Development of a predictive model for long-term cardiovascular disease risk after the Great East Japan Earthquake: The Fukushima Health Management Survey

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Background

►The nuclear accident caused by the Great East Japan Earthquake led to the prolonged evacuation of residents.

►Evacuation severely hampers quality of life, causing physical and psychological stress for the evacuees.

(M. Harigane, et al., Int. J. Disaster Risk Reduct. 2021)

►The incidence of cardiovascular disease (CVD), a leading causes of disaster-related death, increased after the disaster.

(S. Sato, et al., Int. J. Disaster Risk Reduct. 2023)

►Early identification of high-risk evacuees is essential to prevent disaster-related death

<Suita CVD risk score >

		score
Sex	Men	4
Age	30–39	0
	40–49	8
	50–59	14
	60–64	18
	65–69	22
	70–74	26
	75–79	29
Blood pressure	SPB < 120 mmHg and DPB < 80 mmHg	−4
	⇒Long-term CVD risk score (for normal time)	0
		3
	SPB ≥ 160 mmHg or DPB ≥ 100 mmHg or receiving antihypertensives	6
Non HDL-cholesterol /LDL-cholesterol	Non-HDL-C < 170 mg/dL and LDL-C < 140 mg/dL	0
	Non-HDL-C ≥ 170 mg/dL or LDL-C ≥ 140 mg/dL	2
HDL-cholesterol	HDL-C < 40 mg/dL	0
	HDL-C = 40–59 mg/dL	−2
	HDL-C ≥ 60 mg/dL	−4
Smoking	Yes	4
Diabetes Mellitus	Yes	7
Urinary protein	1+ or more	2

M. Nakai, et al., J. Atheroscler. Thromb. 2020.

<AFHCHDC7 risk score>

		score
Age	≥ 75 years	1
Family	Death or hospitalization (partner, parents, or children)	1
House	Completely destroyed	1
Community	Completely destroyed	1
Hypertension	Positive (under medication, or SBP > 160 mmHg)	1
Diabetes mellitus	Positive	1
History of CVD	Positive (coronary artery disease, stroke, heart failure)	1

K Kario, et al., Circ J. 2012.

⇒Short-term CVD risk score (for post-disaster)

Objective

To explore new potential predictors for developing long-term CVD risk scores for evacuees.

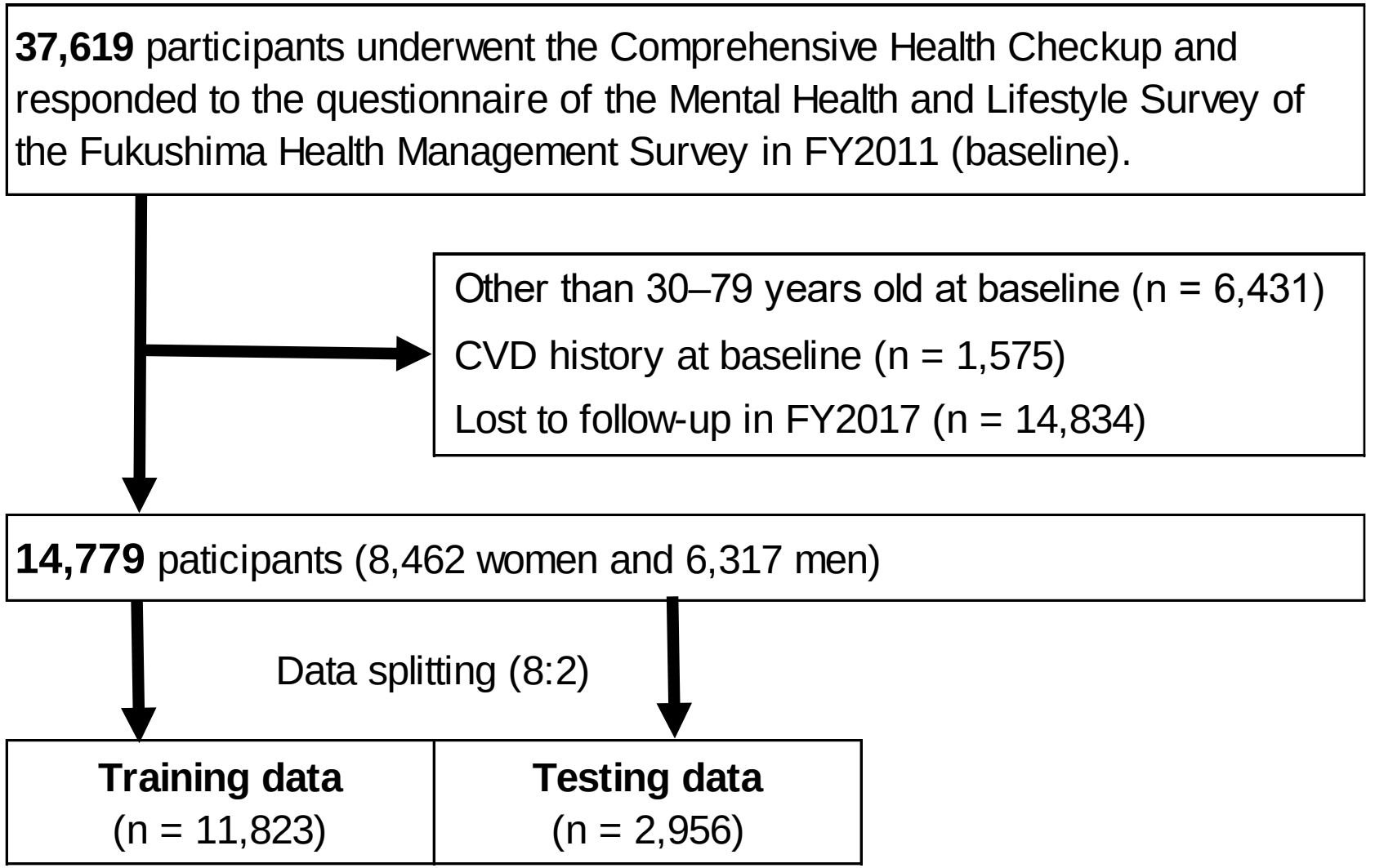
►A Japanese evacuation area residents database was used.
⇒Fukushima Health Management Survey

(M. Yasumura, J. Epidemiol. 2012)

►The analysis utilized three different methods, including machine learning-based method.

Methods

- Flow chart of the selection of the participants



►Prediction model construction

- Survey period: 6 years
- Outcome: CVD onset (myocardial infarction and stroke) or death caused by CVD
- Covariates: Gender, age, medical history, smoking status, alcohol habit, exercise habit
- Predictive models※: Stepwise, Random forest, L1-regularized logistic regression analysis

※These methods are also used for variable selection.

※Data were separated for training and testing; training data were constructed using a 10-fold cross-validation method after under-sampling.

►Model performance evaluation

- Area under the curve (AUC) : Compare with Suita CVD and AFHCHDC7 risk scores

►Software: Python

Results

Factors		Stepwise (Coefficient)	L1 regularized logistic regression (Coefficient)	Random forest (Feature Importance)
Sex	Men	0.621	0.518	0.029
Age	30–39	Reference	Reference	0.090
	40–49		-0.282	0.064
	50–59	0.934		0.012
	60–64	1.211	0.153	0.002
	65–69	1.356	0.127	0.002
	70–74	1.827	1.056	0.054
	75–79	2.334	1.451	0.166
Body mass index (BMI)	Standard (18.5 ≤ BMI ≤ 25)	Reference	Reference	
	Lean (BMI < 18.5)		0.029	
	Obesity (BMI > 25)			0.000
Hypertension	No	Reference	Reference	0.071
	Yes	0.293	0.469	0.141
Diabetes mellitus	No	Reference	Reference	0.021
	Yes	0.338	0.355	0.011
Hyperlipidemia	No			0.005
	Yes		0.116	0.008
Renal dysfunction	No	Reference	Reference	0.000
	Yes (Including renal failure/hemodialysis)	0.292		
Liver dysfunction	No	Reference	Reference	
	Yes (Including hepatic cirrhosis and liver failure)		0.191	0.002
Cardiovascular disease	No	Reference	Reference	0.076
	Yes (Angina pectoris, myocardial infarction, heart failure, stroke)	0.602	0.613	0.041
Family history of cardiovascular disease	No	Reference	Reference	0.007
	Yes (Heart disease, stroke)		0.096	0.001

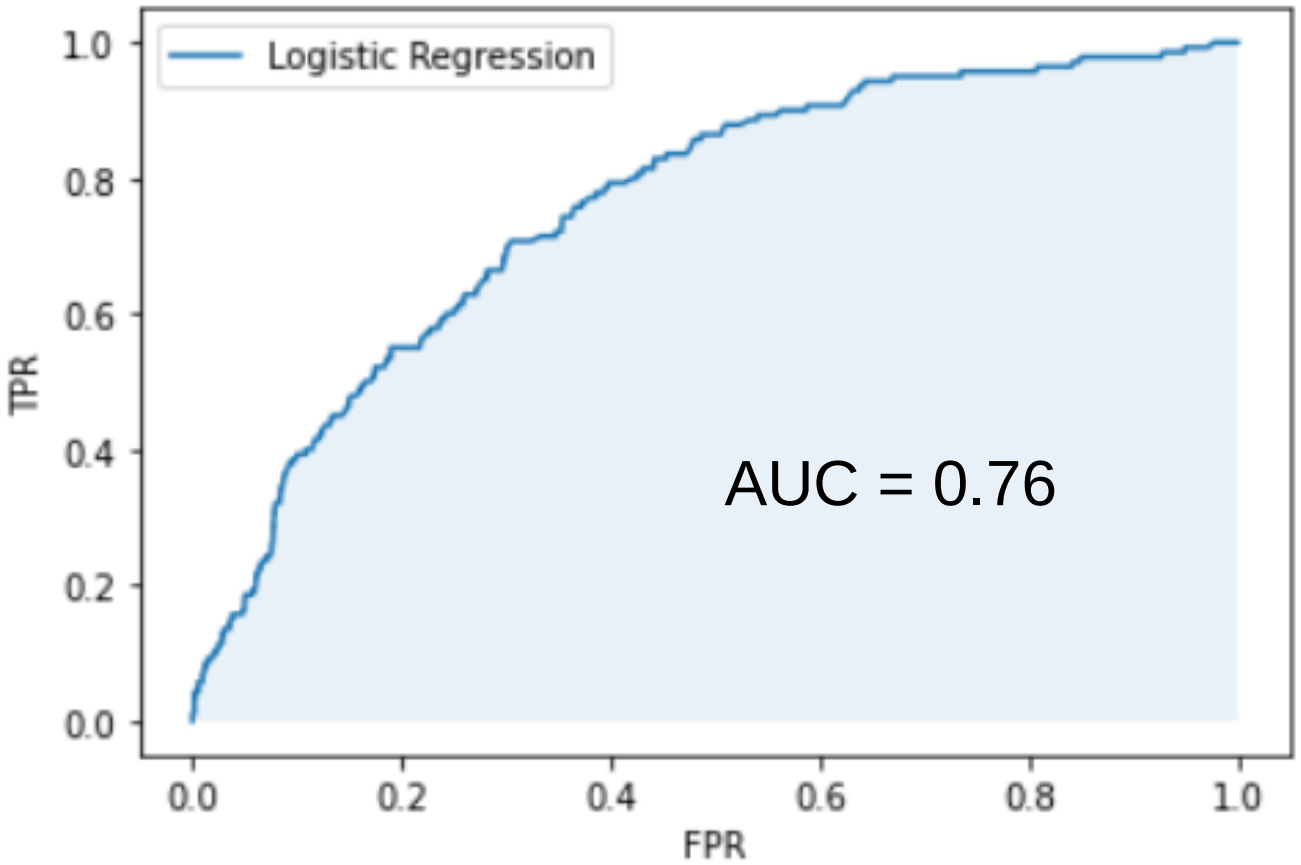
Drinking habit	Never drinks or rarely drinks	Reference	Reference	0.002
	Former drinking			
	Drink at least once a month / no heavy drinking		-0.017	
	Drink at least once a month / heavy drinking			
Smoking habit	Never smoked	Reference	Reference	0.002
	Former smoking			0.006
	Current smoking	0.309	0.066	0.001
Exercise habit				
Sleep satisfaction				
Subjective health status				
Psychological distress				
PTSD symptoms				
Evacuation				
Family death				
House damage	No	Reference	Reference	
	Yes (Partially destroyed)		-0.002	
	Yes (Half destroyed)			0.0003
	Yes (Large-scale partially destroyed)			
	Yes (Completely destroyed)		-0.013	0.0003

▶Common factors extracted across the three methods

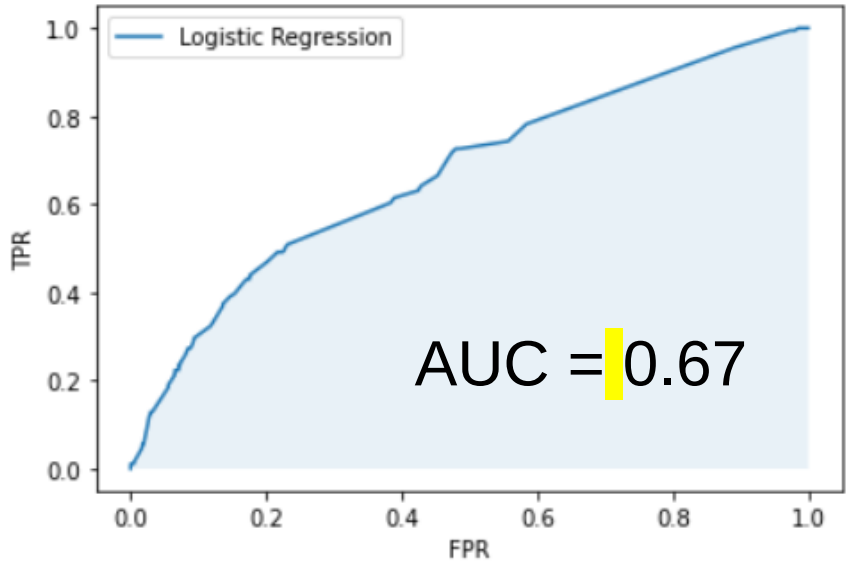
- Sex
- Age
- Smoking status
- Medical history (hypertension, diabetes mellitus, CVD)
- Sleep quality
- Subjective health status
- Post- traumatic stress disorder (PTSD) symptoms

►AUC results of test data

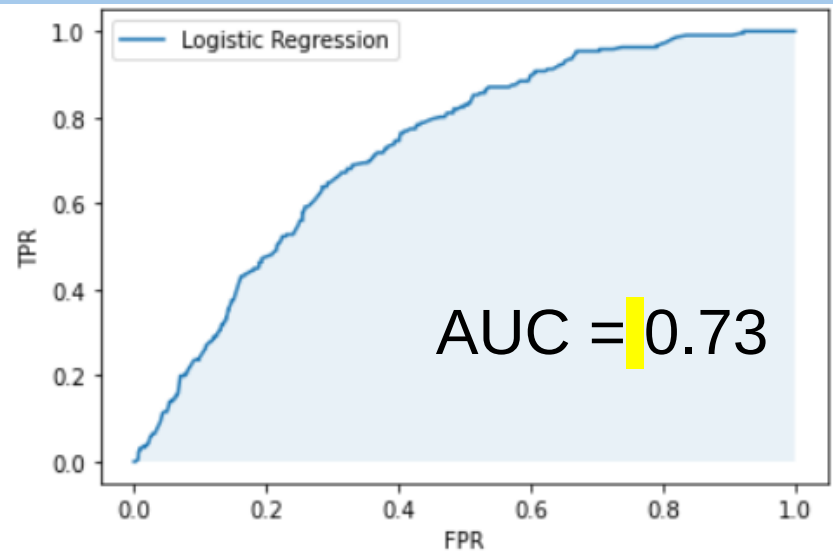
New model (consisting of common factors)



AFHCHDC7 risk score model



Suita CVD risk score model



Discussion

►Three algorithms (stepwise, random forest, and L1-regularised logistic regression analysis) were used to extract critical predictors of CVD incidence (sleep quality, PTSD symptoms, and subjective health status).

►Sleep disturbance is a hallmark symptom of PTSD and a well-established risk factor for the development of CVD.

(C Meinhausen, et al., Health Psychol. 2021)

►Subjective health status is correlated with CVD risk in pre-diabetic and diabetic patients. *(Kwak S, et al., Int J Environ Res Public Health. 2022)*

►These factors are not included in conventional scores and may be as useful in predicting CVD after a disaster.

►Our final objective is to develop a more accurate long-term post-disaster CVD risk score. This score would require no laboratory data and can be useful in preventing disaster-related deaths in evacuees. The factors extracted in this study would be candidates for this score item.

►The external validity of these factors should also be confirmed in other evacuee data.

Conclusion

Using methods including machine learning, variable selection was used to extract common sleep quality, PTSD symptoms, and subjective health status.

These factors are candidate items for long-term CVD incidence prediction scores.