Quantifying the Risk

Corwin (Cory) Zass

Founder, Principal & Consulting Actuary

Actuarial Risk Management, Ltd.

Micro View of Longevity – Fretting Over the Small Stuff

- Agenda
  - Short History of Modelling Mortality
  - Understanding the Basics
  - Transitioning, the “life table” to a “personalized” survival curve
  - Life Settlement Mortality Risk Conversation

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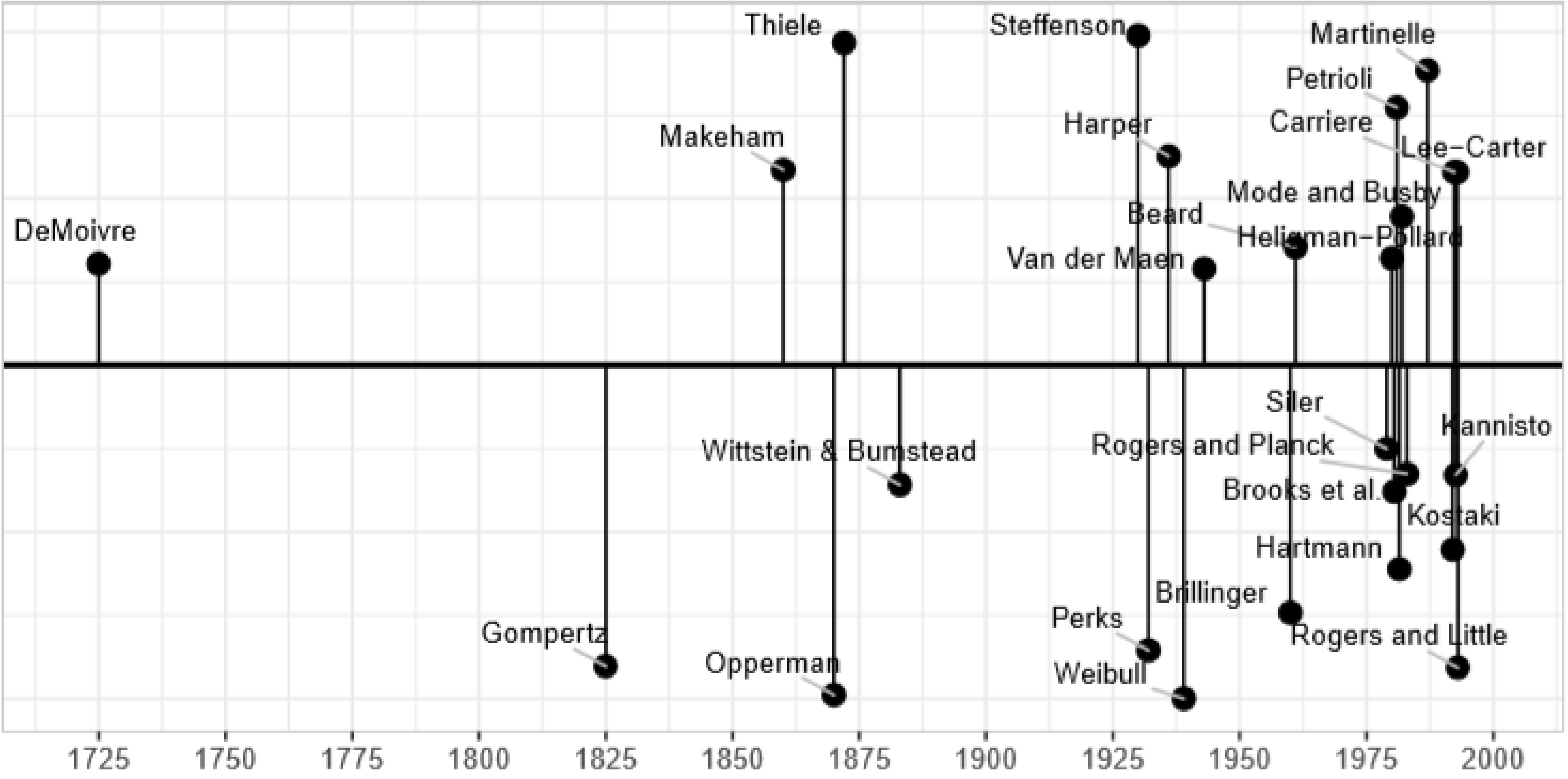
- Timeline of Modeling Mortality



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Author	**Publication**	**Model**
De Moivre	1725	$\mu(x) = 1/(\omega - x)$
Gompertz	1825	$\mu(x) = Ae^{Bx}$
Gompertz	–	$\mu(x) = \frac{1}{\sigma} exp\left\{\frac{x-M}{\sigma}\right\}$
Inverse–Gompertz	–	$\mu(x) = \frac{1}{\sigma} exp\left\{\frac{x-M}{\sigma}\right\} / \left(exp\left\{ e^{\frac{-(x-M)}{\sigma}} \right\} - 1 \right)$
Makeham	1867	$\mu(x) = Ae^{Bx} + C$
Martinelle	1987	$\mu(x) = (Ae^{Bx} + C)/(1 + De^{Bx}) + Ke^{Bx}$
Carriere	1992	$S(x) = \psi_1 S_1(x) + \psi_2 S_2(x) + \psi_3 S_3(x)$
Carriere	1992	$S(x) = \psi_1 S_1(x) + \psi_4 S_4(x) + \psi_3 S_3(x)$
Kostaki	1992	$q(x)/p(x) = A^{(x+B)^C} + De^{-E_i(\ln x - \ln F)^2} + GH^x$
Kannisto	1998	$\mu(x) = Ae^{Bx}/(1 + Ae^{Bx})$
Kannisto–Makeham	–	$\mu(x) = Ae^{Bx}/(1 + Ae^{Bx}) + C$

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- Mortality Forecasting (Mathematical) Models
  - Until the 1980s, relatively simple and included a fair amount of subjective judgement used to forecast qx or LE
  - Last 30 years shifted to stochastic models:
    - Lee–Carter model (c1992) - first extrapolative model used to predict the central mortality rates for all ages.
    - Cairns–Blake–Dowd (c2006) - designed for modelling mortality at higher ages and builds on the observation that log death rates are approximately linear at ages above 40.

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- Basics of Survival Models
  - Defining the population and the “event” exposure
  - Linking the results to mathematical distribution
  - Survival analysis isn’t just a single model.
  - Many sets of tests, graphs, and models used with different data and study design situations.
  - The challenge, choosing the most appropriate model after testing multiple models
  - Regardless, they share a basic concept, “*test how risk factors can predict the transition in morbidity severity to ultimate death*”

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- Evolution of Methods
  - Standard models
    - Kaplan-Meier, Cox proportional hazards, Parametric, Frailty, etc.
  - Artificial Intelligence (AI) based algorithms
    - Random Forest
    - Logistic Regression
    - Gradient Boosting
    - Neural
    - Others

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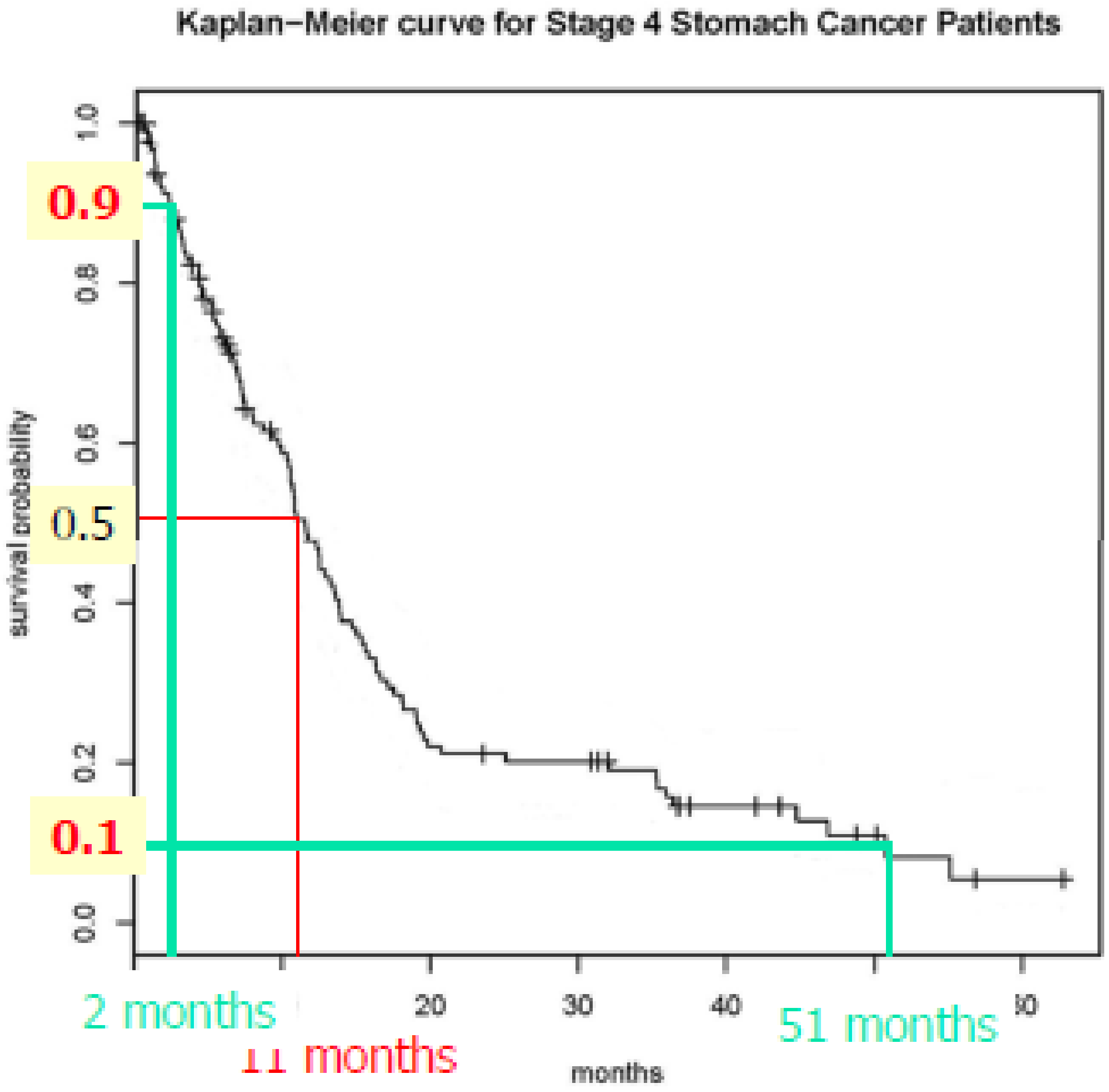

- Over 128 patients
- Median survival time:
  - 11 months
- 80% confidence interval
  - 10% to 90%
  - 2 – 51 months

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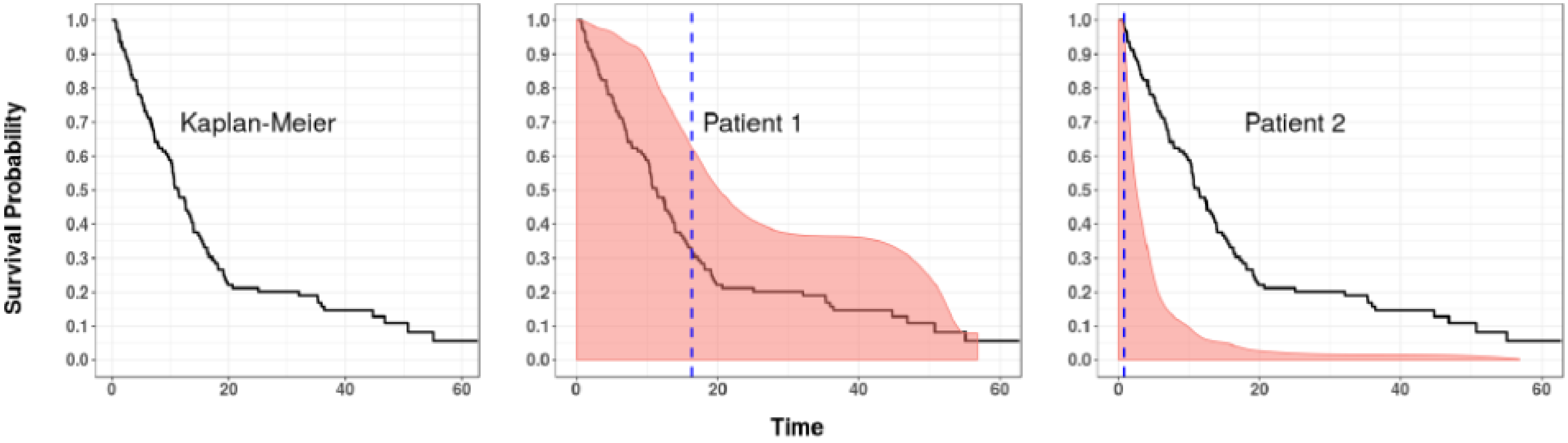

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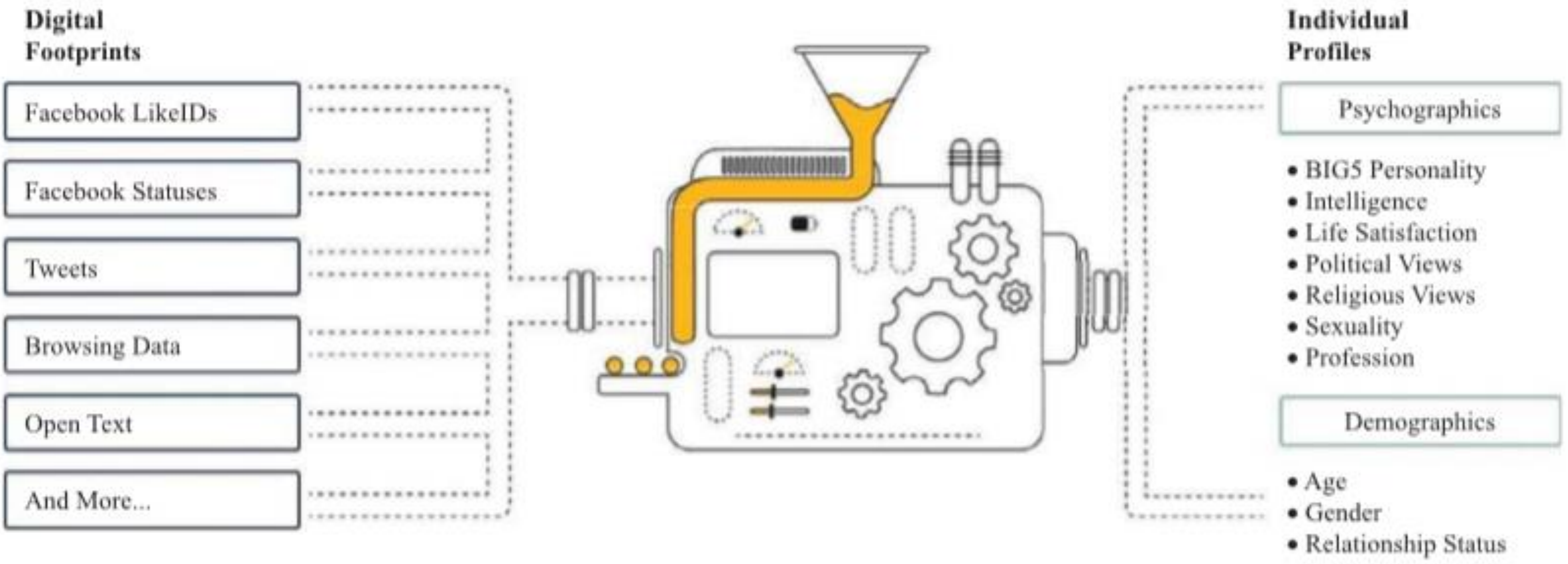

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- Basic Steps in Measuring Mortality Risk
  - Data source of population/sub-population
  - Common risk factor characteristics (this is what is expanding)
  - Evaluate stratifications
  - Count deaths & exposures
  - Smooth crude results
  - Evaluate “rate” metrics or use as baseline (life table)
  - Result: benchmark to larger population of similar make-up

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- Types of Risk
  - Pandemic risk (i.e. Spanish influenza in 1918-19)
  - Mis-estimation risk (i.e. wrong initial base (reference) table, poor model build, erroneous distribution function, etc.)
  - Trend risk (i.e. past not a predictor of the future)
  - Systematic risk (i.e. ignoring mortality improvement or ‘dis’-improvement)
  - Idiosyncratic risk (i.e. random fluctuation risk)
  - Others?

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- Practical Concerns in Underwriting Life Settlements
  - Greater variability of actual deaths if small # of policies (LLN)
  - Dealing w/ judgement or empirical evidence of predictors
  - Sub-population not the same
  - Only use one LE u/wer's view
  - Sole reliance on the LE metric (it is the "slope"!)
  - Ignoring impact of morbidity risks increase as seniors ages
  - Early deaths implies more later deaths too ("false positives)
  - No granular A/E% regardless of 'E'

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- Life Insured Survival Predictions
  - Future will leverage predictive analytics & computing power
  - Are individualized survival probabilities possible? (still can’t predict “hit by the bus”)
  - What to do? (i) current LE u/wers use of medical record data, (ii) SOA VBT (adjusted or not), (iii) deeper dive to account for individual risk factors to create adjustments, (iv) other??
  - Demand LE u/wers to do more than medical u/wing
  - Opportunity for underwriters linked to AI

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- Corwin (Cory) Zass, Founder, Principal, Consulting Actuary
- Actuarial Risk Management (ARM)
- czass@actrisk.com | +1 512 345 5200 (o) | +1 512 659 2075 (c)

- About ARM,
  - 13+ year consulting firm
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  - deliverer of honest views that challenge current ideas and methods
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