# Investigation of Fatality Probability Function Associated with Injury Severity and Age

Toshiyuki Yanaoka, Akihiko Akiyama, Yukou Takahashi

***Abstract*** The goal of this study is to develop a fatality probability function associated with injury severity and age, which could provide a useful method to estimate the fatality rate accurately. Seven types of logistic regression models were taken into consideration. The results of the estimations from the 7 logistic regression models were compared to select the best fit regression model by using the data from US accident statistics (NASS-CDS: National Automotive Sampling System Crashworthiness Data System) in year 2001. In addition, the constant coefficients of the model best fit to the year 2001 data were replaced by regression functions as a function of year to develop a model incorporating the effect of the year change. The following results were found: 1) the best fit regression model was a function of maximum AIS (Abbreviated Injury Scale) of each body region and age; 2) the accuracy of the regression model was improved by applying regression functions of the coefficients as a function of the year; and 3) the regression functions of the coefficients show that the fatality rate decreases with each progressing year.

***Keywords*** Aging, Fatality Probability Function, Frailty, Injury Severity, Regression Model

## I. INTRODUCTION

In order to estimate the fatality rate in traffic accidents accurately, it is necessary to take into account not only the fragility, which means the probability of injury in a given exposure, but also the frailty, which means the probability of fatality for a given injury. For example, the Statistical Database for road traffic accidents from UNECE (United Nations Economic Commission for Europe) [1] showed that the fatality rate defined as the ratio of fatalities to the sum of fatalities and injuries in the elderly older than 65 years was 5.4%, while that of persons from 25 to 64 years old was 2.6%. Additionally, elderly people tend to result in a higher probability of injury in a given exposure compared to younger people [2]. Furthermore, elderly people tend to result in a higher probability of fatality for a given injury compared to younger people [3-4]. From these situations, it is crucial to establish a methodology to accurately predict probability of fatality that takes into account the age of victims.

One way to predict probability of injuries for a given exposure is a computer simulation using a model for a victim of a traffic accident subjected to a given crash environment. Although it is a useful tool to study the injury mechanism in investigating the effect of passive and active safety technology to reduce fatalities in traffic accidents, it can only predict the probability of injury based on the fragility of the victim. Therefore, estimation of fatality rate based on the estimated probability of injuries from the computer simulation requires clarification of the probability of fatality for given injuries sustained by a victim when calculating the fatality rate using the result of the computer simulation. While there have been many studies focusing on the mechanism and probability of injury (e.g. Petitjean et al. [2] and Takahashi et al. [5]), only a few have focused on a method to predict the probability of fatality with a given injury to be used with the results of the computer simulation.

In order to predict the probability of fatality for given injuries using the result of a computer simulation, the information related to the injury severity, injured body region and age are needed. Earlier studies have investigated the probability of fatality for given injuries. Goertz et al. [6] showed the relationship between the probability of fatality and known maximum AIS (Abbreviated Injury Scale), but they did not consider age and the body region in which the injury with the maximum AIS occurred. Baker et al. [3] showed the relationship between the probability of fatality and ISS (Injury Severity Score) for each age group (0 to 49 years, 50 to 69

T. Yanaoka is assistant chief engineer (tel: +81-80-3212-7581, e-mail: Toshiyuki_Yanaoka@n.t.rd.honda.co.jp), A. Akiyama is assistant chief engineer and Y. Takahashi is chief engineer, all at Honda R&D Co., Ltd. Automobile R&D center in Japan.

years, 70+ years), but did not consider the body region in which the injury with the maximum AIS occurred. Additionally, their results may not be relevant to the current situation of traffic accidents because they conducted the study 40 years ago. Boyd et al. [7] developed the regression function for the probability of survival associated with RTS (Revised Trauma Score) [8], ISS and age. However, most human computer simulation models (e.g. Takahashi et al. [5] and Dokko et al. [9]) cannot predict vital signs, such as blood pressure and respiration rate, which are necessary for determining RTS. Therefore, a methodology for estimating the probability of fatality based on the injury severity and age to be used with the result of a computer simulation is still lacking.

The objective of this study is to develop a fatality probability function associated with injury severity and age, which could estimate the fatality rate accurately. Seven types of logistic regression models associated with injury severity and age were taken into consideration to find the best fit regression model by using the data from US accident statistics (NASS-CDS: National Automotive Sampling System Crashworthiness Data System) [10] in year 2001. The numbers of fatalities in other years were then estimated by applying the best fit regression model and its coefficients determined against the data for 2001 to each of the datasets from year 2002 to 2010, and were compared to the actual numbers of fatalities for the corresponding years, to clarify the applicability of the model to the dataset in different years. In addition, the constant coefficients of the model best fit to the year 2001 data were replaced by regression functions as a function of year to develop a model incorporating the effect of the year change.

## II. METHODS

### *Variables for Regression Model*

In order to investigate fatality probability functions as a function of injury severity and age, thirteen variables were defined based on the relevant variables from NASS-CDS [11] and body region code (first digit of AIS code [12]). Table 1 summarizes the thirteen variables (summary of thirteen variables can be found in the APPENDIX). The data including "unknown" were excluded from this study.

TABLE 1
DEFINITION OF THIRTEEN VARIABLES

| Variables | Range | Definition |
|---|---|---|
| $DEATH$ | 0 or 1 | 0: "Time to Death" defined in [11] was equal to 0, 1: other |
| $AGE$ | 0 to 99 | "Age of Occupant" defined in [11] |
| $ISS$ | 1 to 75 | "Injury Severity Score" defined in [11] |
| $MAIS$ | 1 to 6 | "Maximum Known Occupant AIS" defined in [11] |
| $MAIS_1$ | 0 to 6 | Maximum AIS in body region 1 (first digit of AIS code [12]) |
| $MAIS_2$ | 0 to 6 | Maximum AIS in body region 2 (first digit of AIS code [12]) |
| $MAIS_3$ | 0 to 6 | Maximum AIS in body region 3 (first digit of AIS code [12]) |
| $MAIS_4$ | 0 to 6 | Maximum AIS in body region 4 (first digit of AIS code [12]) |
| $MAIS_5$ | 0 to 6 | Maximum AIS in body region 5 (first digit of AIS code [12]) |
| $MAIS_6$ | 0 to 6 | Maximum AIS in body region 6 (first digit of AIS code [12]) |
| $MAIS_7$ | 0 to 6 | Maximum AIS in body region 7 (first digit of AIS code [12]) |
| $MAIS_8$ | 0 to 6 | Maximum AIS in body region 8 (first digit of AIS code [12]) |
| $MAIS_9$ | 0 to 6 | Maximum AIS in body region 9 (first digit of AIS code [12]) |

### *Investigation of the Best Fit Regression Model*

Figure 1 and Figure 2 show the fatality rate from NASS-CDS as a function of the age group and the body region for each MAIS (Maximum AIS), respectively. From these two graphs, the following were found: 1) the fatality rates for MAIS 6 and MAIS 1 are almost constant in all age groups and body regions; 2) although the fatality rate for MAIS 2 in the thorax is high compared to that for other body regions, it is almost constant in all age groups; 3) the fatality rates for MAIS 5 and MAIS 3 increase with age and are different between body regions; and 4) although the fatality rate for MAIS 4 is almost constant in all body regions, it does not increase continuously with age. In this study, therefore, 7 types of logistic regression models were taken into consideration in order to confirm the effect of the information about age and injured body region, respectively. They were: 1) 2 types of simplified regression models, which only include MAIS or ISS; 2) 1 type of regression model, which only includes the information about the injured body region for MAIS; 3) 2 types of regression models, which only include the information about age with MAIS and ISS, respectively; and 4) 2 types of regression models, which include the information about age and injured body region for MAIS. Table 2 shows the 7 types of logistic regression models.

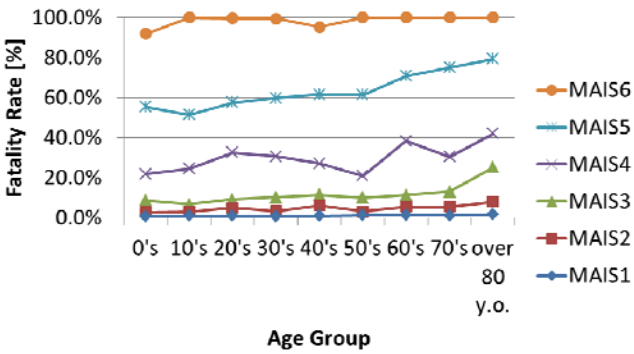


Fig. 1. Fatality rate for each MAIS by age group (data from NASS-CDS from year 2001 to 2007).

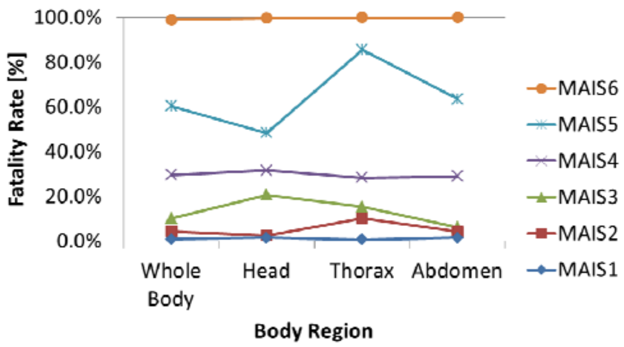


Fig. 2. Fatality rate for each MAIS by body region (data from NASS-CDS from year 2001 to 2007).

TABLE 2
CANDIDATE FOR THE BEST FIT REGRESSION MODEL

| ID | Regression Model |
|---|---|
| A | $p = \frac{\exp(aMAIS + b)}{1 + \exp(aMAIS + b)}$ |
| B | $p = \frac{\exp(aISS + b)}{1 + \exp(aISS + b)}$ |
| C | $p = \frac{\exp(\sum_{i=1}^{9} a_i MAIS_i + b)}{1 + \exp(\sum_{i=1}^{9} a_i MAIS_i + b)}$ |
| D | $p = \frac{\exp(aMAIS + bAGE + c)}{1 + \exp(aMAIS + bAGE + c)}$ |
| E | $p = \frac{\exp(aISS + bAGE + c)}{1 + \exp(aISS + bAGE + c)}$ |
| F | $p = \frac{\exp(\sum_{i=1}^{9} a_i MAIS_i + bAGE + c)}{1 + \exp(\sum_{i=1}^{9} a_i MAIS_i + bAGE + c)}$ |
| G | $p = \frac{\exp(\sum_{i=1}^{9} a_i MAIS_i^{2} + bAGE^2 + c)}{1 + \exp(\sum_{i=1}^{9} a_i MAIS_i^{2} + bAGE^2 + c)}$ |

where $p$ is probability of fatality, and $a$, $b$, $c$ and $a_i$ are the coefficients of the regression model.

The coefficients of each regression model were optimized to the data from NASS-CDS in year 2001 by the maximum likelihood estimation. The regression model with the best fit was chosen, based on the Akaike

Information Criterion (AIC) and Root Mean Square Error (RMSE). The AIC assesses the likelihood of the model and takes into account the number of variables used in the model. The lowest AIC and RMSE indicate the best fit model. The AIC and RMSE are defined by the following equations:

$$AIC = -2 \times LogLiklihood + 2 \times Number\ of\ Variables,$$

(1)

$$RMSE = \sqrt{\frac{\sum (DEATH - Probability\ of\ Fatality)^2}{n}},$$

(2)

where $n$ is the number of occupants in the dataset of NASS-CDS. Additionally, a chi-square test was conducted only for the best fit regression model to confirm the conformity degree of the prediction.

Furthermore, the numbers of fatalities estimated by applying the best fit regression model determined from the year 2001 data to each dataset from year 2002 to 2010 were compared to those of actual fatalities to clarify the applicability of the model to the dataset in different years.

***Investigation of Coefficients of Regression Model***

Since the result of the comparison between the actual and estimated fatalities showed the low applicability of the model to the dataset in different years, regression functions for replacing the constant coefficients of the model best fit to the year 2001 data were investigated. The constant coefficients of the best fit regression model determined from the year 2001 data were optimized for each dataset of NASS-CDS from year 2002 to 2010. Regression functions as a function of the year for replacing each constant coefficient were then determined by using the coefficients optimized for each year. Furthermore, RMSE and the number of fatalities were compared between 2 estimations. One was estimated from the regression model best fit to the year 2001 with the coefficients from the year 2001 data by applying the regression model best fit to the year 2001 to the year 2011 data. The other was estimated from the regression model best fit to the year 2001 with the coefficients calculated from the regression functions for replacing the constant coefficients by applying the regression model best fit to the year 2001 to the year 2011 data.

## III. RESULTS

***Investigation of the Best Fit Regression Model***

Figure 3 shows the comparison of AIC and RMSE for each regression model from the result of optimization. AIC and RMSE of the regression model G were lowest among all of the regression models (AIC: 1332.7 and RMSE: 0.177). From the results, the best fit regression model is G. Additionally, Figure 4 shows the comparison of the actual fatalities and the estimated fatalities by regression model G which confirms that the distribution of the estimated fatalities is similar to that of the actual fatalities. Furthermore, as a result of chi-square test, there was no significant difference between the distribution of the actual fatalities and that of the estimated fatalities calculated from the best fit regression model G (p=0.67), which means the conformity degree of distribution of fatalities by the best fit regression model is high.

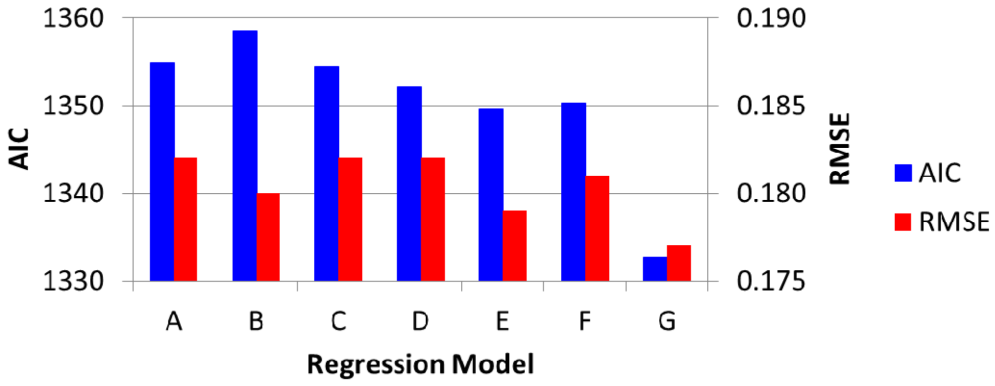


Fig. 3. Comparison of AIC and RMSE among regression models

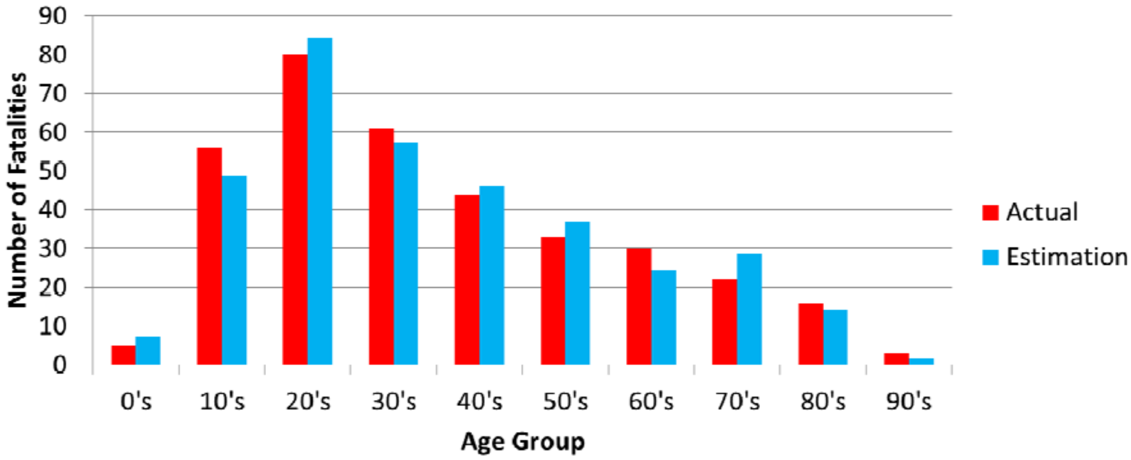


Fig. 4. Comparison of actual fatalities and fatalities estimated by regression model G

Table 3 and Figure 5 show the comparison of the actual fatalities and the fatalities estimated by applying the best fit regression model determined from the year 2001 data to each dataset from year 2002 to 2010. From Figure 5, the degree of overestimation of the estimated fatalities to the actual fatalities increased with each progressing year.

TABLE 3
COMPARISON OF ACTUAL FATALITIES AND FATALITIES ESTIMATED BY APPLYING THE REGRESSION MODEL G TO EACH OF DATASET FROM YEAR 2002 TO 2010

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|
| Actual | 350 | 378 | 392 | 393 | 413 | 505 | 415 | 320 | 186 | 151 |
| Estimated | 350.0 | 385.2 | 402.7 | 427.2 | 417.3 | 530.2 | 474.9 | 417.0 | 239.4 | 183.0 |
| Estimated/ Actual | 1.00 | 1.02 | 1.03 | 1.09 | 1.01 | 1.05 | 1.14 | 1.30 | 1.29 | 1.21 |

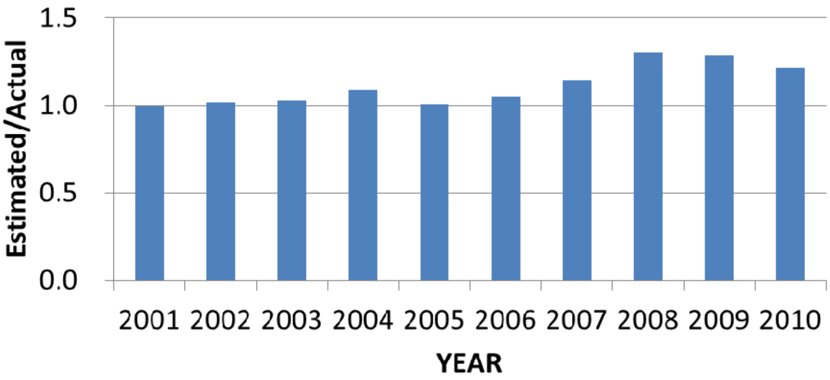


Fig. 5. Ratio of estimated fatalities calculated from the regression model G to actual fatalities for each year

***Investigation of Coefficients of Regression Model***

Table 4 shows the regression function related to the year for the coefficients of the regression model G, as well as the coefficients for the year 2011 determined from the regression function, and the constant coefficients of the regression model G optimized for the year 2001. Table 4 shows that the coefficients $a_1$, $a_5$, $a_7$, $a_9$ and $b$ had a positive correlation while other coefficients had a negative correlation with each progressing year.

TABLE 4
REGRESSION FUNCTION FOR COEFFICIENTS OF REGRESSION MODEL G, ESTIMATED COEFFICIENTS FOR YEAR 2011 FROM REGRESSION FUNCTION AND CONSTANT COEFFICIENTS OF REGRESSION MODEL G OPTIMIZED FOR YEAR 2001

| Coefficients | Regression function for replacing the constant coefficients | | Estimated for 2011 from the regression function | Constant coefficients optimized for the year 2001 |
|---|---|---|---|---|
| | Regression function | Correlation Coefficient | | |
| $a_1$ | $1.97E-03 \times YEAR - 3.83E+00$ | 0.48 | 1.35E-01 | 1.19E-01 |
| $a_2$ | $-1.87E-03 \times YEAR + 3.76E+00$ | -0.13 | 3.22E-03 | 4.30E-02 |
| $a_3$ | $-6.44E-02 \times YEAR + 1.30E+02$ | -0.63 | 8.85E-02 | 1.01E+00 |
| $a_4$ | $-1.95E-03 \times YEAR + 4.06E+00$ | -0.27 | 1.41E-01 | 1.50E-01 |
| $a_5$ | $3.61E-03 \times YEAR - 7.16E+00$ | 0.37 | 9.55E-02 | 1.07E-01 |
| $a_6$ | $-5.26E-03 \times YEAR + 1.06E+01$ | -0.66 | 1.09E-02 | 9.07E-02 |
| $a_7$ | $5.56E-04 \times YEAR - 1.10E+00$ | 0.04 | 2.14E-02 | 2.33E-02 |
| $a_8$ | $-1.70E-03 \times YEAR + 3.46E+00$ | -0.27 | 5.15E-02 | 7.83E-02 |
| $a_9$ | $4.36E-03 \times YEAR - 8.55E+00$ | 0.30 | 2.16E-01 | 1.58E-01 |
| $b$ | $8.28E-06 \times YEAR - 1.95E-03$ | 0.52 | 2.07E-04 | 1.26E-04 |
| $c$ | $-5.90E-02 \times YEAR + 1.14E+02$ | -0.57 | -5.16E+00 | -4.81E+00 |

where $a_i$, $b$, $c$ and are the coefficients of the regression model G shown in below.

$$p = \frac{\exp(\sum_{i=1}^{9} a_i MAIS_i^{\ 2} + bAGE^2 + c)}{1 + \exp(\sum_{i=1}^{9} a_i MAIS_i^{\ 2} + bAGE^2 + c)}$$

Figure 6 shows the comparison of RMSE from the estimation of the total number of fatalities in 2011 using the regression model G between the constant coefficients optimized for the year 2001 and the coefficients estimated for 2011 from the regression functions (all of the coefficients are shown in Table 4). Additionally,

Figure 7 shows the comparison of the ratio of the total number of fatalities in 2011 estimated by applying the regression model G to the actual total number of fatalities in 2011 between the constant coefficients optimized for the year 2001 and the coefficients estimated for 2011 from the regression functions (all of the coefficients are shown in Table 4). Furthermore, Figure 8 shows the comparison of the actual number of fatalities in 2011, the estimated number of fatalities in 2011 calculated by applying the regression model G with the constant coefficients optimized for the year 2001, and the coefficients estimated for 2011 from the regression functions (all of the coefficients are shown in Table 4) by age group. Figure 6 and Figure 7 show that RMSE and the ratio of the estimated total number of fatalities to the actual total number of fatalities were improved from 0.160 to 0.156 and from 1.20 to 0.92, respectively, when the regression functions for the coefficients were taken into consideration. Additionally, from Figure 8, it was found that the representativeness of the number of fatalities improved especially in 20s, 30s and 50s.

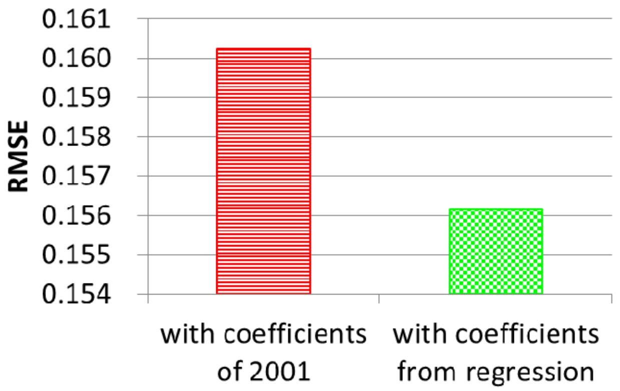


Fig. 6. Comparison of RMSE for year 2011

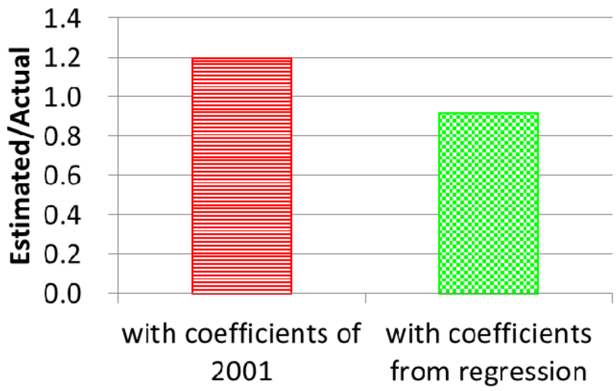


Fig. 7. Comparison of ratio of estimated to actual total number of fatalities in 2011

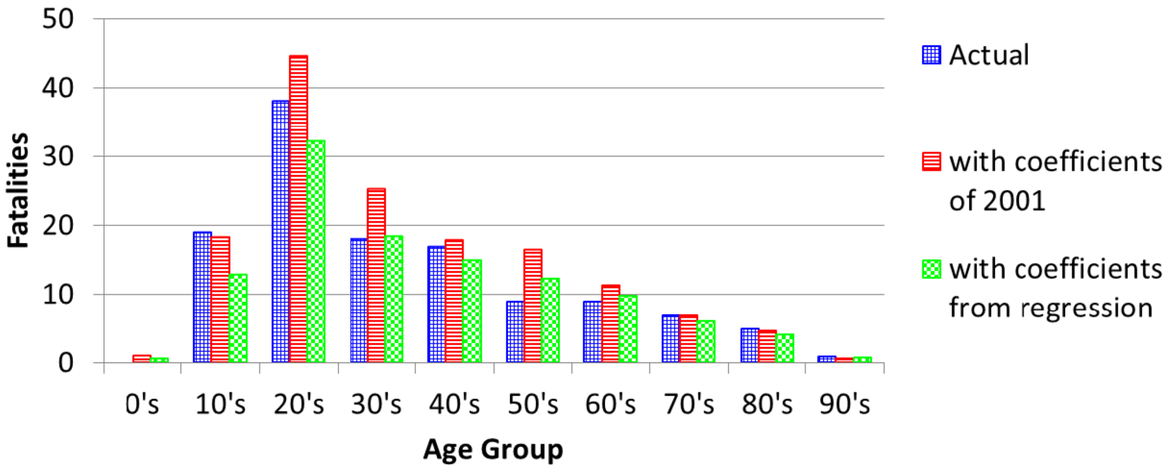


Fig. 8. Comparison of number of fatalities in 2011 by age group

## IV. Discussion

As shown in Figure 3, comparing the regression models A and D, B and E, and C and F, the differences of which were age, AIC and RMSE of the regression models which included age were lower than those which did not include age. Additionally, comparing the regression models F and G, the difference of which was the degree of variables, AIC and RMSE of the regression model G were lower than those of F. Furthermore, comparing the regression models D and F, and E and G, the differences of which were the consideration of the injured body region, AIC and RMSE of the regression models which considered the injured body region were lower than those which did not consider the injured body region. These results suggest that it is important to consider the influence of age, degree of variables and injured body region when estimating the probability of fatality accurately. This can explain why the best fit regression model is the regression model G in Table 2.

As shown in Table 4 and Figures 6 through 8, the regression model G with the estimated coefficients from the regression functions for 2011 shown in Table 4 can predict the fatalities more accurately than that with the constant coefficients optimized to the year 2001. This result suggests that the coefficients of the regression model are significantly dependent upon each progressing year.

From Figure 7 and Table 4, it can be said that the coefficients for the regression model G change with year progress and that the probability of fatality decreases even if injury severity and age do not change. In order to investigate the factors for the change of the coefficients of the regression model, the year change of the fatality rate in hospitals was checked. Zimmerman et al. [13] showed the year change of the fatality rate in intensive care units in the U.S. Figure 9 shows the year change of fatality rate.

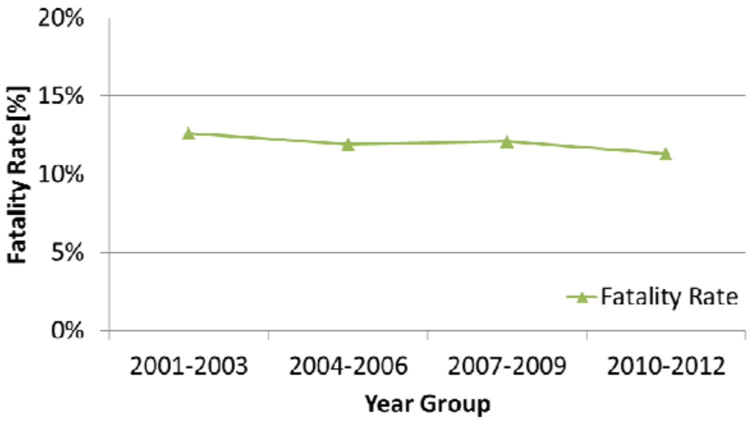


Fig. 9. Fatality rate for 482,601 intensive care units from 2001-2003 to 2010-2012 from the result of Zimmerman et al. [13]

From Figure 9, the fatality rate in intensive care units decreases with the progressing year. This tendency of year change of fatality rate is similar to the result of the year change of the coefficients. Furthermore, Zimmerman et al. [13] cited that the decrease in fatality rate might be attributable to improvements in quality of care. It can be presumed that the fatality rate in a hospital is related to the medical technology and medical infrastructure. Although the change of the coefficients of the regression model is affected by various factors, it is possible that one of the factors which changes the coefficients of the regression model is the improvement of medical technology and medical infrastructure. This suggests that the coefficients of the regression model should be changed when factors such as the country or year change to reflect current medical technology and medical infrastructure.

In this study, since the fatality probability function was developed using the accident data from a single country, additional parameters related to different environments may need to be taken into consideration to develop a more comprehensive regression model.

Additionally, while this study focused on the fatal outcome, there are many non-fatal outcomes, such as disability and impairment. A similar kind of regression model to predict these non-fatal outcomes may be identified in the future by considering such information about disability as described, for example, in the Functional Capacity Index (FCI) [14].

## V. CONCLUSIONS

In this study, seven types of regression models were investigated to identify the best fit fatality probability function associated with injury severity and age relative to US accident statistics (NASS-CDS). Additionally, regression analyses for the coefficients of the regression model were conducted to develop a model incorporating the effect of the year change. The followings results were found:

- The best fit fatality probability function was the maximum AIS of each body region and age.
- The overestimation of the fatalities calculated from the regression model to the actual fatalities increased with each progressive year.
- The accuracy of the regression model was improved by applying the regression functions of the

coefficients as a function of the year.

## VI. References


[1] United Nations Economic Commission for Europe, Statistical Database, Transport Statistics, Road Traffic Accidents, "Persons Killed or Injured in Road Traffic Accidents by Country, Category of User, Accident Type, Age Group and Time", http://w3.unece.org/pxweb/database/STAT/40-TRTRANS/01-TRACCIDENTS/.

[2] Petitjean A, Trosseille X, Praxl N, Hynd D, Irwin A. Injury Risk Curves for the WorldSID 50th Male Dummy. *Stapp Car Crash Journal,* 2012, 56:323-347.

[3] Baker SP, O'Neill B, Haddon W, Long, WB. The Injury Severity Score: A method for describing patients with multiple injuries and evaluating emergency care. *Journal of Trauma*, 1974, 14(8):187-196.

[4] Leitgeb J, et al. Outcome after severe brain trauma due to acute subdural hematoma. *Journal of Neurosurgery,* 2012, 117:324-333.

[5] Takahashi Y, Suzuki S, Ikeda M, Gunji Y. Investigation on pedestrian pelvis loading mechanisms using finite element simulations. *Proceedings of IRCOBI Conference*, 2010, Hannover, Germany.

[6] Goertz A, Yaek J, Compton C. Accident Statistical Distributions from NASS CDS. *SAE Technical Paper* 2010-01-013.

[7] Boyd CR, Tolson MA, Copes WS. Evaluating Trauma Care: The TRISS Method. *Journal of Trauma*, 1987, 27: 370-378.

[8] Champion HR, Sacco WJ, Copes WS, Gann DS, Gennarelli TA, Flanagan ME. A revision of the trauma score. *Journal of Trauma,* 1989, 29:623-629.

[9] Dokko Y, Yanaoka T, Ohashi K. Validation of the age-specific human FE models for lateral impact, *SAE Technical Paper*, 2013-01-1242.

[10] NHTSA, National Automotive Sampling System (NASS), Crashworthiness Data System, 2001-2011.

[11] NHTSA, National Accident Sampling System (NASS), Crashworthiness Data Subsystem Analytical User's Manual 2009 File, U.S. Department of Transportation, National Highway Traffic Safety Administration, National Center for Statistics and Analysis, Washington, D.C.

[12] Association for Advancement of Automotive Medicine, The Abbreviated Injury Scale 1990 Revision, Update 98, Association for Advancement of Automotive Medicine, Des Plaines, IL, USA, 1998.

[13] Zimmerman JE, Kramer AA, Knaus WA. Changes in hospital mortality for United States intensive care unit admissions from 1988 to 2012. *Critical Care,* 2013, 17:R81.

[14] MacKenzie E, Damiano A, Miller T, Luchter S. The Development of the Functional Capacity Index. *Journal of Trauma,* 1996, 41:799-807.


## VII. Appendix

Appendix 1

Numbers of available cases and unknown cases for each year

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Available | 5567 | 6297 | 6426 | 7102 | 5939 | 6405 | 6090 | 6006 | 3703 | 3203 | 2663 |
| Unknown | 88 | 76 | 87 | 59 | 66 | 92 | 116 | 70 | 60 | 91 | 65 |
| Total | 5655 | 6373 | 6513 | 7161 | 6005 | 6497 | 6206 | 6076 | 3763 | 3294 | 2728 |

Appendix 2

Numbers of fatal cases and non-fatal cases for each year (only available cases)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fatal | 5217 | 5919 | 6034 | 6709 | 5526 | 5900 | 5675 | 5686 | 3517 | 3053 | 2540 |
| Non-Fatal | 350 | 378 | 392 | 393 | 413 | 505 | 415 | 320 | 186 | 150 | 123 |

APPENDIX 3

NUMBERS OF CASES BY EACH AGE GROUP FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0s | 267 | 335 | 278 | 337 | 267 | 276 | 241 | 226 | 141 | 123 | 86 |
| 10s | 1107 | 1284 | 1217 | 1351 | 1136 | 1194 | 1088 | 1055 | 518 | 399 | 342 |
| 20s | 1433 | 1598 | 1701 | 1861 | 1488 | 1714 | 1715 | 1566 | 1091 | 840 | 750 |
| 30s | 921 | 1051 | 995 | 1147 | 961 | 1001 | 904 | 903 | 549 | 510 | 421 |
| 40s | 732 | 870 | 921 | 990 | 827 | 839 | 823 | 823 | 494 | 429 | 320 |
| 50s | 456 | 484 | 600 | 620 | 616 | 622 | 582 | 665 | 387 | 394 | 350 |
| 60s | 275 | 292 | 325 | 383 | 317 | 366 | 361 | 416 | 277 | 267 | 216 |
| 70s | 242 | 241 | 249 | 256 | 208 | 254 | 231 | 191 | 147 | 137 | 115 |
| 80s | 123 | 135 | 131 | 142 | 112 | 123 | 131 | 146 | 91 | 95 | 55 |
| 90s | 11 | 7 | 9 | 15 | 7 | 16 | 14 | 15 | 8 | 9 | 8 |

APPENDIX 4

NUMBERS OF CASES BY EACH ISS RANGE FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-9 | 4455 | 5060 | 5138 | 5743 | 4583 | 4859 | 4631 | 4764 | 3008 | 2696 | 2278 |
| 10-19 | 614 | 646 | 699 | 734 | 708 | 735 | 741 | 635 | 353 | 256 | 187 |
| 20-29 | 212 | 276 | 256 | 268 | 286 | 350 | 295 | 265 | 144 | 120 | 89 |
| 30-39 | 105 | 123 | 141 | 142 | 126 | 166 | 153 | 135 | 75 | 55 | 38 |
| 40-49 | 62 | 73 | 71 | 70 | 82 | 89 | 91 | 69 | 41 | 22 | 23 |
| 50-59 | 45 | 39 | 42 | 58 | 61 | 61 | 75 | 54 | 32 | 20 | 14 |
| 60-69 | 1 | 4 | 7 | 5 | 4 | 11 | 4 | 3 | 4 | 1 | 5 |
| 70-75 | 73 | 76 | 72 | 82 | 89 | 134 | 100 | 81 | 46 | 33 | 29 |

APPENDIX 5

NUMBERS OF CASES BY EACH $MAIS$ FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3516 | 4042 | 4108 | 4736 | 3623 | 3829 | 3705 | 3914 | 2514 | 2209 | 1808 |
| 2 | 931 | 988 | 1012 | 972 | 928 | 975 | 877 | 833 | 467 | 479 | 466 |
| 3 | 633 | 713 | 722 | 780 | 772 | 809 | 799 | 679 | 392 | 277 | 205 |
| 4 | 233 | 270 | 293 | 305 | 306 | 398 | 367 | 305 | 166 | 126 | 100 |
| 5 | 181 | 208 | 220 | 228 | 224 | 263 | 242 | 197 | 118 | 80 | 55 |
| 6 | 73 | 76 | 71 | 81 | 86 | 131 | 100 | 78 | 46 | 32 | 29 |

APPENDIX 6

NUMBERS OF CASES BY EACH $MAIS_1$ FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 3824 | 4405 | 4481 | 5105 | 4064 | 4395 | 4114 | 4161 | 2607 | 2332 | 1910 |
| 1 | 813 | 959 | 912 | 972 | 874 | 932 | 911 | 926 | 573 | 405 | 311 |
| 2 | 501 | 470 | 518 | 539 | 501 | 453 | 514 | 468 | 260 | 270 | 283 |
| 3 | 144 | 138 | 153 | 134 | 160 | 187 | 185 | 147 | 71 | 61 | 43 |
| 4 | 134 | 144 | 172 | 161 | 153 | 205 | 165 | 130 | 78 | 72 | 63 |
| 5 | 110 | 136 | 150 | 140 | 143 | 158 | 141 | 124 | 84 | 50 | 38 |
| 6 | 41 | 45 | 40 | 51 | 44 | 75 | 60 | 50 | 30 | 13 | 15 |

APPENDIX 7

NUMBERS OF CASES BY EACH $MAIS_2$ FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 3264 | 3859 | 4095 | 4615 | 3794 | 4034 | 3956 | 3939 | 2582 | 2295 | 1900 |
| 1 | 2085 | 2196 | 2086 | 2235 | 1896 | 2095 | 1863 | 1832 | 976 | 825 | 678 |
| 2 | 166 | 181 | 183 | 192 | 184 | 217 | 188 | 183 | 101 | 78 | 82 |
| 3 | 52 | 61 | 61 | 60 | 65 | 59 | 83 | 52 | 44 | 4 | 3 |
| 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

APPENDIX 8

NUMBERS OF CASES BY EACH $MAIS_3$ FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5230 | 5933 | 6049 | 6709 | 5650 | 6028 | 5754 | 5651 | 3485 | 3018 | 2517 |
| 1 | 322 | 354 | 354 | 371 | 276 | 346 | 315 | 331 | 207 | 176 | 135 |
| 2 | 10 | 6 | 15 | 11 | 7 | 20 | 8 | 11 | 4 | 4 | 5 |
| 3 | 3 | 2 | 6 | 8 | 3 | 9 | 10 | 6 | 4 | 5 | 5 |
| 4 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 3 | 0 | 0 | 1 |
| 5 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 1 | 0 | 0 | 0 |
| 6 | 2 | 1 | 0 | 1 | 2 | 2 | 1 | 3 | 3 | 0 | 0 |

APPENDIX 9

NUMBERS OF CASES BY EACH $MAIS_4$ FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 3721 | 4207 | 4285 | 4814 | 3895 | 4102 | 3860 | 3936 | 2435 | 2108 | 1755 |
| 1 | 1205 | 1313 | 1360 | 1460 | 1215 | 1321 | 1297 | 1261 | 843 | 740 | 637 |
| 2 | 128 | 167 | 155 | 136 | 151 | 159 | 164 | 134 | 82 | 54 | 44 |
| 3 | 244 | 314 | 326 | 342 | 319 | 346 | 321 | 317 | 157 | 192 | 136 |
| 4 | 178 | 201 | 200 | 241 | 242 | 336 | 311 | 254 | 132 | 65 | 62 |
| 5 | 70 | 73 | 77 | 91 | 94 | 113 | 107 | 80 | 45 | 33 | 19 |
| 6 | 21 | 22 | 23 | 18 | 23 | 28 | 30 | 24 | 9 | 11 | 10 |

APPENDIX 10

NUMBERS OF CASES BY EACH $MAIS_5$ FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 4693 | 5233 | 5435 | 5923 | 4900 | 5193 | 4933 | 4924 | 3091 | 2676 | 2219 |
| 1 | 553 | 680 | 608 | 746 | 639 | 749 | 730 | 721 | 415 | 374 | 306 |
| 2 | 196 | 235 | 239 | 277 | 219 | 260 | 239 | 196 | 118 | 90 | 80 |
| 3 | 55 | 82 | 65 | 86 | 79 | 83 | 78 | 70 | 27 | 26 | 20 |
| 4 | 47 | 38 | 53 | 44 | 67 | 65 | 69 | 60 | 35 | 28 | 22 |
| 5 | 19 | 27 | 26 | 25 | 34 | 53 | 37 | 32 | 16 | 9 | 15 |
| 6 | 4 | 2 | 0 | 1 | 1 | 2 | 4 | 3 | 1 | 0 | 1 |

APPENDIX 11

NUMBERS OF CASES BY EACH $MAIS_6$ FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 3953 | 4508 | 4461 | 5018 | 4117 | 4474 | 4118 | 4062 | 2498 | 2261 | 1874 |
| 1 | 1269 | 1400 | 1536 | 1649 | 1327 | 1351 | 1425 | 1457 | 944 | 710 | 602 |
| 2 | 229 | 237 | 275 | 261 | 322 | 374 | 319 | 314 | 146 | 153 | 123 |
| 3 | 67 | 100 | 109 | 113 | 129 | 138 | 161 | 125 | 84 | 54 | 48 |
| 4 | 6 | 11 | 7 | 13 | 9 | 10 | 17 | 12 | 9 | 4 | 3 |
| 5 | 28 | 29 | 26 | 27 | 19 | 39 | 30 | 22 | 17 | 14 | 10 |
| 6 | 15 | 12 | 12 | 21 | 16 | 19 | 20 | 14 | 5 | 7 | 3 |

APPENDIX 12

NUMBERS OF CASES BY EACH $MAIS_7$ FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 2762 | 3183 | 3287 | 3643 | 3060 | 3295 | 3096 | 3037 | 1863 | 1595 | 1349 |
| 1 | 2193 | 2417 | 2498 | 2771 | 2239 | 2342 | 2306 | 2345 | 1483 | 1340 | 1089 |
| 2 | 453 | 511 | 453 | 476 | 446 | 532 | 459 | 432 | 221 | 222 | 193 |
| 3 | 159 | 186 | 188 | 212 | 194 | 236 | 229 | 192 | 136 | 46 | 32 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

APPENDIX 13

NUMBERS OF CASES BY EACH $MAIS_8$ FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 2718 | 3102 | 3326 | 3668 | 3048 | 3206 | 3181 | 3131 | 1890 | 1721 | 1452 |
| 1 | 2012 | 2270 | 2191 | 2511 | 1947 | 2117 | 1988 | 2028 | 1317 | 1105 | 908 |
| 2 | 426 | 463 | 453 | 433 | 442 | 501 | 392 | 372 | 227 | 216 | 175 |
| 3 | 409 | 457 | 446 | 482 | 496 | 563 | 509 | 454 | 261 | 148 | 117 |
| 4 | 2 | 5 | 9 | 7 | 6 | 13 | 14 | 16 | 7 | 9 | 9 |
| 5 | 0 | 0 | 1 | 1 | 0 | 5 | 6 | 5 | 1 | 4 | 2 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

APPENDIX 14

NUMBERS OF CASES BY EACH $MAIS_9$ FOR EACH YEAR (ONLY AVAILABLE CASES)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5430 | 6161 | 6282 | 6977 | 5815 | 6250 | 5948 | 5861 | 3593 | 3099 | 2569 |
| 1 | 129 | 123 | 126 | 110 | 110 | 121 | 132 | 141 | 100 | 98 | 87 |
| 2 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 3 | 0 | 1 |
| 3 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 1 |
| 4 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 5 | 7 | 4 | 2 | 6 | 0 | 1 | 0 | 2 | 0 |
| 6 | 5 | 7 | 9 | 8 | 9 | 24 | 9 | 3 | 7 | 4 | 5 |