Risk of death at oldest ages

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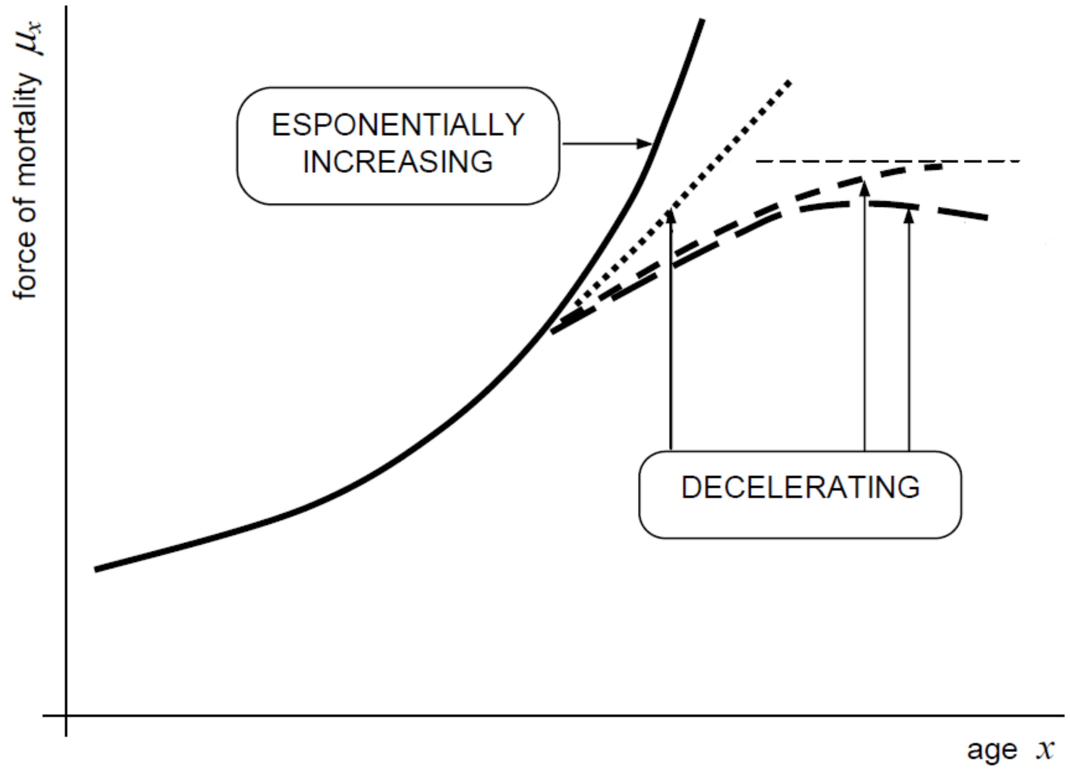
Research project: Mortality trajectory at oldest ages

- What could be the most **plausible** mortality trajectory at oldest ages?



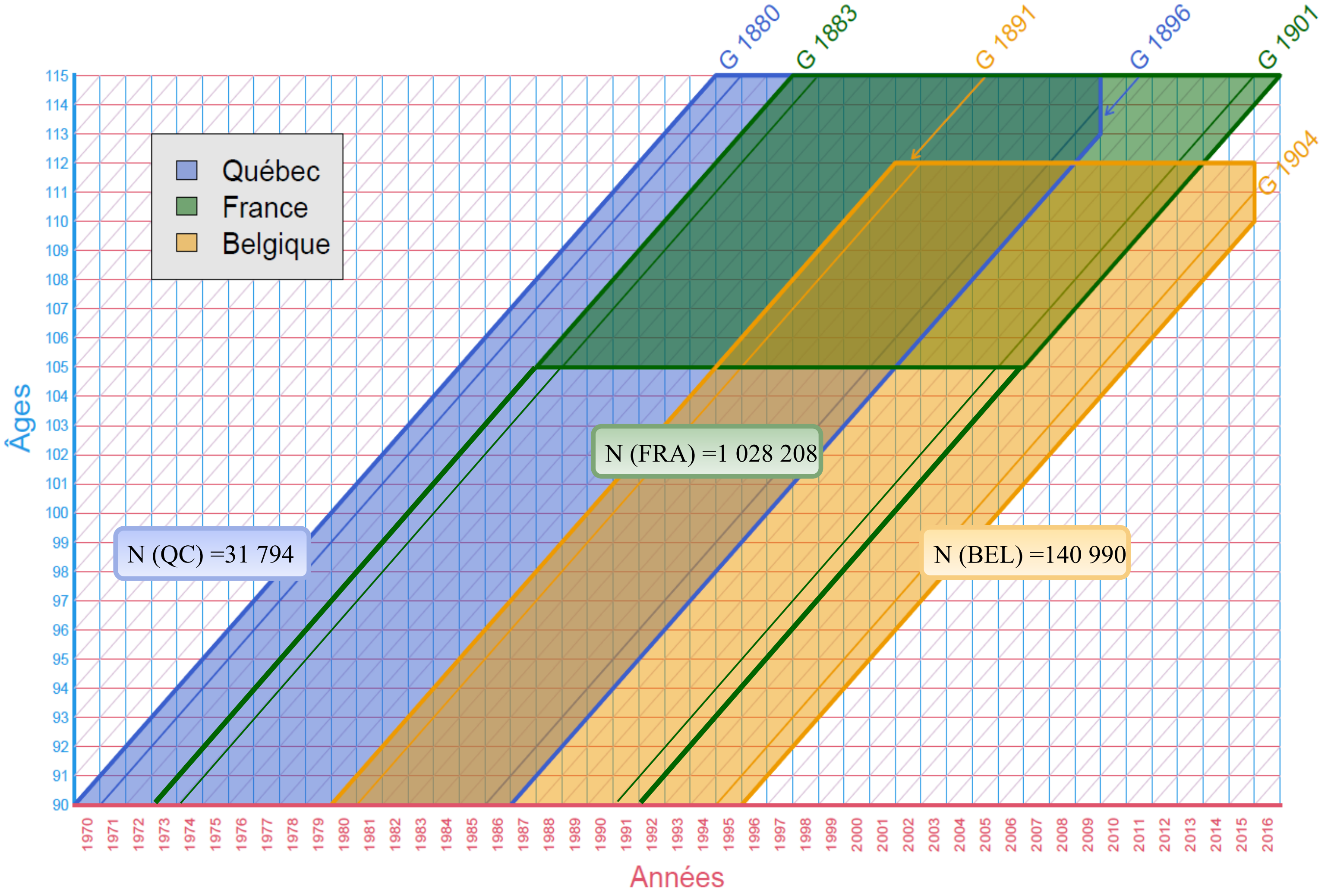
Source: Pitacco (2017)

→ *Reliable* data

→ *Coherent* statistical methods

→ *Adequate* evaluation criteria

Data



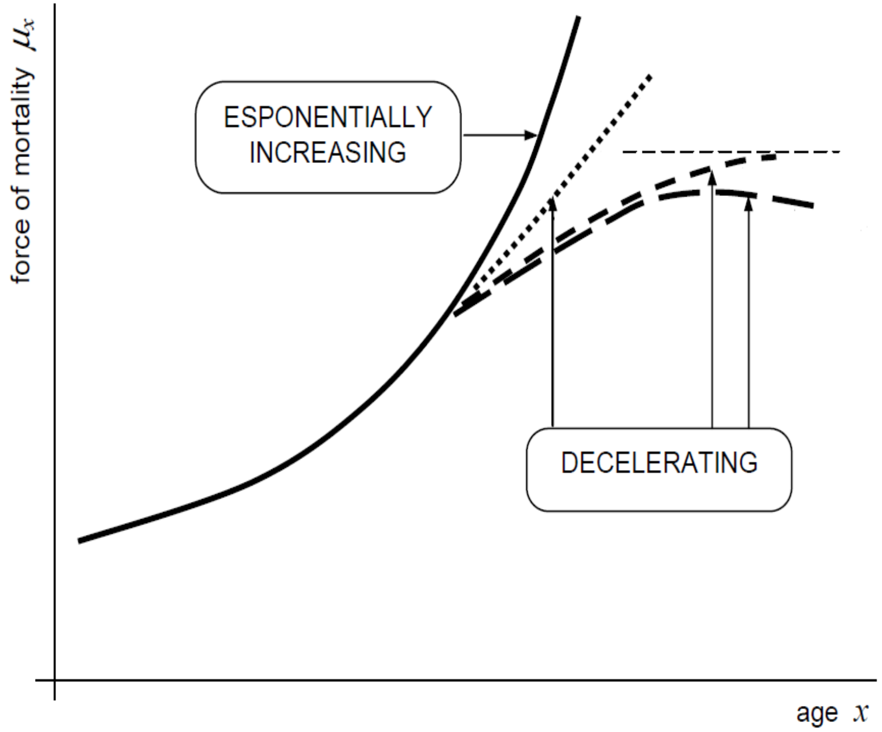
Exceptional data quality:

- ➢ Data collection
  → Exhaustive list of individuals
- ➢ Data validation
  → Accuracy of information
- ➢ Approach by extinct birth cohorts
  → Lessen the problems caused by truncation and censoring in data

➔ **8 datasets**

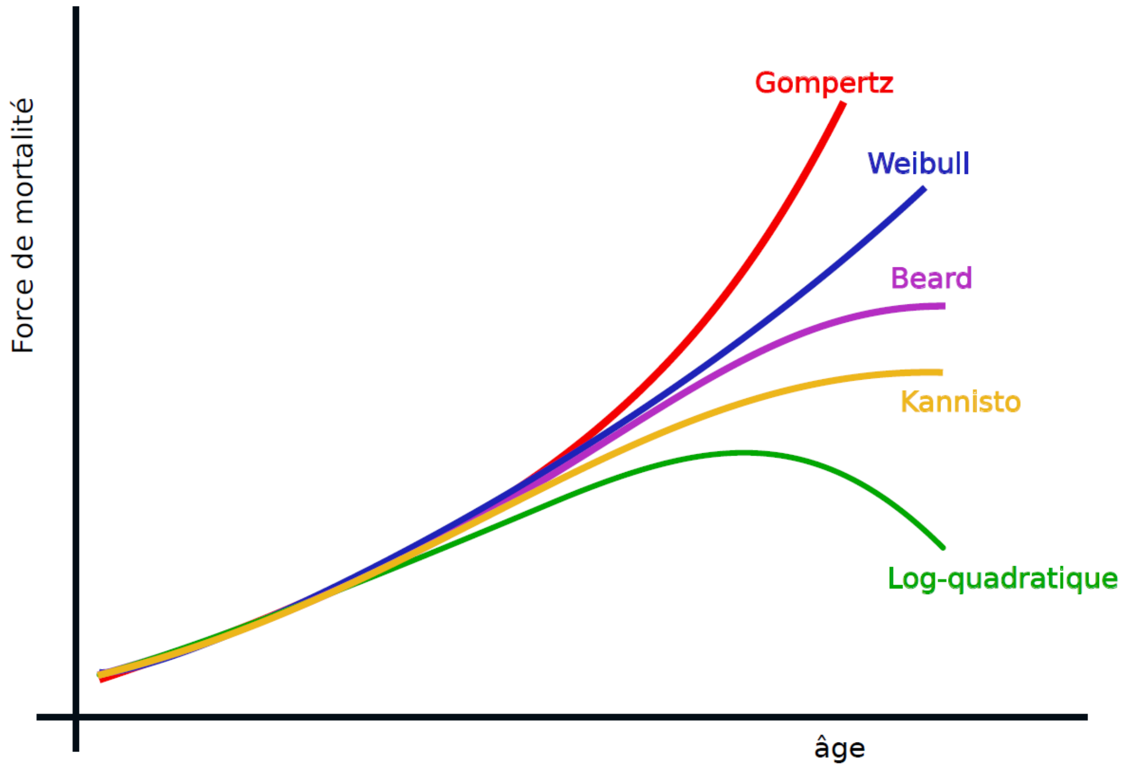
Methods (1/3) – Trajectory modelling

Mortality trajectories



Source: Pitacco (2017)

"Classic" parametric models



Methods (2/3) - Statistical analysis framework

Homogeneous population	Heterogeneous population	
	Unobservable heterogeneity	Observable heterogeneity
"Classic" models	Frailty models	Survival data analysis models
Aggregate data	Aggregate data	Individual data
- Validity of Poisson distribution - Plausible trajectory of population mortality	Plausible trajectory of individual mortality	- Existence of plateau - Impact of mortality determinants

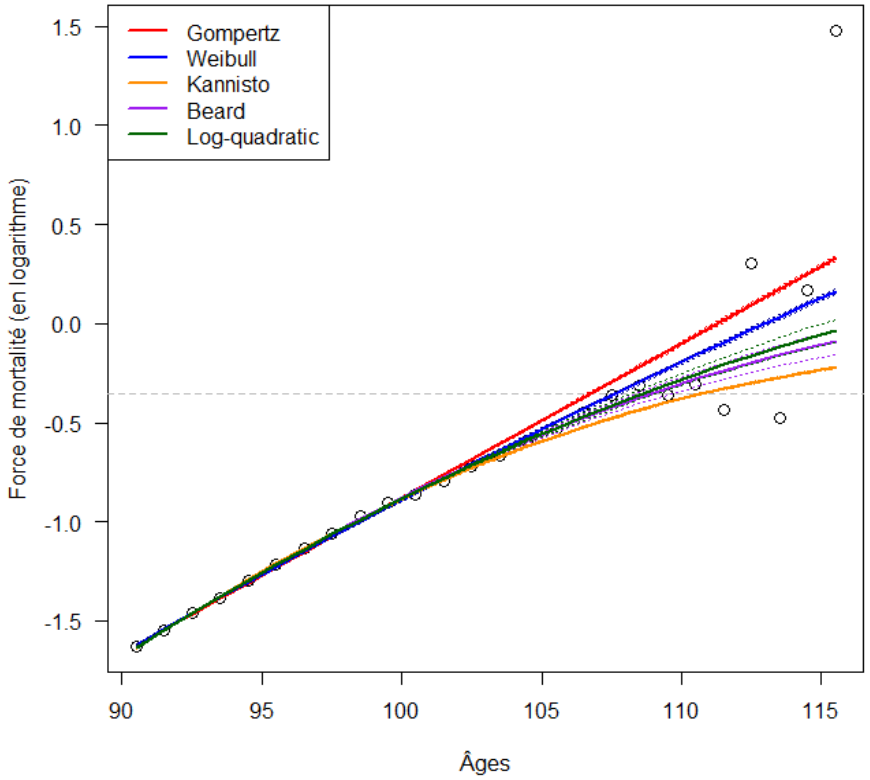
Methods (3/3) – Battery of evaluation tools

- Estimates precision: confidence intervals using delta method
- Estimates bias: deviance residuals
- Trade-off between goodness-of-fit and parcimony: AIC criteria, built on deviance residuals

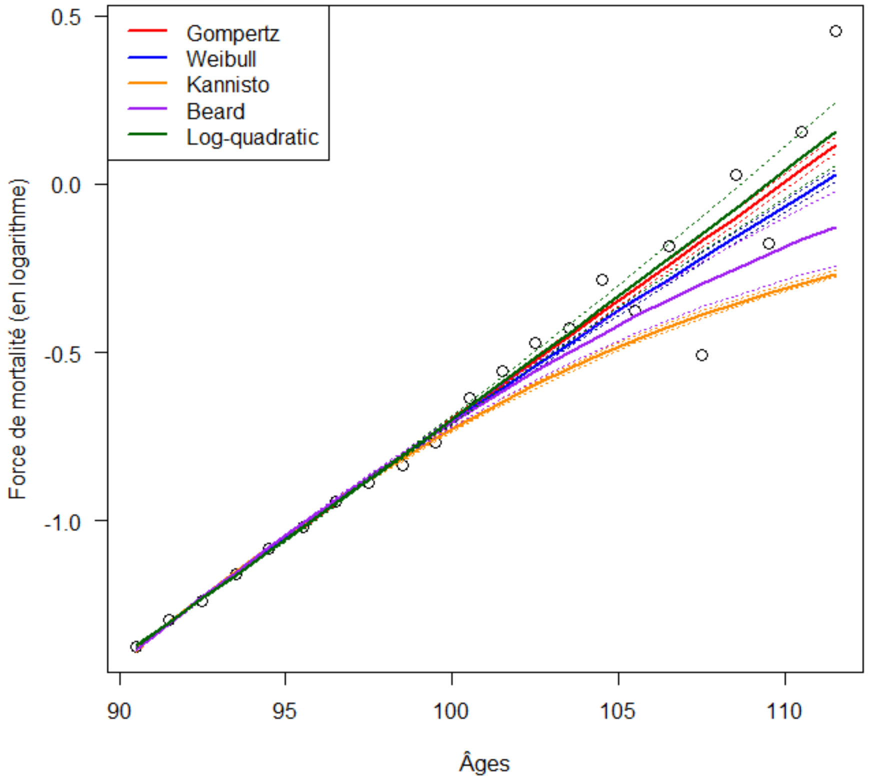
Results (1/3) – Mortality trajectory, homogenous population (90+)

- **Aggregate data, Poisson distribution:**

Females



Males



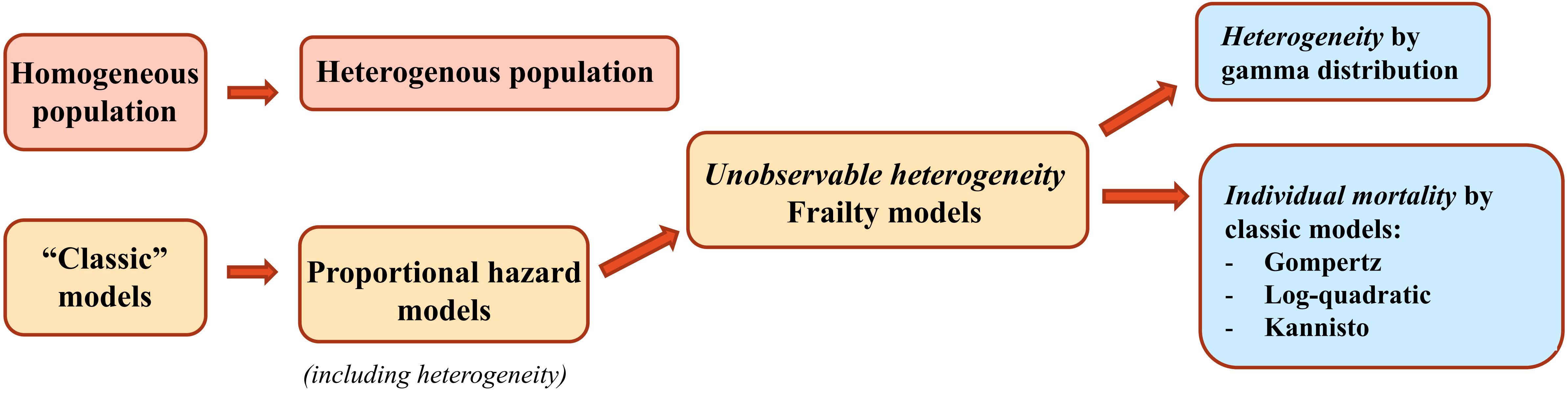
Onset of mortality deceleration after age of 100 for females

Kannisto model underestimates mortality above age 100

Mortality plateau higher than 0.7

- Under the assumption of **Poisson distribution**, **negative binomiale distribution** et **binomial distribution**:
  → quasi-totality of female populations: deceleration of mortality at oldest ages
  → majority of male populations: Gompertz model, exponential increase of mortality

Results (2/3) – Mortality trajectory, unobservable heterogeneity (90+)

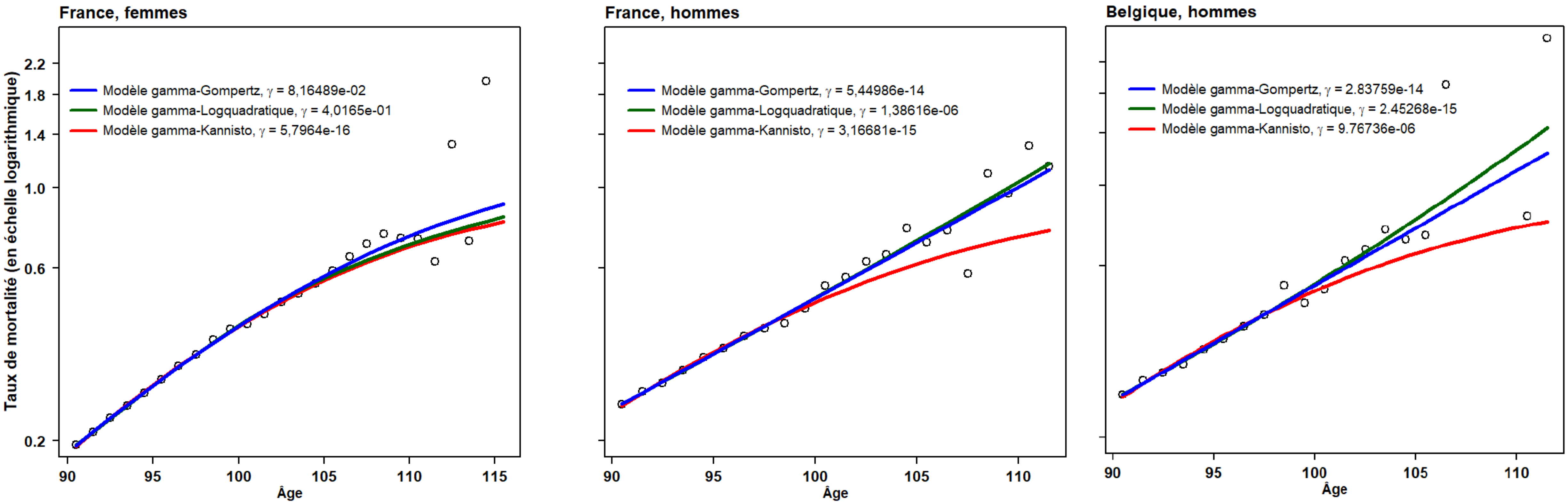


gamma-Gompertz model: $\bar{\mu}(x) = \dfrac{a\, e^{b\,x}}{1 + \gamma \frac{a}{b}(e^{b\,x} - 1)}$
(Vaupel et al., 1979)

gamma-logquadratic model: $\bar{\mu}(x) = \dfrac{\exp(a + bx + cx^2)}{1 + \gamma \int_{x_0}^{x} \exp\,(a + bx + ct^2)dt}$
(Horiuchi, 2003)

gamma-Kannisto model: $\bar{\mu}(x) = \dfrac{ae^{b\,x}/(1 + ae^{b\,x})}{1 + \gamma b \ln(ae^{b\,x} + 1)}$

Result (2/3) – Mortality trajectory, unobservable heterogeneity (90+)



- ➢ gamma-Gompertz and gamma-logquadratic models plausible, gamma-Kannisto model underestimates mortality
- ➢ Heterogeneity level of the population is very sensitive to the choice of individual mortality function → Challenge to use frailty models framework to explain the deceleration of mortality in a population through heterogeneity

Résultat (3/3) – Trajectoire de mortalité, hétérogénéité observable (105+)

Homogeneous population → **Heterogeneous populations**

"Classic" models → **Proportional hazard models**

(including heterogeneity)

→ ***Unobservable heterogeneity*** **Frailty models**
- ***Heterogneity*** **by gamma distribution**
- ***Individual mortality*** **by classic models**

→ ***Observable heterogeneity*** **Survival analysis models**
- ***Heterogeneity*** **by determinants (sex, cohort, population)**
- ***Individual mortality*** **by Gompertz baseline and constant baseline**

$$h(t_i) = a \quad \exp(\beta_1 C_i + \beta_2 M_i + \beta_3 P_{Bi} + \beta_4 P_{Qi})$$

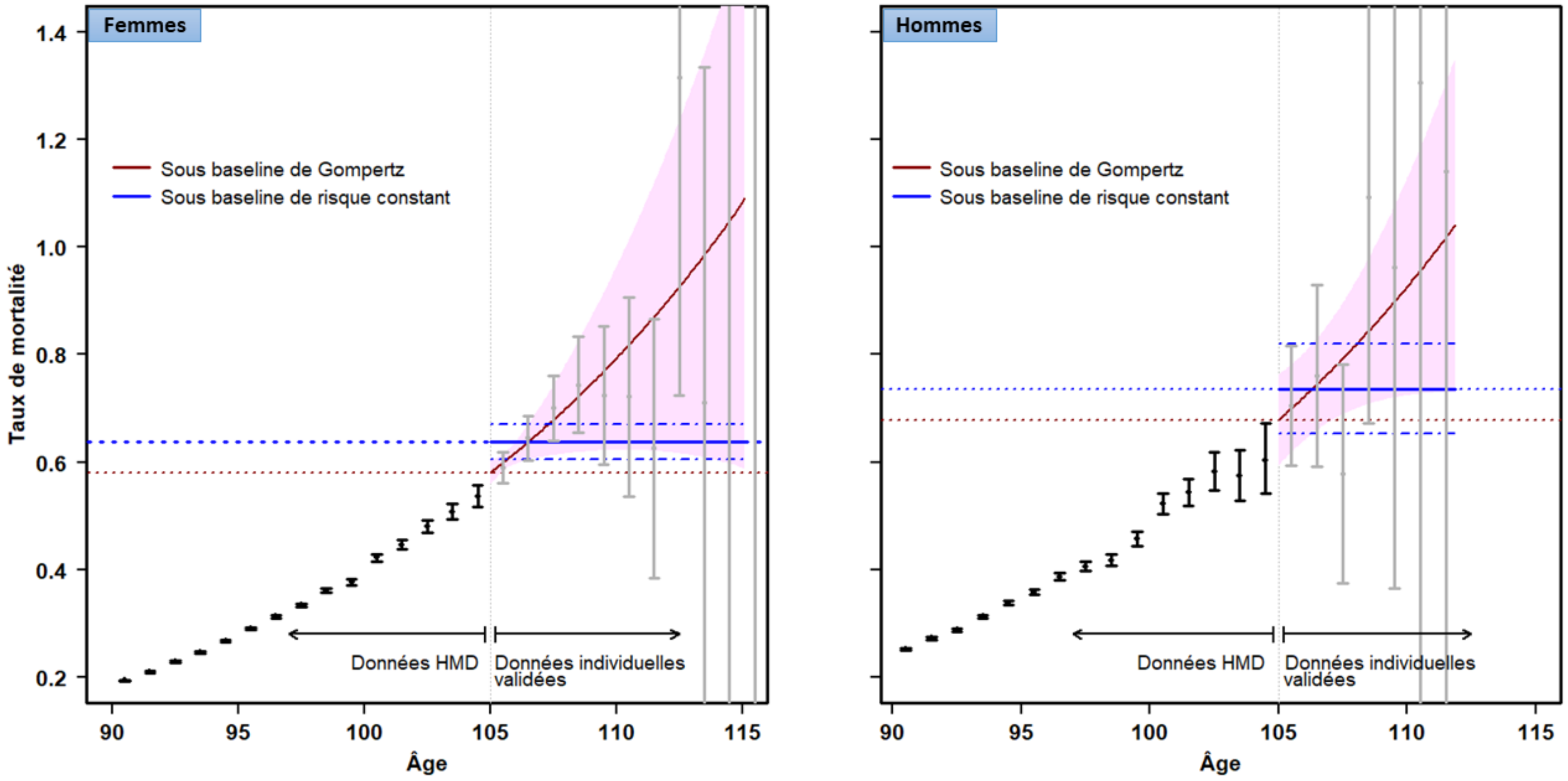
$$h(t_i) = ae^{b\,t} \exp(\beta_1 C_i + \beta_2 M_i + \beta_3 P_{Bi} + \beta_4 P_{Qi})$$

β_1: birth cohort effect, β_2: sex effect, β_3: Belgium population effect, β_4: Quebec population effect, ref: French female born in 1891

Result (3/3) – Mortality trajectory, observable heterogeneity (105+)

- Hypothesis testing on parameter *b* of baseline function : no mortality plateau at age of 105
- Optimal model: male disadvantage persistent but no cohort effect

French data



Key messages:

- The most plausible trajectory:
  for female populations: mortality deceleration
  for male populations: exponential increase of mortality

- Not one single model is optimal for all populations
  The most flexible model is not always the optimal model

- In practice, Poisson distribution is still reasonable to model death counts at highest ages

- Kannisto model should not be used to close mortality tables

- No evidence of mortality plateau has been found yet for French, Belgium and Quebec populations
  If a mortality plateau was to exist, its level should be higher than 0.7

- Both gamma-Gompertz and gamma-logquadratic models can be used to model mortality at highest ages (with unobserved heterogeneity)

- Male disadvantage still persists even at extreme old ages

Future research (data, methods, application)

- Data : continuous effort to collect data (IDL)
- Methods : construction of confidence intervals for other statistical distributions, introduction of other criteria (Focused Information Criteria - FIC), modelling by nonparametric methods
- Application : construction of life table by birth cohorts

Acknowledgements

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Thank you for your kind attention

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