and dedication of the community. In some communities, participation in evacuation drills was much less than satisfactory, whereas in others, safety education and drills, particularly at schools, were carried out regularly.[18 20] Such differences in community-based preparedness may have had life-and-death consequences in the tsunami on 11 March, as described below.

LESSONS FROM THE TSUNAMI ON 11 MARCH 2011

The unexpectedly massive tsunami on 11 March 2011 overwhelmed all coastal defences in northeastern Japan and caused devastation over vast areas. Collapsed buildings due to the tremor were minimal and most of the casualties were the result of the tsunami.[2] The lessons learnt are twofold. First, prediction-based technology-oriented measures may fail because we cannot predict accurately the maximum magnitude of future natural disasters. The height of the tsunami was far greater than the predictions used in designing seawalls and breakwaters.[2] Although corrected later, the initial tsunami warning underestimated the actual tsunami's height, which possibly affected people's evacuation behaviour. The information network of the tsunami warning system did not work as expected in some areas because of the destruction caused by the tremor or electrical failures.[2 21] Furthermore, the tsunami struck areas outside the potential danger zones indicated on hazard maps, underlining the inaccuracy of the predictions. In addition, people (particularly those outside the designated danger zones) may not have evacuated promptly after the earthquake despite calls to do so because of the false sense of security provided by the extensive coastal defences and the initial failure of the warning system.

Second, community-based preparedness could save lives despite the failure of coastal defences and the warning system. Well-prepared evacuation planning through regular drills led to the prompt evacuation (immediately after the earthquake) of some locals who did not wait for evacuation calls. Examples of such good practices include the successful evacuation of schoolchildren in Kamaishi; as they had been regularly trained and rushed to the designated spot on higher grounds immediately after the tremor, and all survived even though the tsunami engulfed the school.[20] In contrast, at a school in another city in the northern part of the Miyagi Prefecture that did not have a designated evacuation site, the teachers discussed possible evacuation sites only after the quake, thereby delaying the evacuation and the tsunami engulfed the children as they were evacuating.[22]

Future tsunami preparation and emergency response plans should incorporate such experiences. An expert panel to the Central Disaster Prevention Council recently issued an interim report on future countermeasures. It pointed out the limitations of previous approaches, which relied mainly on prediction-based technology-oriented solutions and it stressed the necessity of putting greater priority on residents' evacuation planning and land use.[6 7] This is a clear transition from the previous approach to a more balanced approach, involving comprehensive measures that incorporate land use and evacuation plans. Such comprehensive measures to facilitate immediate evacuation are crucial in preparing for a once-in-a-millennium tsunami because it is not feasible to predict accurately the maximum possible magnitude of tsunamis, even though predictions are useful in the protection against such tsunamis. This approach is actually a return to the basic principle stated in the government's previous guidelines, which emphasised the importance of three components: coastal defences, evacuation planning and land use. Necessary measures include the designation of evacuation sites and routes, high-rise reinforced concrete buildings to be considered as evacuation sites in lowland areas that are far from higher ground,[23 24] regular evacuation drills, safety education for residents so that they can undertake immediate evacuation after an earthquake or evacuation call, careful evacuation plans for vulnerable groups and changing land use in areas at extremely high risk of damage (eg, relocating residential areas to higher grounds).

RESEARCH AGENDA

A better understanding of health issues during and after disasters based on geographical, demographic, communal and architectural characteristics would provide information that is useful for developing better disaster mitigation plans and post-disaster management.[25] The health sector should play a variety of roles in disaster situations, including the dispatching of disaster medical assistant teams, healthcare activities in shelters ranging from prevention of infectious diseases to management of chronic diseases and long-term care for mental health problems in the affected areas. Epidemiological data from previous disasters can guide these activities. Previous experience of earthquakes reveals the need for wide-area transportation between the affected zone and outside areas for a large number of trauma victims, as well as for the management of chronic diseases and mental health problems—all of which are issues that tend to be aggravated in disaster-affected areas.[26 27] The lessons learnt after the tsunami on 11 March 2011 will improve the post-disaster responses by the health sector: unlike in previous massive earthquakes, there were few severely injured victims and healthcare needs for chronic diseases were far greater than those for acute care, even in the early stages.[28] The attention of healthcare personnel is currently focused on monitoring post-disaster morbidity, particularly because of the explosions that occurred at the Fukushima power station.[29 30]

However, we should also pay attention to the necessity of learning from this terrible disaster for the primary prevention of future tsunami-related casualties. Identifying vulnerable groups may lead to customised evacuation plans. Environmental risk factors, such as distance or routes to evacuation sites, may be modified by designating safe high-rise building as evacuation sites or by installing special roads to higher grounds. Putting such knowledge into practice would require collaboration in such areas as health science, behavioural science, social science, civil engineering, architecture and urban planning.

Although disaster epidemiology is still in its infancy, several studies have examined casualty patterns in earthquakes and have identified risk factors: being inside a building during the earthquake; location within the upper floors of a building; building type, height and construction materials of buildings; being unmarried, female, elderly or physically disabled; and health status.[31–34] A study on the Great Hanshin–Awaji Earthquake revealed that old age and physical disability increased the risk of death; physical disability particularly increased the risk when dwellings were not completely destroyed, suggesting that the ability to escape from a collapsed building is related to survival chances.[35] Epidemiological studies on tsunamis, although limited, indicated an increased risk of death in the Indian Ocean tsunami in 2004 among the following groups or factors: children, elderly people, women; living on flat, low land; being indoors or being out fishing at the time of the tsunami.[36–38]

So far, no such epidemiological studies have been carried out with regard to the tsunami in Japan on 11 March 2011. In fact, only anecdotal information is available and the Japanese government has reported summary figures based on police data. As of 11 April 2011, among the 13 135 confirmed deaths in the three most affected prefectures, 92.5% were by drowning and 65.2% of those who died were aged 60 years and over.[2 3] These figures clearly indicate the necessity of investigating why elderly people are a vulnerable group. To improve preparedness for future disasters, we need to answer the following questions (this list may not be exhaustive): Who were the vulnerable groups? What structures (buildings and coastal defences) did/did not play their protective roles? Who did/did not evacuate the disaster-affected zones? What facilitated/impeded prompt evacuation? What behaviour increased/decreased the risk of injuries? What preparation and emergency response plans were effective/ineffective in preventing injuries? What environmental factors had protective/harmful effects?

CONCLUSIONS

This paper describes how Japan, having learnt from its past experience, has improved its countermeasures against earthquakes and tsunamis, however, it also indicates that there is still much to be improved on. Extensive coastal defences provided good protection against once-in-a-decade tsunamis with predictable magnitudes. However, the failure of such prediction-based technology-oriented tsunami countermeasures during the tsunami on 11 March 2011 has urged us to return to the basic principles in developing comprehensive measures. Given that the maximum possible magnitude of tsunamis cannot be predicted accurately, protection for all by means of coastal defences is not possible. This obliges us to develop better evacuation plans with safety education and drills. Epidemiological studies analysing the data from the tsunami that took place on 11 March 2011 will surely make a strong contribution to such planning efforts. Japan's experience in developing comprehensive countermeasures will also benefit other countries that suffer from frequent earthquakes and tsunamis. In countries where constructing huge coastal defences is not feasible, evacuation plans, behavioural approaches through safety education and drills, and prompt warning systems are of particular importance.

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Man charged after stepson shot teenager

Police in British Columbia allege a 10-year-old boy accidentally shot and killed a teenager. Charges of criminal negligence and careless storage of a firearm are being laid against the boy's stepfather. The boy unintentionally discharged a shotgun that killed a 17-year-old friend. The Royal Canadian Mounted Police said that such incidents are rare, but completely preventable, noting that the boy's access to the gun was 'unimpeded'. Ed note: *This stands in sharp contrast to experience elsewhere and it is worth stressing that the RCMP seized* ***numerous*** *firearms from the home.* http://www.theglobeandmail.com/news/national/british-columbia/bc-man-charged-after-10-year-old-stepson-shot-teen-dead/article2190786/

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原　　著

ICD と AIS へ変換可能な新たな外傷分類の作成

聖マリアンナ医科大学予防医学[1]・帝京大学救命救急センター[2]・東京医科大学救命救急センター[3]・市立堺病院[4]
中原慎二[1]　内田靖之[2]　織田　順[3]　横田順一朗[4]

外傷の診断分類は，診療記録あるいは診療報酬請求といった診療情報管理に国際疾病分類（International Classification of Diseases and Related Health Problems：ICD），解剖学的重症度を必要とする外傷登録に Abbreviated Injury Scale（AIS）と，目的別に2通りの方法が使い分けられることが多い．両者間の直接変換は困難であるため，中間的な新分類から ICD と AIS に変換するという方法を考案した．単一コード使用という ICD の制約は外し，ICD と AIS で分類粒度が異なる場合には細かい分類を採用し，四肢の例でみられる分類境界が異なる場合にはすべての境界を使用することで，新分類から ICD および AIS への一義的変換を可能にした．これにより二重コーディングの負担解消と，外傷登録を利用した診療の質評価・改善の活発化が期待できる．

索引用語：外傷診断分類，国際疾病分類，AIS，外傷登録

Abbreviations

International Classification of Diseases and Related Health Problems：ICD
ICD based injury severity score：ICISS
ICD clinical modification：ICD-CM
Abbreviated Injury Scale：AIS
Injury Severity Score：ISS
Trauma and Injury Severity Score：TRISS
Diagnosis Procedure Combination：DPC

緒　言

外傷の診断分類として，診療記録あるいは診療報酬請求といった診療情報管理には疾病および関連保健問題の国際統計分類（国際疾病分類，International Classification of Diseases and Related Health Problems：ICD），解剖学的重症度を必要とする外傷登録には Abbreviated Injury Scale（AIS）と，目的別に2通りの方法が使い分けられることが多い[1)-4)]．両者間の変換が容易であればこのような二重コーディングを避けられるのだが，ICD は単一コードにより死亡原因を分類し，AIS は複数コードにより解剖学的重症度を記述するという，成り立ちと使用原則の違いから，直接変換は困難であった[1)5)]．

本研究では両者の中間的な新分類を作成し，新分類から ICD と AIS に変換するという方法を考案した．

方　法

上記の，ICD と AIS 相互の変換における問題点の多くは，分類の粒度が双方で異なること，解剖学的分類の境界が違うことに起因する．粒度が粗い分類から細かい分類への変換（分割）には追加の詳細情報を診療記録や画像情報から得る必要が生じるため，自動変換は不可能である．粒度の細かい分類から粗い分類への変換（集約）は自動的に行いうるが，ICD から AIS，AIS から ICD のどちらの変換方向であっても，分割を伴う変換が生じる．全般的に AIS の分類粒度（特に損傷性

Table 1 The new classification system bridging differences in anatomical classification between ICD and AIS

<table>
<tr><th>ICD</th><th>New classification</th><th>AIS</th></tr>
<tr><td colspan="3">Upper extremity</td></tr>
<tr><td rowspan="2">S4x
Shoulder/upper arm</td><td>Shoulder</td><td>Shoulder</td></tr>
<tr><td>Upper arm</td><td rowspan="2">Upper arm/elbow</td></tr>
<tr><td rowspan="2">S5x
Elbow/forearm</td><td>Elbow</td></tr>
<tr><td>Forearm</td><td rowspan="2">Forearm/wrist</td></tr>
<tr><td rowspan="2">S6x
Wrist/hand</td><td>Wrist</td></tr>
<tr><td>Hand</td><td>Hand</td></tr>
<tr><td colspan="3">Lower extremity</td></tr>
<tr><td rowspan="2">S7x
Hip/thigh</td><td>Hip</td><td>Hip</td></tr>
<tr><td>Thigh</td><td rowspan="2">Thigh/knee</td></tr>
<tr><td rowspan="2">S8x
Knee/lower leg</td><td>Knee</td></tr>
<tr><td>Lower leg</td><td rowspan="2">Lower leg/ankle</td></tr>
<tr><td rowspan="2">S9x
Ankle/foot</td><td>Ankle</td></tr>
<tr><td>Foot</td><td>Foot</td></tr>
</table>

ICD, International Classification of Diseases and Related Health Problems ; AIS, Abbreviated Injury Scale

状分類）の方が細かいが，一部ICDの粒度の方（解剖学的分類）が細かい．分類境界の相違は四肢の解剖学的分類で顕著である．例えば，ICDで上肢は肩と上腕，肘と前腕，手首と手に3分類されるのに対し，AISでは肩，上腕と肘，前腕と手首，手に4分類される．AISで上腕と肘の外傷と分類されたものをICDに変換しようとすると，正確な受傷部位情報（上腕のみ，肘のみ，あるいは両方）を得る必要が出てくる．

そこで，本研究においてはICDとAIS間の直接変換ではなく，ICD，AIS分類とは別の新分類を作成し，新分類コードからICDあるいはAISに変換するという方法を取った．ICDとAISのコードには，ICD-10のS00-S99とAIS2008の1xxxxxから8xxxxxまでを用いた．ICDとAISで分類の粒度が異なる場合，新分類にはより細かい分類を採用し，全体として分類粒度を均一化した．解剖学的分類の境界が異なる場合には，両者の境界を併用してより細かい分類とした．どちらか一方に対応する分類が存在しない（その他または詳細不明）場合は，存在する方の分類を用いるとともに，損傷性状分類については類似の外傷コードを援用した．また，新分類では多発外傷はAIS同様にそれぞれの外傷にコードを与えることとし，ICDにおける同一部位の多発外傷を示すコードSxx.7および，複数部位の多発外傷を示すコードT00-T07は変換表には含めていない．多発外傷の場合には，各損傷の新分類コードからICDコードに変換した後に，多発外傷コードに変換する．また，受傷部位詳細不明（ICDのT08-T14，AISの9xxxxx）および非外傷（AISの0xxxxx）は除外した．

結　果

Table 1に，ICDとAISの分類境界が異なる場合の例として四肢の解剖学的分類を示す．新分類では，上腕，肘，前腕，手首，手のように細かく分類した．下肢も臀部，大腿，膝，下腿，足首，足に分類した．これにより，新分類からICDとAISへの変換が一義的に決まる．Table 2に新分類の一例として肩～肘の刺創分類を示す．AISでは肘と上腕が同一部位に含まれるため，716014～716017が上腕と肘に分割される．ただし，AIS2008コードではlocalizerをドット以下2～5桁目につけて，ICDと解剖学的分類を一致させることは可能（61が上腕，62が肘，63が前腕）である．新分類における損傷性状分類は，より粒度の細かいAISのものを採用した．Table 2では刺創以外の開放創は省略した．

Table 2 Classification of penetrating injury of the upper arm (from shoulder to elbow)

ICD	New classification	AIS*
S41.0 Open wound of shoulder	Penetrating injury of upper arm, NFS as to severity	716010.1 Penetrating injury at shoulder, NFS as to severity
	superficial ; minor	716011.1 superficial ; minor
	with tissue loss>25cm²	716012.2 with tissue loss>25cm²
	with blood loss>20% by volume	716013.3 with blood loss>20% by volume
S41.1 Open wound of upper arm	Penetrating injury of upper arm, NFS as to severity	716014.1xx61 Penetrating injury at or above elbow, below shoulder, NFS as to severity
	superficial ; minor	716015.1 xx61 superficial ; minor
	with tissue loss>25cm²	716016.2 xx61 with tissue loss>25cm²
	with blood loss>20% by volume	716017.3 xx61 with blood loss>20% by volume
S51.0 Open wound of elbow	Penetrating injury of elbow, NFS as to severity	716014.1xx62 Penetrating injury at or above elbow, below shoulder, NFS as to severity
	superficial ; minor	716015.1xx62 superficial ; minor
	with tissue loss>25cm²	716016.2xx62 with tissue loss>25cm²
	with blood loss>20% by volume	716017.3xx62 with blood loss>20% by volume
S51.8 Open wound of other parts of forearm	Penetrating injury of forearm, NFS as to severity	716018.1xx63 Penetrating injury below elbow, at or above wrist, NFS as to severity
	superficial ; minor	716019.1xx63 superficial ; minor
	with tissue loss>25cm²	716020.2xx63 with tissue loss>25cm²

ICD, International Classification of Diseases and Related Health Problems ; AIS, Abbreviated Injury Scale ; NSF, not further specified
*The first localizer (L1) and second localizer (L2) can follow the post-dot severity score. Both L1 and L2 are two-digit numbers : L1 indicates the side and aspect of an injury location and L2 indicates further specificity (e.g., 61 indicates upper arm, 62 elbow and 63 forearm).

Table 3に上腕の神経損傷分類の一部を示す．正中神経と橈骨神経については，AISの損傷性状分類を採用した．腋窩神経損傷はAISでは詳細不明の神経損傷（730099.9），ICDではS44.3と単一の分類となるが，粒度を均一化するため他の神経損傷と同様の分類を採用した．その結果，他の神経損傷と同様の重症度スコア（カッコ内）を当てはめることも可能となる．

原則として同一部位の多発外傷を示すICDの多発外傷コード（Sxx.7）は削除し，それぞれの

Table 3　Classification of nerve injury of the upper arm/shoulder

ICD	New classification	AIS*
S44.1 Injury of median nerve at upper arm level	Injury of median nerve at upper arm level, NFS	730499.1 Median nerve, NFS
	contusion	730402.1 contusion
	laceration	730404.2 laceration
	with motor loss	730406.2 with motor loss
S44.2 Injury of radial nerve at upper arm level	Injury of radial nerve at upper arm level, NFS	730699.1 Radial nerve, NFS
	contusion	730602.1 contusion
	laceration	730604.2 laceration
	with motor loss	730606.2 with motor loss
S44.3 Injury of axillary nerve	Injury of axillary nerve, NFS	730099.9 (.1) Nerve injury in upper extremity NFS
	contusion	730099.9 (.1)
	laceration	730099.9 (.2)
	with motor loss	730099.9 (.2)

ICD, International Classification of Diseases and Related Health Problems ; AIS, Abbreviated Injury Scale ; NSF, not further specified
*Although AIS does not have specific codes for axillary nerve injuries, the new classification system can adopt the same injury severity scores as in other nerve injuries (in brackets).

外傷についてコードを選択することとしたが，肋骨骨折・骨盤骨折については胸郭および骨盤輪を一つの解剖学的単位と考え，多発骨折を複数の単発骨折とは別の病態とする分類を採用した．Table 4に肋骨骨折と動揺胸郭の分類を示す．骨折した肋骨の本数および胸郭の安定性が重症度と関連し，AISでも骨折本数に関する情報をコードに含んでいることから，多発骨折を示すコードを残した．

骨盤骨折の例をTable 5に示す．骨盤骨折の分類方法は，ICDとAISで全く考え方が異なり，ICDでは骨折部位を記述するのに対し，AISでは重症度と関連する骨盤輪の安定性により分類する．そこで，骨盤骨折についてのみ，骨盤輪の安定性の分類と，骨折部位のコードという2通りの分類コードを含めることとした．ただし，寛骨臼骨折については，AISでも骨盤輪とは独立に記載されているので，別に分類を設けた．

新分類の具体例をTable 6に示す．例に挙げた症例は頭部の開放創，肝挫傷，骨盤骨折，肩甲骨骨折，上腕と肘の開放創があり，それぞれの新分類コードとAISとICDへの変換を示した．新分類コードの1桁目はICDと同様の解剖学的分類を，2桁目は左右を（左右別のない場合は0），3桁目は臓器分類（血管，神経，骨など），4～5桁目は臓器詳細分類（腓骨，脛骨など），6～7桁目は損傷性状を示す．前述のように，骨盤骨折では骨盤輪の安定性と骨折部位を示す2つのコードがつけられ，それぞれAISとICDに変換される．上腕と肘の開放創は，ICDでは異なるコードを使用するが，AISでは同じコード（同一分類）となる．従来通りにICDの単一の多発外傷コードを使用する場合にはT06.8（多部位のその他の明示された損傷）に変換する．

Table 4　Classification of rib fracture and flail chest

ICD	New classification	AIS
S22.3 Fracture of rib	Single rib fracture	450201.1
S22.4 Multiple fractures of ribs	Multiple rib fractures, NFS	450210.2
	two ribs	450202.2
	3 ribs	450203.3
S22.5 Flail chest	Rib fractures with flail chest, NFS	450209.3
	unilateral flail chest, NFS	450211.3
	3–5 flail ribs	450212.3
	＞5 flail ribs	450213.4
	bilateral flail chest	450214.5

ICD, International Classification of Diseases and Related Health Problems ; AIS, Abbreviated Injury Scale ; NSF, not further specified

Table 5　Classification of pelvic fracture by pelvic stability and fracture location

ICD	New classification*	AIS
	Pelvic ring stability	
/	Pelvic ring fracture, posterior arch intact	856151.2
	Pelvic ring fracture, incomplete disruption of posterior arch, NFS	856161.3
	blood loss ≦20% by volume	856163.4
	blood loss ＞20% by volume	856164.5
	Pelvic ring fracture, complete disruption of posterior arch and pelvic floor, NFS	856171.4
	blood loss ≦20% by volume	856172.4
	blood loss ＞20% by volume	856173.5
	Fracture (s) and dislocation (s) †	
S32.1	Fracture of sacrum	/
S32.2	Fracture of coccyx	
S32.3	Fracture of ilium	
S32.5	Fracture of pubis	
S33.2	Dislocation of sacroiliac joint	
	Dislocation of sacrococcygeal joint	
S33.4	Traumatic rupture of symphysis pubis	

ICD, International Classification of Diseases and Related Health Problems ; AIS, Abbreviated Injury Scale ; NSF, not further specified

*Two codes are selected for the new classification : one for pelvic ring stability and the other for location of fracture(s) and dislocation(s).

† Fracture of acetabulum is separately described.

Table 6　An example of coding for multiple injuries in a patient

New classification		AIS code	ICD-10 code	
Code	Description			
0110224.2	Scalp laceration, major（right）	110604.2	S01.0	T06.8
3061804.3	Liver contusion subcapsular,>50% surface area	541814.3	S36.1	
3057820.4 3157320*	Pelvic ring fracture, incomplete disruption of posterior arch blood loss ≤20% by volume with fracture of ilium（right）	856163.4	S32.3	
4154100.2	Scapula body fracture（right）	750951.2	S42.1	
4110442.1	Penetrating injury at upper arm（right） superficial	716015.1	S41.1	
5110242.1	Penetrating injury at elbow（right） superficial	716015.1	S51.0	

*A code indicating the location of the fracture.

以上のような分類方法，コーディング方法を使用することにより，ICD の S00から S99まで(Sxx.7除外)，AIS の1xxxxx から8xxxxx までのコードについて，新分類から ICD と AIS への変換を一義的に行うことができた．

考　察

我が国において日本外傷データバンクに参加している施設の多くは，外傷診断分類に2通りの方法を使用している[1]．ひとつは，施設内すべての患者を対象とした診療情報の管理（診療録への記載，診療報酬請求，院内データの分析など）に用いられている ICD である．これは世界保健機関が死亡・疾病統計の国際比較を目的として作成した標準的分類で，現在使われているのは1990年に採択された第10回改訂（ICD-10）で，2015年の採択を目指して ICD-11への改訂が進められている[6]．従来 ICD は死因分類，医学研究，政策決定等に使用されてきたが，2003年から始まった診断群分類（Diagnosis Procedure Combination：DPC）による包括評価では分類に ICD-10を使用し，ICD によるコーディングが収入に直結することから診療現場における診断分類の重要性が認識されるようになった[2]．

いまひとつは，外傷に特化し，損傷形態と重症度を解剖学的に記述・分類するため，米国自動車医学振興協会によって開発された AIS である[3)4]．AIS の重症度スコアをもとに，Injury Severity Score（ISS）を算出し，さらに ISS と生理学的指標から外傷患者の予後予測指標である Trauma and Injury Severity Score（TRISS）を算出する．これらの指標は外傷診療の質を評価する際の標準的方法として広く使用されていることから，日本外傷データバンクの診断分類には AIS が用いられている[1]．

このように ICD と AIS は異なった目的と使用原則を持ち，お互いに代替不可能であるために，両者ともに用いた二重コーディングが行われることになった．DPC は ICD コードに基づいており AIS で代用することはできないし，TRISS スコア算出には AIS 重症度スコアが必要であるから重症度情報を含まない ICD で代用することはできない．コーディングには，人員と正確なコーディングのためのトレーニングやコードブックなどが必要であり，二重コーディングを行うことは人的・金銭的な負担が大きい[1)4)7]．

二重コーディングを避けるために様々な方法が試みられているが，必ずしも満足できる実用的なものとは言えない．ICD の Clinical modification (ICD-CM）から AIS 重症度スコアに変換するコンピュータソフトが開発されたが，ICD と AIS の改訂にソフトのアップデートが追い付かないうえ，DPC に ICD-CM ではなく ICD-10を用いている我が国では利用価値が低い[5)8]．また，ICD から直接予後予測を行う手法として ICD based injury severity score：ICISS）も開発されているが，すべての ICD コードに対して我が国独自の死亡確

率を計算するために膨大なデータが必要となり，現時点でただちにTRISSの代用となるものではない[5][7][9]．

我が国においてもICD-AIS変換表が作成されたが，以下の問題により実用に供されるには至っていない[1]．1）1対1あるいは多対1（集約）の変換は可能であるが，1対多（分割）の変換を要する場合がある，2）対応する分類が存在しない場合がある，3）ICDでは単一コードで多発外傷を表現するため解剖学的に複数の外傷を表現するAISと対応させることができない，などである．

これまでの試みは，ICDとAISの一方から他方への変換方式で上記のような困難が存在した．コーディングを一回だけ行い，後は自動的に他の分類方式に変換するという方針を取るならば，最初のコーディングは必ずしもICDやAISを用いなくてもかまわないはずである．そこで，本研究では第3の分類としてICDとAISの中間的な新分類（以下新分類）を導入することにより直接変換で発生する問題を回避し，二重コーディングの問題を解決しうる可能性を示した．これにより予後予測指標を用いた外傷診療のアウトカム評価実施が促進されると期待できる[1]．

新分類はICDおよびAISに一義的に変換できることから，2つの利点を有する．まず，変換に際して不足する情報を補う（例えば分割を伴う変換であれば不足情報を診療録から収集する，あるいは他の利用可能な情報から推論するなど）必要がないため，単純な自動変換が行えることである．新分類コードからICDコードとAISコードを導き出す変換ソフトは複雑なアルゴリズムを必要とせず安価に作成可能である．

さらに，AISへの一義的変換が可能であることから，対応するAIS重症度スコアを新分類コードに組み込み，AISへの変換を行うことなくISSやTRISSなどのスコアを計算することも可能である．新分類作成の際，多くの場合にICDよりAISの分類粒度の方が細かいためAISの方を採用し，解剖学的分類に差異がある場合でも損傷性状の分類はAISの分類が使用可能であったことを反映して，新分類とAISの類似性は非常に高い．したがって，新分類はICDとの適合性（変換可能性）を高めたAIS改訂版とも考えることができる．

ICDの本来の利用目的は主として死因分類であったが，現在改訂中のICD-11では利用目的を疾病分類，診療報酬の算定，診療の質評価などの臨床的利用にも拡大することとされており（現時点でICD-10はDPCで利用されているがこれは本来想定されていた利用方法ではない）[6]，臨床的利用に広く利用されているAISをICDに統合することも検討すべきではないかと考える．新分類をICD-11の19章として，あるいはICD-11CMとして組み込むことで，従来のAIS，ICD-10との変換可能性を保ちつつ，AISが持つ解剖学的外傷記述機能や重症度表現をICDの臨床的利用に活かすことができる．さらに，現在ICDで用いられている単一コードによる分類方法は，複数の病態を表現するのに情報の欠落が大きく表現の柔軟性に乏しいため，複数のコードを用いて多発外傷のみならず合併症や基礎疾患の情報を表現するといったことが求められるようになると予想される[10][11]．このような場合にもそれぞれの外傷を記述するAISの方法論が有用となるであろう．

新分類には今後検討すべき課題がいくつかある．まず，新分類の非常に細分化された分類がコーディング作業を煩雑にしたり，新分類の習得に時間を要するなどの実用上の問題が出てこないかということである．分類粒度の違う場合は細かい方を採用し，分類境界が違う場合はすべての境界を用いた細分類を採用したことから，全体的に非常に詳細な分類になっている．例えば，上肢の解剖学的分類を，肩，上腕，肘，前腕，手首，手に細分化したため，上肢損傷の基本コード数はAISで324であるのに対して，新分類では894である．しかし，AISでもlocalizerを使用して新分類同様の細分類が可能であることから，コーディング作業上，大きな問題にはならないだろうと考えている．コード数は非常に多いが，新分類は基本的にICDとAISの組み合わせであり，ICDとAISに関する知識があれば，習得に係る労力はそれほど大きくはないであろう．しかし，ICDかAISが改訂された場合には新分類の修正も必要になり，外傷登録システムや患者データシステムの頻回の修正を要するという弱点を内在することになる．

また，ICDあるいはAISのどちらかに分類コードが存在しない場合に，新たに分類を作成し重症度スコアは同種の損傷分類と同様のものを使用した．例えば，腋窩神経損傷では他の神経損傷と同様の分類と重症度スコアを当てはめた．これらは