Traffic Safety of Elderly Road User: the World Trend and the Japanese Case

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Based on a meta revision of 133 traffic safety studies related to elderly road users, the goal of this study is to depict an overall picture of the literature, in which the most common findings as well as shortcoming issues were identified. A further effort was made to validate those findings in the case of Japan. Results of this study showed that aged people are probably at a remarkably high risk of traffic accidents due to a higher frequency of failures, especially non-automobile travelers. Notably, although conventional studies have successfully investigated various causes leading to elderly accidents, for example, situation-based causes (e.g., traffic conditions, on-going activities) and human-related causes (e.g., perception, reaction, decision making), a highlight of importance order given to those factors was not observed. In other words, comparative analyses between the causes seem to be ignored in the literature. Analyses made on statistical data of Japan showed that Japanese old travelers were not in the same situation as their counterparts in other nations, that is they did not have a higher frequency of failures compared with young travelers. Interestingly, improper steering and/or braking was the most cause of failure that result in traffic accident in aged group of Japan.

Key Words : *Elderly road user, Japan, accident, failure, steering.*

1. INTRODUCTION

Aging population has been an adverse trend all over the world, especially in developed regions. The proportion of elderly people in these areas is projected to climb to alarming rate, at just under one third in 2050[1)]. In Japan, at that time the proportion of people who aged 65 or over is projected to increase to roughly 40%[2)]. Increasing elderly population combined with active lifestyle of elderly people have resulted in rapidly increasing proportion of elderly road users on the road.

Nevertheless, many studies suggested that aged road users are one of the most vulnerable road user groups. Findings of the literature (Appendix I with 24 studies reviewed) of elderly vulnerability which shows that they are not only at much higher risk of accident[e.g.3, 4)] but also suffered more severity from their injuries[e.g.5, 6)].

It is however that a restrict of elderly people from independent mobility is not reasonable because independent outdoor mobility is an essential part of the quality of life of older persons[7, 8)]. In addition, if elderly travel dependently, the social will be charged a heavy burden related to their mobility. For example, instead of driving or cycling by themselves, they have to be driven by their children or taken by a taxi or a bus. In a society in which majority of population are elderly people, this is a really big burden, or even an impossible task.

As such, studying about elderly traffic safety is an indispensable and urgent task in order to increase safety of elderly travelers.

2. LITERATURE REVIEW

The literature review has documented numerous studies focusing on older road users. There are 133 studies those considered different contexts over the world have been reviewed. That aims to systematize the popular aspects in this field of study then find out overall trends of older road users safety globally, and illustrate shortcoming of the literature if there is any.

One of the most common aspects in the literature is to study about mental and physical declines of older adults since these declines could be the important factors which could result in reductions of traveling practice performance among elderly. Various types of decline among older travelers have been documented (Appen-

dix II.1, II.2 and II.3 with 21 studies). The most popular declined functions can be concluded containing: (1) vision (e.g. acuity reduction[9, 10], loss of visual field[11, 12]); (2) cognitive performance (e.g. underestimating the risk and overestimating their ability to handle the situation[13], poor understanding traffic signs and poor estimating speed or distance[14-17]); (3) longer reaction time[18, 19]; and (4) physical performance (e.g. difficulties in controlling movement rapidly and accurately[20], general driving skill declines[21, 22]).

On the other hand, risk of accident related to elderly traveling performance is also well considered. In which, risk of accident due to human error and level of risk of accident while aged people traveling by different transport modes.

(1) Failures of safe traveling practice among elderly road users

Human error is always considered as one of the main causes of traffic accident[23]. To aged travelers, who are even more frequently to make failures while traveling[24]. Unsurprisingly, studying about elderly safety in relation with their failure has been widely studied. The literature review of elderly failure (Appendix II.4 with reviewed 24 studies) shows that aged road users are not only overrepresented in accident, but also more frequently responsible for these accidents[25] regardless they often seriously abide the laws. In fact, they are hardly involved in law violations such as speeding or alcohol usage[26, 27]. Instead, they usually legally make failures of safe traveling practice[28, 29].

Among studies of elderly traveler failure, studying about characteristics of the failure is well documented. Firstly, older road users tend to make failure more at intersection[26, 27], where the traffic condition is complicated[30, 31] and at stop sign[26, 27]. Secondly, regarding to the situation of the failure, elderly people are in more frequently involved in failure while making a turn[32, 33], yielding[27, 34], stopping[26, 27], crossing[28] and in comparison with younger ones, elderly are tend to overrepresented in crashes under the "safe" conditions such as at low speed limits, in daylight, when traffic is low, good weather, and when the road is dry[35]. Thirdly, these studies have also investigated various factors leading to elderly accidents, for example, situation-based causes (e.g., traffic condition, on-going activities) and human-related causes (e.g., perception, reaction, decision making).

However, a highlight of importance order given to those causes was not observed. In other words, comparative analyses between the causes seem to be ignored in the literature. In case of elderly travelers, with their physical and mental declines, naturally, they are more susceptible to affected by the factors leading to failure and accident because of their general driving skill reduction[36] combined with reduced handling quality[20]. In a certain traffic situation, with only minor fault can bring severe accident to elderly travelers. Nevertheless, the most important impact factors have not been clarified.

In another aspect, studying about causes of elderly failure in case of single crash is even more important. Single crash refers to an accident that does not involve any other moving objects (other road users)[37] that means traveler make the accident by him/herself. So, single accident is more likely to be caused by failure of the traveler[38]. While rate of single crash among elderly are relatively high (Appendix IV – with 37 studies reviewed), the cause of this has not been clarified.

So, studying about the causes of failure in relation with elderly traveler safety, especially to find out which are the most important ones and how these constitute elderly accidents is critically essential while proposing solutions to tackle traffic safety problems of aged people.

(2) Risk of elderly traveler accident by transport mode

The literature of accident among elderly by transport mode (Appendix III with reviewed 25 studies) show a trend that elderly travelers are at very high risk of accident while traveling by non-automobile modes[e.g.39, 40]. The possible cause that is due to the critical difference between automobile and non-automobile mechanical control combined with the declines of elderly people. While automobile vehicles can be self-balanced, so there are two tasks of driving which are directional steering and speed control, traveling by non-automobile modes is on the other hand, beside the two tasks, at the same time travelers also have keep their balance properly. So, to safely travel by non-automobile modes (following the planned trajectory, at properly speed while keeping it balance) is much more complicated in comparison with car driving. In addition, under the effects of aging phenomenon, elderly often have poorer performances in both keeping balance[39] or handling complicated task. Traveling by non-automobile modes also usually consume much more energy as well as directly affected by unfavorable weather condition that may lead to tiredness, distraction or reduction of handling quality. With all of these disadvantages of aged non-automobile travelers, that could result in unsafe traveling performance. In brief, the combination of difficulties of traveling by non-automobile modes and the declines of elderly could be the cause of non-automobile users' severity.

So, the higher figure of non-automobile accident among elderly is well illustrated. However, the different level of aging impact on safety of elderly automobile driver and non-automobile traveler has not been documented well. As automobile driving is simpler combined with the well supported of driving system, there is a high possibility that aging phenomenon will impact on

automobile drivers less than that of non-automobile users.

Nowadays, in response to the environmentally friendly traffic movement combined with health concerns, the number of non-automobile travelers, especially cyclist and walker numbers have remarkably developed. To elderly, cycling or walking is even more meaningful mode because it is a good way to keep fit and also considered as a enjoyable activity to them[41]. Thus, studying to improve safety for non-automobile users is an important issue for researchers to deal with now and in the future.

(3) Summary

As can be seen from the literature review based on a meta analysis, this study has indicated general findings and short coming issues of elderly safety study. As can be seen, elderly road users are one of the most vulnerable road user groups, especially those who travel by non-automobile modes. Aged travelers are also more likely to be involved in failures of safe driving practice. However, the causes which directly lead to their failures have not been clarified regardless of their critical importance. If this can be shed the light on, that will be valuable in finding solutions for elderly traffic safety improvement.

Japan is one of the most obvious countries which has experienced the consequences of the graying population phenomenon, including traffic safety problems. Investigating the mentioned issues in context of Japan is suitable and necessary.

3. OBJECTIVE

The objective is twofold. Firstly, to provide the world trends of elderly traffic safety based on a meta revision. Secondly, to validate these trends in Japanese context then find out if there is any special point and particularly focus on the analyzing causes of failures made by elderly drivers to find out what are the most important ones which contribute to elderly traffic accident severity.

4. METHODS

The accident data is collected from website of National Police Agency: https://www.npa.go.jp. This data is monthly updated until May 2015 with high detail level. The data of traffic accidents is classified by many aspects such age group, transport modes, violation, place, etc.

Because the accident figures are presented at form of number of accident. When comparing traffic accident figure between age groups, using number of accident seems to be unsuitable. In this study, using rate of accident per head of population to compare. Data of population by age group is collected from Official Statistics of Japan: http://www.e-stat.go.jp/

5. ANALYSIS AND DISSCUSTION

(1) General trends

In general, within previous decade the overall trend of traffic accident in Japan has remarkably decreased.

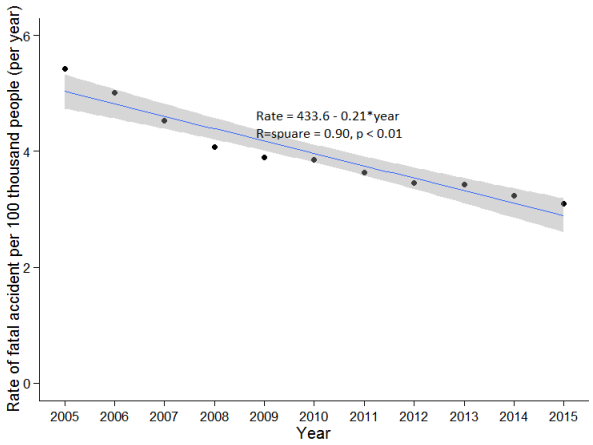

Fig. 1 Overall trend of fatal accident in Japan

As can be seen from **Fig. 1**, rate of fatal accident per head of population in Japan rapidly decreased over recent ten years. The linear regression model shows the speed of the annual decline is 0.21 fatal accident per 100 thousand people (roughly 5%) every year. This shows a contrast with overall trend over the world that the literature shows significantly increasing trend[42, 43) 44)].

However, this reducing trend of Japan seem to be contributed by non-elderly road users rather than older ones, while elderly people accident figure is still at very high as shown in **Fig. 2** below.

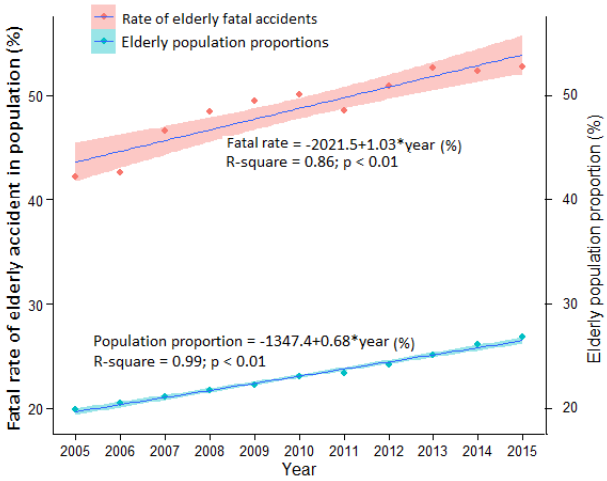

Fig. 2 Elderly proportion and their rate of fatal accident among population

Fig. 2 illustrates accident proportions of elders always contribute roughly double more than their head

proportions among population. From 2005 to 2015[A] elderly population has increased from 19.9 to 26.8% (0.68% annually) while their accident rate has grown from 42.2 to 52.7% (1.03% every year).

To illustrate the level of vulnerability of elderly road users, the comparison the rate of fatal accident per head of population between elderly group (65+) with other age groups will be analyzed as **Fig. 3** below.

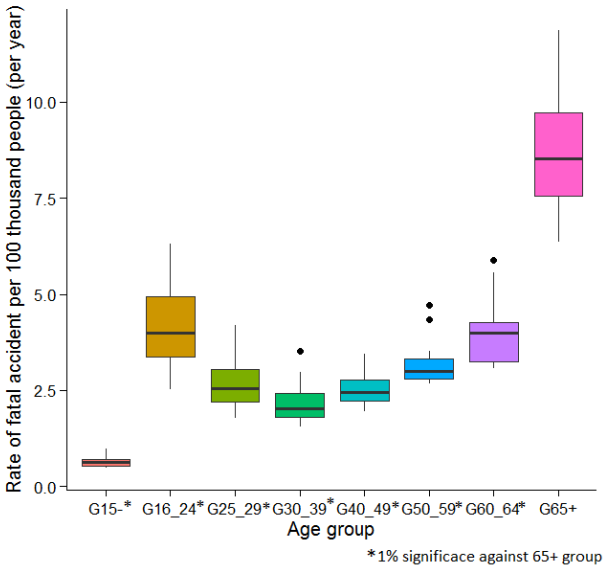

Fig. 3 Rate of fatal accident by age group

Whereas among high-income countries, adults aged between 15 and 29 years have the highest rates of injury[45], not aged people. Japan is an exception, elderly road users are much more vulnerable in comparison with other age groups, while there are 33 fatal accident per 1 million of elderly people that is roughly 2-3 times higher than other age group. The differences are all statistical significance.

Excluding aged 0-15 group, the rate gradually decreases from adolescence to middle aged period before slowly rising until the ages of early sixties. Finally, it rockets as going through older period. That could be the representation of the great effect of older ages to people safety while participating in the traffic.

(2) Failures of safe driving practice among elderly

(a) Frequency of failure made by elderly driver in comparison with younger ones.

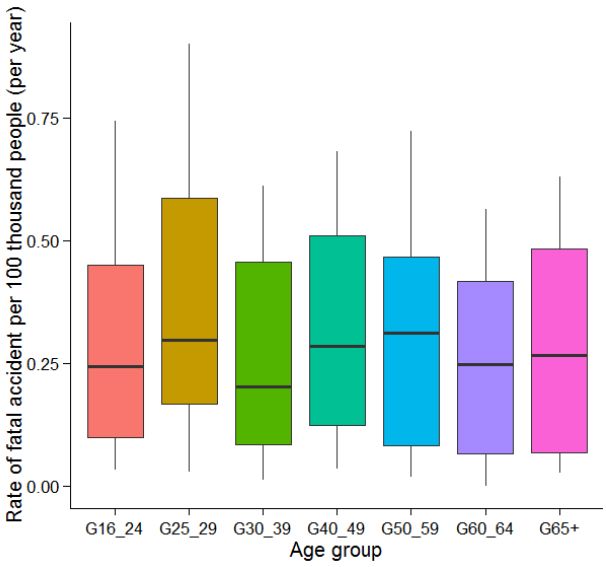

Fig. 4 Rate of fatal accident made by failure of driver by age group

Fig. 4 shows that in comparison with younger age groups, rate of fatal accident as a result of safe driving practice failures has made by older drivers is not different from other groups very much. The differences are not statistically significant.

From the literature review (Appendix I.5 – 16 studies reviewed), as can be seen the overall trend is that older drivers tend to be involved in failure more. Interestingly, in case of Japan that is not true.

(b) Main impact factors of failure among elderly drivers

One of the shortcomings of the literature is that the comparative analyses of various causes on elderly traveler safety have been poorly documented. In Japan, there are six popular cause which frequently lead to failures of car driver those as shown in **Fig. 5**.

In general, among non-elderly age groups, the cause of careless driving (Cause 2) contributes the most to their failures. Elderly drivers, on the other hand, improper steering and/or braking (Cause 1) accounted for the highest proportion. While Cause 2 is due to careless attitude of the driver, Cause 1 is more likely impacted by the driving performance reduction which could be due to the mental and physical declines of older people. This is the representation of aging declines on safety traveling among elderly.

[A] Accident data of 2015 is calculated until the end of May

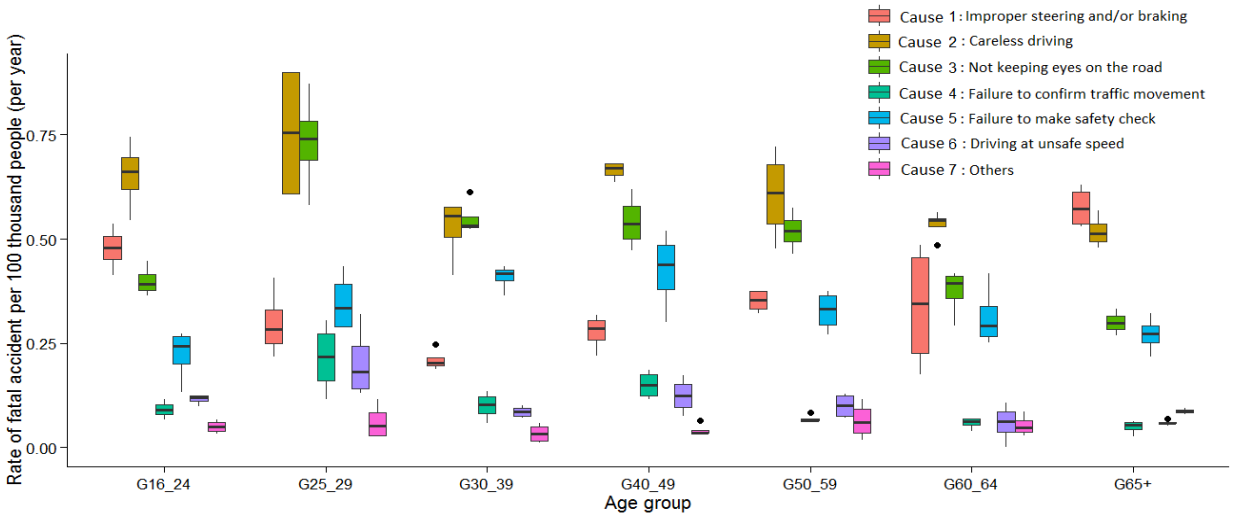

Fig. 5 Rate of fatal accident made by failure of drivers by age group and cause

Focusing on elderly age group, distribution of fatal accidents made by failure and statistical comparison between different causes are shown in **Fig. 6**

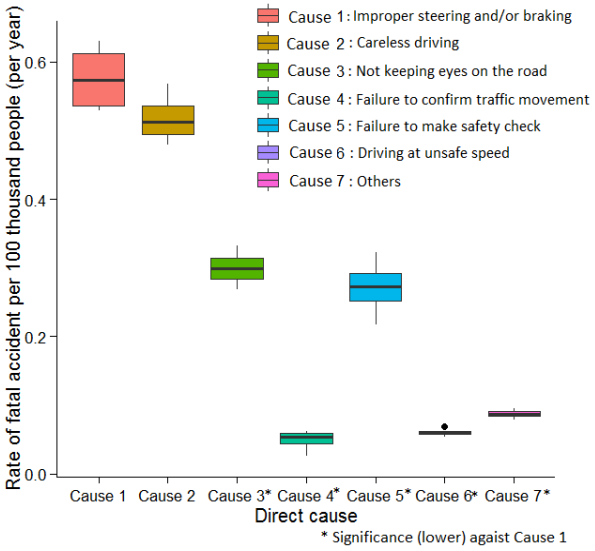

Fig. 6 Rate of fatal accident made by failure of elderly drivers cause

As can be seen from **Fig. 6**, among elderly drivers, fatal accidents are caused by Cause 1 is at nearly 0.6 fatal accident per 100 thousand people per year, slightly higher than Cause 2 and remarkably higher than the others. There are statistically significant differences between Cause 1 and Cause 3, 4, 5, 6, & 7.

(c) Causes of failure leading to single crash

As mentioned, single crash is more likely occurred due to failure of the driver. So, finding the causes those are more likely lead to single accident is very important. **Fig. 7** represents the distribution of single crash by factor.

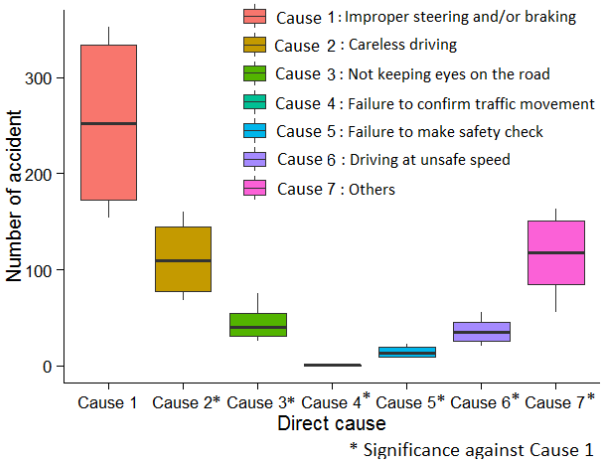

Fig. 7 Single crash by cause

Fig. 7 shows a much higher figure of number fatal single accidents resulted by Cause 1 compared to other causes. The differences are all significant.

(3) Automobile and none-automobile travelers' severity

(a) Severity of automobile and none-automobile travelers in comparison with younger groups.

To illustrate the difference between the figures of non-automobile accident and automobile accident, Accident Ratio = (number of non-automobile accident)/(number of automobile accident) will be calculated for each age group. The figures of this ratio is shown in **Fig. 8** as below.

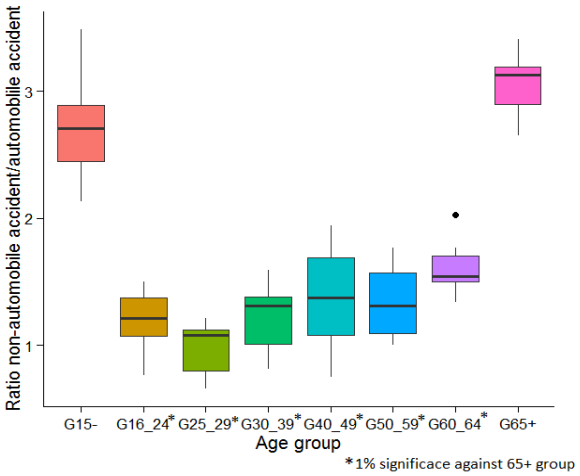

Fig. 8 Automobile and non-automobile Accident Ratio

The risk of elderly road users to be involved in traffic accident while traveling by non-automobile modes as shown in **Fig. 9** is remarkably higher (over double) than that of those aged from 16 to 64. In comparison with the figure of 0-15 year-old group, elderly show a higher at median but not significant. This trend is fit with the overall trend that has been reviewed in the literature (Appendix III).

(b) Automobile and none-automobile elderly travelers' severity by transport mode

To investigate in more detail the relationship between older ages and accident figures, elderly group will be divided into three sub-age groups: G65-69 (aged 65-69), G70-74 (aged 70-74) and G75+ (aged 75 or over). The rate of elderly accident will be analyzed by automobile and non-automobile mode separately.

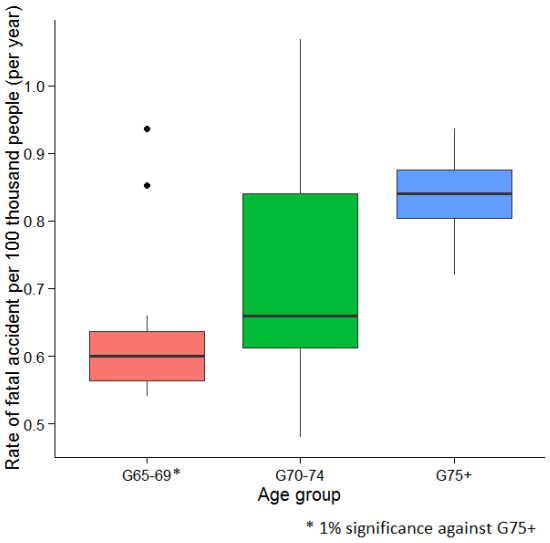

Fig. 9 Elderly automobile travelers' accident by sub-age group

Although there is an increase of median of the accident rate along with aged of travelers, the differences are small (median ranging from 0.5 to 0.69 unit) and the significant difference is only exist between G65-69 and G75+.

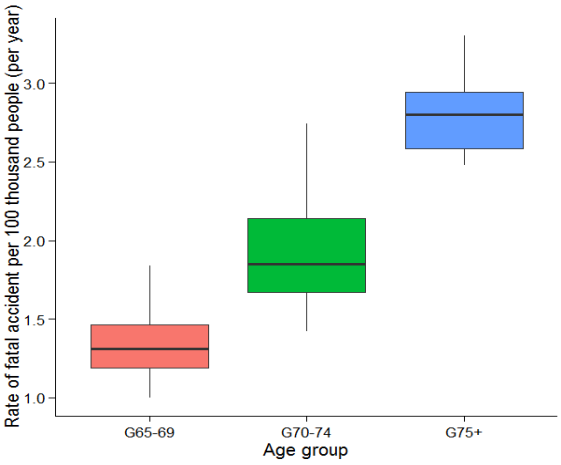

Fig. 10 Elderly non-automobile travelers' accident by sub-age group

In contrast with the figures of automobile, rate of accident of non-automobile users older is sharply increase with their age (ranging from 1.1 to 2.3 unit). When comparing between groups (G70-75 and G65-69; G75+ and G70-74; and G75+ and G65-69), all comparisons show statistical significance.

6. CONCLUSION

Basing on a meta analysis, from reviewing 133 studies, the outstanding global trends of traffic safety of elderly people has been shown. As can be seen, elderly road users are one of the most vulnerable road user groups, especially those who travel by non-automobile modes. Aged travelers are also more likely to be involved in failures of safe driving practice. The figures of accident in Japan has also validated. The findings are as follow

Firstly, while global traffic accident trend is sharply increasing, the overall number of accident in Japan is declining rapidly by roughly 5% annually in this decade. However, with elderly road users, their situation is getting worse. The proportion of older people accident among population accounts for very high rates, at roughly a half compared to under a quarter of their population, and this is sharply growing even faster than their growing speed of their population.

Secondly, in a contrary with the global trend, elderly drivers in Japan tend to make less failures while traveling. Whereas the literature poorly illustrated the important order of the causes which lead to failures of drivers, from analyzing the figure of accident in Japan, as can seen, improper steering control is the most popular cause that lead to failure among elderly driver. The causes related to careless attitude such as careless driving or not keeping eyes on the road are most popular in case of younger drivers.

Thirdly, sharing common point with the literature, elderly non-automobile travelers in Japan are at much higher risk of accident compared to their automobile counterparts. The specific point that the impact of aging to safety of automobile travelers is negligible, whereas non-automobile travelers show the significant rise of accident rate as they getting older, is also found.

This study's limitations however are unavoidable. Firstly, there are several other factors that could be affect traveling safety performance of older road users such as road condition, weather or lighting condition have not been considered. Secondly, Although, the literature shows that elderly road users tend to make failures when traveling by non-automobile modes frequently, when analyzing the causes of the failures, this study does not consider these modes that is due to the constrain of collected data.

Since the higher severity of aged road users, study about elderly safety urgent nowadays and could be a promising field of study in the future. In which, proposing the particular elderly-oriented solutions to improve senior adult safety is necessary. Because although general solutions to improve traffic safety, in Japan for example, have worked well when these have greatly contributed to the reduction the total number of accident but these seem not to benefit elderly road users well. In fact, our road infrastructures have not been designed for particular elderly road user group but for normal man, so tackling elderly traffic safety problem considering adverse road condition to aged travelers is critically important.

While studying about the declines brought by aging phenomenon has been well documented, the causes of failure should be considered more. Among the popular cause improper steering is one of the major causes of older drivers' failures. Because of the complication in controlling non-automobile modes especially two-wheeled vehicles such as bicycle or motorcycle combined with the elderly declines, to keep properly steering control while traveling seem to be even more difficult to older people and their risk of accident consequently could be higher. Thus, studying about steering performance of two-wheeled modes focusing on aged adults is necessary.

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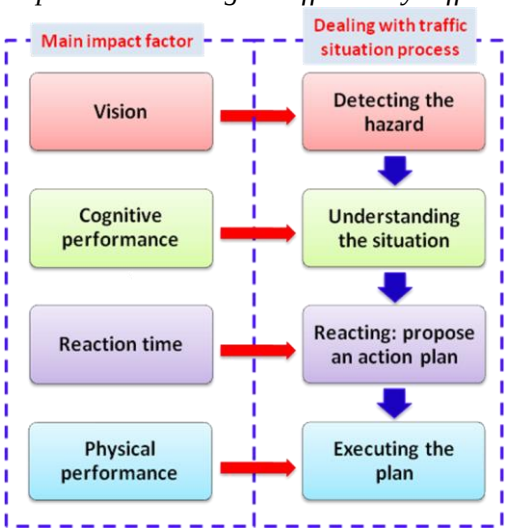
APPENDIX

I. Elderly Vulnerability
I.1. Figures of elderly accident
- On a per population basis, older drivers had a significantly lower "all road users" fatality rate than all age groups[1)]. - However, on a per licence basis, older drivers had significantly higher. On a per-distance basis, older drivers had significantly higher all road users fatality rate[1)].
About 1.3 million lose their life worldwide, and this is set to double by 2030 if status quo continues[2)]
There was almost no difference in crash risk for older drivers based on population (Australia) [3)]
The likelihood of fatality increases particularly by the age of 65[4)].
The number of fatalities are also highest for this age group compared with other age groups. It is also observed that the ratio of deaths to total casualties are higher for the older age groups with a maximum of about 45% for those above 75 years old[5)]
While older drivers were at low crash involvement rate per head of population, their involvement rate is markedly higher than that for their younger counterparts in terms of time spent on the road and kilometres driven[4, 6, 7)]
The number of fatalities for women and men aged 65 and older will increase respectively by 373% and by 271% between 1975 and 2015[8)].
- Elderly drivers are more at risk of crash involvement than the average driver[9)]. - Older occupants of vehicles are much more likely to be severely injured or killed than middle-aged occupants in crashes[9)].
In high-income countries, adults aged between 15 and 29 years have the highest rates of injury[10)].
Significant increases in fatalities per driver began at the ages of 70–74[11)].
Fatal crash involvement rates increased with age[12)].
Drivers under 25 years had the highest rates on a population and licence basis, but when the distance travelled was taken into account, rates of crash involvement for the 75 or more age group were as high as those of the youngest age group[13)].
- The number of the elderly involved in police reported crashes is expected to increase by 178% as well as fatal involvements by 155% by 2030 while for all other drivers these numbers are expected to increase by 34%, and 39% respectively[14)]. - In 2030, it is anticipated that senior drivers will account for 25% of total driver fatalities as compared to 14% presently (2002)[14)].
The risk of being hospitalized is increased only among elderly older cyclists women have the highest risk[15)].
For a given crash, elderly drivers are also more likely to be injured [16-19)]
- Fatality risk increases with age. Drivers aged 70–74, 75–79 and 80 are 1.37, 1.42, and 2.26 times respectively as likely to be involved in fatal-crashes as compared with drivers at the age of 65–69[20)]. - Crashes involving male senior drivers are 1.4 times as likely to be fatal as those of female senior drivers[20)].
Older people have lower injury thresholds and suffer poorer clinical outcomes once injured[21)].
I.2. Severity of older victims
The odds of serious injury on admission are greater for the elderly than for those in other age groups[22)].
Older people were more likely to sustain serious injuries in a given accident and they are more vulnerable to injury and have a reduced capacity for recovery compared to younger people[18)].
Significant increases in fatalities per driver began at the ages of 70–74 and most likely victims were the older drivers followed by their passengers, who were older and more fragile[11)].
Show a sharp increase in the rate of serious injury and deaths for pedestrians aged 75 years and above[23)].
The study states that drivers over about 50 years have an increased risk of death when a crash occurs, that is, physiological factors associated with ageing play a role comparable to that due to declines in driving skill[24)].

In the UK, pedestrians aged 65 and over were at higher risk per kilometre of travel for all walking as well as alongside traffic and per roads crossed than were adults generally but interestingly considerably less at risk than children and younger adults. In addition, this seemed to be a particular problem for females[25].

II. Failures of safe driving practice of elderly

While dealing with a dangerous traffic situation, the participant usually sequentially follow a process. In which, performance of the participant in each stage is affected by different factors as the following chart:



Every violation made in each stage can result in accident. Following will be the review of literature of how elderly road users perform related to each of the impact factors and figures of accident due to violation of elderly road users

II.1. Vision

Vsion as the primary sensory channel, which is responsible for up to 95% of driving-related inputs[7, 26]. However, aging is a significant factor that produces declines of visual abilities[27].

Age-related declines have been noted in dynamic and static visual acuity, peripheral vision, resistance to glare, contrast sensitivity, visual processing speed, visual search, low light sensitivity, perception of angular movement, movement in depth, colour vision and a variety of other functions[28, 29]

There is an evidence of an association between poor visual search, attention and cognitive skills and faulty crossing decisions among older pedestrians[30]

The visual problems of elderly increased with age along five visual dimensions: unexpected vehicles, vehicle speed, dim displays, windshield problems and sign reading[31]

Static visual acuity is the ability to discriminate fine, stationary, high-contrast details and this declines with age, particularly after the age of 50[32].

While testing target detection and contrast recognition under low lighting conditions for older drivers, older drivers show poorer steering accuracy under high lighting conditions, drivers of all ages drive faster under high lighting conditions[33].

Dynamic visual acuity is the ability to resolve details of a moving object. This also declines with age[26].

Dynamic visual acuity and has been correlated with accident involvemen because it combines multiple sensory and motor skills necessary for safe driving[34]

Found the prevalence of visual field loss was 3-3,5% for individuals between the ages of 16 and 60, about 7% for the 60 to 65 year age group, and 13% for those over 65 years[35]. However, there is an association between peripheral visual field loss and driving performance[35, 36]. Obviously, older drivers have to be suffered the declines of driving performance related to visual field loss.

II.2. Cognitive performance (connected with mental processes of understanding the traffic situation)

Underestimate the risk and overestimate their ability to handle the risk when compared with middle-aged drivers. Further, they believed they had the necessary skills and abilities to avoid such accidents but did not believe such skills were possessed by their peers[37]

Elderly drivers, with their cognitive deficiencies that can affect driving ability include confusion and inattentiveness, slowed psychomotor reaction and decision time, difficulty in adjusting to traffic conditions, difficulty judging the speed and distance of other vehicles, and difficulty in reading and understanding traffic signs[38-41)]
Complecated traffic condition such as congestion is a concern for older drivers particularly for older women drivers[42)].
Older people's ability to perform complex tasks such as driving becomes more difficult as age increases. Diminishing psychomotor and cognitive capabilities pose specific problems and limitations [40)].
Older drivers subject overlook more signals and need more time to decipher the content[43)].
Older drivers experience difficulty in estimating distance and speed, particularly at dusk and in darkness. Complex situations can place demands on elderly drivers that may exceed their abilities and may cause problems in the selection of information and decision making; in such situations, older drivers are less likely to make decisions in a simultaneous parallel fashion, but rather in sequence[44)]
Older drivers show poorer average speed accuracy and road sign recognition than younger ones in all lighting conditions, drivers of all age groups are negatively affected by low lighting conditions[45)].
One of the most robust findings in the older road user literature is the problem of poor safe gap selection[46-48)]
Older drivers found cognitive problems relating to difficulties in dynamic vision, visual processing speed, visual search, light sensitivity and near vision and that becomes the main reason for them to give up driving[29)]
II.3. Reaction
Regarding to reacting function, reaction time (time interval between the presentation of stimulus and the initiation of a response) seem to be the most important.
Older drivers aged 60 or over have reaction time increased by 20 to 30%[49)]
- With advancing age, it takes longer to acquire information, process information, select and plan a response, and execute that response[50)] - When responding to a visual event - a difference of around 2 seconds between reaction times of older and younger groups[50)].
Older road users were often unaware of the extent of their declining eyesight and reaction times. They did not perceive complex intersections as posing any particular problem to them, considered their reaction time as good as when aged 50 years[51)]
Ageing process negatively results in biological, psychological changes: - Biologically, the body gradually loses the ability to renew itself, various bodily functions slow down and vital organs become less acute[52)]. - Psychologically, there are changes to sensory processes, perception, motor skills and problem-solving abilities[52)].
While driving significant increase in perception reaction time with increasing age[53)].
Age-related declines in the efficiency of processing incoming information lead to particularly in dusk and in darkness difficulty in estimating distance and speed[44)].
Greater deviations from target speed by older driver under complex conditions[54)].
elderly often require more information on which to base driving decisions and may experience reduced performance (i.e. slowed reaction time) in recognition/response tasks compared with younger drivers[55)]
II.4. Physical performance
More likely to affect the ability of the older adult to control movement rapidly and accurately, resulting in less than adequate acceleration, braking, steering, general manoeuvring of the vehicle and operation of controls[23)].
Senior drivers take more time to turn than other drivers[56)].
- Senior drivers tend to run the left of the road as well as to drive in the outer lane[57)]. - They experience trouble when they position themselves on the curve section[57)]. - A tendency to stop without paying attention to vehicles behind is common[57)].
Along with ageing process, older people are losing their agility[58)].

More than half of the current older drivers anticipate they will have some difficulties of driving within 5 years, but they plan to drive beyond 5 years[59].
Older people suffer physiological changes in their cardiovascular, musculoskeletal and sensory systems[60]
While checking performance in on-road test on fixed route with manual and automatic transmission. Older drivers commit more errors than younger ones under both conditions, automatic transmission improves performance in older drivers but not in younger drivers[61].
Older drivers show poorer overall performance amd reaction times slower[62].
Driving skills decline with age[63].
- In general, age-related motor impairments have been linked to decreases in sensory receptivity, muscle mass and elasticity, bone mass, and central and peripheral nerve fibres[39]. - Older drivers may experience difficulty in looking behind and turning their head from side to side, causing specific problems in taking off at intersections and in merging traffic situations[39].
Older drivers in general behave more cautiously, but drivers of all age groups fail to compensate for difficult lighting conditions[45].
If speeds exceed 69mph prior to crash or at impact, the risk of fatality skyrockets as compared with speeds less than 35mph[64].
II.5. Accident due to elderly failures
Older drivers (60+) are more likely involved uncontrolled intersections and failure to give way while middle-aged drivers had the highest proportion of alcohol and speed-related crashes. Drivers aged 70-79 were most likely to crash at stop and give way signs. Drivers aged 80 years and beyond were most likely to be seriously injured or killed in, and at-fault for, crashes, and had the greatest number of crashes at both conventional and circular intersections [65]
Older drivers are overrepresented in side impact collisions and while making turns than in rear-end collision[66].
Older drivers, particylarly female ones are overrepresented in crashes under the "safe" conditions, on roads with low speed limits, in daylight, when traffic is low when the weather is good, and when the roads are dry[67].
Among victims of pedestrian accident while crossing, failure to see, or to see in time to take evasive action, the vehicle that struck them was reported by 63 percent of respondents. About two thirds of those who saw the vehicle that struck them saw it only when it was within about 9 m of them[68].
The types of crashes that older drivers experience such as slow speed, intersections, and failure to yield on left-hand turns are highly susceptible to the roadways and vehicle design[69].
In Ulaanbaatar, Mongolia, the reasons of the accidents: driver's faults was at 81,4%, pedestrian's was 18,3% , technical defects was 0.1% and road conditions was 2,2 %.
The presence of two or more passengers increases the likelihood of involvement of drivers aged 75 and older and being at fault in crashes[70].
- Whereas middle-aged drivers involved in a collision at stop-controlled intersections are either going straight or slowing or stopping, elderly drivers are involved in a collision while turning left or right across traffic[71]. - The elderly is more likely to engage in left-turn and angle collisions[71].
- Senior drivers are overrepresented in crashes at intersections, due to failure to yield the right way of traffic, unseen objects, and failure to heed (pay attention to) stop signs and signals[72]. - They are also more likely to be involved in crashes while turning right/left, changing lanes, and merging into traffic but less likely to be involved in crashes occurring because of alcohol[72].
Visual impairments increase crash risk among senior drivers[73].
Older drivers tend to be legally at fault in their collisions[74].
The elderly constitute a high risk group for traffic crashes because of the progressive slowing of reaction time, deterioration of vision and hearing, and degenerative changes in the musculoskeletal system causing balance and stability problems[75].

- Not only are the elderly over-represented in multi-vehicle and intersection crashes, but that they are also more frequently responsible for these accidents[76)]. - This could be due to elderly drivers making more errors in perception, judgement, decision-making and reaction time[76)].
They were more likely than young drivers to have right-angle and left-turn collisions involving failure to yield, they ran stop signs, disregarded traffic signals and made improper turns[77)].
Elderly drivers experience problems in proper handling of left turns (an American study - equivalent to right turns in Japan). They frequently cause accidents that involve a tum and have a greater chance of being cited for a violation than the average driver[78)].
Older driver are in increased number of accidents in certain situations and a higher level of fault in crashes[76)].
III. Risk of accident by transport mode
Crash rates of older pedestrians and cyclists clearly show that they are at much higher risk of death or serious injury while using these forms of transport, compared with other forms such as the private car, and compared with other age groups[31)].
Japan has an extremely high level of traffic accidents involving elderly pedestrians as compared with the world's leading countries in traffic safety. Whereas pedestrian accidents among the non-elderly age segments are on a significant downward trend the accident incidence among the elderly has only leveled off or is showing signs of increasing[79)]
In context developing countries, non-automobile road users (regardless of age) are at higher risk compared with car drivers[80)].
Older pedestrians and cyclists are over-involved in serious injury and fatal crashes and under-represented in crashes of minor severity, compared to younger adult pedestrians and cyclists. This is most likely due to their vulnerability and increasing fragility with age[47, 74, 81, 82)].
In Britain, older pedestrians have far more risk of accident in comparison with their counterparts of drivers and passengers[83)].
Injuries in Australia, Japan, Malaysia and Singapore, the highest injury risk was found among motorcyclists with a provisional licence, followed by those in their first year of riding[84)].
Elderly pedestrians are more at risk of being involved in an accident and are more susceptible to severe injury or death than their younger counterparts[85)].
Compared to other road users (e.g., car occupants), older pedestrians and cyclists are at significantly higher risk of death. It is estimated that pedestrians have a 9-times higher and cyclists an 8-times higher death risk than car occupants[86-88)].
Motorcycle users make 60% or more of the road accident fatalities in countries such as Thailand [2)]
In 1997 in Cracow, crashes involving pedestrians accounted for 54 percent of all crashes, but fatal pedestrian crashes represented as much as 77 percent of all road fatalities[89)].
Netherlands' accident figures show that pedestrians and cyclists of all ages are at higher risk of death per billion kilometres travelled than car occupants. For older age groups, this risk increased for all modes of transport, but particularly for older pedestrians and cyclists where risk was 0.6 for cyclists and close to 0.7 for pedestrians compared to 0.1 for car drivers aged 65 years and above[90)].
Car travel is the safest private travel mode for older people[74)].
Ingeneral, fatalities of elderly cyclists and pedestrian in European countries (particularly, Poturgal, United Kingdom, Spain, Sweden, German, France, Denmark, Switzerland, Norway) are higher than that of car drivers[91)].
For persons aged 75 years or above, victim risk while cycling also was about 5 times as high as victim risk while driving a car and about 12 times as high as victim risk as a car passenger[92)].
They have been reported as significantly over- represented in pedestrian crash statistics in a number of publications[23, 93, 94)].

The likelihood of fatal and severe injuries are, in general, greater for pedestrians and cyclists than for motor-vehicle occupants[95].
In the United Kingdom sought to investigate the risk of cycling in absolute terms and with respect to other modes of transportation[96].
This highlights the need for safety improvements for cyclists and pedestrians who are, on average, at 14 and12 times greater risk than motorists, respectively, at signalized intersections[97].
IV. Single crash
Collisions with another road user represent only 30% of the injured cyclists in medical databases whereas up to 70% of the patients experienced loss of control, obstacle avoidance or near miss collisions. However, most of the cycling safety literature is based on police records containing important bias on the type of crashes; indeed, about 90% of police-reported crashes are collisions. Hence, single bicycle crashes have been much less studied than collisions[98-100].
A 'single accident' refers to an accident that does not involve other moving objects[101].
Older drivers tend to hit fixed objects other than moving objects[67].
Older pedestrians also appear to be over-represented in non-vehicle, many occurring as a result of a fall[31].
In 2003, out of 855,000 accidents, about a quarter that led to injury or death in Canada, France, Germany and the Netherlands have been classified as single-vehicle accidents (24%). This rises to more than one third (36%) when accidents in urban environments are excluded from the analysis[102].
Substantial number of non-vehicle-related events occur and pose significant injury risks for older pedestrians[103-105].
Older drivers also suffer from a deterioration of steering performance in low light conditions that can be potential risk of single crash accident[106, 107].
A great proportion of older pedestrian injuries (75%) and cyclist injuries (76%) occurred as a result of a fall or hitting some object on the road[104]
Older cyclists (60+) have significant higher risk of involving single-crashes in comparison with young ones[108].
single crashes with older cyclists are more likely at low speed, especially loss of balance while mounting or dismounting the bike[109, 110].
Ostergotland county, Sweden, 57% percent of all transportrelated injuries comprised pedestrians and cyclists without involvement of vehicles[111].
This research reported that many pedestrian falls occurred because of poor surface conditions including slippery surfaces from ice and snow, and presence of surface holes or openings[103].
Collisions with obstacles occur more often with older cyclists, cyclist who are unfamiliar with the crash location[112].
Large proportion of cyclist injuries are the result of non-vehicle collisions, and that these often involve older cyclists[47].
Older drivers aged 70 or over are involved in single vehicle crashes in only 22.5% of events, compared with 42.0% for the control group aged 35-54 (in North Dakota, American, 2004-2008)[113].
In Finland, 80 percent of hospitalised cyclists were injured in road-related crashes, and non-vehicle events accounted for 58 to 72 percent of the inpatients and 93 percent of the outpatients treated[114, 115].
Poor road conditions have been identified as an importantthe direct cause in 29% of the single bicycle accidents in the Netherlands[116].
The negative correlation between the traffic volume and the accident rate (especially the single vehicle accident rate) was expected and in line with earlier research in Israel[117].
Older drivers were less likely to have crashes involving driver fatigue, during adverse weather, involving a single vehicle, and while traveling at high speeds. Conversely, older drivers were over-represented in crashes at intersections and/or involving failure to yield the right of way, unseen objects, and failure to heed stop signs or signals[72].

single-vehicle side impacts are not popular risk for older drivers. In contrast, the risk of injury in multi-vehicle side impacts increases steadily with age and is a major problem for older drivers[118].
In Denmark, the results of a survey of 3,000 cyclists treated in hospital emergency departments revealed that 60 percent of cyclists had been injured in bicycle-only events and only 40 percent in collisions with other vehicles[119].
By analysing accidents on rural roads in South Africa, number of single vehicle accident increases as the decreasing of present serviceability index (PSI) of road surface. The type of accident rate mostly affected by the road features is the single vehicle accident rate[120].
In American, older drivers (60+) involved in single accidents more than younger drivers[121].
In the Netherlands, more than half of cycling crashes are reported as single-vehicle crashes, where the cyclist fell or slipped (47%) or collided with an obstacle or animal (12%)[122].
In Denmark, after single-vehicle accidents, the second most common type of accident is an accident involving a left-turning vehicle[123].
A New Zealand study revealed that nearly three-quarters (74%) of cyclists admitted to a hospital for treatment during 1988 were injured on the roadway, and two-thirds of these did not involve a collision with a vehicle[124].
There was 70 percent of bicycle injury cases presenting to hospital emergency departments did not involve a vehicle[105, 125].
In the USA, older cyclists were over-represented in crash types: falls, collisions with animals, pedestrians, other cyclists, or collisions with other moving or stationary objects[126].
A larger share of older driver accidents involve collisions with another vehicle. They have a smaller share of single-vehicle and speed-related accidents. Older drivers are “under-represented” in single-vehicle accidents involving loss of control or collisions due to speeding or risky overtaking[74].
Others
Most studies have chosen to define 'the elderly' as the population of persons aged 65 years or more [127]. However, variability in performance on various measures of cognition, vision, complex reaction time and other driving-related skills makes it difficult to select a chronological age at which drivers should be labelled as 'elderly'[128]
elderly drivers are strongly interested in keeping their possibility of traffic participation as car drivers for many years after retirement and that traffic participation is a ubstantial part of elderly people's quality of life [128-131]
Traffic participation has become an essential part of living in society today. It has been suggested that the elderly of today are more affluent, healthier, and active [131]
They live mainly in low-medium density dwellings in the suburbs, most own their own cars and make an overwhelming percentage of their trips in private vehicles, rather than by public transport or by walking[9, 130, 132]

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