Chapter 9

Traffic safety and medicine

Kazuhiko Kibayashi
Professor, Department of Legal Medicine, School of Medicine, Tokyo Women's Medical University
Takashi Moriya
Professor, Emergency Department, Saitama Medical Center, Jichi Medical University
Masaya Takahashi
Senior Researcher, National Institute of Occupational Safety and Health, Japan

9.1 Traffic accident casualty statistics

Traffic accident casualty statistics issued by the Japanese National Police Agency (NPA) are for on-road accidents as defined by the Road Traffic Act that resulted in fatality within 24 h of the accident. This statistic is the conventional reference when discussing traffic accident fatalities. Beginning in 1993, to better grasp the number of deaths occurring after that 24-h window and to allow for easier international comparisons, separate statistics that additionally include deaths occurring between 24 h and 30 days following an accident have also been calculated. NPA statistics for injury from traffic accidents classify injuries requiring treatment for less than 30 days as minor injuries, and those requiring 30 days or more of treatment as serious injuries. General injury statistics report a combination of both minor and serious injuries. In contrast, demographic statistics tally all persons dying within 1 year of a traffic accident, regardless of the site of the accident. Note that regardless of the period following the accident, medically speaking, all deaths due to involvement in modes of transportation are considered traffic accident deaths.

Nationwide statistics for 24-h traffic fatalities since 1989 peaked at 11,452 in 1992, and then fell for 13 consecutive years to 9,943 fatalities in 1996, 7,768 in 2003, 4,968 in 2009, and 4,373 in 2013. Fatalities between 24 h and 30 days following a traffic accident were 1,176 in 2003, 863 in 2009, and 779 in 2013, this being a similar reduction to the 24-h traffic fatalities, being equal to 10–20% the number of fatalities within 24 h of accidents for that same year (Fig. 1). The number of traffic accident-related injuries also fell over 9 consecutive years to

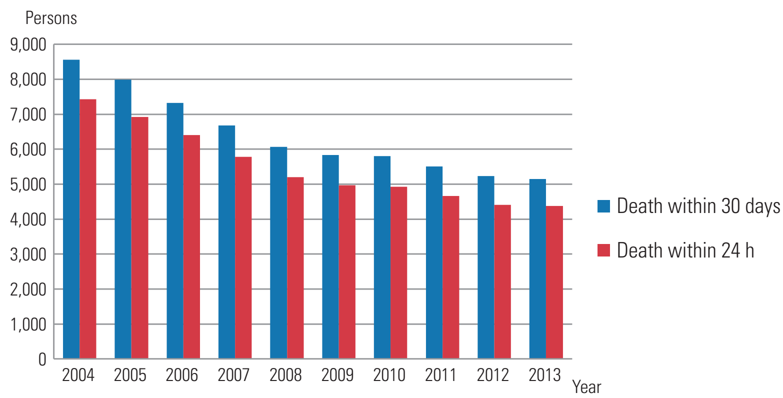

Figure 1. Traffic fatalities

781,494 in 2013, with approximately 6% of injuries being serious injuries and requiring over 30 days of treatment (Fig. 2).

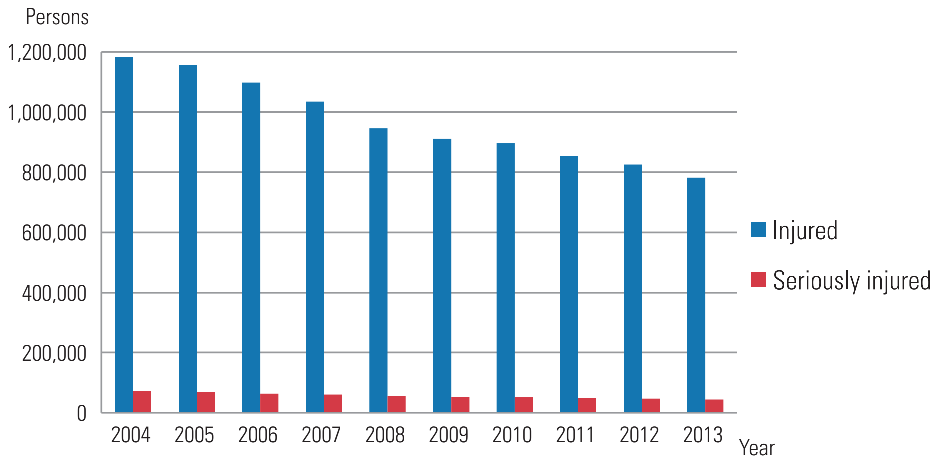

Figure 2. Injuries due to traffic accidents

This reduction in casualties is the result of several efforts, including legal efforts such as strengthening laws against drunk driving and making seatbelt usage mandatory, the development of accident-resistant road environments, automobile structural developments, improvements in public transportation facilities and medical rescue systems, and comprehensive accident prevention measures such as traffic safety education. Viewing casualty statistics by age, the ratio of fatalities and injuries among the elderly is relatively high, and the amount of reduction experienced among all age groups was smallest among the elderly; the rate of elderly fatalities is approximately 6.6 times that of other age groups, and the rate of serious injury is approximately 3 times as high (Fig. 3).[1)]

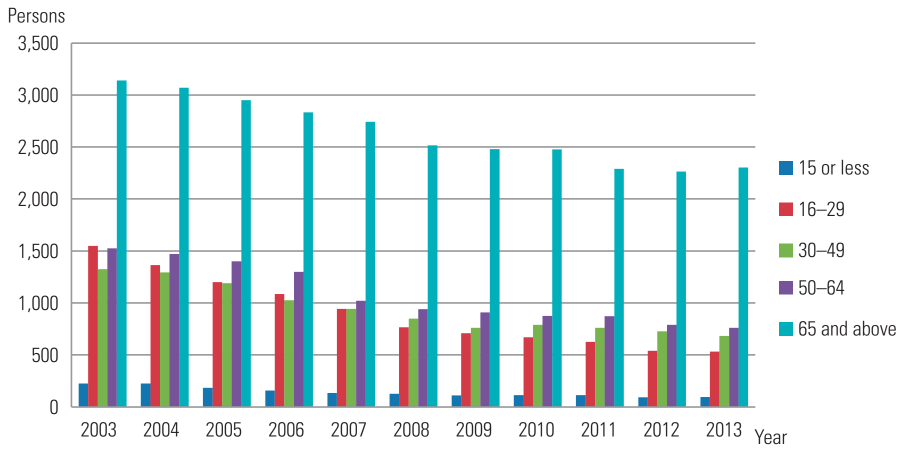

Figure 3. Traffic fatalities by age (death within 24 h)

While the number of traffic accident-related fatalities has reduced for all age groups, the ratio of elderly fatalities overall is increasing since the reduction rate for elderly fatalities is small. To address this issue, since June 2009 persons aged 75 years or older wishing to renew their driver's license must undergo a cognitive function test, and must furthermore undergo a driving course designed for the elderly. Other traffic accident-prevention measures targeting elderly pedestrians will likely be particularly needed.[2)]

9.2 Damage due to traffic accidents

Table 1. Traffic accident damage by riding position in terms of mechanism of injury

1. Pedestrians	
	Injury due to bumper, hood, windshield
	Injury due to being run over (tire marks, abrasion) or dragged
	Primary injuries: Injury due to initial impact
	Secondary injuries: Injury due to being flung up and colliding with the vehicle
	Tertiary injuries: Injury due to impact with the ground
2. Drivers	
	Injury due to steering wheels, seatbelts, and air bags
	Injury due to dashboards, windshields
	Cervical spine injury (whiplash)
	Lower extremity injury or pelvic fracture due to legs being extended to depress brake at impact
	Injury due to being ejected from vehicle
3. Passengers	
	Injury due to steering wheels, seatbelts, and air bags
	Injury due to dashboards, windshields
	Cervical spine injury (whiplash)
	Injury due to being ejected from vehicle

One feature of personal injury due to automobiles is that even when injury externally seems to be minor, internal damage can be quite severe. Automobile accident-related fatalities are categorized into deaths of pedestrians, drivers, and passengers, and other possible categorizations are for fatalities by motorcyclists and bicyclists. Each group has characteristic injuries (Table 1).

Injuries to pedestrians are categorized as those occurring due to the initial impact (primary injuries), those due to being flung up and subsequently colliding with the vehicle (secondary injuries), and those due to impact with the ground (tertiary injuries). Pedestrian injuries are highly dependent on the automobile's form and its speed at the time of impact. For standard passenger vehicles, pedestrian impact with the front bumper will result in lower extremity injuries at approximately bumper height, but in the case of hoodless cab-type vehicles, primary injuries will occur in the chest and lumbar regions. Such correspondence between primary injury locations and vehicle collision sites are vital to vehicle identification in hit-and-run accidents. In the case of low-speed (around 20 km/h) accidents, pedestrians are thrown in front of or to the side of vehicles. In the case of mid-speed (20–60 km/h) accidents, pedestrians tend to be flung up onto the hood or windshield. In high-speed (60–100 km/h) accidents, pedestrians are flung over the vehicle, and subsequently impact with the ground. In low-speed accidents where pedestrians are thrown in front of the vehicle, in some cases the pedestrian will be run over by the same vehicle, and when hit by cars at high speed, pedestrians will often sustain severe head injuries due to the subsequent impact with the ground.[3)] Brain damage is a very severe injury frequently seen in traffic accidents, and diagnosis and pathology of brain damage are important issues related to saving the lives of accident victims (Fig. 4).[4)]

Damage to drivers and passengers occurs when the vehicle collides with other vehicles or roadside structures, and resulting in contusions from being hit by objects from within the vehicle. The same can occur when vehicles roll over or when passengers are ejected from the vehicle. When the steering wheel impacts the driver's chest or abdomen, cardiac rupture and other serious injuries can occur. Seatbelts prevent the head and chest from impacting the windshield and steering wheel, and furthermore prevent ejection from the vehicle, which can result in serious injury. The usage or non-usage of seatbelts is an

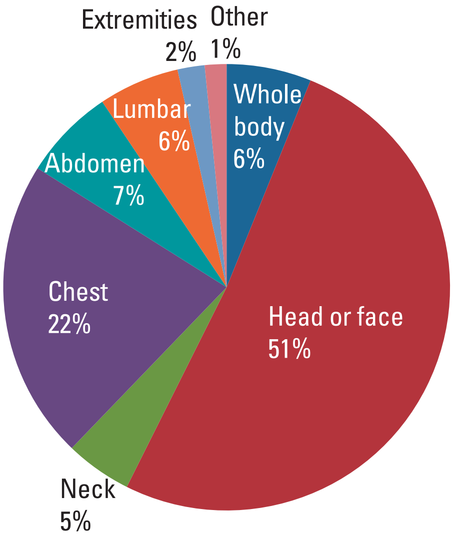

Figure 4. Fatalities by injury site

(2013; death within 30 days; 5,152 persons)

important predictor of injury severity. Seatbelt usage is required even when airbags are present; rapidly inflating airbags can cause serious contusions to the chest and abdomen if seatbelts are not worn.

Extent of damage is quantified to objectively study traffic accident damage. In 1971 the U.S. Association for the Advancement of Automotive Medicine created the Abbreviated Injury Scale (AIS) and performed research such as comparisons of treatment prognosis between multiple facilities, the relationship between collision speed and damage, and differences in damage when seatbelts were or were not worn. The AIS divides the body into seven areas (body surface, head, neck, chest, abdomen and pelvic organs, spine, and extremities), and assigns scores to each area based on damage according to 6 severity levels (1: minor; 2: moderate; 3: serious; 4: severe; 5: critical; 6: fatal). The largest score is also called maximum AIS. There is also the injury severity score (ISS), a severity evaluation method for multiple trauma that is calculated based on the AIS. In the ISS, the body is divided into six areas (head and neck, face, chest, abdomen, extremities and pelvic organs, and body surface), and assigns an AIS score of 1–5 to each injury. The ISS score is calculated by taking the maximal score from each area, and summing the squares of the top three AIS scores. Accordingly, the maximum value is 75. Alternatively, if any single location has an AIS score of 6, the ISS score is automatically calculated as 75. The ISS score represents severity well and is correlated with death rates, particularly in the case of multiple trauma patients. Analysis of mechanism of injury through analysis of three factors in traffic accidents—personal injury, accident vehicle, and scene of the accident—provides fundamental data for ensuring the safety of persons, vehicles, and road environments to prevent the occurrence of accidents (active safety) and reduces damage to passengers and pedestrians following accidents (passive safety).

9.3 Emergency medical care

9.3.1 Regional characteristics and the importance of immediacy in emergency medicine

Emergency medical care is the keystone of medicine, and is considered by all citizens to be the last bastion in the medicine for care of unexpected acute pathology.

Acute pathology is characterized by progress, regardless of differences in the degree of onset. A sudden headache may indicate subarachnoid hemorrhage. Chest pain may indicate acute myocardial infarction. A fall from a high location will likely lead to severe injuries caused by high-energy trauma. All of these cases require rapid transport to a hospital. Brain aneurysm rupture, which is known to be a cause of subarachnoid hemorrhage, has a high probability of fatality due to a second rupture on the same day of onset. Acute myocardial infarction can easily lead to a form of arrhythmia called ventricular fibrillation within 4 h of onset. High-energy trauma is highly likely to result in severe injury, and failure to determine a course of treatment by performing a diagnosis of the injury within 1 h of occurrence has a statistically significant increase in likelihood of death.[5)]

Maintaining an emergency care supply system that provides an "anytime, anywhere, anyone" level of care for such acute pathology is extremely important but at the same time very difficult. In Japan, differences in treatment outcomes for severe trauma have been reported by region and facility. To address this, Japan Trauma Care and Research developed a course called Japan Advanced Trauma Evaluation and Care (JATEC™) to demonstrate a protocol for trauma care, and is working toward its implementation through off-the-job participation throughout the country. The JATEC course was originally centered on doctors, but given the importance of team medical care, it was later extended to include nurses. Year after year, the course has been confirmed to contribute to substantial improvement of death rates due to trauma.[6)]

The status of emergency medical care takes on a different meaning between large and small cities. In many hospitals in large cities there are many specialists capable of providing leading-edge treatment, but for example in Tokyo, there have been unfortunate incidents of death believed to have been due to refusal of hospitals to admit patients or delays in transporting patients between hospitals. In contrast, hospitals in smaller cities often concentrate the role of emergency care for an entire region in one location, requiring them to admit patients with both minor and severe injuries, which presents the danger of losing the ability to function as a hospital. Setting aside the issue of which problem is easier to solve, given this situation it is necessary to consider the significance of the existence of emergency care within the framework of the community. Such problems must thus be solved through the combined efforts of the local hospitals, emergency services, fire brigades, police departments, and governments of each individual region.[7)]

9.3.2 Current status and problems related to time for emergency medical care

Time is of the essence for reducing death and sequela in emergency care, so it is necessary that ambulances reach emergency patients as quickly as possible, that hospital selection is rapidly performed, and that the time to arrival at the hospital is as short as possible. Nationwide data, however, indicates that the time to reach patients and the time required for hospital admittance continue to lengthen (Fig. 5). Multiple factors related to these increased delays have been identified at ambulance dispatch points, scenes of injury, and at hospitals, and measures have been taken to address each, but currently, effective solutions have not yet been found.

The Tokyo Fire Department has experienced an increase in the number of ambulance dispatch incidents, and so has increased its number of emergency crews to meet with increased regional populations and demands for appropriate emergency care (Fig. 6). Nonetheless, the number of dispatches per ambulance crew has not decreased; indeed, the number has increased from 1,488 in 1963 to 3,183 in 2013. There are a number of factors behind this increase, including increased reliance on ambulances for relatively minor situations, increased emergency service requests from the elderly, changes in disease trends, increased elderly population, and physiological characteristics of the elderly. These trends are similar across Japan, and due to the increased elderly population, about 40% of emergency patient transport is now for patients aged 70 years or older.

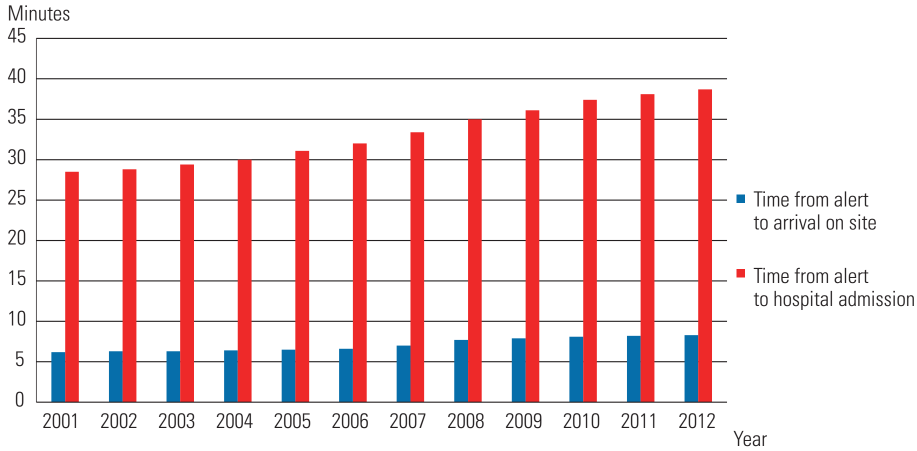

Figure 5. Trends in arrival time and time to hospital admission

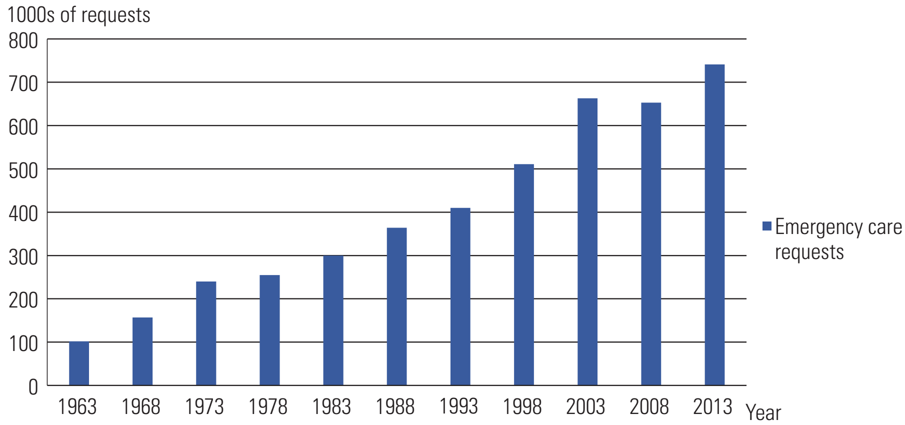

Figure 6. Trends in number of emergency care requests in Tokyo

Changes in blood pressure or state of consciousness in the elderly, which can rapidly worsen due to the effects of medication or difficulty in maintaining homeostasis, can in many cases be alleviated simply through body position adjustments or observation over time. In many cases, the situation improves during the wait for an ambulance to arrive, but the ambulance will often be used for transport to a hospital for examination, just in case. Unlike exogenous disease, inferring the prognostics of endogenous disease is considered difficult,[3] and this difference is even more pronounced in the elderly. With the goal of better optimizing ambulance usage, in 2007 the Tokyo Fire Department became the first in Japan to offer a telephone-based triage service for the general public, aiding in the determination of whether pathologies are sufficiently acute to warrant requesting emergency services. This service, called "#7119,"[8] helped to lower the number of emergency requests in 2008, but by 2013, numbers were again increasing. This illustrates the difficulty of restraining the number of incidents, given that emergency medical care is viewed as an administrative service.

9.4 Driving and health

Operating an automobile requires skillful judgment and operation on the part of drivers. It is thus inappropriate to drive while impaired due to the influence of fatigue, illness, alcohol, or drugs.

Illnesses that can affect automobile operation can be broadly classified into two types: chronic illness that is likely to hinder vehicle operation, and acute illness that can cause sudden death of the driver. The Japanese Road Traffic Act and other enforcement orders classify illnesses that can hinder vehicle operation as follows: 1) Schizophrenia with symptoms of hallucinations (excluding individuals that do not exhibit symptoms that prevent any one of the abilities required for safe vehicle operation, such as perception, prediction, decision-making, and operational control); 2) Epilepsy (excluding individuals in whom there is no risk of seizure recurrence, those in whom seizure recurrence does not result in movement disorders or impaired consciousness, and those in whom seizure recurrence occurs only during sleep); 3) Recurrent syncope (defined as disease that results in disturbance of consciousness due to transient ischemia of the whole brain, for which there is a possibility that episodes may recur); 4) Hypoglycemia unawareness (excluding individuals who are able to artificially modulate blood sugar); 5) Manic depression (including mania and depression, but excluding individuals that do not exhibit symptoms that prevent any one of the abilities required for safe vehicle operation, such as perception, prediction, decision-making, and operational control); 6) Sleep disorders with symptoms of severe drowsiness; 7) Other illnesses that involve symptoms that prevent any one of the abilities required for safe vehicle operation, such as perception, prediction, decision-making, and operational control; and 8) Dementia.

These illnesses can hinder vehicle operation present a risk of injury to others, and thus acquisition and renewal of driver's licenses is restricted for affected persons. Operation of automobiles by persons with chronic disease that causes episodes of impaired consciousness can result in the occurrence of serious accidents. Therefore, the Road Traffic Law establishes that 1) persons acquiring or renewing driver's licenses are required to respond to a questionnaire related to symptoms of certain diseases, 2) physicians who have diagnosed persons as having certain diseases that they feel may increase their chances of being involved in a serious accident may elect to submit forms stating such, and 3) persons suspected of having certain diseases can immediately have their driver's license provisionally revoked.[9)]

Sudden death is defined as the unexpected death of an otherwise healthy individual within 24 h of onset of an endogenous disease, and is most commonly due to cardiovascular disease such as myocardial infarction, cardiomyopathy, aortic aneurysm rupture, aortic dissection, cerebral aneurysm rupture, and hypertensive cerebral hemorrhage. Such disease can sometimes occur suddenly while driving, but while they can result in death of the driver, in most cases the driver is able to retain sufficient functioning to stop the car by the side of the road after onset, and thus they rarely result in the death of passengers or pedestrians. There are, however, cases in which sudden onset results in driver incapacitation, thus leading to a fatal traffic accident. Early diagnosis of underlying disease during standard health examinations and rapid treatment are therefore important for preventing sudden death while driving, which is classified as death by disease instead of by traffic accident. In cases where sudden death while driving is suspected, the cause of death is investigated, because distinguishing between such causes and lack of attention is important for elucidation of the cause of the accident and the dignity of the deceased.

Because alcohol impairs judgment and hinders vehicle operation, and can thus lead to traffic accidents, driving under the influence of alcohol is prohibited. In Japan, drunk driving is defined as operating an automobile with a blood alcohol concentration of 0.3 mg/mL or more, or with a breath alcohol

Table 2. Relation between blood/breath alcohol concentration and drunkenness

	Blood concentration (mg/mL)	Blood concentration (%)	Breath concentration (mg/L)	Drunkenness
Stage 0:	0.1–0.5	0.01–0.05	0.05–0.25	Euphoria: Feeling slightly intoxicated
Stage 1:	0.5–1.0	0.05–0.1	0.25–0.5	Mild drunkenness: Mild cognitive disturbance
Stage 2:	1.0–1.5	0.1–0.15	0.5–0.75	Light drunkenness: Cheerfulness, talkativeness, excitement
Stage 3:	1.5–2.5	0.15–0.25	0.75–1.25	Moderate drunkenness: Lowered decision-making, lowered ability to walk
Stage 4:	2.5–3.5	0.25–0.35	1.25–1.75	Strong drunkenness: Slurred speech, clouded consciousness
Stage 5:	3.5–4.5	0.35–0.45	1.75–2.25	Stupor: Loss of consciousness, hypothermia
Stage 6:	4.5–	0.45–	2.25–	Coma: Cardiac dysfunction, respiratory paralysis, death

concentration of 0.15 mg/L or more (breath alcohol concentration is taken as approximately 1/2000 that of blood alcohol concentration). In contrast, driving under the influence of alcohol is defined as driving in a situation where alcohol consumption may prevent normal automobile operation, regardless of blood or breath alcohol concentration. The relation between drunkenness and the degree of blood or breath alcohol concentration is important for determination of driving ability at the time of an accident (Table 2). Blood alcohol levels peak 1–2 h following consumption, then exhibit a gradual, linear decline as alcohol is metabolized. Maximum blood concentration increases with the amount of alcohol consumption, but the rate at which alcohol can be metabolized is fixed (a decrease of 0.16 mg/mL per hour), so large amounts of alcohol consumption will result in residual blood alcohol persisting over an extended time. It is therefore sometimes the case that one believes oneself sober the morning after heavy drinking, but in fact residual blood alcohol results in driving under the influence of alcohol. Note that in cases of hit-and-run accidents where alcohol concentrations could not be measured at the time of the accident, concentrations can be still estimated according to a mathematical equation, based on the amount of alcohol consumed or alcohol concentrations at a later time.[10)]

Other substances frequently abused in Japan, such as solvents, stimulants, and narcotics, can also act on the brain to lower decision-making abilities and prevent normal driving, and there have been accidents where solvents and stimulants have led to traffic accidents. There has been an increase in the abuse of dangerous drugs, and in the future it will likely be necessary to develop tests to screen for the use of illegal drugs, such as stimulants and dangerous drugs, by drivers involved in traffic accidents. Thorough implementation of such screenings would likely have a deterrent effect on driving while under the influence of illegal drugs, which can result in fatal traffic accidents.

9.5 Traffic safety and sleep

9.5.1 Two major factors pertaining to sleep and safe driving

Safe driving requires appropriate perception, decision-making, and control, three operational abilities that are disturbed by drowsiness. Good sleep is essential to preventing drowsiness.[11), 12), 13)]

A good understanding of accidents due to drowsiness calls for some fundamental background knowledge. Among other things, there are two major sleep-related factors that have an effect. One is the human body's circadian (internal) clock.[14)] The circadian clock functions to regulate daily rhythms through various bodily functions such as temperature and hormone control, and its effects on operational ability increase from morning until night. The effects then decrease to a minimum in the early morning, after which they begin to rise again (Fig. 7A).

The other factor is the duration of time spent awake.[15), 16)] Operational ability worsens as the time of continual wakefulness increases (Fig. 7B). Shortening the period of continual wakefulness by sleeping or napping can thus inhibit worsening of operational ability.

Interaction occurs between the effects of the circadian clock and time spent awake, which determines the actual level of operational ability. As an example, Fig. 7C shows the results of an experiment in which response time was measured after 36 h of being continually awake (participants were asked to press a button as quickly as possible after viewing a light, or other visual stimulation).[17)] Pressing a button in response to visual stimuli corresponds well to extremely fundamental driving skills, such as braking when seeing a red signal or using the steering wheel to avoid a stopped car. This data makes it easy to see that driving from late night to early morning or for long periods of time makes accidents more likely.

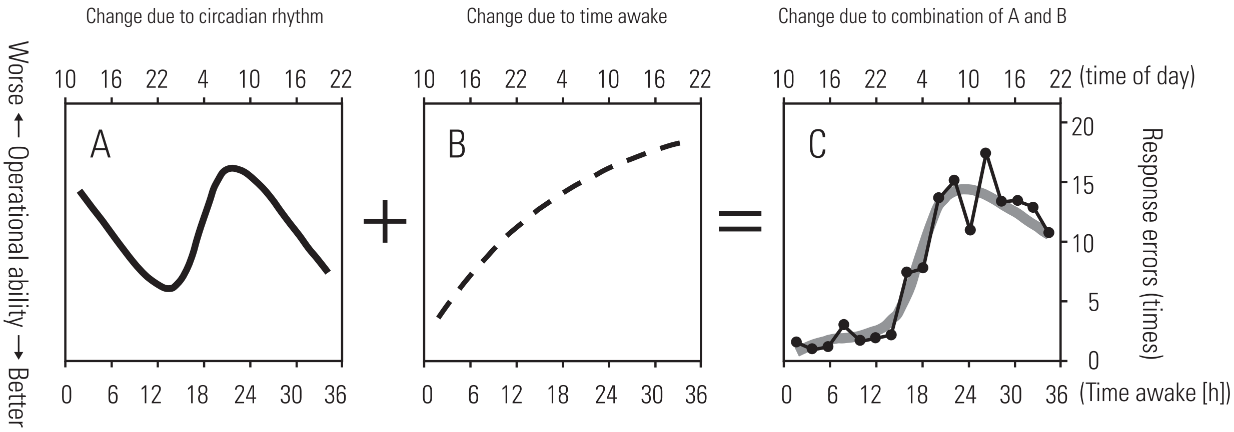

Figure 7. Effects of circadian rhythmicity and time awake on operational ability

The vertical axis represents the number of errors (lapses) in a reaction time test; C: Dots and black lines show measured values, gray lines are fitted according to A and B

In addition to the circadian clock and time spent awake, the amount and quality of sleep before driving are also closely related to safety. Not only sleep deprivation before automobile operation, but also chronically short sleep, increases the risk of traffic accidents.[18), 19)] Lowered quality of sleep often occurs due to environmental conditions such as noise or high temperature,[20)] work- or family-related stress,[21)] disorders such as insomnia or sleep-related breathing disorders,[22)] or other illnesses including depression or back pain.[23)] Such sleep quality-related problems increase the likelihood of traffic accidents.[24), 25)] Furthermore, the use of medications that can result in drowsiness should be avoided when driving.[26)]

Sleep-related problems may lead to traffic violations that can then cause motor vehicle crashes. Short sleep duration has been found to increase the frequency of driver inattention,[27] and a group of sleep apnea patients was shown to commit more stopping violations than did a control group.[28]

9.5.2 Significance of sleep in traffic safety measures

Traffic safety can be ensured using several approaches. As described above, sleep and sleep-related problems have a large effect on drivers, and thus there is a critical need for establishing effective measures to improve drivers' sleep by sharing knowledge regarding proper sleep among drivers and their families and employers, and also by developing workplace-based and other organizational programs for adequate sleep.[29]

References

1) Traffic Bureau, National Police Agency. 2014. *Heisei 25 nen chu no kotsu jiko no hassei jokyo* [Traffic accident situation 2013]. (in Japanese)
2) Kibayashi, K., R. Shimada, and K. Nakao. 2013. "Temporal and Regional Variations in Accidental Deaths of Elderly People in Japan." *Medicine, Science and the Law* 53: 172–176.
3) Payne-James, J., R. Jones, S. B. Karch, and J. Manlove. 2011. *Simpson's Forensic Medicine*. 13th ed. Hodder Arnold.
4) Kibayashi, K., R. Shimada, K. Nakao, and A. Ro. 2012. "Analysis of pituitary lesions in fatal closed head injury." *American Journal of Forensic Medicine and Pathology* 33: 206–210.
5) Cowley, R. A., F. Hudson, E. Scanian, W. Gill, R. J. Lally, W. Long, and A.O. Kuhn. 1973. "An economical and proved helicopter program for transporting the emergency critically ill and injured patient in Maryland." *Journal of Trauma* 13, 12: 1029–1038.
6) Hondo, K., A. Shiraishi, S. Fujie, D. Saitoh, and Y. Otomo. "In-hospital trauma mortality has decreased in japan possibly due to trauma education." *Journal of the American College of Surgeons* 217, 5: 850–857.
7) Moriya, T., and K. Tanjoh. 2009. "Current status of emergency medical services and role of prehospital care." *IATSS Review* Vol. 34, No. 3: 260–269. (in Japanese)
8) Sakurai, A., N. Morimura, M. Takeda, K. Miura, N. Kiyotake, T. Shiahara, and T. Aruga. 2014. "A retrospective quality assessment of the 7119 call triage system in Tokyo: telephone triage for non-ambulance cases." *Journal of Telemedicine and Telecare*. http://doi.org/10.1177/1357633X14536347.
9) Kibayashi, K., and H. Shojo. 2002. "Incipient Alzheimer's disease as the underlying cause of a motor vehicle crash." *Medicine, Science and the Law* 42: 233–236.
10) Kibayashi, K, T. Sumida, H. Shojo, and M. Hanada. 2007. "Dementing diseases among elderly persons who suffered fatal accidents: a forensic autopsy study." *American Journal of Forensic Medicine and Pathology* 28: 73–79.
11) Mitler, M. M., M. A. Carskadon, C. A. Czeisler, W. C. Dement, D. F. Dinges, and R. C. Graeber. 1988. "Catastrophes, sleep, and public policy: consensus report." *Sleep* Vol. 11, No. 1: 100–109.
12) Åkerstedt, T. 2000. "Consensus statement: fatigue and accidents in transport operations." *Journal of Sleep Research* Vol. 9, No. 4: 395.
13) Folkard, S., D. A. Lombardi, and P. T. Tucker. 2005. "Shiftwork: safety, sleepiness and sleep." *Industrial Health* Vol. 43, No. 1: 20–23.
14) Golombek, D. A., and R. E. Rosenstein. 2010. "Physiology of circadian entrainment." *Physiological Reviews* Vol. 90, No. 3: 1063–1102.
15) Cajochen, C., S. B. Khalsa, J. K. Wyatt, C. A. Czeisler, and D. J. Dijk. 1999. "EEG and ocular correlates of circadian melatonin phase and human performance decrements during sleep loss." *American Journal of Physiology* Vol. 277, No. 3 Pt. 2: R640–649.
16) Dawson, D., and K. Reid. 1997. "Fatigue, alcohol and performance impairment." *Nature* Vol. 388, No. 6639: 235.
17) Van Dongen, H. P., A. M. Bender, and D. F. Dinges. 2012. "Systematic individual differences in sleep homeostatic and circadian rhythm contributions to neurobehavioral impairment during sleep deprivation." *Accident Analysis & Prevention* Vol. 45 Suppl.: 11–16.

18) Dawson, D., and K. McCulloch. 2005. "Managing fatigue: it's about sleep." *Sleep Medicine Reviews* Vol. 9, No. 5: 365–380.
19) Dorrian, J., M. Sweeney, and D. Dawson. 2011 "Modeling fatigue-related truck accidents: Prior sleep duration, recency and continuity." *Sleep and Biological Rhythms* Vol. 9, No. 1: 3–11.
20) Kayaba, M., T. Ihara, H. Kusaka, S. Iizuka, K. Miyamoto, and Y. Honda. 2014. "Association between sleep and residential environments in the summertime in Japan." *Sleep Medicine* Vol. 15, No. 5: 556–564.
21) Takahashi, M., K. Iwasaki, T. Sasaki, T. Kubo, I. Mori, and Y. Otsuka. 2012. "Sleep, fatigue, recovery, and depression after change in work time control: a one-year follow-up study." *Journal of Occupational and Environmental Medicine* Vol. 54, No. 9: 1078–1085.
22) Rosekind, M. R., and Gregory K. B. 2010. "Insomnia risks and costs: health, safety, and quality of life." *American Journal of Managed Care* Vol. 16, No. 8: 617–626.
23) Finan, P. H., and M. T. Smith. 2013. "The comorbidity of insomnia, chronic pain, and depression: Dopamine as a putative mechanism." *Sleep Medicine Reviews* Vol. 17, No. 3: 173–183.
24) Léger, D., V. Bayon, M. M. Ohayon, P. Philip, P. Ement, A. Metlaine, M. Chennaoui, and B. Faraut. 2014. "Insomnia and accidents: cross-sectional study (EQUINOX) on sleep-related home, work and car accidents in 5293 subjects with insomnia from 10 countries." *Journal of Sleep Research* Vol. 23, No. 2: 143–152.
25) Tregear, S., J. Reston, K. Schoelles, and B. Phillips. 2009. "Obstructive sleep apnea and risk of motor vehicle crash: systematic review and meta-analysis." *Journal of Clinical Sleep Medicine* Vol. 5, No. 6: 573–581.
26) Hetland, A., and D. B. Carr. 2014. "Medications and impaired driving." *Annals of Pharmacotherapy* Vol. 48, No. 4: 494–506.
27) Anderson, C., and J. A. Horne. 2013. "Driving drowsy also worsens driver distraction." *Sleep Medicine* Vol. 14, No. 5: 466–468.
28) Vakulin, A., P. G. Catcheside, C. J. Van Den Heuvel, N. A. Antic, R. D. McEvoy, and S. D. Baulk. 2011. "Increased rate of traffic law infringements during on-road metropolitan driving in obstructive sleep apnea patients." *Sleep and Biological Rhythms* Vol. 9, No. 3: 144–149.
29) Takahashi, M. 2012. "Prioritizing sleep for healthy work schedules." *Journal of Physiological Anthropology* Vol. 31, No. 1: 1–8.

Recommended Reading

1) Bloomberg, H., B. Svennblad, K. Michaelsson, L. Byberg, J. Johansson, and R. Gedeborg. "Prehospital trauma life support training of ambulance caregives and the outcomes of traffic-injury victims in Sweden." *Journal of the American College of Surgeons* 217, 6: 1010–1019.e2.
2) Czeisler, C. A. 2013. "Perspective: casting light on sleep deficiency." *Nature* Vol. 497, No. 7450: 13.
3) Takahashi, M. 2014. "Assisting shift workers through sleep and circadian research." *Sleep and Biological Rhythms* Vol. 12 (2): 85–95. http://doi.org/10.1111/sbr.12065.
4) Williamson, A., R. Friswell, J. Olivier, and R. Grzebieta. 2014. "Are drivers aware of sleepiness and increasing crash risk while driving?" *Accident Analysis & Prevention* 70: 225–234. http://doi.org/10.1016/j.aap.2014.04.007.
5) Ayas, N., R. Skomro, A. Blackman, K. Curren, M. Fitzpatrick, J. Fleetham, C. George, T. Hakemi, P. Hanly, C. Li, et al. 2014. "Obstructive sleep apnea and driving: A Canadian Thoracic Society and Canadian Sleep Society position paper." *Canadian Respiratory Journal* Vol. 21, No. 2: 114–123.
6) Strohl, K. P., D. B. Brown, N. Collop, C. George, R. Grunstein, F. Han, L. Kline, A. Malhotra, A. Pack, B. Phillips, et al. 2013. "An official American Thoracic Society Clinical Practice Guideline: sleep apnea, sleepiness, and driving risk in noncommercial drivers. An update of a 1994 Statement." *American Journal of Respiratory and Critical Care Medicine* Vol. 187, No. 11: 1259–1266.

Practical application projects for reference

Addressing issues associated with prehospital emergency transportation: 176–179
Dissemination and promotion of screening for sleep disorders: 180–183