―Case Reports―

# A System That Uses Advanced Automatic Collision Notification Technology to Dispatch Doctors to Traffic Accidents by Helicopter: The First 4 Cases

Tomokazu Motomura[1,2], Hisashi Matsumoto[1], Kunihiro Mashiko[2,3],
Hirotoshi Ishikawa[2], Tetsuya Nishimoto[2,4] and Yoshihiro Takeyama[5]

[1]Shock and Trauma Center, Hokusoh HEMS, Nippon Medical School Chiba Hokusoh Hospital, Chiba, Japan
[2]HEM-Net, the D-Call Net Research Society, Tokyo, Japan
[3]Minamitama Hospital, Tokyo, Japan
[4]Biomechanics Research Unit, Nihon University, Fukushima, Japan
[5]Hakodate Municipal Hospital, Hokkaido, Japan

**Introduction:** To increase survival rates of patients with severe trauma from road traffic accidents, Japan launched the D-Call Net (DCN) system, which utilizes advanced automatic collision notification technology to dispatch doctors by helicopter. The DCN system began in November 2015 and, as of October 2019, has dispatched doctors 4 times.

**Cases:** Case 1-Canceled because trauma was mild. Case 2-Doctor made contact with 2 patients with moderate trauma 29 minutes earlier than would have occurred conventionally. This was the first case in the world to use automotive engineering data to dispatch a doctor to a patient. Case 3-An accident involving 3 severely injured patients activated DCN, enabling doctor-patient contact 20 minutes earlier than would have been possible conventionally. Case 4-DCN was ineffective.

**Discussion:** According to 2008 data from Chiba Prefecture, in accidents where victims sustain severe trauma, the interval from accident occurrence to hospital arrival was 67 minutes, even when doctors were dispatched by air ambulance (Doctor-Heli [DH]). Use of accident information for faster doctor dispatch effectively improved survival rates. An algorithm was developed to use accident information to assess trauma severity (severity probability). DCN dispatches doctors by using data, including information on accident site and severity probability, which are sent to smartphones of doctors, thereby reducing the interval from accident to DH request by approximately 17 minutes. DCN is the first system in the world to use automotive engineering information for faster doctor dispatch to traffic accident sites. The system is crucial for improving survival rates and mitigating the aftereffects of traffic accidents. (J Nippon Med Sch 2020; 87: 220–226)

**Key words:** trauma system, helicopter emergency medical services, automatic collision notification, intelligent transportation

## Introduction

To improve survival rates among persons severely injured in road traffic accidents, the time from injury to physiological stabilization via doctor contact and to life-saving treatment (including hemostasis) at a hospital must be reduced[1]. To this end, Japan launched the D-Call Net (DCN) in November 2015. The DCN system uses advanced automated collision notification (AACN) technology to dispatch doctors by helicopter (Doctor-Heli [DH] in Japan) to road traffic accident sites[2-4]. As of October 2019, doctors have been dispatched by DCN on 4 occasions.

## Report of Cases

### Case 1

In April 2017, DH was activated in northern Chiba Prefecture upon receipt of a DCN notification. On arrival at the accident site, however, the emergency medical team judged the victim's injury to be mild, and the DH request was canceled.

### Case 2

In January 2018, the DH base hospital in northern Chiba Prefecture received a DCN notification 1 minute after a road traffic accident. Upon collision, the change in vehicle velocity (Δv) was 33 km/h, and the driver severity probability was 19%; thus, DH was activated. The DH arrived above the accident site only 17 minutes later, although the accident site was 40 minutes from the hospital by ambulance. The driver of the light vehicle (a woman in her 40s) was hospitalized with sternal and foot fractures (Injury Severity Score [ISS], 12). The driver of the standard-sized vehicle, which was equipped with DCN, sustained mild trauma. In this case, DCN was judged to have shortened the time to doctor-patient contact by 29 minutes. This was the first case in the world in which automotive engineering information and predicted trauma severity were used to dispatch doctors to administer treatment.

### Case 3

In December 2018, a road traffic accident occurred during a snowstorm on an expressway in southern Hokkaido Prefecture. The Δv of the DCN-equipped vehicle was 49 km/h, and the severity probability of the driver and passenger was 67% each. The driver of the light truck (a man in his 50s) was in cardiopulmonary arrest by the time the emergency medical team made contact. The driver of the standard-sized vehicle (a man in his 60 s) sustained severe abdominal injury, which required emergency surgery, while the passenger (a woman in her 60s) sustained severe lumbar burst fracture. DCN shortened the time to doctor-patient contact by 20 minutes, as compared with conventional dispatch.

### Case 4

In March 2019, a standard-sized vehicle and a light vehicle collided in Gifu Prefecture. The severity probabilities of the driver and passenger of the standard-sized vehicle were 15% and 6%, respectively. Both were ultimately determined to have sustained mild injuries. However, the driver of the oncoming light vehicle (a male teenager) sustained severe injury (ISS, 26), including kidney injury and open femoral fracture requiring emergency transcatheter arterial embolization and intensive

care unit admission. The fire department that received the DCN notification deemed DH to be unnecessary. Rather than being activated immediately, DH was activated 55 minutes later.

From November 2015 to October 2019, there were 665 DCN notifications involving 778 vehicle occupants. DH was activated 4 times in these cases (**Table 1**). The number of monthly DCN notifications has gradually increased over time (**Fig. 1**). The threshold for DH activation (severity probability ≥5%) was met in 215 accidents (247/778 occupants). In 211 cases, DH was not dispatched despite a severity probability of ≥5%. Reasons for this included refusal by the victim (n = 99, 47%) and inability to activate DH (incidents outside DH service hours, inclement weather, and response to other calls; n = 64, 30%; **Table 2**).

## Discussion

The annual number of traffic fatalities in Japan peaked at 16,765 in 1970 and decreased gradually after that. However, this decreasing trend has recently stalled. In 2018, 3,532 people (out of a total Japanese population of approximately 120 million) died within 24 hours of sustaining injuries in road traffic accidents. In the Tenth Five-Year Fundamental Plan for Traffic Safety, the Japanese government aims to reduce the annual number of traffic fatalities to fewer than 2,500 by 2020. To meet this goal, the Japanese government has recommended maintaining road traffic laws, improving the road traffic environment, and promoting safe driving and safe vehicles, as well as developing advanced measures that use information and communications technology and various forms of data[5].

Trauma outcomes are greatly affected by the time from injury to physiological stabilization of the patient via doctor-patient contact and to treatment and/or surgery at a hospital. Saving the life of a patient who has lost a large amount of blood because of severe trauma requires that definitive surgery begins within the "golden hour", that is, 60 minutes after injury[1,6]. DH first began service in Japan in 2001 to reduce the time from injury or acute disease onset to medical intervention and definitive treatment, thereby improving survival rates and mitigating aftereffects[7,8].

According to 2008 survey data from the Chiba Traffic Accident Investigating Committee, the average time from a serious, potentially fatal road traffic accident (injury) to notification of the fire department (receipt of emergency medical services call) was 5 minutes, the average time from notification of the fire department to DH request

Table 1 The 4 cases of D-Call Net (DCN) notifications where Doctor-Heli (DH) was activated

| Case | Date of accident | Location of accident | Time of accident | Time of D-Call Net notification | Time of DH take-off | Time of doctor-patient contact | Time to doctor-patient contact saved by DCN** (min) | Patient age/sex | Car type | Position in car | Direction of collision | Δv (km/h)*** | Seat belt usage/Airbag operation | Severity probability**** | Trauma diagnosis | MAIS | ISS | Outcome |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | April 2017 | Chiba Prefecture | 10:56 | 10:57 (1)* | 11:09 (13)* | – | – | Unknown | Passenger vehicle | Driver seat | Perpendicular, opposite side | 7 | + / – | 1% | Contusion | 1 | 1 | DH canceled by on-site EMS |
| 2 | January 2018 | Chiba Prefecture | 15:07 | 15:08 (1)* | 15:16 (9)* | 15:43 (36)* | 29 | 50s/M | Passenger vehicle | Driver seat | Head-on | 33 | + / + | 19% | Contusion | 1 | 1 | Returned home after initial treatment |
| | | | | | | | | 40s/F | Light passenger vehicle | Driver seat | | (DCN not installed) | | | Concussion, sternal fracture, foot fracture | 2 | 12 | Hospitalized |
| 3 | December 2018 | Hokkaido (Expressway) | 10:40 | 10:41 (1)* | 10:57 (17)* | 11:14 (34)* | 20 | 60s/M | Passenger vehicle | Driver seat | Head-on | 49 | + / + | 67% | Mesenteric injury | 4 | 17 | Emergency surgery, admitted to ICU |
| | | | | | | | | 60s/F | Passenger vehicle | Passenger seat | | | + / + | 67% | Lumbar burst fracture | 3 | 11 | Admitted to ICU, elective surgery |
| | | | | | | | | 50s/M | Light truck | Driver seat | | (DCN not installed) | | | Traumatic CPA | Unknown | Unknown | Death |
| 4 | March 2019 | Gifu Prefecture | 09:02 | 09:03 (1)* | 09:57 (55)* | 10:21 (79)* | 0 | 10s/M | Light passenger vehicle | Driver seat | | (DCN not installed) | | | Left kidney injury, right open femoral fracture | 4 | 26 | TAE, admitted to ICU |
| | | | | | | | | 40s/F | Passenger vehicle | Driver seat | Head-on | 32 | + / + | 15% | Chest contusion | 1 | 3 | Hospitalized |
| | | | | | | | | 40s/M | Passenger vehicle | Passenger seat | | | + / + | 6% | Chest contusion | 1 | 3 | Hospitalized |

CPA: cardiopulmonary arrest
DCN: D-Call Net
DH: Doctor-Helicopter
ICU: intensive care unit
ISS: Injury Severity Score
MAIS: Maximum Abbreviated Injury Score
TAE: transcatheter arterial embolization
* Time elapsed after accident, min
** Compared with conventional emergency service
*** Change in velocity upon collision
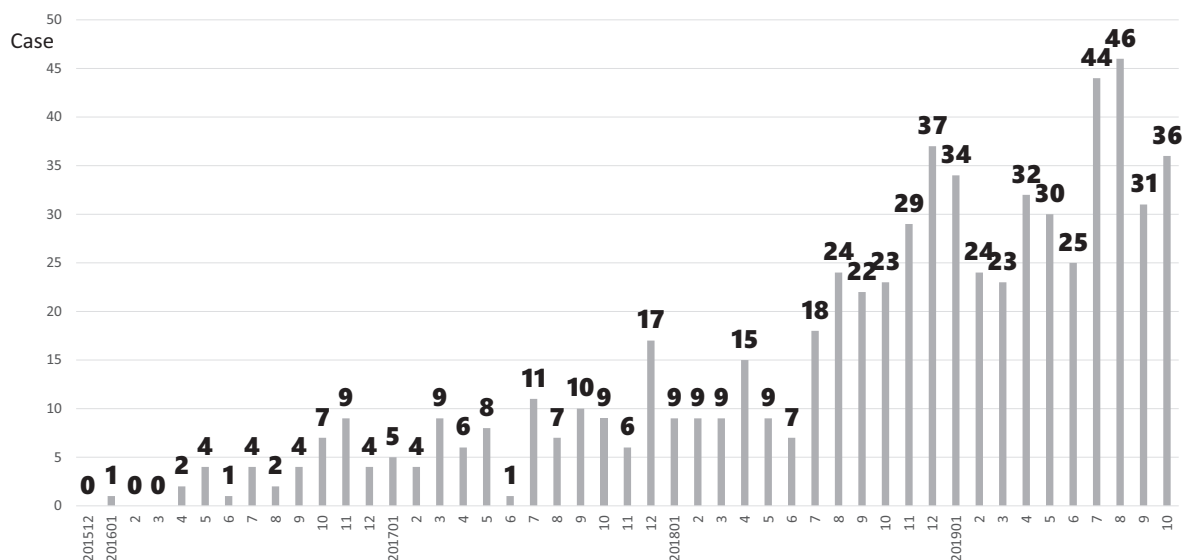**** Predicted probability of death or severe injury

Fig. 1  Monthly number of D-Call Net notifications

Table 2  Reasons for Docter-Heli (DH) not being activated despite D-Call Net (DCN) probability of death/severe injury exceeding the DH activation threshold of ≥ 5% (211 cases)

| Reason | No. of cases |
| --- | --- |
| Driver refused assistance when contacted by operator | 99 (47%) |
| Reported to DH base hospital but DH not activated: | |
| Incident outside DH service hours, inclement weather, responding to other calls, or reasons associated with local rules. | 64 (30%) |
| Other | 48 |

Table 3  Time required (average time in minutes) from traffic accident (injury) to different phases of emergency medical services with conventional means and D-Call Net notifications

| | TA | EC | EMS, ADH | Dr | Hospital | OPE | Total |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Conventional | 0 | +5 | +15 | +18 | +29 | +α | 67+α |
| D-Call Net | 0 | ----- directly ----- | +3 | +18 | +29 | +α | 50+α |

TA: traffic accident; EC: emergency call; EMS: emergency medical service; ADH: activation of Doctor-Heli; Dr: doctor-patient contact; OPE: surgery for lifesaving in hospital.

was 15 minutes, the average time from DH request to on-site doctor-patient contact was 18 minutes, and the average time from on-site doctor-patient contact to patient arrival at hospital was 29 minutes. Thus, the average time from injury to patient arrival at hospital was 67 minutes (**Table 3**)[9]. Because additional time is required from patient arrival at the hospital until definitive surgery is begun (+α in **Table 3**), the total time from injury to definitive surgery can easily exceed 60 minutes in Japanese emergency medical services, even if a DH is used to dispatch doctors and transport patients. Further time reduction was considered necessary to improve survival rates. The time from road traffic accident (injury) to DH request (average 20 minutes) could be shortened by early

notification.

The Automatic Collision Notification (ACN) system was deployed in 2000 to decrease the time from a road traffic accident to notification of the fire department. However, the only information that the ACN system could transmit was the location of an airbag-deploying accident. Thus, the time to notification was shortened by only 4 minutes[10]. AACN extends ACN to incorporate information on the probable severity of occupant injuries and is now being developed worldwide. Based on automotive engineering information on road traffic accidents, this newer system can predict the probability of death or severe injury. The AACN system eCall is used in Europe, and its installation in new vehicles has been required
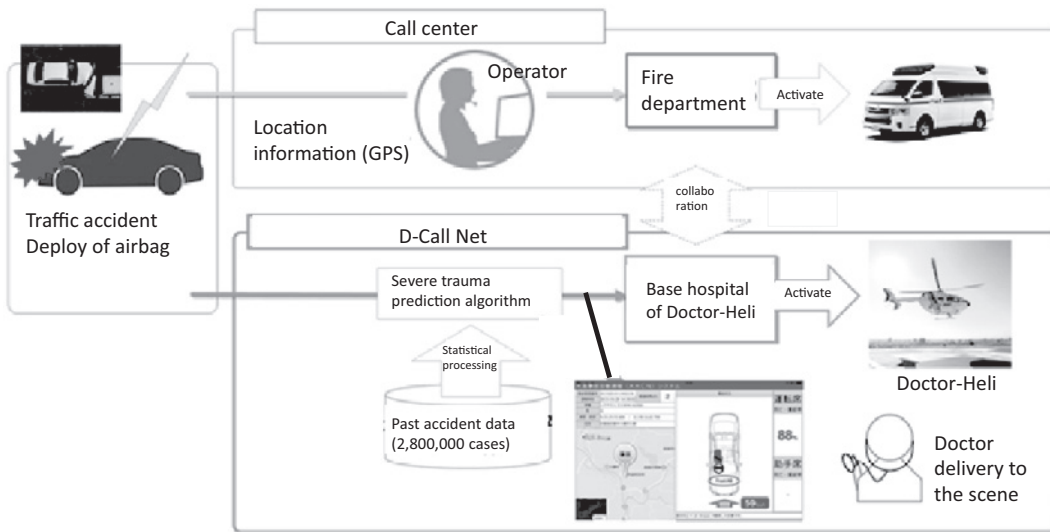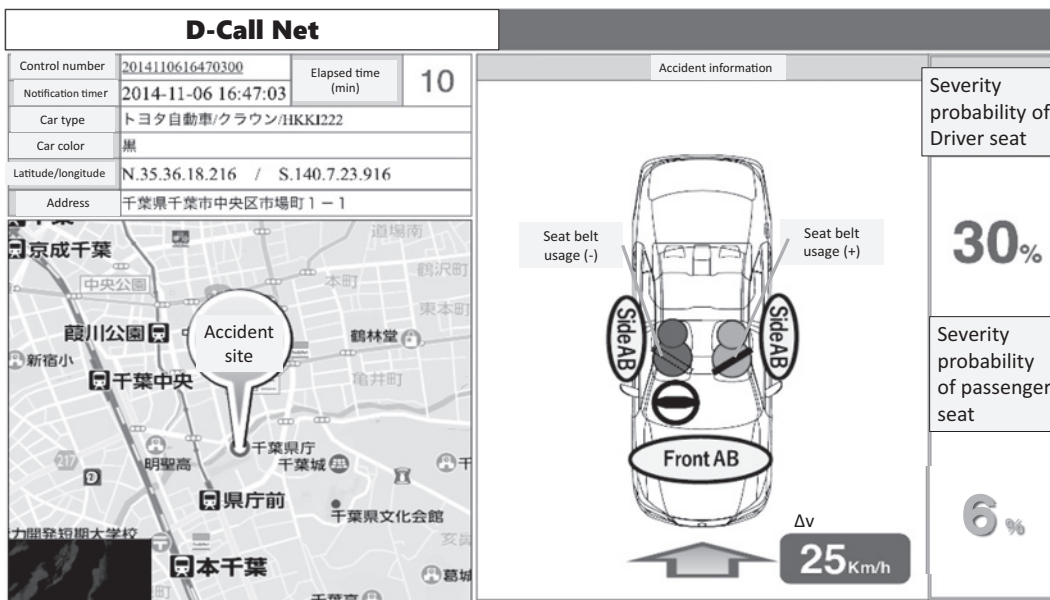
Fig. 2   The D-Call Net System



Fig. 3   Incoming link to D-Call Net information and smartphone information display screen
In the event of a serious accident, emergency physicians at the Doctor-Heli base hospital covering the accident site are notified by e-mails to their smartphones. Clicking the link in the e-mail displays detailed accident information.

since April 2018[11]. In the United States, an AACN system deployed by automakers such as GM and Ford uses the URGENCY algorithm created by the National Highway Traffic Safety Administration, but this system is used to notify fire dispatch centers rather than to dispatch doctors[12].

In Japan, the DCN system was developed by the D-Call Net Research Society and uses AACN technology to dispatch doctors by DH more quickly[2]. This is the only system in the world in which notifications are used both to alert the fire department and dispatch doctors to acci-

dent sites. Significant time savings are expected with this system[10]. The algorithm for predicting severity probability of vehicle occupants is based on a macrodata set comprising 2.8 million traffic accidents over the past 10 years. The algorithm used in Japan is based on automotive engineering information, including Δv, direction of the collision, number of impacts, and safety equipment information (seatbelts and airbags)[13]. In the police data used in this algorithm, severe injury was defined as an injury requiring ≥30 days of hospitalization.

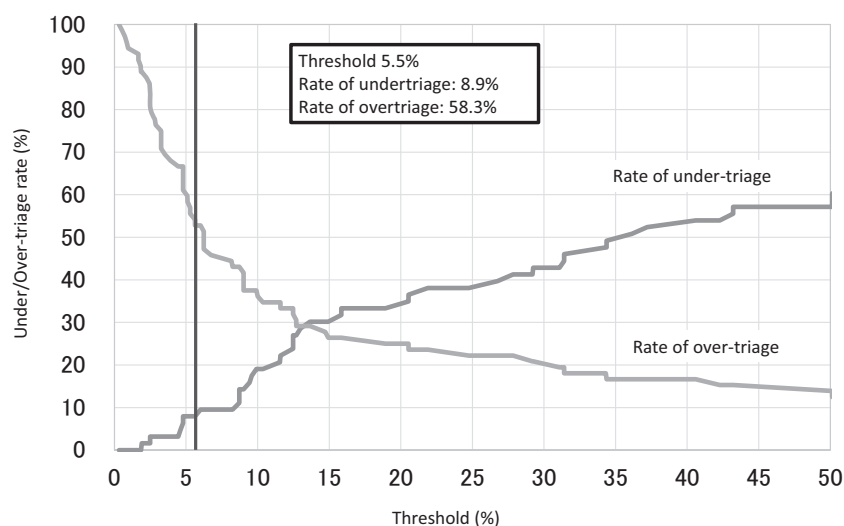The structure of the DCN system is shown in **Figure 2**.

Fig. 4  Relationship between the threshold (severity probability [%]) for doctor dispatch system activation, under-triage rate, and over-triage rate in D-Call Net.

When a traffic accident occurs, the vehicle transmits automotive engineering information about the accident to a dedicated server at a call center. This server then uses an algorithm to calculate the severity probability of injury sustained by vehicle occupants. An operator then attempts to contact the driver. If the driver consents to assistance or does not respond, detailed information is transmitted to the fire department, including the accident location (map display and latitude/longitude), time of the accident, time elapsed since the accident (in minutes), and the car make, model, and color (**Fig. 3**). The server then sends an automated e-mail to the smartphones of doctors at the regional DH base hospital. Doctors can access the above detailed information via a link in the e-mail. As of October 2019, DH is activated in principle when the severity probability threshold is 5% or higher.

**Figure 4** shows associations between predicted severity rate, under-triage rate, and over-triage rate[13]. Here, under-triage is defined as severe injury misidentified as mild, and over-triage as mild injury misidentified as severe. The threshold setting for DH dispatch was set so that the under-triage rate would be less than 10%, taking into account the accuracy of global prehospital triage[14]. This 5% threshold was established to achieve an under-triage rate of less than 10%; with this threshold, the over-triage rate is approximately 60%[13].

As confirmed in field training, the DCN shortens the time from an accident to DH request from an average of 20 minutes to less than 3 minutes, a 17-minute reduction[2] (**Table 3**). This 17-minute DCN-associated reduction in time to DH request is reflected in the shorter interval to

doctor-patient contact and hospital arrival. According to calculations based on Japan Trauma Data Bank data, if all of the approximately 60 million vehicles registered in Japan were equipped with DCN, and the system could also handle not only vehicle occupants but also vulnerable road users such as pedestrians and cyclists, 282 of the 4,863 people who died in traffic accidents in Japan in 2010 could have been saved[10].

On November 30, 2015, DCN was launched in 9 DH regions (areas within a 50-km radius from DH base hospitals) across Japan. As of October 2019, DCN is operational in 51 of the 53 DH regions nationwide. Although launched in Japan in 2015, DCN has led to the dispatch of doctors in only 4 cases. In the first case, the patient's injury was mild, but it was the first instance of DH being activated by DCN. The second case was the first instance in the world of doctors being dispatched on the basis of automotive engineering information about a traffic accident; in this case, DCN led to faster doctor-patient contact and evidently shortened the time required. In the third case, which occurred on a snowy expressway, effective utilization of DCN information shortened the time to doctor-patient contact and helped save patients' lives. In the fourth case, DCN information was not utilized effectively. In any case, DCN is still in its infancy. Thus, it is not yet widely known and has been used in only a small number of cases. In addition to DH, DCN should be applied to other doctor dispatch systems, such as rapid response cars. DCN notifications with rapid response cars will likely reduce transport times and improve survival rates in the same manner as DH[15].

Although approximately 60 million passenger vehicles are currently registered in Japan, only 1 million (1.7%) were equipped with DCN as of October 2019. However, Toyota has announced that all of its cars will be equipped with DCN from 2022, while Honda is also planning to equip more of its models with DCN. Nissan, Mazda, and Subaru also began developing and marketing vehicles equipped with DCN in April 2019. In addition, development is underway on a retrofitting device (called "Type 2 DCN") for vehicles not equipped with DCN.

This study has some limitations. To determine the time required for emergency medical services using DH in Japan, data from all over the country should be used. However, a nationwide dataset could not be collected, so data from a single prefecture (Chiba) were used in this study.

Although many issues with DCN need to be resolved, the system takes full advantage of rapidly progressing sensor and communications technology to dispatch doctors to traffic accidents, thereby potentially saving the lives of traffic accident victims who otherwise would not have survived.

## References

1. Champion HR, Augenstein JS, Blatt AJ, et al. New tools to reduce deaths and disabilities by improving emergency care: Urgency software, occult injury warnings, and air medical services database. Proceedings of the 19th International Technical Conference on the Enhanced Safety of Vehicles (ESV) [Internet]. 2005 [cited 2019 Dec 17]; 05-0191. Available from: https://www-esv.nhtsa.dot.gov/Proceedings/19/05-0191-W.pdf
2. Matsumoto H, Mashiko K, Hara Y, et al. Dispatch of helicopter emergency medical services via advanced automatic collision notification. J Emerg Med. 2016;50(3):437−43.
3. Motomura T. The actual request from D-Call Net and activation of Doctor-Heli system. Journal of Society of Automotive Engineers of Japan. 2017;71(12):40−4.
4. Motomura T, Matsumoto H, Mashiko K, et al. Development and testing of Advanced Automatic Collision Notification: AACN(D-Call Net) to activate Doctor-Heli in Japan. Journal of Japanese Society for Emergency Medicine. 2018;21:513−8.
5. Cabinet office, Government of Japan. Tenth five-year fundamental plan for traffic safety [Internet]. 2016 [cited 2019 Dec 18]. Japanese. Available from: https://www8.cao.go.jp/koutu/kihon/keikaku10/pdf/kihon_keikaku.pdf
6. Cowley RA, Hudson F, Scanlan EW, et al. An economical and proved helicopter program for transporting the emergency critically ill and injured patient in Maryland. J Trauma. 1973;13:1029−38.
7. Matsumoto H, Mashiko K, Hara Y, et al. Effectiveness of a "Doctor-Helicopter" system in Japan. Isr Med Assoc J. 2006;8:8−11.
8. Sakamoto Y, Mashiko K, Matsumoto H, et al. Effectiveness of helicopter emergency medical service system for trauma according to the Japan Trauma Data Bank. J Jpn Soc Emer Med. 2010;13:356−60.
9. Motomura T, Mashiko K, Matsumoto H, et al. Preventable trauma deaths after traffic accidents in Chiba Prefecture, Japan, 2011: Problems and Solutions. J Nippon Med Sch. 2014;81:320−7.
10. Takayama S, Ono K, Sato I, et al. Effect estimation of automatic crash notification system for the reduction of traffic accident fatalities utilizing the Japan trauma data bank. Journal of JSAE. 2014;135:11−4.
11. Miriam C, Filipe F, Tania P, et al. Universal access to eCall system. 2014. Procedia Comput Sci. 2014;27:104−12.
12. Augenstein J, Digges K, Ogata S, et al. Development and validation of the urgency algorithm to predict compelling injuries. SAE Technical Paper. 2001;06-0051.
13. Nishimoto T, Mukaigawa K, Tominaga S, et al. Serious injury prediction algorithm based on large-scale data and under-triage control. Accid Anal Prev. 2017;98:266−76.
14. Centers for Disease Control and Prevention. Guidelines for field triage of injured patients. Recommendations of the National Expert Panel on Field Triage, 2011. MMWR Recomm Rep. 2012;61:1−20.
15. Takayama S, Takatori O, Inoue S, et al. Time reduction effect estimation using an automatic crash notification system: by using the doctor car for the AACN system. JARI Research Journal. 2016;10:1−4.