Estimation of Emergency Transportation Time Using Ambulance Probe Data and Pavement Survey Data

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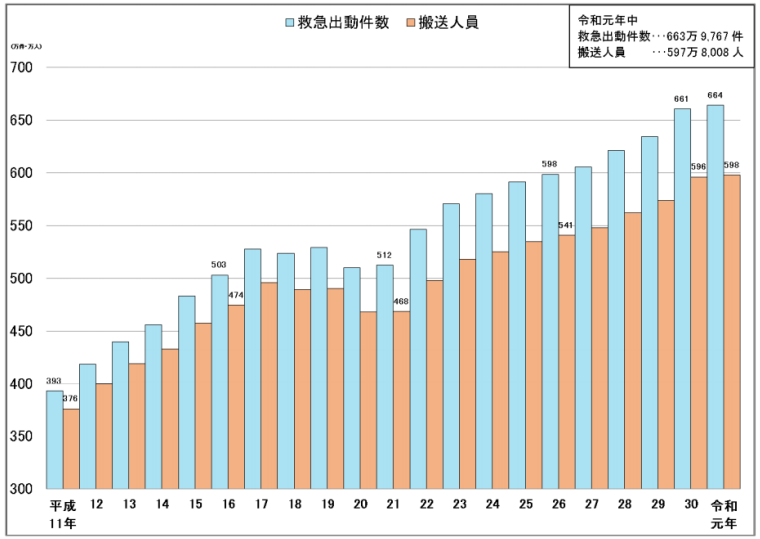
1.1 Background

- The aging of the population.

→ Increase in demand for emergency transportation.

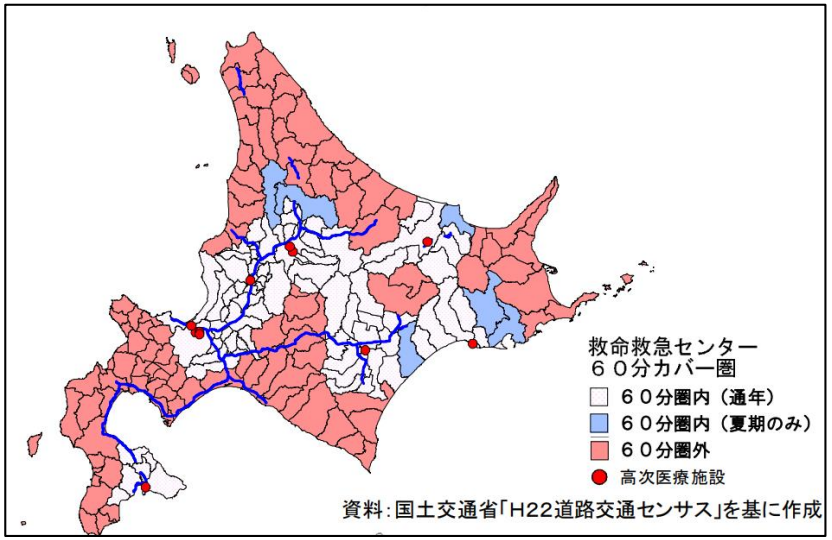
- The uneven distribution of higher-level medical facilities.

→ Emergency transportation takes 60 min or more.



The change in the number of transportation (Blue line)

Source: https://www.fdma.go.jp/



Areas with a transportation time of more than 60 minutes (Red zone)

Source: https://www.hkd.mlit.go.jp/

1.1 Background

➢ Increase in the number of pavement damage spots.
→ Impact on vehicle vibration and ambulance travel time.

➢ Prevent the patient's condition from getting worse.
→ Need to drive carefully on the road conditions.

It is important to solve these local issues from a pavement perspective.

1.2 Previous research

To identify areas of caution for ambulance crews when driving, a driving experiment was conducted.

- Bridge joints, low-temperature cracked spots found to be subject to driving caution.
- The presence of more than 1 to 3 low-temperature cracks per -100m- affects the vibration more than bridge joints.

"Evaluation of pavement surface in terms of emergency transportation by ambulance", Journal of Japan Society of Civil Engineers, 2019.

Example of low-temperature crack

1.3 Aim

<Previous research>

- There are few cases of statistical analysis from data fore both ambulance and road conditions.
- There is no clarity on the effect of pavement repairs on reducing emergency transport times.

<This research>

- Analyze the relationship between the road surface damage and the ambulance running speed.
- Estimate the ambulance travel time when pavement repair was performed using a statistical model.

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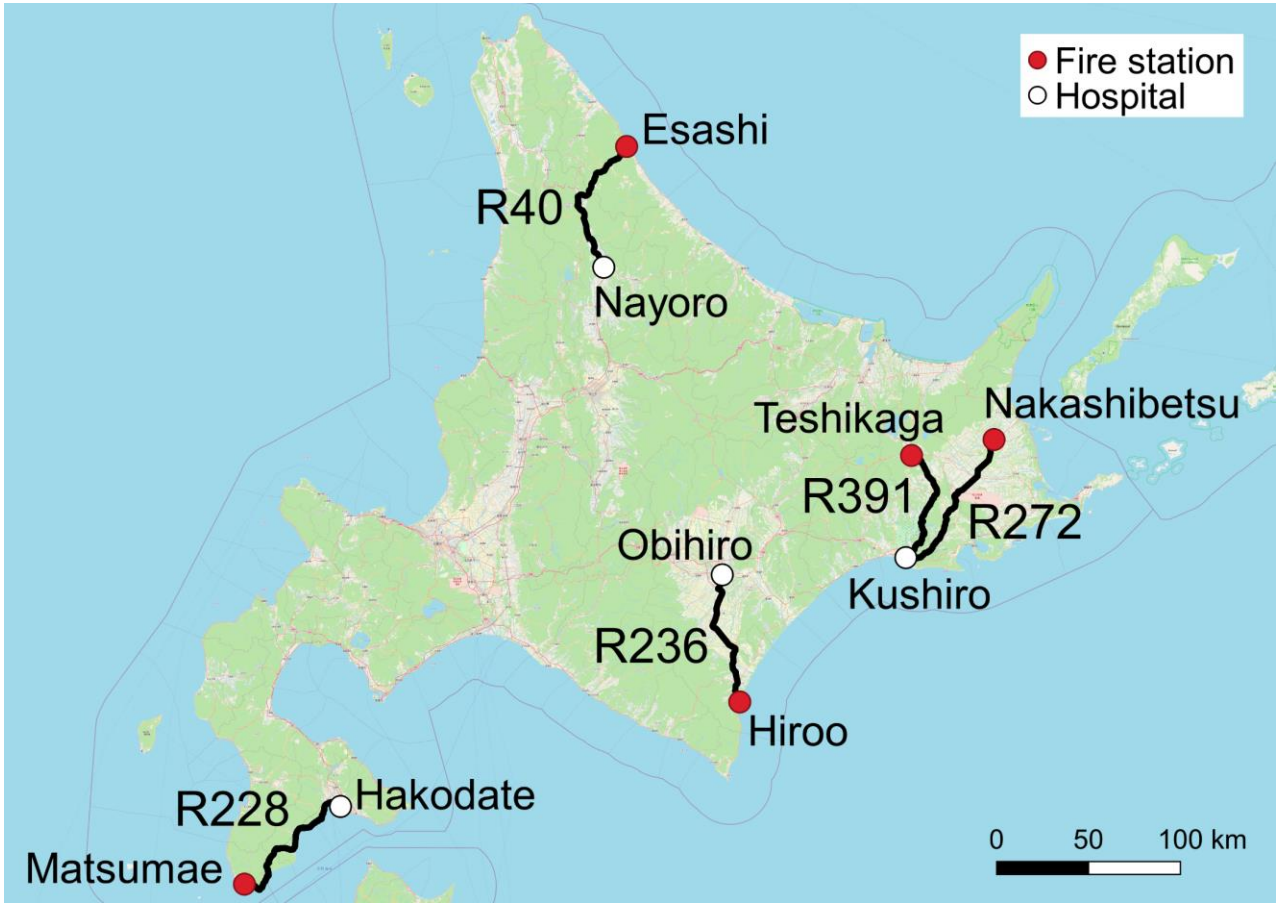
2.1 Outline of survey

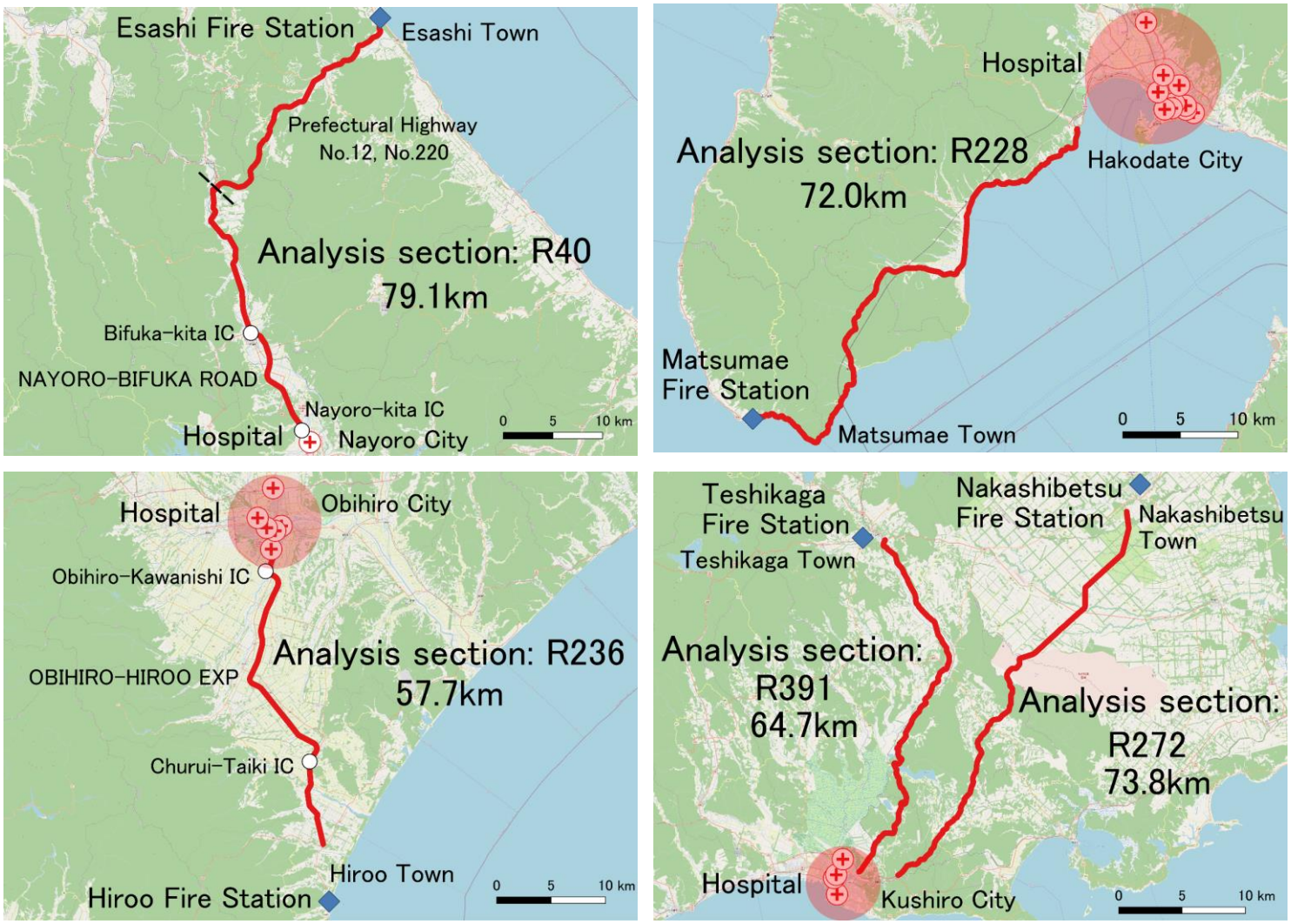
Studied areas	Five areas in Hokkaido
Studied routes	Emergency transportation routes (Fire station → Urban hospital)



Target areas

2.1 Outline of survey

Analysis section : The section where ambulances pass every time.
(※Section excluding urban area)



Analysis section (Red line)

2.1 Outline of survey

- **The ambulance probe survey**
  Requested five fire stations to survey

Period	Sep.2019 ~ Jun.2020
Method	Measurement by smartphone (Fujitsu Traffic & Road Data Service Limited)
Record	● Running speed ● Running path ● Location information (Sampling frequency : 10Hz, Analytical unit : 100m)

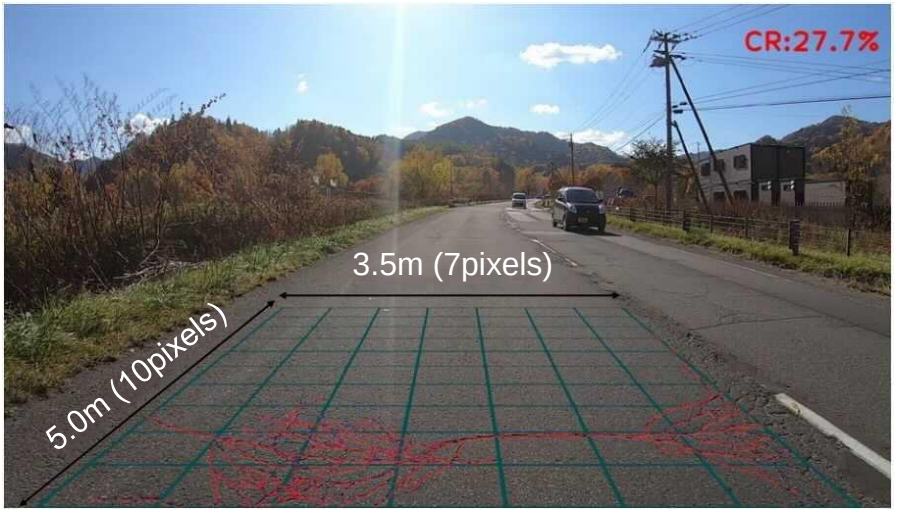
2.1 Outline of survey

➢ **The road surface condition survey**

Collecting road surface condition data in the analysis section.

Period		Jun.2020 ~ Oct.2020
Method		● Measurement by Car-mounted camera ● STAMPER (Taisei Rotec Corporation)
Record	**Crack Survey**	● Crack ratio : CR_{max} ● Number of low-temperature cracks : ***NLC*** ※Presenters conducted this survey. (Analytical unit : 100m)
	IRI Survey	● International Roughness Index : IRI_{max} (Analytical unit : 100m)

Car-mounted camera



Example of sketch image (U-net)

2.2 Outline of analysis

➢ Dataset

The analysis section is divided into -100m- sections and the data for each section is aggregated.

Objective variable	**Speed rate (0 to 1)** Normalize the speed at each point by its maximum speed for each dispatch.
Explanatory variable	● **Road structure** (“Bridge”, “Curve”, “Signal intersection”, etc.) ● **Road surface conditions** (“IRI_{MAX}”, “CR_{MAX}”, “NLC”)
Model	**Logistic regression model**

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Model	**Logistic regression model**

Contents

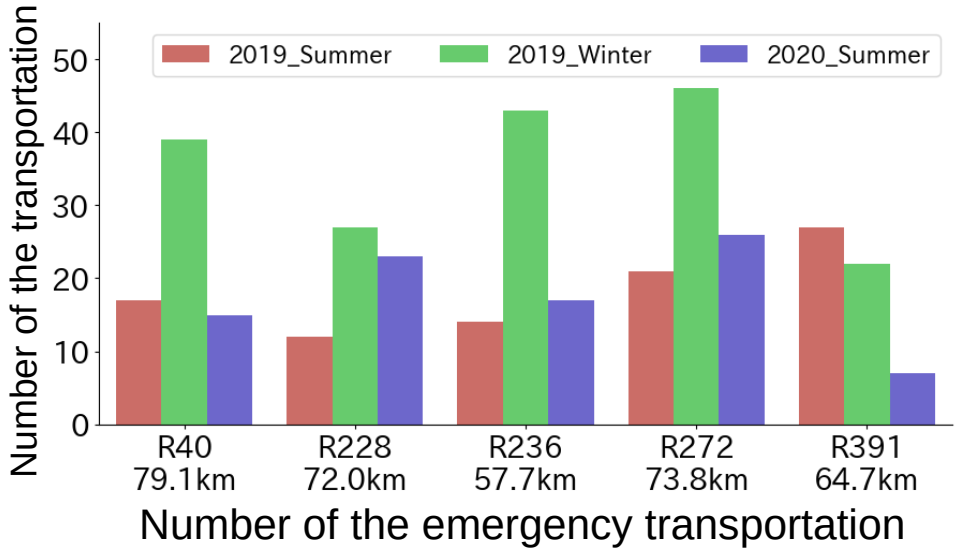
3. A Basic Analysis of Emergency Transportation

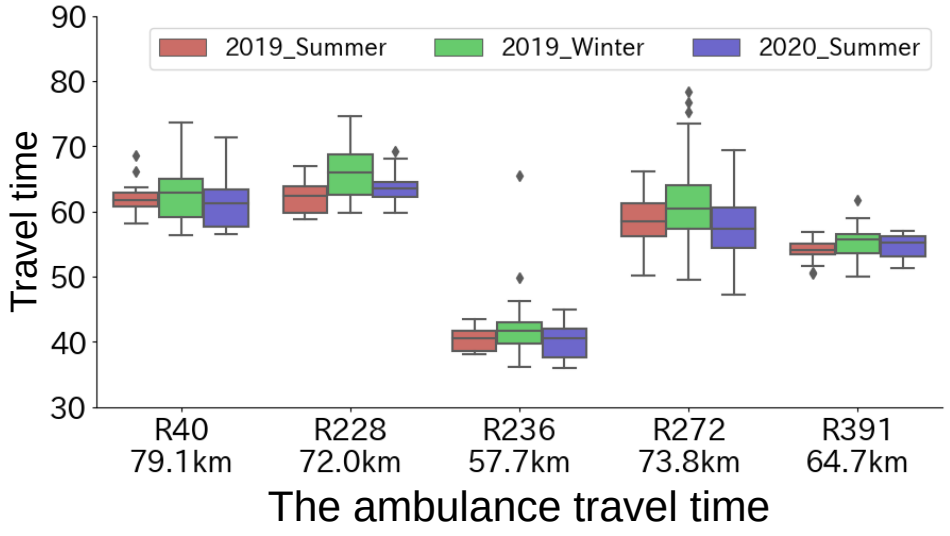
■ **Number of the emergency transportation**

→ Emergency transportation occurs about once every 3 days on most routes.

■ **The ambulance travel time (Only in analysis section)**

→ Most routes took over 60 minutes of travel time.





2019_summer : Sep.2019~Nov.2019, 2019_Winter : Dec.2019~Mar.2020,
2020_Summer : Apr.2020~Jun.2020

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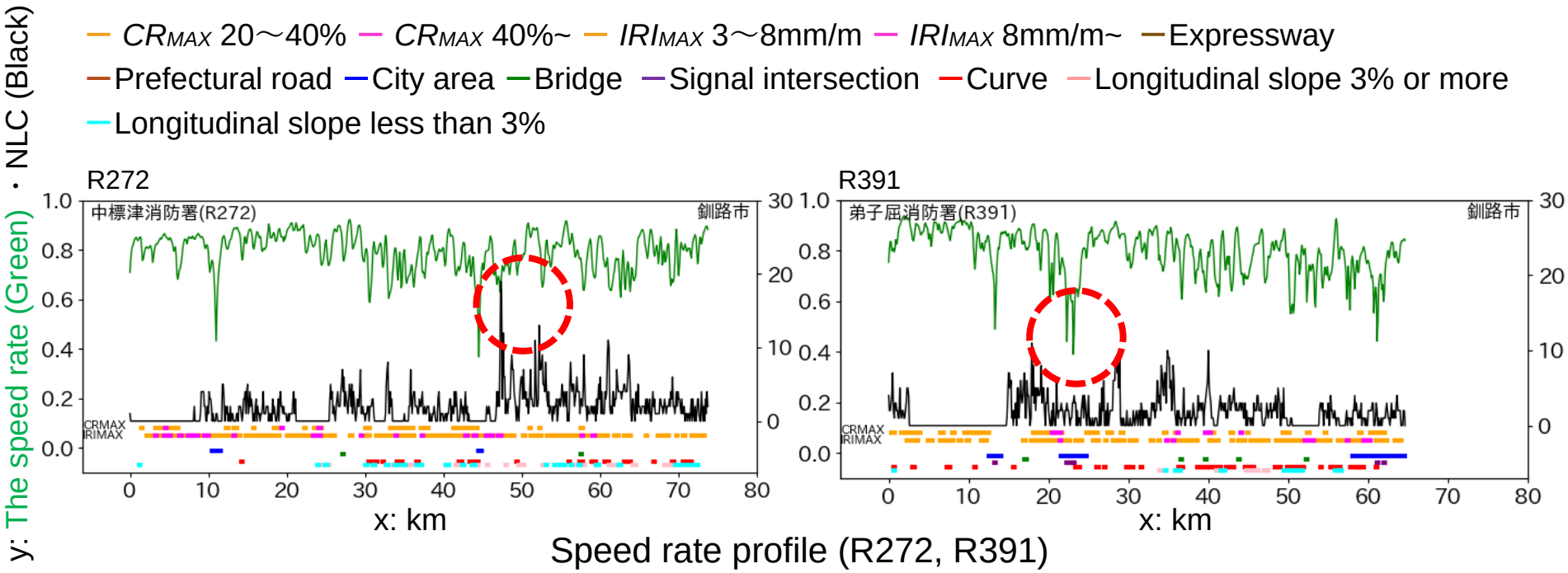
4.1 A Basic aggregation on speed rate

➢ Speed rate profile



Speed rate profile (R272, R391)

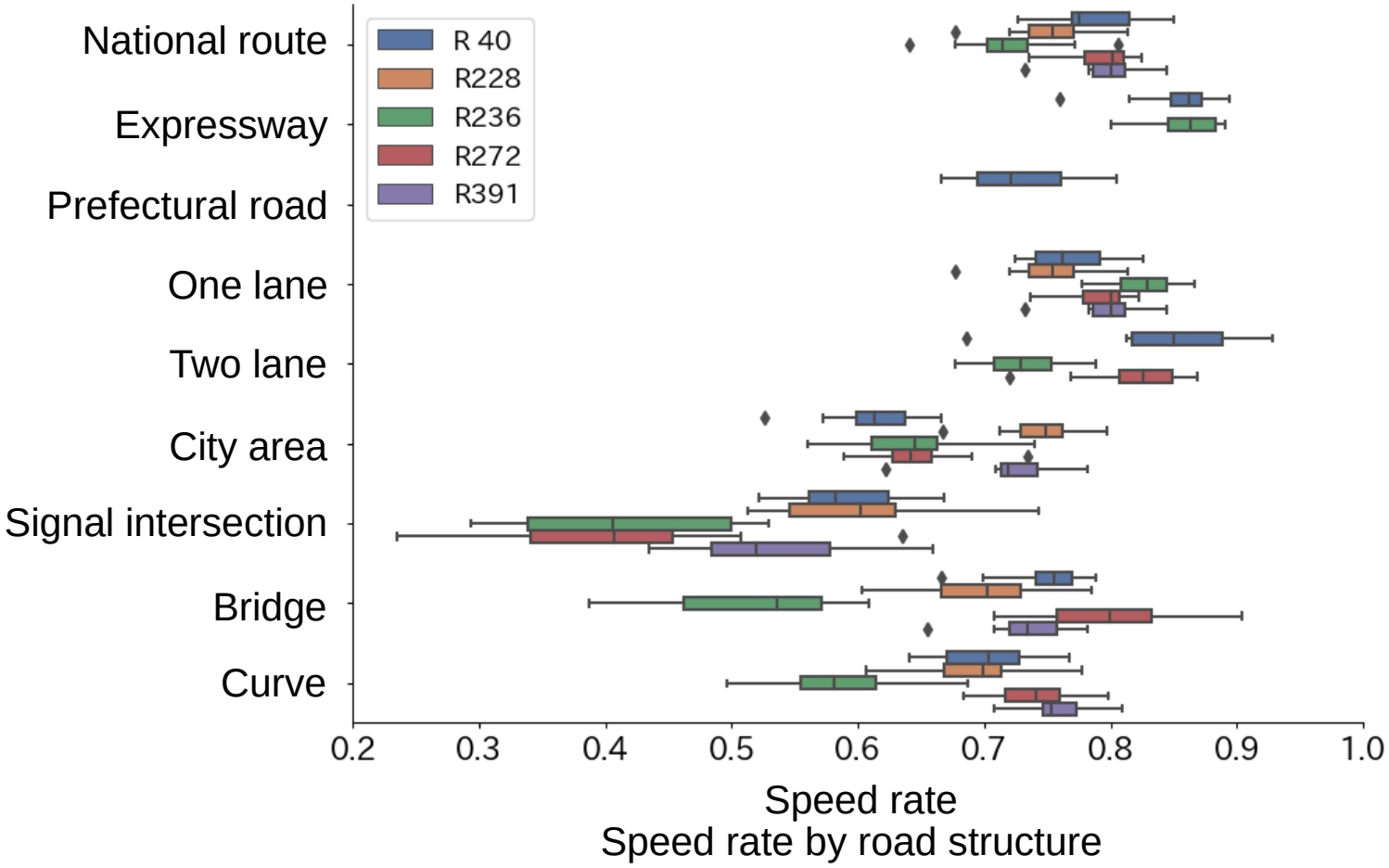
■ Speed rate significantly decreased in city areas and at signalized intersections, etc.

→ Road structure is a significant influence.

4.1 A basic aggregation on speed rate

➢ Speed rate by road structure

- **Highway** → Speed rate is higher than on national route.
- **Bridge**, **Curve** → Speed rate is relatively low.



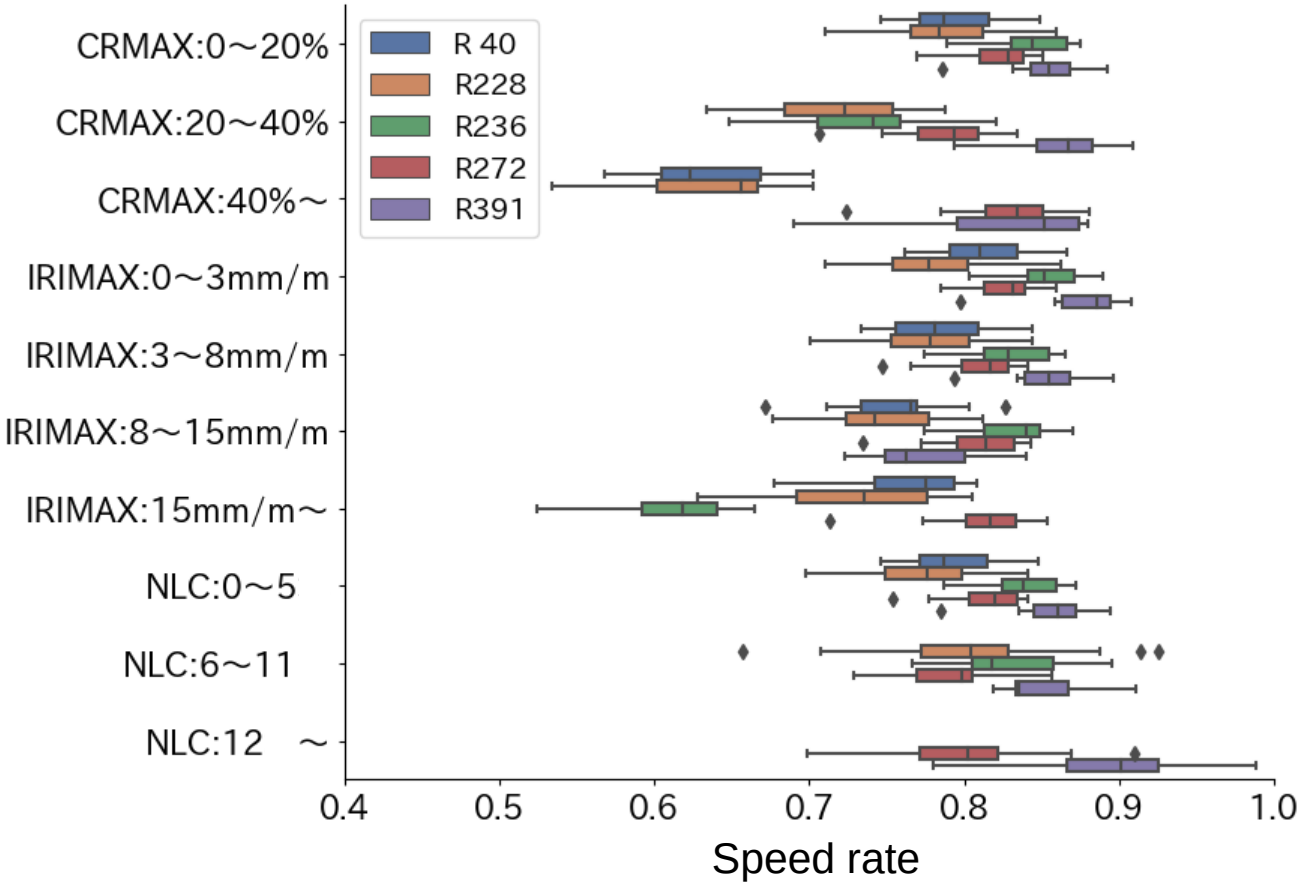
Speed rate by road structure

4.1 A Basic aggregation on speed rate

➢ Speed rate by road surface conditions

■ Speed rate decreases as CR_{MAX} and IRI_{MAX} increase.

■ **CR_{MAX}=40%~** → Speed rate is almost the same as in bridges.



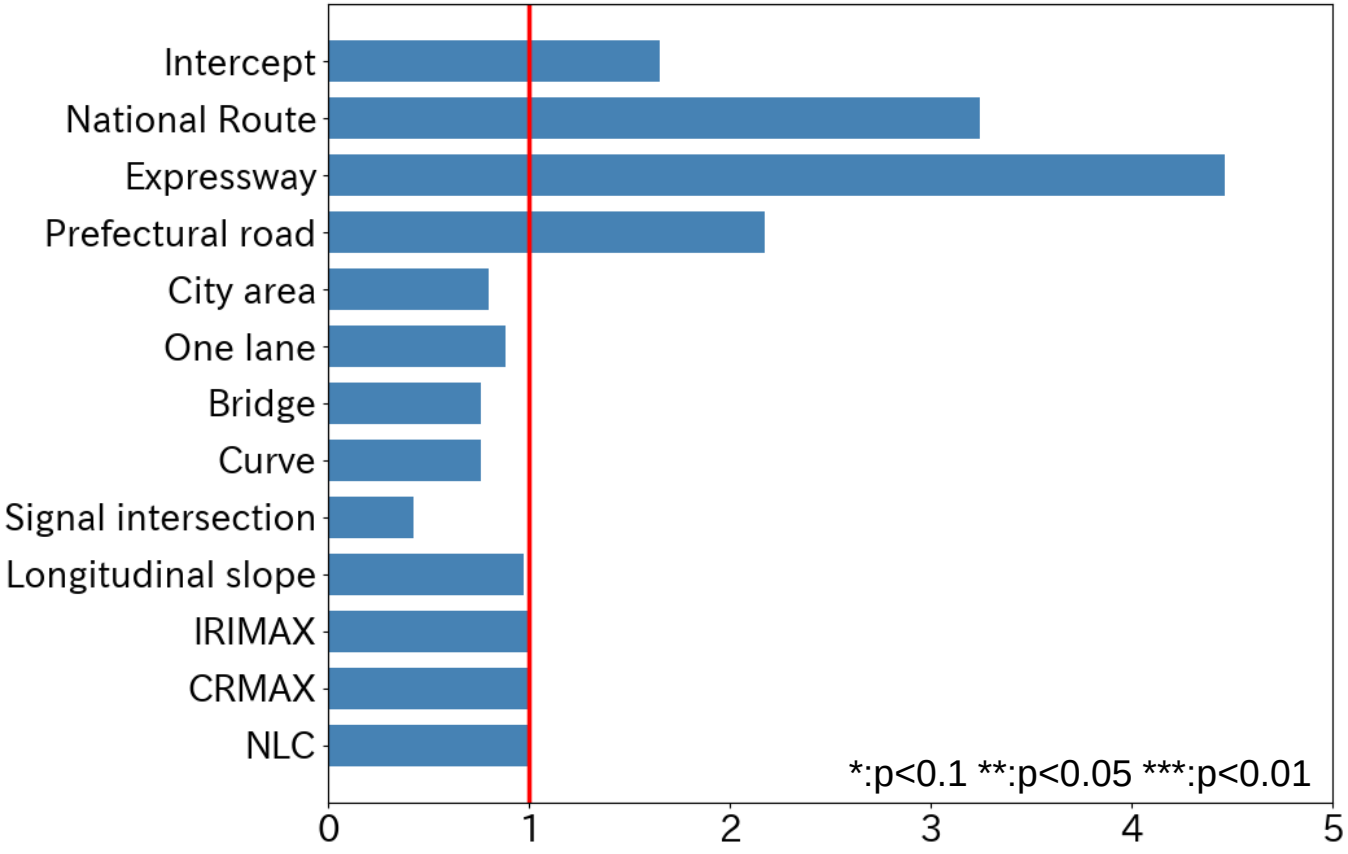
Speed rate by road surface conditions (City streets, bridges, curves, etc. are excluded.)

4.2 Results of logistic regression analysis

Compare odds ratios for each explanatory variable.

■ ***IRI$_{MAX}$***, ***CR$_{MAX}$***, ***NLC*** : Odds ratio less than 1.

→ Road surface damage is a factor in reduced running speed.



Odds ratio for each explanatory variable (Integration of all routes)

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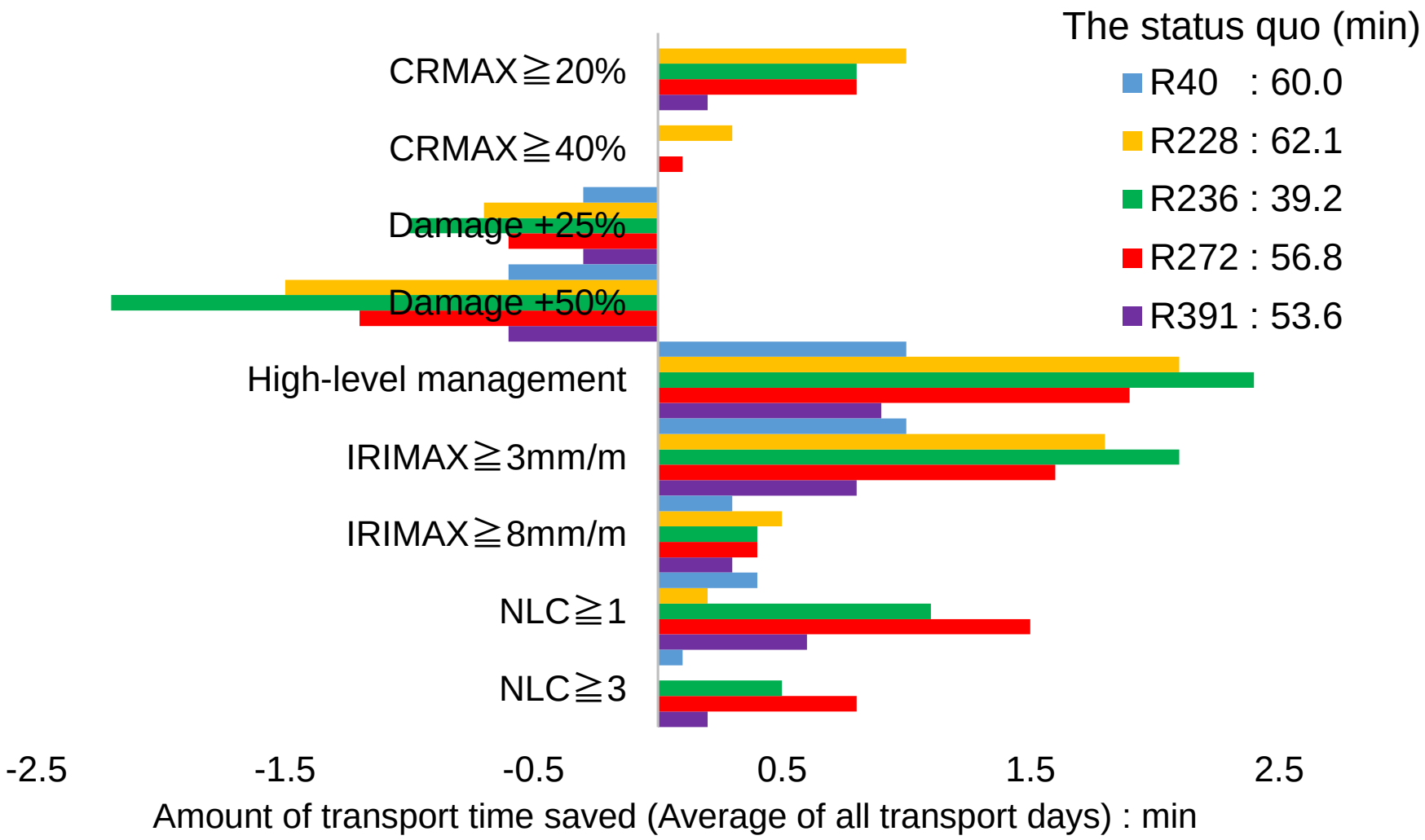
5. Impact of Pavement on Ambulance Driving

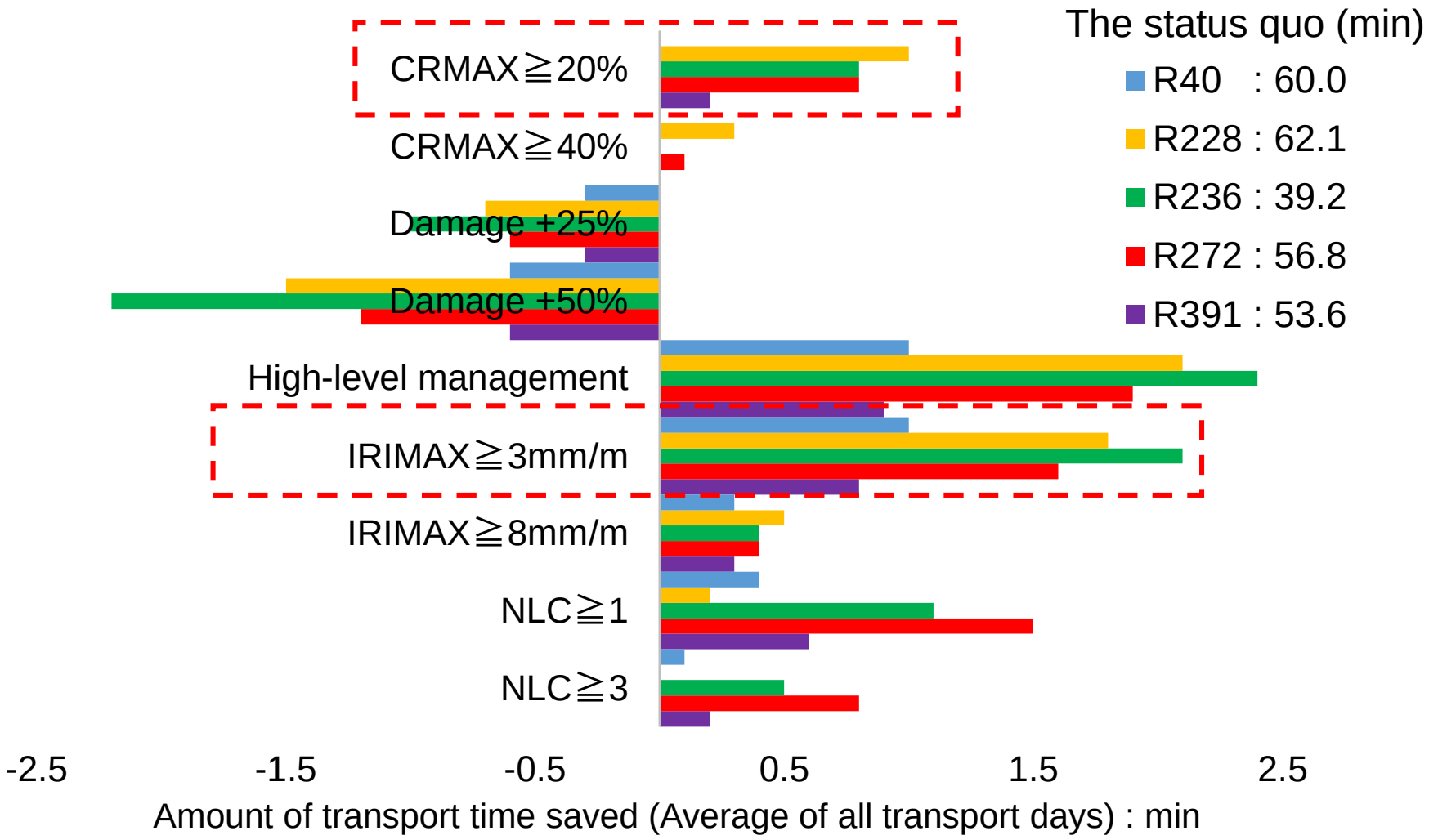
Estimate transport times for multiple pavement repair scenarios using models built for each route.



5. Impact of Pavement on Ambulance Driving

■ **Sections that are Category II (*CR*$_{MAX}$≧20%, *IRI*$_{MAX}$≧3mm/m)**

→ It is possible to shorten the time by about 1 to 2 minutes.

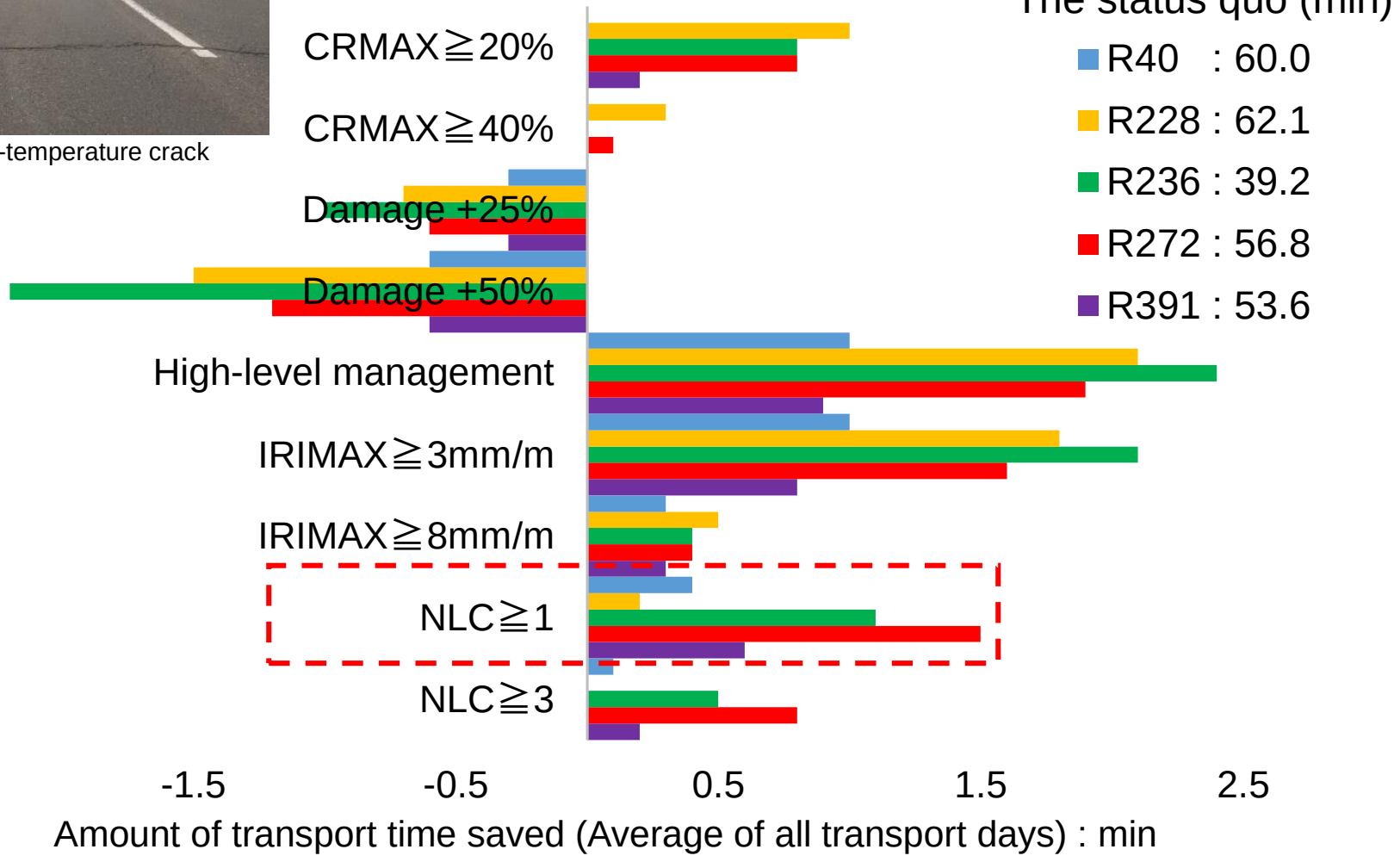


5. Impact of Pavement on Ambulance Driving

■ **Section with 1 or more low temperature cracks (*NLC*≧1)**

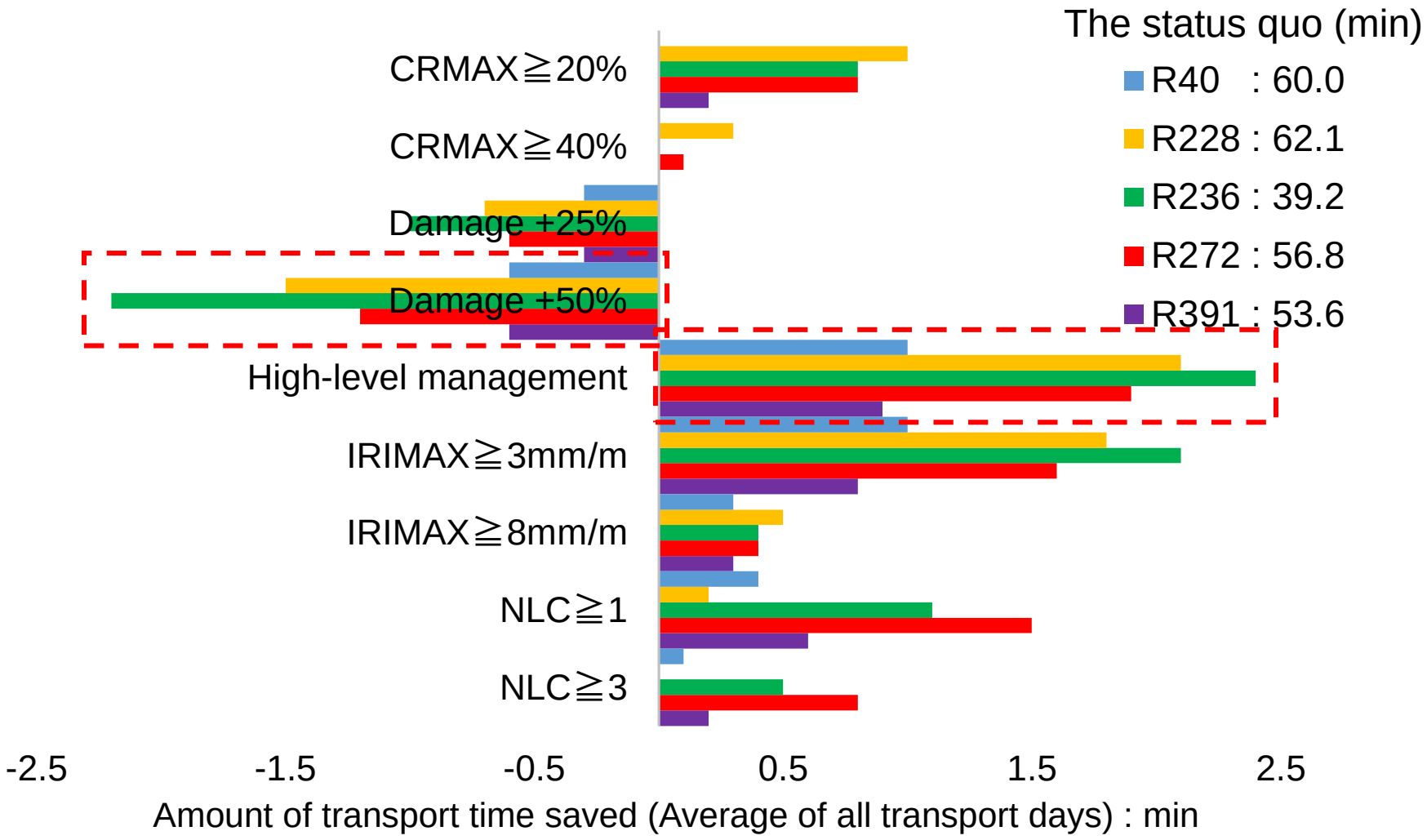
→ It is possible to shorten the time by about 2 minutes. (R272)

Example of low-temperature crack



5. Impact of Pavement on Ambulance Driving

■ Compare “**Damage +50%**” and “**High-level management**”
→ There are routes where about 4 minutes or more occur.



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6.1 Conclusion

- It was found that long-distance transports of 55-70 minutes took place about once every 3 days on the studied routes.
- It was found that road surface properties such as CR_{MAX}, IRI_{MAX}, and *NLC* affected the speed reduction.
- It was found that a simple repair of a -100m- section with 1 or more low-temperature cracks could shorten the time from the current condition by about 2 minutes.
- It was found that an increase of 1.5 times in the degree of damage caused an arrival delay of about 4 minutes or more compared to the case with a high level of road surface management

6.2 Future works

- Analysis of the effect of pavement repair on reducing vehicle vibration.
- A cost-benefit analysis using population and emergency transport frequency projection data.
- Analysis of pavement repair and transport route optimization for emergency transport in urban areas.

Thank you for your attention

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