SCOR Chair on mortality research

Workshop 3

April 3-4, 2025, Odense, Danemark

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Executive summary

Context

- SCOR Foundation for science is currently funding a chair of research on mortality with researchers of the Interdisciplinary Centre on Population Dynamics (Cpop).
- The objective of the chair project is to initiate research actions in the fields of demography and actuarial science applied to the analysis of mortality and longevity.
- This third workshop is hosted under this partnership.

Description

- **Date**: **April 3-4, 2025**
- **Hybrid event:**
  - on site event: **Odense (Danmark)**
  - and **remote event** (through Microsoft Teams)
- **Free** and **open to all internally** (through Microsoft Teams)
- Thematic:
  - Day 1 Morning**: Multiple causes of death analysis**
  - Day 1 Afternoon : **Mortality modelling and forecasting**
  - Day 2 Morning : **Health and healthcare utilization**

Communication

- Internal via emailing and Microsoft Teams invitation

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Program Day 1 – April 3

Timing	Topic	Speakers
10am – 10.30am	Welcome address and round table presentation	Marie-Pier Bergeron Bouchet (CPop)
10.30am – 11.00am	Understanding end-of-life multimorbidity	Cosmo Strozza (CPop)
11.00am – 11.30am	Visualizing disease dynamics in the lethal process	Elizaveta Ukolova (CPop)
11.30am - 12pm	Changes in modal age at death of ageing-related diseases	Paola Vazquez-Castillo (CPop)
12pm – 1pm	Lunch break	
1pm – 1.30pm	Mortality prediction using transformer models	Sören Schen (SCOR)
1.30pm – 2pm	Segmenting mortality: A study on groups composition	Julien Tomas (SCOR)
2pm – 2.30pm	How stable is senescence?	Silvio Cabral Patricio (Cpop)
2.30pm – 3pm	Quantifying harvesting	Trifon Missov(Cpop)
3.pm – 3.15pm	Coffee break	
3.15pm – 4.15pm	Steering Committee Meeting	

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Program Day 2 – April 4

Timing	Topic	Speakers
10am – 10.30am	The effect of cognitive ageing on healthcare utilisation	Óskar Jóhannsson (CPop)
10.30am – 11am	Multimorbidity progression patterns and healthcare use implications	Sahar Ahmed (Cpop)
11am – 11.30am	Socioeconomic disparity in the dynamics of health	Alexander Marin (CPop)
11.30am – 11.45am	Concluding remarks	Marie-Pier Bergeron Bouchet (CPop)
12.00pm – 1pm	Lunch break	

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Abstracts

Abstracts

Cosmo Strozza Cpop, University of Southern Denmark

Understanding end-of-life multimorbidity: An analysis of multiple causes of death in Denmark

The process leading to death is often complex, involving numerous health risks and diseases over a lifespan. Ultimately, death is attributed to a single underlying cause—the condition that triggered the sequence of events resulting in death. While valuable for identifying key health threats, focusing solely on the underlying cause offers a limited view of the broader morbidity process leading to death. Multiple causes of death (MCoD) data, which capture all contributing conditions, provide a more complete understanding of mortality risks.

In this study, we investigate the reliability of MCoD data and whether they accurately reflect health conditions near death. Combining the Population and Death Danish registers with the Chronic Diseases and Severe Mental Disorders and Cancer registers, we trace diagnoses from specific diseases—cancer, chronic obstructive pulmonary diseases, and dementia—and examine (1) time between diagnoses and death, (2) how often these causes are recorded among MCoD by number of year since diagnosis, and (3) what role they played: underlying, immediate, intermediate, or contributory cause. The analysis is conducted by age, sex, and over as many years as the registers allow. The findings will enhance our understanding of end-of-life multimorbidity patterns and assess the quality of Danish MCoD data.

Abstracts

Elizaveta Ukolova CPop, University of Southern Denmark

Simplex plots and Lexis surface plots for visualizing disease dynamics in the lethal process

The lower the level of cause-of-death classification, the greater the variation in underlying causes of death across countries. Research has shown that a multiple-cause-of-death approach, which includes all conditions recorded on the death certificate, can help mitigate this effect. However, this approach also adds complexity to cause-of-death analysis.

This paper introduces an approach to interpreting data on shifting mortality trends, considering mortality from both underlying and multiple causes of death, as well as the changing role of diseases in the lethal process. To achieve this, we use standardized death rates and simplex plots illustrating the proportions of causes recorded in different roles within the lethal process. A color scheme in these plots visually represents how diseases transition between being classified as the underlying cause of death (UCD), a multiple cause of death (MCD), or a contributory condition (CC). Simplex plots are then used as a color legend for Lexis surface plots, which display these transitions by age and in time. The findings indicate remarkable shifts in the roles of several diseases, particularly in Czechia and Denmark, including specific cardiovascular diseases, alcohol-related disorders, diabetes, and other metabolic conditions. The study provides insight into trends in the lethal process in Western countries that have fallen behind other low-mortality countries in mortality improvements.

Abstracts

Paola Vazquez-Castillo CPop, University of Southern Denmark

Changes in the modal age at death of ageing-related diseases in the United States: A multiple causes of death approach

This paper aims to quantify trends in the US modal age at death (M) for old-age major mortality causes from 1999 to 2022, comparing by sex and assessing the role of contributing causes. Using National Center for Health Statistics data on 16 cause-of-death categories for the population over 50 years old, we applied a data-driven weighting method to summarize multiple causes of death in one event. We estimated smoothed cause-specific mortality distributions and calculated M for both underlying and multiple cause-of-death distributions by sex.

All causes showed an increasing M until 2020, when COVID-19 caused declines. Trachea, bronchus, and lung cancer had the largest gains, with M increasing over 6 years, while influenza had the smallest (<0.5 years). Females consistently had higher M, but sex differences varied by cause. Under the multiple cause-of-death approach, diabetes had peaks, highlighting comorbidities' role in late-life mortality. M explains changes in late-life mortality patterns often overlooked by life expectancy. Incorporating multiple causes recognizes multimorbidity’s complexity and highlights key opportunities for public health interventions.

Abstracts

Sören Schen SCOR

Mortality prediction using transformer models

This study compares the predictive performance of transformer models and traditional machine learning models in predicting mortality. The models are trained on electronic health records (EHR) of patients admitted to the Beth Israel Deaconess Medical Center in Boston between 2008 and 2019. This data includes demographic information, ICD codes of diagnoses during hospital admission, and vital measurements from the intensive care unit (ICU). The models are trained on data collected from ICU patients within the first 24 hours after hospital admission, with mortality predicted for the following 8 hours.

Transformer models evaluated include Med-BERT and the Temporal Fusion Transformer. Med-BERT is particularly interesting in an insurance context, as it allows direct creation of embeddings from ICD diagnosis codes. Results indicate that in this study setup with short time windows and sequences, traditional models, particularly the hybrid LSTM and random forest, outperform transformer models in terms of Area Under the Receiver Operator Curve (AUROC) and Area Under the Precision Recall Curve (AUPRC).

However, this study also raises the question of whether transformer models could outperform traditional models in longitudinal data, as transformer models typically excel in creating dependencies in long sequences.

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Abstracts

Julien Tomas SCOR

Segmenting mortality: A study on groups composition with illustrations on U.S. cities population

In studying mortality experience as well as for reserving and pricing, insurance companies have key dimensions about policyholders such as age, gender, health class, face amount, etc. These dimensions are observed at underwriting. But there can be deeper stories and drivers. Incorporating additional lifestyle information from public data sources provides a more nuanced understanding of the mortality.

A household-based segmentation system is created that classifies all households and neighborhoods in unique types and groupings that share similar mortality behavior by demographic and socioeconomic characteristics. A model-based recursive partitioning approach, see Zeileis et al. (2008), is used to partition data into groups that die in terms of the parameters in the model. Rather than fitting one global model to a dataset, it estimates local models on subsets of data that are learned by recursively partitioning. The basic idea is to grow a tree in which every node is associated with a model that captures the mortality behavior by attained age.

Finally, these unique groupings that share similar mortality behavior are used to study the composition of the population of US cities.

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Abstracts

Silvio Cabral Patricio Cpop

How stable is senescence? Assessing the consistency of aging across time and populations

Aging is inevitable, but the rate at which it progresses remains an open question in demography. This study examines whether the pace of senescence—defined as the rate at which mortality increases with age—is stable or varies across populations and historical periods.

Using cohort mortality data from Denmark, France, Italy, and Sweden (1850–1916), we apply a gamma-Gompertz model combined with penalized splines in a Bayesian framework to account for population heterogeneity and non-senescent mortality.

Our findings indicate that while minor fluctuations exist, the pace of senescence remains largely stable across time and populations, suggesting that fundamental biological mechanisms of aging persist despite external influences.

Abstracts

Trifon Missov CPop, University of Southern Denmark

Quantifying harvesting: Estimating and forecasting the effect of mortality shocks on population dynamics

Harvesting" denotes a specific type of mortality displacement when a sudden shock eliminates imminently a higher than anticipated number of individuals, especially those that are expected to die soon. The outcome, in terms of death counts or death rates, is a curve with a sharp peak, corresponding to the excess deaths caused by the shock, followed by a trough, reflecting the lack of deaths because the expected individuals at risk have already been eliminated. The COVID-19 pandemic provides a unique setup to study harvesting in that the epidemic struck every country not just once, but in several waves.

The study develops a harvesting model reflecting the immunity profiles of the population during each of the waves to address the following research questions: What subgroups were more prone to withstand the mortality shock in the first wave? How did this change in each subsequent wave, given the acquired immunity (through recovery or vaccines) after the previous one? How many waves did harvesting affect, i.e., at what stage did acquired immunity eliminate harvesting? The developed dynamic model not only detects but also quantifies the magnitude of the harvesting effect. The model also serves as a basis for short- and mid-term mortality forecasts that can inform policy makers how many pensioners, and in what health, to expect in the years to come, as well as what causes of death have been affected by the pandemic, i.e., what diseases must the health system pay attention to.

Abstracts

Óskar Jóhannsson Cpop

The effect of cognitive ageing on healthcare utilisation in Denmark

As life expectancy rises in Denmark, the healthcare system must address challenges associated with ageing, including cognitive decline. While cognitive decline is common in older ages, its impact on healthcare remains unclear. Existing studies often rely on self-reported healthcare usage. To overcome this, we link data from the Survey of Health, Ageing and Retirement in Europe to Danish registries (SHARE-Reglink) to examine how cognitive decline affects healthcare utilisation over time.

We measure 1) visits to the general practitioner and 2) public healthcare expenditure. Using a two-part random effects model, we account for zero-use cases and nonzero counts: 1) Poisson regression for visits and 2) a log-normal model for costs. We find that, conditional on using healthcare, higher cognitive function reduces doctor visits and costs.

This study improves our understanding of healthcare utilisation in ageing populations and contributes to global research on health and ageing.

Abstracts

Sahar Ahmed Cpop

Multimorbidity progression patterns and healthcare use implications in older adults in Catalonia, Spain

Multimorbidity—the accumulation of chronic diseases—represents a growing global challenge, significantly impacting individuals' quality of life, healthcare utilization, and system-wide costs. Longitudinal perspective is needed to understand how diseases accumulate over time and which socio-demographic factors influence these trajectories. We use data from the HEALIN cohort, a longitudinal dataset comprised of the Electronic Health Records of 1.55 million individuals from Catalunya, Spain, from 2005 to 2022. Using sequence analysis, we first describe disease accumulation trajectories among all individuals ages 45-74 for four condition groups, and their age, sex and income correlates. The four condition groups are metabolic and hypertension, cardiovascular, neurodegenerative and cancer. Optimal matching and hierarchical clustering is then applied to a random subsample of 15,000 sequences.

We use multivariate logistic regression models to examine the clusters' associations with age, sex, income, and the having a number of primary and emergency healthcare visits above the mean. For individuals transitioning from a healthy state, the most prevalent initial conditions were metabolic/hypertensive disorders, frequently progressing to cardiovascular or neurodegenerative multimorbidity. We identified 9 typical disease accumulation trajectories ranging from the healthy clusters, experiencing no transitions, to the complex multimorbidity cluster, with an average of 4 or more transitions. Younger cohorts experience fewer transitions than older cohorts.

Abstracts

Sex differences were also pronounced, with women more represented in clusters experiencing neurodegenerative conditions and men overrepresented in those involving cardiovascular and cancer trajectories. Lower-income individuals exhibited faster transitions to multimorbidity and death, while higher-income individuals remained healthier longer. In general, high-transition clusters showed greater use of both primary and emergency care, however, after adjusting for the number of transitions, some groups (e.g., the healthy cluster) demonstrated high emergency healthcare reliance despite lower transitions, suggesting gaps in preventive care utilization. In this study we identify common multimorbidity progression trajectories for four disease conditions with high morbidity and mortality burdens and show that different trajectories have different healthcare use implications. These findings underscore the need for targeted prevention strategies, proactive healthcare delivery, and resource optimization to improve health outcomes in aging populations.

Abstracts

Alexander Overdal Kjærsgaard Marin Cpop

Socioeconomic disparity in the dynamics of health

This paper examines the evolution of health across socioeconomic groups, addressing a critical gap in the literature on health dynamics. While socioeconomic inequalities in health are well-documented, most studies rely on cross-sectional data, limiting insights into how health unfold for the same group of individuals over time. Using high-quality Danish administrative data, we track a complete cohort of individuals aged 60 in 1997 over a 21-year period, leveraging hospital diagnoses to estimate individual health status based on predicted one-year mortality risk.

Our findings reveal that lower socioeconomic groups not only begin with poorer health but also experience faster rates of deterioration and face significantly lower probabilities of recovery after adverse health events. Additionally, health disparities increase within every group as they age, but the rate is significantly larger among males and individuals with lower educational attainment. By analyzing transitions across health quintiles, we uncover systematic differences in health persistence and deterioration, demonstrating that disadvantaged groups face both greater health uncertainties and steeper declines. These insights highlight the compounding disadvantages faced by lower socioeconomic groups and highlight areas where health policies can potentially mitigate long-term health inequalities.