EGU General Assembly 2020 | Online | 4–8 May 2020

Heat-wave health impacts forecasting model in Korea: development and evaluation

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Introduction

Heat-waves have become one of the most important health problems worldwide due to the urbanization and climate change. Severe temperature events are affecting human health such as ischemic stroke, ischemic heart disease, acute myocardial infarction, angina pectoris, heat-related illness, and even mental illness. The number of heat-waves in Korea has increased gradually (Choi and Kwon, 2005) and the highest temperature in summer was recorded in in 2018 since 1880 (Chae et al., 2018). Early warning of the impacts of Heat-waves has become very important to reduce health damage. Heat-wave impacts depend not just on weather such as temperature and humidity but by socio-economic contexts, including age, occupation, income, household type (Park et al., 2019). Therefore, a heat-wave impact forecasting system in consideration of socio-economic conditions is required. This study developed a Heat-wave health impacts forecast model by considering socio-economic characteristics in Korea. In addition, this study evaluated the developed forecasting model.

Data & Methods

This study used health and meteorological data from 2011 to 2017. For the health data, we used two different measures, the number of mortality and the number of emergency department visits (EDV) with heat-wave related diseases (respiratory diseases, cardiovascular diseases, trauma, infectious diseases, mental and behavioral disorders). Those numbers were obtained from the National Statistical Office and the National Health Insurance Corporation, respectively. For meteorological data, we used temperature and humidity data, which were interpolated at 1 km spatial resolution.

Table 1. Population of 2018 and average maximum temperature during the 2011 - 2017 summer (JJA) in the study area.

Region	Pop. (10,000)	Temp. (℃)
SIG (Seoul, Incheon, and Gyeonggi)	2,543	28.7
GW (Gangwon)	153	26.8
CB (Chungbuk)	159	28.7
DSC (Daejeon, Sejong, and Chungnam)	389	28.6
DGB (Daegu and Gyeongbuk)	512	28.9
JB (Jeonbuk)	183	28.6
GJN (Gwangju and Jeonnam)	333	28.6
BUG (Busan, Ulsan, and Gyeongnam)	793	28.0
JJ (jeju)	66	27.3

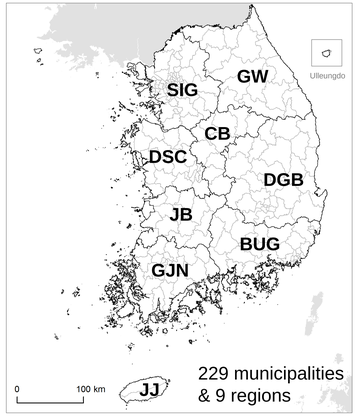


Figure 1. Study area.

Development of the Heat-wave warning levels

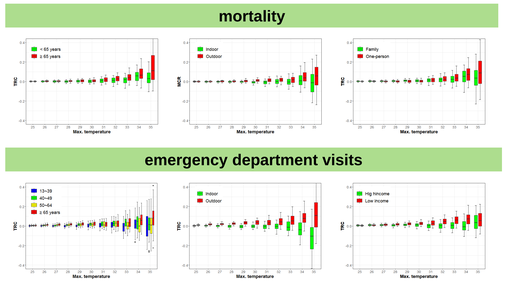


Figure 2. The TRC results of mortality and morbidity according to socio-economic conditions in 229 municipalities.

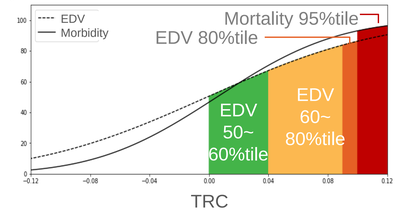


Figure 3. Classification of warning levels considering the cumulative distribution function of TRCs of mortality (non-chronic diseases) and emergency room visits (13~39 ages).

We analyzed the health impacts of heat-wave on health by age, type of work, and income. In addition, we analyzed the weighted effects of humidity on health. The results of Temperature Response Coefficient (TRC) showed age over 65, outdoor workers and low-income groups are relatively vulnerable to heat-wave. The calculation method of TRC is similar to the mortality change rate of Park et al.(2019) Moreover, high relative humidity was a factor that increased the risk of mortality for the population of age over 65. Based on the analysis results, we categorized warning level to 5 levels (from 0 to 4), level 0 means low risk and level 4 means high risk. Figures 2 through 5 show the process of classifying the warning levels from analyzing the health effects of heat waves for 229 municipalities. Warning levels were classified by considering the increased risk of disease and mortality with temperature. We developed warning levels for three different groups, the general public, the elderly, and the outdoor workers.

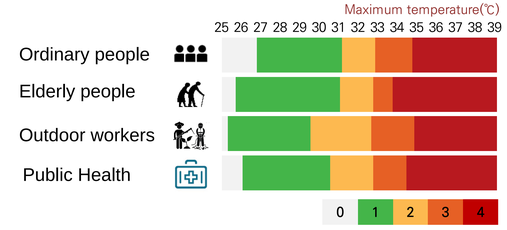


Figure 4. Criterions at each warning level for 229 municipalities. The criterion of public health uses the average of different groups.

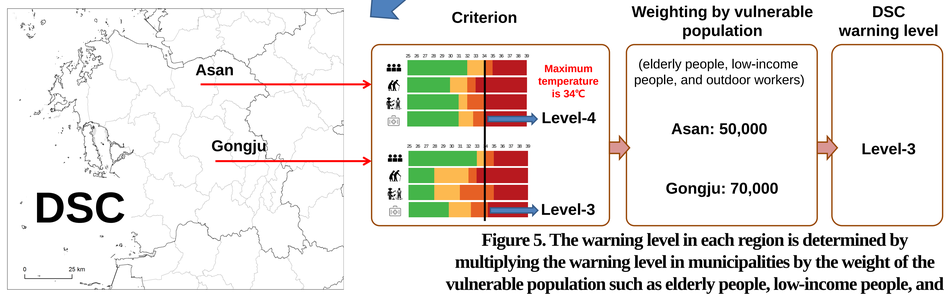
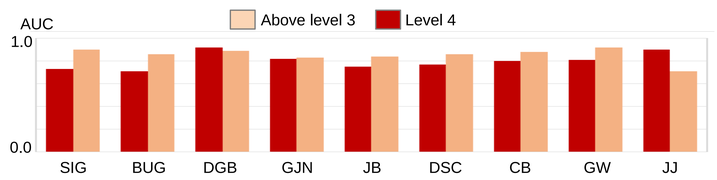


Figure 5. The warning level in each region is determined by multiplying the warning level in municipalities by the weight of the vulnerable population such as elderly people, low-income people, and outdoor workers.

Evaluation using AUC

The performance of the model measured based on the area under the curve (AUC) by using 2018 Heat-related illness (HRI) monitoring data obtained from the Korea Centers for Disease Control. In the assessment for the risk level 4, the AUC ranged from 0.71 to 0.92, with an average of 0.80. The AUC value of above the risk level 3 also ranged from 0.71 to 0.92, with an average of 0.85.



Forecast Success Criteria
Level 4 : A death occurred in heat-related illness or the 99%tile of patients with heat-related illness occurred.
Above level 3 : A death occurred in heat-related illness or the 75%tile of patients with heat-related illness occurred.

Figure 6. AUC evaluation results for 2018 forecast of heat wave impact in each region

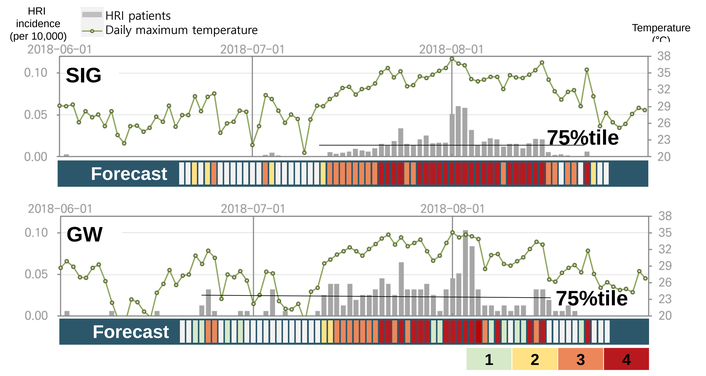


Figure 7. Daily comparison of impact forecast and the occurrence of HRI patients in SGI and GW

Conclusion

These results indicate that the health impact forecasting model suggested in the study is applicable as an operational forecast model. The results are expected to be used to develop a heat-wave early warning system in Korea.

Acknowledgments

This work was funded by the Korea Meteorological Administration Research and Development Program under Grant KMI (KMI2018-01410).

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