DEMOS: Demographic Epidemiological Model Of Singapore

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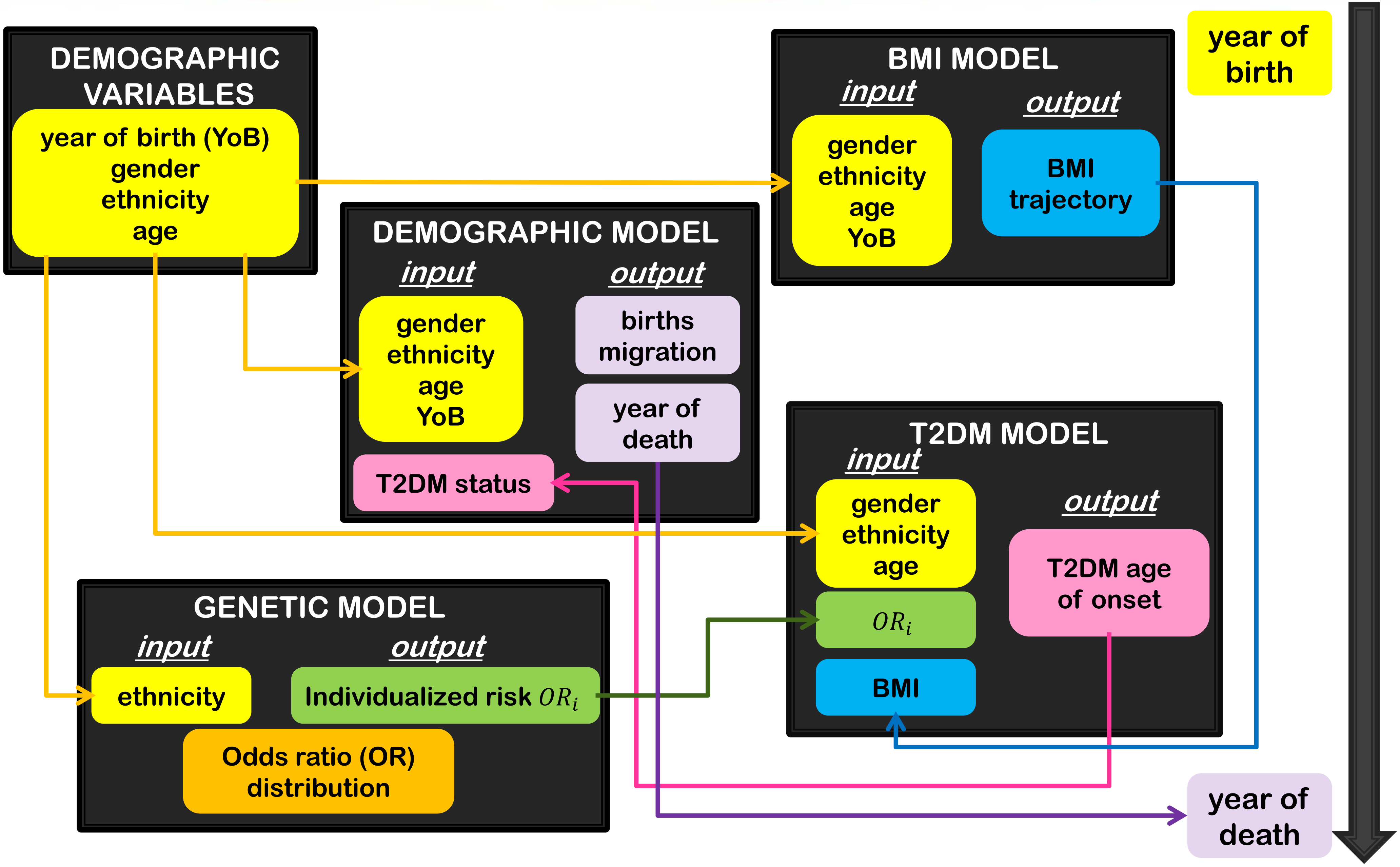
OVERVIEW OF DEMOS



DEMOGRAPHIC DATA

SINGSTAT published data (1990-2010)

- Census
- Number of residents by 5-year age groups, race and sex
- Mortality rates and fertility rates by 5-year age groups
- Life-table (2003-2010)
- Number of deaths (including foreigners)
- TFR in 3 main races
- Crude birth and death rates by race

MORTALITY SUBMODEL

<u>For age 0-84 (IMPROVED MODEL)</u>

Lee-Carter model

$$\tau_{g,a}(t) = \tau_{g,a}(t-1) + \delta_t \times \gamma_a$$

Assume that γ_a is the same within each 5-year age group and δ_t is random walk with drift

MORTALITY SUBMODEL

For older age (a>85)

Coale-Kisker extrapolation method:

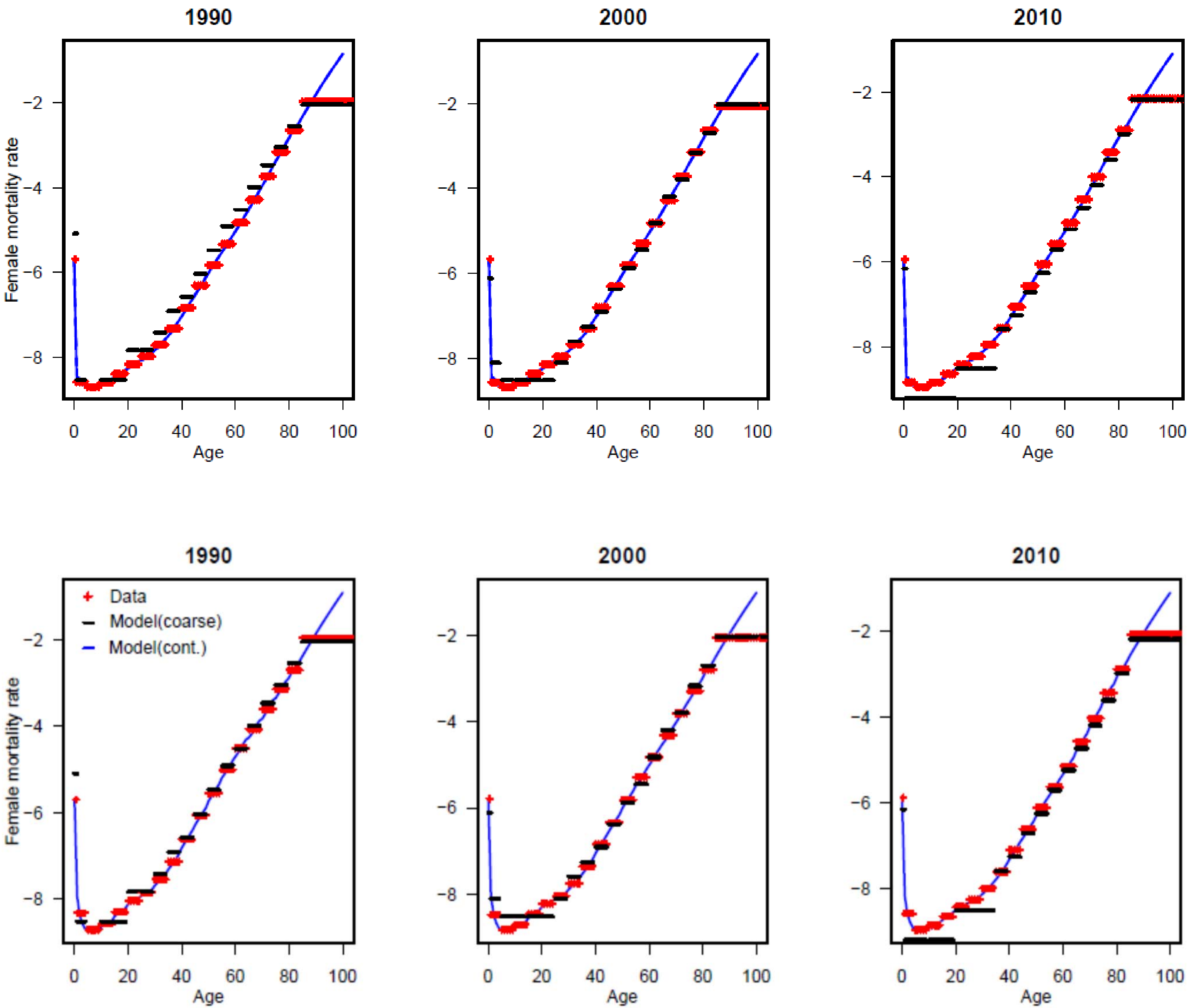
$$\kappa_{g,a} = \tau_{g,a}(0) - \tau_{g,a-1}(0)$$
$$\kappa_{g,a+1} = \kappa_{g,a} - R_g$$

Solving for R yields:

$$R_g = \frac{36 \times \kappa_{g,84} + \tau_{g,84}(0) - \tau_{g,120}(0)}{666}$$

Replace $\kappa_{g,84}$ with moving average of $\kappa_{g,82}$ to $\kappa_{g,86}$

$$R_g = \frac{\frac{37}{5} \times (\kappa_{82} + \kappa_{83} + 3 \times \kappa_{84}) + ln\left(\frac{\mu_{g,82}(0) + \mu_{g,83}(0) + \mu_{g,84}(0)}{3}\right) - ln\big(\mu_{g,120}(0)\big)}{666 + \frac{37 \times 3}{5}}$$



1990
2000
2010
Female mortality rate
Age
Data
Model(coarse)
Model(cont.)

Race-specific mortality rate

Proportional to mortality rate of total population

$$\mu_{g,a}^{r}(t) = e^{\theta_{\mu,r}} \times \mu_{g,a}(t)$$

With $\theta_{\mu,Chi} = 0$; $\theta_{\mu,Mal} \sim N(0.33, 0.25)$;

$\theta_{\mu,Ind} \sim N(0.87, 0.23)$ (informative prior from

literature (Ma et al. 2003))

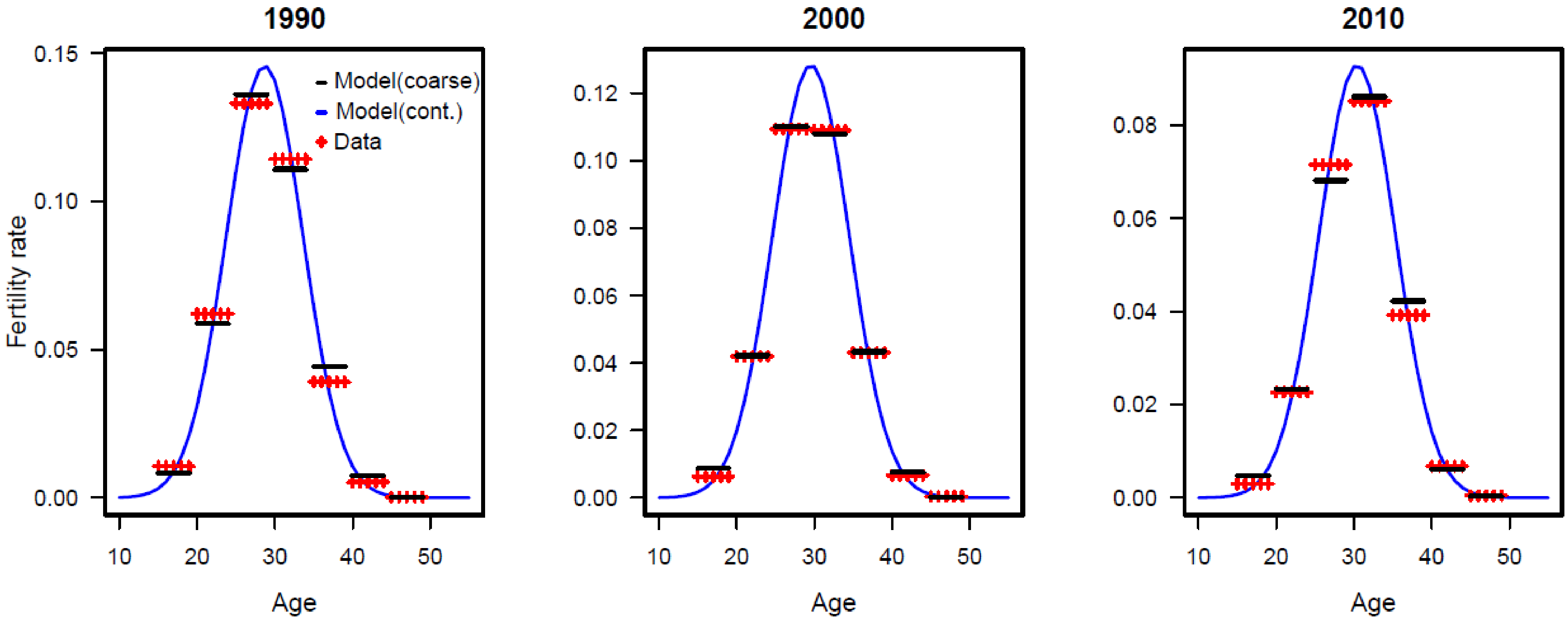
FERTILITY SUBMODEL

Gaussian function with linear trend on peak age

$$f_a(t) = \theta_2 \times \left(\sum_{i=1}^{t} \theta_{3,i} \right) \times \frac{1}{\sqrt{2 \times \pi \times \sigma_f^2}} \times e^{\left(\frac{-[a-\mu+\theta_1 \times (t-1)]^2}{2 \times \sigma_f^2} \right)}$$

Secular trend on scale $\theta_{3,t}$ is random walk with drift

FERTILITY SUBMODEL



MIGRATION SUBMODEL

Alternative model – simplified migration schedule

$$m(x) = a_1 \times e^{-\alpha_1 x} + a_2 \times e^{-\alpha_2(x-\mu)-e^{-\lambda_2(x-\mu)}} + c$$

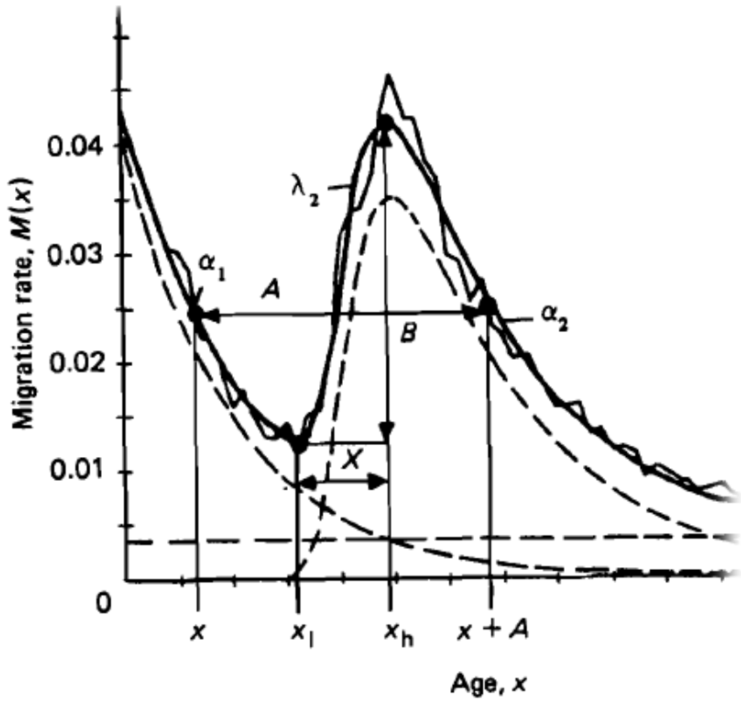
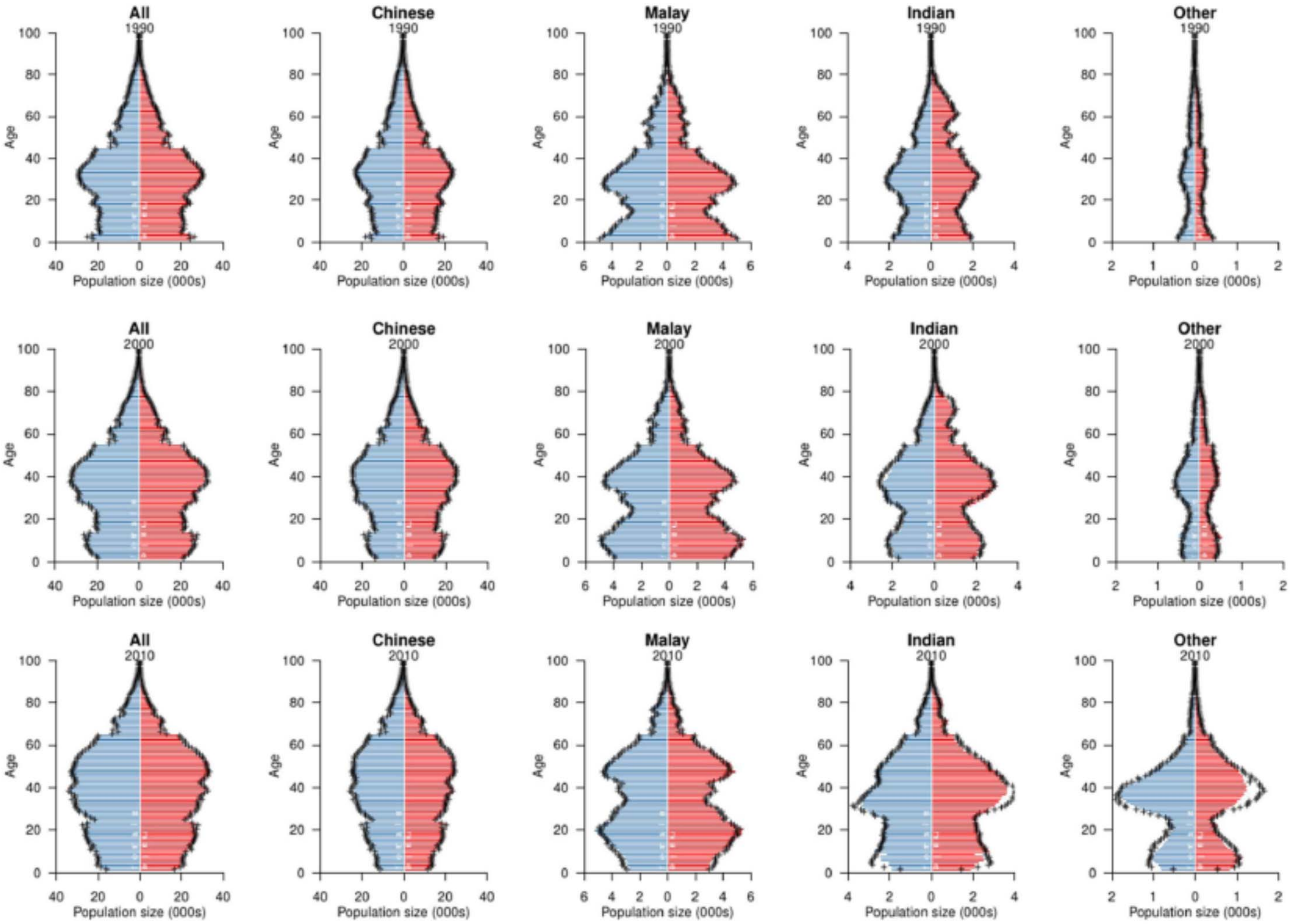


FIGURE 4 The model migration schedule.

Source from Roger & Castro (1981)

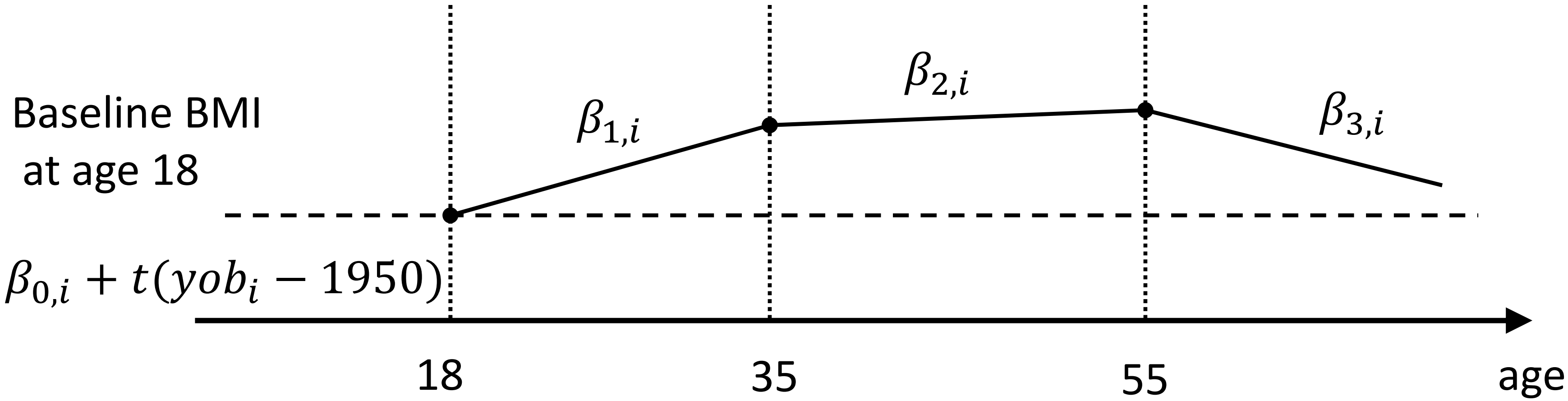

All
1990
Chinese
1990
Malay
1990
Indian
1990
Other
1990
All
2000
Chinese
2000
Malay
2000
Indian
2000
Other
2000
All
2010
Chinese
2010
Malay
2010
Indian
2010
Other
2010
Age
Population size (000s)

DATA

Year 1992	1998	2005-2007	2011-2013
NHS92 n = 1968 n(F) = 1966 n(O) = 1908		**SP2-NHS92** n = 1275 n(F) = 1228 n(O) = 47	**SP3-NHS92** n = 341 n(F) = 318 n(O) = 2
	NHS98 n = 2355 n(F) = 2352 n(O) = 2265	**SP2-NHS98** n = 1666 n(F) = 1641 n(O) = 60	**SP3-NHS98** n = 473 n(F) = 451 n(O) = 13
		MEC n = 528 n(F) = 501 n(O) = 10	**MEC-1** n = 512 n(F) = 510 n(O) = 11

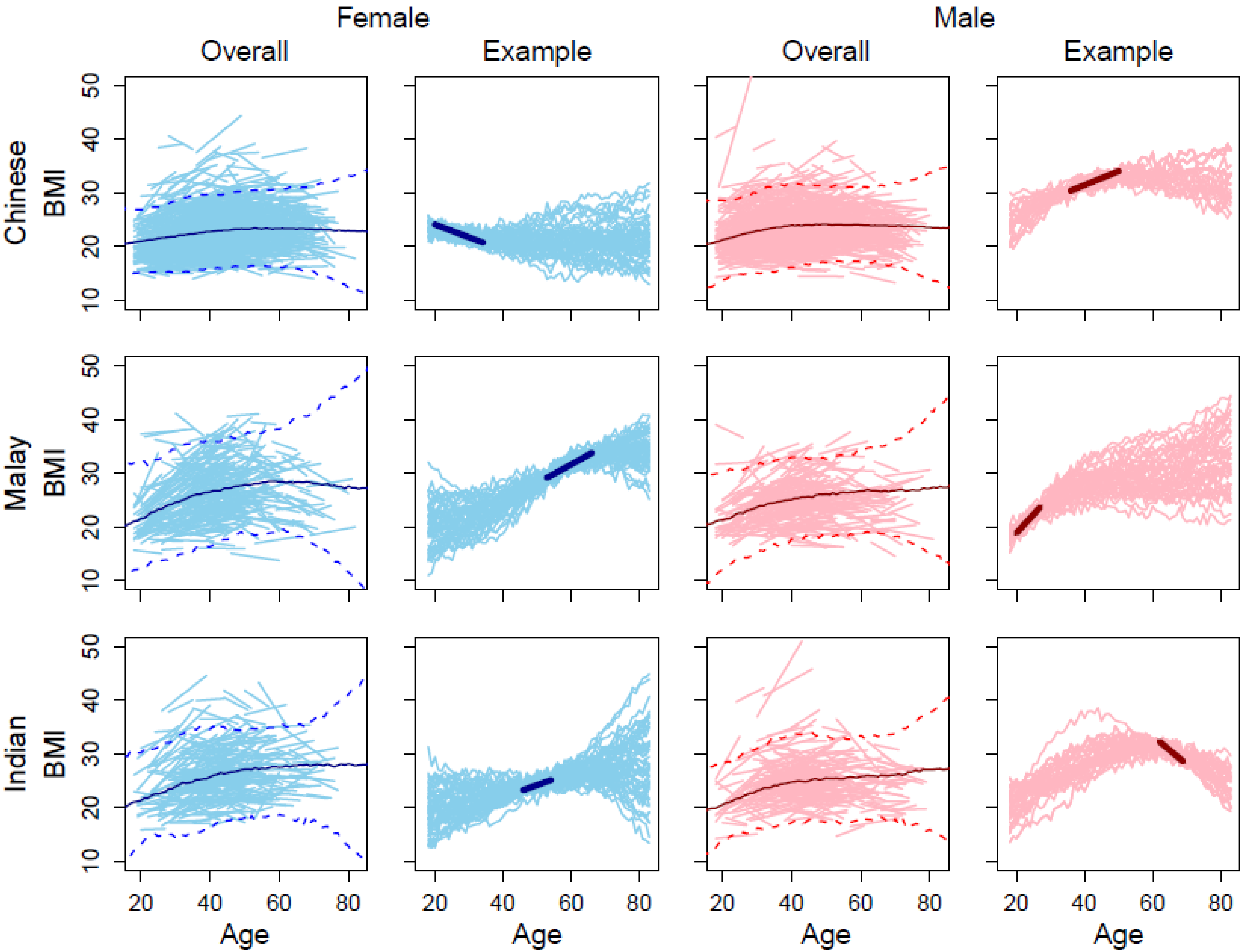
BMI trajectory

BMI model For each race and gender combination, we have:



Individual parameters $(\beta_{0,i}, \beta_{1,i}, \beta_{2,i}, \beta_{3,i})$ are derived from multivariate normal distribution:

$$\begin{pmatrix} \beta_{0,i} \\ \beta_{1,i} \\ \beta_{2,i} \\ \beta_{3,i} \end{pmatrix} \sim \mathrm{MVN}\left(\begin{pmatrix} \varphi_0 \\ \varphi_1 \\ \varphi_2 \\ \varphi_3 \end{pmatrix}, \Sigma \right)$$

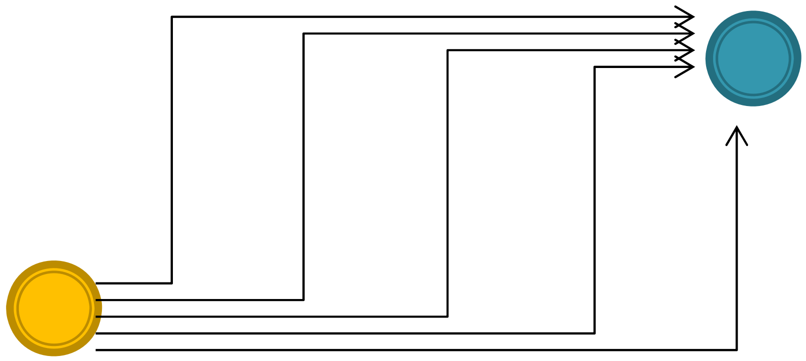


Female
Male
Overall
Example
Overall
Example
Chinese
Malay
Indian
BMI
10
20
30
40
50
20
40
60
80
Age

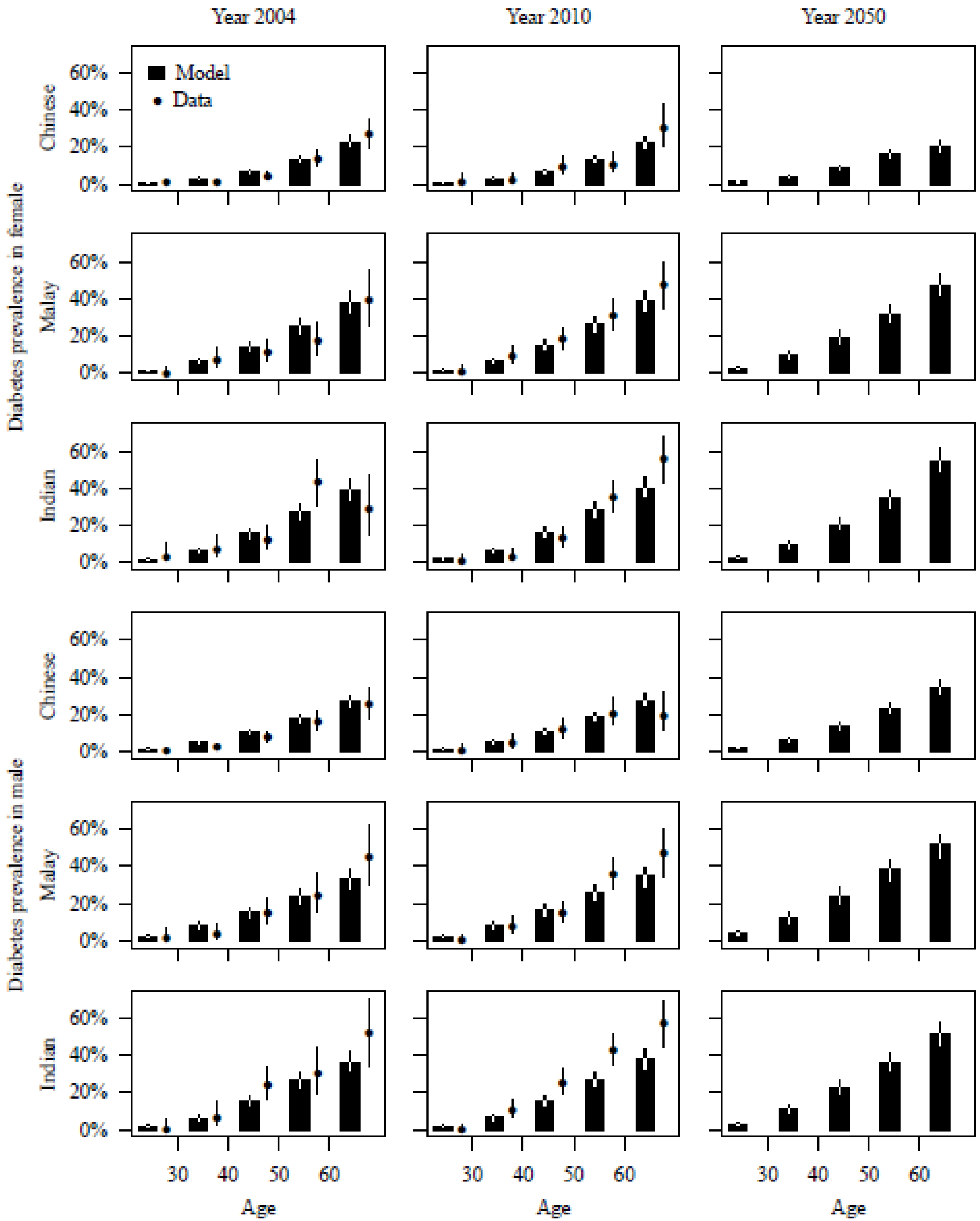
The diabetes model

Annual risk of developing (cryptic) DM, depends on:

- age
- race, sex
- genetic risk
- BMI that year



- Estimated from longitudinal data
- *Corrected* DM status accounts for differing tests



Year 2004
Year 2010
Year 2050
Model
Data
Chinese
Malay
Indian
Diabetes prevalence in female
Diabetes prevalence in male
0%
20%
40%
60%
30
40
50
60
Age