mining software package IBM SPSS Modeler 15.0 was used to develop the CHAID decision trees.

3. RESULTS

3.1 Overall Fatality Rate According to Distance2EMC during 21 Years

Figure 3 shows the change of overall fatality rates as a function of ten-km Distance2EMC categories during 21 years from 1989 to 2009. Total number of 20,390 Distance2EMCs was classified into 10 ten-km categories. In Figure 3, the horizontal axis shows the ten-km Distance2EMC categories, and the vertical axis shows the averaged fatality rate per each ten-km Distance2EMC category. Average fatality rate in the ten-km Distance2EMC category from 0-10km is 12.7%. Afterward, average fatality rate is over 20% per each ten-km category. In case of the ten-km Distance2EMC category from 70-80km is 25.8%, which is the largest average fatality rate among that of 10 ten-km Distance2EMC categories.

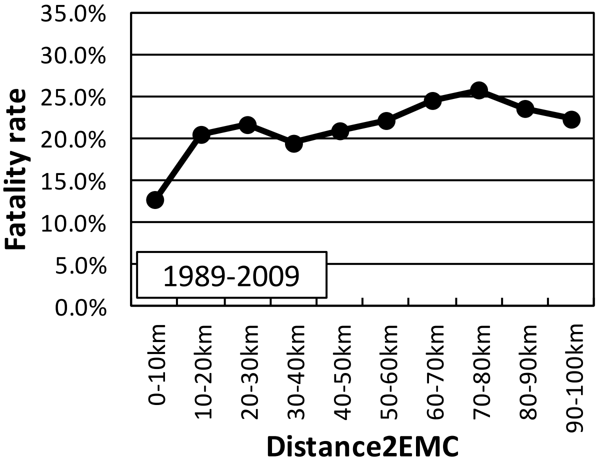

Figure 3. Fatality rate as a function of Distance2EMC from 1989 to 2009

Figure 4 shows the decision tree using Distance2EMC as a response variable. Four Distance2EMC categories, which are 0-5.1km, 5.1-10.8km, 10.8-59.0km and over 59.0km, were found to be significance at a chi-square level of 5%. Average fatality rate in the each Distance2EMC category is 11.2%, 14.8%, 20.9% and 24.8% respectively. Average fatality rate decreased as distance assigned to each Distance2EMC category decreased.

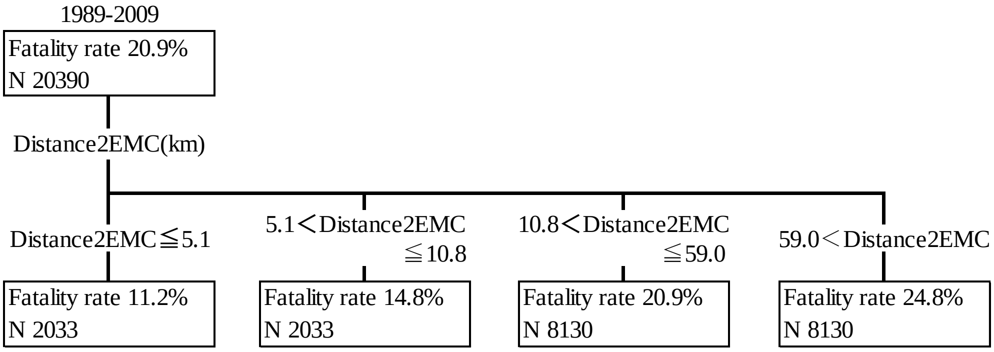

Figure 4. Decision tree to show an effect of Distance2EMS on the fatality rate

3.2 Change of the Fatality Rate per Each 5 Year Period According to Distance2EMC

Figure 5 clearly shows changes of trends of the fatality rate per 5-year period as a function of ten-km Distance2EMC categories in Hokkaido. Average fatality rates of the ten-km Distance2EMC categories less than 40km decreased as the 5-year period is updated. In 0-10km Distance2EMC category, average fatality rate is 16.8% in 1990-1994, and it reduced to 9.6% in 2005-2009. In 30-40km Distance2EMC category, average fatality rate in 2005-2009 reduced to less than 15.0%. However, average fatality rates of the ten-km Distance2EMC categories, which distance is over 40km, did not show decreasing trend as the 5-year period is updated. The average fatality rate kept over 20.0% with these ten-km Distance2EMC categories. Especially, average fatality rate of these long distance ten-km Distance2EMC categories in 2005-2009 still was over 20.0%.

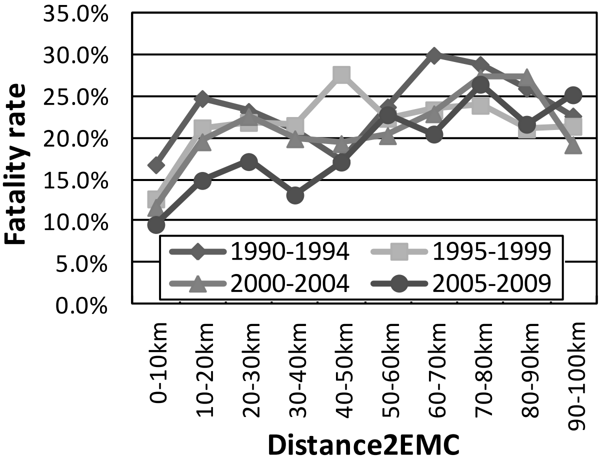

Figure 5. Fatality rate per 5-year period as a function of Distance2EMC

Figure 6 shows the decision tree using Distance2EMC as a response variable as a function of 5-year period in Hokkaido. There are a total of four 5-year periods, and each 5-year period had four Distance2EMC subgroups. In 1990-1994, four Distance2EMC subgroups, which are classified by 0-14.3 km, 14.3-28.2 km, 28.2-54.4 km and over 54.4 km, were found to be significance at a chi-square level of 5%. Average fatality rate in the each subgroup is 18.2%, 24.9%, 20.1% and 26.8% respectively. In 2005-2009, four Distance2EMC subgroups, which are classified by 0-3.7 km, 3.7-11.9 km, 11.9-47.6 km and over 47.6 km, were found to be significance at a chi-square level of 5%. Average fatality rate in the each subgroup is 5.9%, 11.7%, 20.9% and 25.4% respectively. Average fatality rate decreased as the distance assigned to each Distance2EMC subgroup decreased.

The shortest Distance2EMC subgroup is ranged from 0 to 14.3km in 1990-1994, 0 to 5.8km in 1995-1999, 0 to 4.6km in 2000-2004 and 0 to 3.7km in 2005-2009. As the period is updated, distance of the shortest Distance2EMC subgroup becomes short, and average fatality rate decreased. Also, distance of the second shortest Distance2EMC subgroup decreased as the period is updated except from 1995-1999. Distance of the second shortest Distance2EMC category in 2005-2009 is ranged from 3.7 to 11.9km, which is longer than that of the shortest Distance2EMC subgroup in 1990-1994. In addition, average fatality rate decreased as the period is updated. On the other hand, distances of the longest Distance2EMC subgroup did not change largely as the period is updated, and average fatality rates of these Distance2EMC subgroups did not change and kept large values over 25.0%.

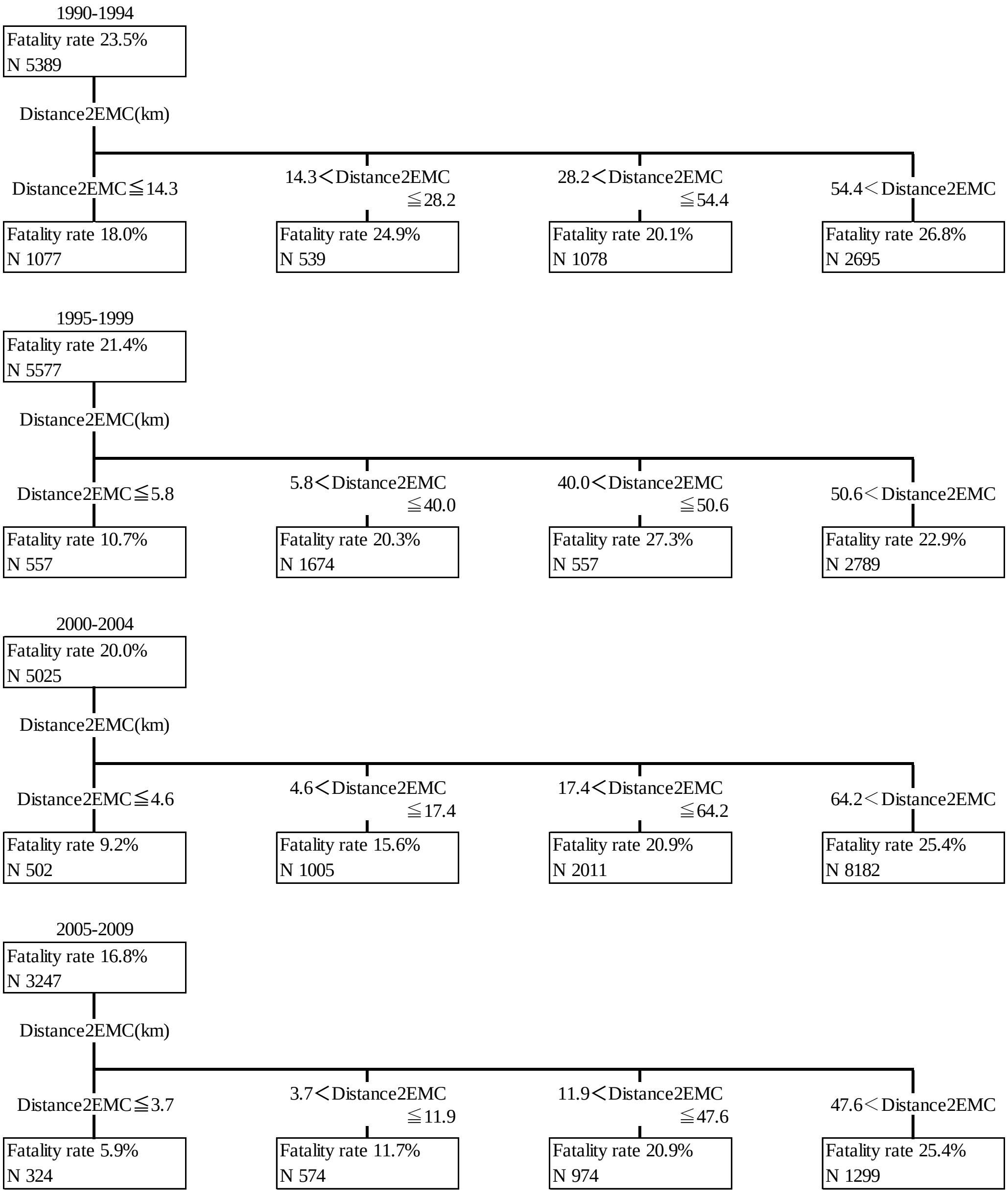

Figure 6. Decision tree using Distance2EMC as a function of 5-year period

3.3 Decision Trees per Using Accident Variables and Distance2EMC

A set of CHIAD analysis was run using fatality rate as the dependent variable. Figure 7 shows the decision tree developed to investigate effects of accident characteristics and Distance2EMC on fatality rate at all national roads in Hokkaido as a function of four 4-year period, which are 2002-2005 and 2006-2009. We focused on accident data after 2002, that the hazard recognition speed is available on record.

Figure 7(A) shows results of the decision tree in 2002-2005. Fifteen significant combinations of variables were found in the decision tree. “Hazard recognition speed” was found to have the most significant correlation with the fatality rate. There were five subgroups as a function of “Hazard recognition speed”. The fatality rate increased as the hazard recognition speed increased. “Hazard recognition speed less than 20.0km/h” had the lowest fatality rate (7.09%), “Hazard recognition speed over 70 km/h” was the highest fatality rate

(47.7%). After “Hazard recognition speed”, partitioning of the second level was trigged by different variables for different subgroups.

1) For “Hazard recognition speed less than 20km/h”, “Distance2EMC” was the second significant variable correlated with fatality rate. There are three subgroups as follows; less than 4.5km, 4.5 to 16.0km and over 16km. Fatality rate of each subgroup was 0.57%, 4.06% and 11.6% respectively.

2) For “Hazard recognition speed” was 20.0km/h to 40.0km/h, “Accident type” was the second significant variable. Fatality rate of “Pedestrian” was 19.5%, and “Car-to-car” and “Single car” was 8.26%. After “Cat-to-car” and “Single car”, “Day/Night” was selected as the third level variable. Fatality rate of “Day” was 10.0%, and “Night” was 4.41%.

3) For “Hazard recognition speed” was 40.0km/h to 50.0km/h, “Accident type” was the second significant variable. Fatality rate of “Pedestrian” was 30.7%, and “Car-to-car” and “Single car” was 14.6%.

4) For “Hazard recognition speed” was 50.0km/h to 70.0km/h, “Accident type” was selected as the second significant variable. Fatality rate of “Pedestrian” was 51.0%, “Car-to-car” was 24.7% and “Single car” was 11.2%. These fatality rates are very high compared with those for “Hazard recognition speed from 20.0km/h to 40.0km/h. After “Car-to-car”, “Distance2EMC” was selected as the third level variable. Fatality rate of “Distance2EMC less than 16.0km” was 13.0%, and “Distance2EMC over 16.0km” was 26.8%.

5) For “Hazard recognition speed” was over 70.0km/h, “Day/Night” was selected as the second significant variable. Fatality rate of “Day” was 42.3% and “Night” was 53.0%.

Figure 7(B) shows results of the decision tree in 2005-2009. Ten significant combinations of variables were found in the decision tree. “Hazard recognition speed” was found to have the most significant correlation with the fatality rate. There were five subgroups as a function of “Hazard recognition speed”. The fatality rate increased as the hazard recognition speed increased. “Hazard recognition speed less than 10km/h” had the lowest fatality rate (2.53%), “Hazard recognition speed over 70 km/h” was the highest fatality rate (41.7%). After “Hazard recognition speed”, partitioning of the second level was trigged by different variables for different subgroups.

1) For “Hazard recognition speed from 30.0km/h to 50.0km/h”, “Type of accident” was selected as the second significant variable correlated with fatality rate. Fatality rate of “Pedestrian” was 21.8%, and “Car-to-car” and “Single car” was 12.8%. After “Car-to-car” and “Single car”, “Distance2EMC” was selected. There were two subgroups by “Distance2EMC”. For “Distance2EMC less than 60.6km”, the fatality rate was 9.79, and “Distance2EMC over 60.6km” was 19.3%.

2) For “Hazard recognition speed from 50.0km/h to 70.0km/h”, “Type of accident” was selected as the second significant variable correlated with fatality rate. Fatality rate of “Pedestrian” was 49.3%, and “Car-to-car” and “Single car” was 23.7%. These fatality rates were twice as much as those in case of “Hazard recognition speed from 30.0km/h to 50.0km/h”.

3) For “Hazard recognition speed over 70.0km/h”, “Location” was selected as the second significant variable correlated with fatality rate. Fatality rate of “Urban” and “Rural” was 38.5%, and “Suburban” was 64.0%. This fatality rate is the largest among ten combinations.

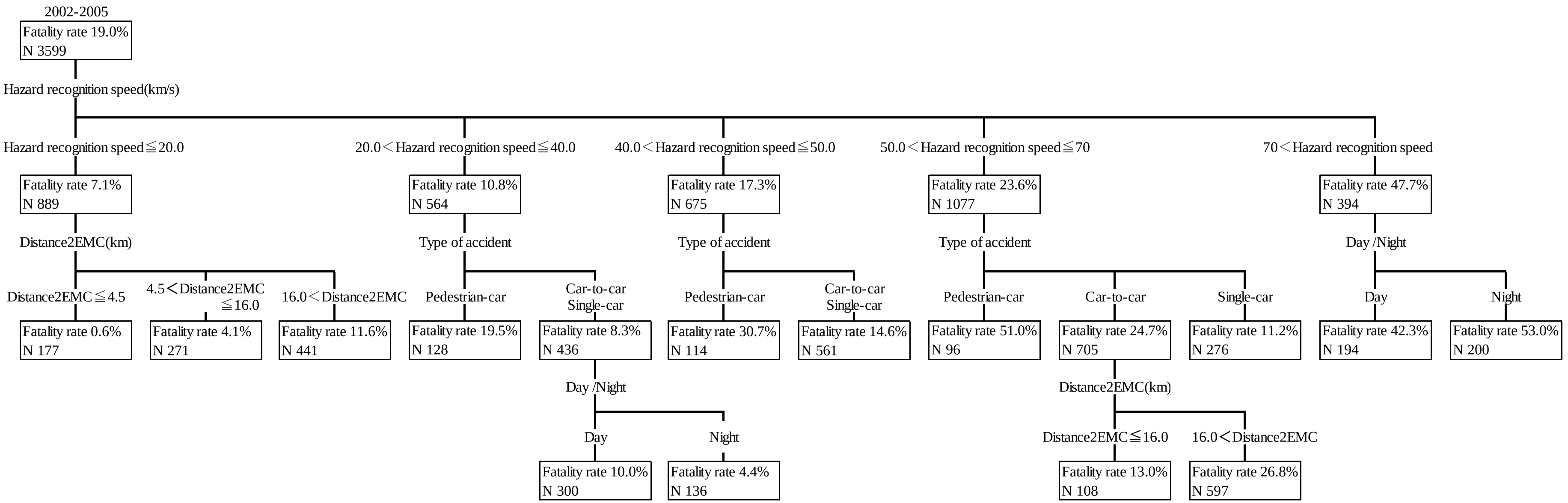

Figure 7(A). Decision tree developed to investigate with the fatality rate in 2002-2005

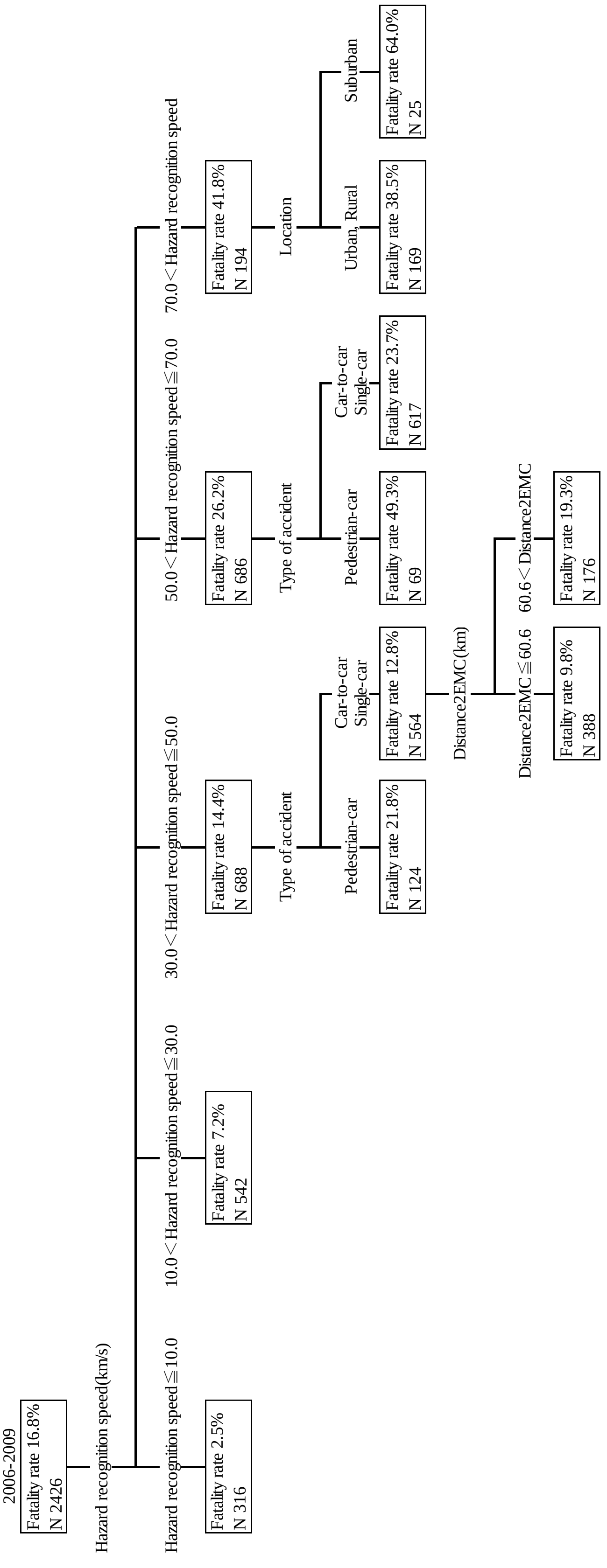

Figure 7(B). Decision tree developed to investigate with the fatality rate in 2006-2009

4. SUMMARY

In this study, we investigated effects of distance between accident site and location of the Life-Saving Emergency Center (Distance2EMC) on the fatality rate at all national roads in Hokkaido, Japan. Average fatality rate where Distance2EMC is less than 40km decreased as the 5-year period is updated. According to results of CHAID analysis, distance of the shortest Distance2EMC subgroup becomes short, and the fatality rate of that subgroup decreased as the period is updated. On the other hand, distance of the longest Distance2EMC subgroup did not change largely as the period is updated, and the fatality rate of that subgroup kept large values over 25.0% during 20 years. These results might indicate that the Distance2EMC has positive effect on reducing the fatality rate, and also this positive effect becomes dominantly as the period is updated.

Next, we examined an effect of accident characteristics including Distance2EMC on the fatality rate used decision tree. Decision tree in 2002-2005 was similar to that in 2006-2009. Variable of the first level was “Hazard recognition speed” in both periods. “Accident type” was mostly selected as the second level variable. The fatality rate was over 20% when “Hazard recognition speed” was over 50.0km/h in both of periods. Also, “Pedestrian” subgroup indicated larger fatality rate than that for “Car-to-car” and “Single car” subgroup within the same “Hazard recognition speed”. In 2002-2005, “Distance2EMC” was selected as the second level after “Hazard recognition speed less than 20.0km/h”. And, “Distance2EMC” was selected as the third level after “Accident type” with “Hazard recognition speed from 50.0km/h to 70.0km/h”. Also, in 2006-2009, “Distance2EMC” was selected as the third level after “Accident type” with “Hazard recognition speed from 30.0km/h to 50.0km/h”. In addition, in 2002-2005, “Distance2EMC” was selected as the third importance variable, and selected as the second importance variable in 2006-2009 next to “Hazard recognition speed”. Based on these results, the fatality rate increased as “Hazard recognition speed” increased, the fatality rate of “Pedestrian” was approximately twice as much as that of “Car-to-car” and “Single car” accident with the same hazard recognition speed subgroup, and “Distance2EMC” was selected as the secondary or thirdly significant variable to affect the fatality rate.

These findings could indicate that Emergency Medical Services in Hokkaido are becoming important components to reduce the fatality rate. According to these findings, it is possible to arrange the location of a new trauma center considering severe crash locations. However, there are several limitations to this study. It should be noted that the details of effects of Emergency Medical Services are not yet clear, we should conduct a new study using actual time of Emergency Medical Services response in near future. And, the accident data should be linked with hospital records, and clinical outcomes towards a better understanding of the contributions of EMS to reducing the injury severity outcome of motor vehicle crashes.

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