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Shaping human mortality patterns through intrinsic and extrinsic vitality processes

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Abstract

Background: While historical declines in human mortality are clearly shaped by lifestyle and environmental improvements, modeling patterns is difficult because intrinsic and extrinsic processes shape mortality through complex stochastic interactions.

Objective: To develop a stochastic model describing intrinsic and extrinsic mortality rates and quantify historical mortality trends in terms of parameters describing the rates.

Methods: Based on vitality, a stochastic age-declining measure of survival capacity, extrinsic mortality occurs when an extrinsic challenge exceeds the remaining vitality and intrinsic mortality occurs with the complete loss of vitality by aging. Total mortality depends on the stochastic loss rate of vitality and the magnitude and frequency of extrinsic challenges. Parameters are estimated using maximum likelihood.

Results: Fitting the model to two centuries of adult Swedish period data, intrinsic mortality dominated in old age and gradually declined over years. Extrinsic mortality increased with age and exhibited step-like decline over years driven by high-magnitude, low-frequency challenges in the 19th century and low-magnitude high-frequency challenges in the 20th century.

Conclusions: The Swedish mortality was driven by asynchronous intrinsic and extrinsic processes, coinciding with well-known epidemiological patterns involving lifestyle and health care. Because the processes are largely independent, predicting future mortality requires projecting trends of both processes.

Comments: The model merges point-of-view and classical hazard rate mortality models and yields insights not available from either model individually. To obtain a closed form the intrinsic-extrinsic interactions were simplified, resulting in biased, but correctable, parameters estimates.

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