CHIME2 (Chinese Hong Kong Integrated Modeling and Evaluation): An Updated Model to Simulate Lifetime Health Outcomes of Patients with Type 2 Diabetes

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Background

Most existing predictive models for type 2 diabetes have been developed and validated using historical data from European populations, which may not be suitable for East Asian populations due to differences in epidemiology, risk factors, and complications associated with the disease.

To address these issues, we developed Chinese Hong Kong Integrated Modeling and Evaluation (CHIME), a patient-level simulation model for type 2 diabetes health outcomes in East Asian populations, based on data from prior to 2017.

Objectives

We updated the CHIME model incorporating recent patient data to refit models for mortality, complications, and time-varying progression of biomarkers. Hemodialysis was added as a new model outcome.

Methods

We updated the CHIME health outcome model using data from a population-based cohort of 96,360 individuals diagnosed with type 2 diabetes between 2013 to 2016 with follow-up until 2022 (mean follow-up: 5.9 years). For time to event outcomes, we tested exponential, Weibull, log-logistic, log-normal, Gompertz and logistic models with selection based on AIC. Equations were derived using parametric proportional hazard models except for mortality (logistic regression) and retinopathy (flexible parametric survival model). Biomarker progression models for glycated hemoglobin (HbA1c), estimated glomerular filtration rate (eGFR), systolic blood pressure, and low- density lipoprotein (LDL) cholesterol were derived using linear and logistic regression.

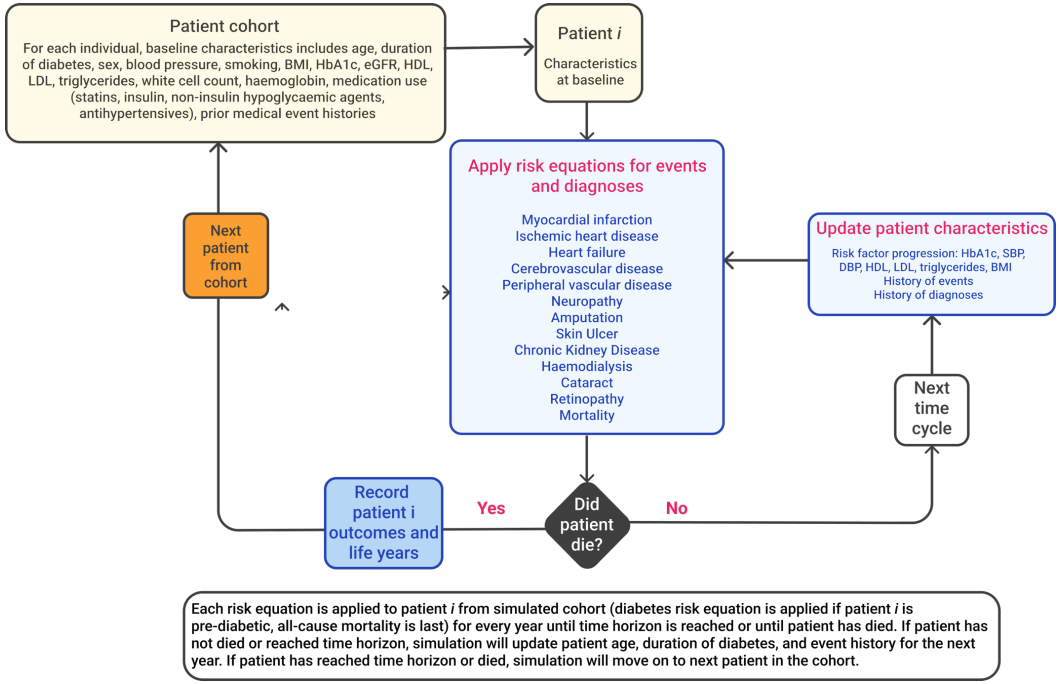

Figure 1. CHIME model schematic

Results

The updated CHIME2 simulation model comprised of 13 risk equations to predict mortality, microvascular, and macrovascular complications (myocardial infarction, ischemic heart disease, heart failure, cerebrovascular disease, peripheral vascular disease, neuropathy, amputation of lower limb, ulcer of skin, chronic kidney disease, retinopathy, and cataracts). The original CHIME model underestimated mortality. The improved CHIME2 model developed updated mortality and time-varying risk factors (biomarkers) risk equations.

Outcome	Events (n)	Distribution	Model	Events (n)	Follow-up (person-years)	Rate (per 100,000 person-years)	Distribution
Mortality	24,147	Logistic	Mortality	9,878	397,617	2,484.30	Log-logistic
Myocardial infarction	3,520	Log-log	Myocardial infarction	2,270	392,119	578.91	Log-normal
Ischemic heart disease	9,260	Log-log	Ischemic heart disease	4,265	368,246	1,158.19	Log-normal
Heart failure	4,107	Log-log	Heart failure	3,237	382,439	846.41	Log-logistic
Peripheral vascular disease	1,208	Log-log	Peripheral vascular disease	865	393,719	219.70	Log-normal
Neuropathy	1,767	Log-log	Neuropathy	457	395,473	115.56	Weibull
Amputation	35	Log-log	Amputation	242	396,878	60.98	Log-normal
Ulcer of skin	1,588	Log-log	Ulcer of skin	995	395,374	251.26	Log-normal
Renal failure	4,921	Log-log	Renal failure	2,314	389,957	593.40	Log-logistic
Cataract	9,094	Log-log	Cataract	7,010	373,473	1,876.98	Log-normal
Retinopathy	7,382	Gompertz	Retinopathy	2,802	384,035	729.62	Log-normal
Hemodialysis	856	Log-log	-	-	-	-	-
Cerebrovascular disease	-	-	-	4,363	382,132	1,141.75	Log-normal
Diabetes mellitus*	-	-	-	6,078	171,458	3,544.90	Log-normal

Table 1. Internal validation of CHIME prediction models.

Conclusions

The updated CHIME2 simulation model can be applied to assist health service planners and policymakers in decision-making, such as setting HbA1c, BMI, and lipid targets, to optimize health outcomes. Further validation is needed to assess the performance.

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