Prize Winner

Modernizing Mortality Modeling: The Actuary's Response to AI-Driven Longevity Gains

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INTRODUCTION

Mainstream adoption of artificial intelligence (AI) has ushered in a transformative era across several industries. In particular, AI is redefining traditional approaches to disease prevention, diagnosis, and treatment in healthcare. By leveraging AI's capacity for rapid data analysis, pattern recognition, and decision-making, healthcare professionals are unlocking new ways to preserve and enhance human lives. Below are some ways AI is pushing the boundaries of healthcare, with a particular focus on how its applications contribute to mortality improvements and extending life expectancy.

- Diagnostic Services: AI algorithms, such as those used in medical imaging, have enhanced diagnostic accuracy, aiding in early disease detection and treatment.
- Management of Chronic & Terminal Conditions: Personalized care plans generated by AI models optimize treatment regimens based on individual patient responses, enhancing both outcomes and quality of life.
- Life-Saving Procedures: AI-enhanced surgical procedures result in increased precision and better outcomes.
- Drug Discovery: The adoption of AI significantly accelerates drug discovery times, making crucial medications available sooner, improving lives.
- Gene Therapy: AI advances gene therapy by analyzing genomic data and contributing to gene editing technologies, offering potential treatments for genetic disorders.

These innovations in AI-driven healthcare have not only reshaped the treatment landscape but also revealed new challenges and opportunities for actuarial practice. These advancements necessitate a re-evaluation of traditional mortality modeling techniques, which may struggle to account for the rapid and uneven shifts in longevity trends driven by AI's integration. By understanding the limitations of current actuarial methods, professionals can explore ways to incorporate AI-driven insights into their models, ensuring relevance in an evolving healthcare environment.

TRADITIONAL MORTALITY MODELLING

The actuarial profession has long relied on established models such as the Lee-Carter and Cairns-Blake-Dowd models to project mortality and longevity trends. However, these traditional approaches face limitations in an era of AI-driven healthcare advancements.

- Lee-Carter Model: This model decomposes historical mortality rates into age-specific factors, a time-dependent mortality trend, and random error components (Lee, 1992). It assumes stable patterns in mortality improvements over time and is often used as a benchmark tool for long-term survival projections.
- Cairns-Blake-Dowd Model (CBD): Focuses on age-cohort dynamics, this model is particularly suited for older populations where mortality variations are more pronounced (Cairns, 2006).

LIMITATIONS OF CURRENT MODELS IN AN AI-DRIVEN WORLD

- Capturing Step-Change Mortality Improvements: Traditional models assume that past trends persist without drastic disruptions. However, AI-driven healthcare innovations can spur abrupt changes. For example, a drug that cures cancer would create a sudden and stable mortality improvement, an effect legacy models might struggle to capture immediately.
- Uneven Improvements Across Populations: Mortality improvements from AI advancements are unlikely to be uniform. Variations in technological adoption, healthcare infrastructure, and socioeconomic factors create disparities. Research highlights gaps in healthcare access across the U.S. (GoodRx, 2021), indicating that certain populations may benefit less from AI-driven therapies. Additionally, the high cost of novel treatments could render them inaccessible for low-income or uninsured individuals, further contributing to these uneven benefits. These are some population-specific dynamics that traditional models fail to account for as they often rely on uniform improvement rates across broader cohorts.

INTEGRATING AI INTO MORTALITY MODELS

To address these limitations, actuaries can leverage AI, specifically machine learning (ML), in their mortality modeling processes. This requires a structured approach that combines advanced technological tools with actuarial expertise. Here's how actuaries can accomplish this:

- Expand Data Sources: Actuaries should consider integrating diverse datasets, such as electronic health records (EHRs), wearable device data, genomic information, and socioeconomic indicators. AI models thrive on high-quality, granular data, which can illuminate trends and disparities overlooked by traditional models.
- Model Selection and Development:
  - Utilize ML techniques, such as neural networks and ensemble methods (e.g., gradient boosting machines), to model mortality trends. These models are particularly suited for detecting non-linear interactions between multiple variables.
  - Develop hybrid models that combine AI-driven predictions with insights from traditional actuarial approaches, ensuring continuity while enhancing accuracy.
- Algorithm Transparency and Explainability: Since AI models can be complex, incorporating explainable AI (XAI) methods ensures predictions are interpretable. Actuaries can validate models with stakeholders and address regulatory concerns without sacrificing performance.
- Scenario Testing and Simulation: Actuaries can employ AI tools to conduct detailed scenario analyses. For example, they could assess the long-term impact of a new AI-enabled therapy on specific demographic cohorts, simulating its ripple effects on mortality assumptions.
- Cross-Disciplinary Collaboration: Actuaries should collaborate with data scientists, healthcare professionals, and policymakers to align AI models with practical applications and ensure robust decision-making processes.

BENEFITS

As actuaries adapt to technology and incorporate AI techniques into the mortality modelling process, some benefits that will accrue to stakeholders include:

- Improved Accuracy of Mortality Estimates: AI significantly enhances accuracy. For instance, a study by Peddamukkula, 2024 reported an 18.7% improvement in predictive performance over traditional approaches.
- Impact on Financial Products:
  - Annuities: Precise mortality predictions help minimize mispricing risks, reducing financial strain caused by extended lifespans on annuity reserves.
  - Pensions and Social Security: Accurate longevity forecasts, anticipating changes in the population's life expectancy, help inform sustainable benefit structures and investment strategies to maintain solvency.
- Personalized Insurance and Annuities: AI enables granular segmentation and dynamic benefit structures linked to cohort longevity forecasts, enhancing product personalization and customer satisfaction.
- Market Expansion and Equity: AI can identify underserved or overlooked markets by analyzing demographic and socioeconomic data, enabling insurers to better target these populations. This helps expand market reach and promotes equity by ensuring that a broader range of consumers, including those in marginalized groups, have access to suitable insurance products.

CHALLENGES AND CONSIDERATIONS

- Bias in Data: AI models reflect the biases in training data. Systemic disparities in healthcare access could perpetuate inequalities, impacting fairness.
- Data Privacy and Security: Ensuring compliance with diverse regulations across different jurisdictions (e.g., GDPR in Europe or HIPAA in the U.S.) can complicate the use of sensitive healthcare and lifestyle data for AI modeling.
- Over-Reliance on AI: Without adequate human oversight, heavy reliance on AI could undermine sound actuarial judgment, particularly when models lack explainability.
- Retirement Age Adjustments: Retirement age might need to be revised upwards on account of the increased life expectancy and quality of life due to AI's impact on healthcare. This adjustment ensures the period between retirement age and death can be adequately funded to prevent financial strain on retirement systems.
- Regulatory Hurdles: Regulatory bodies may be slow to adapt to the rapid advancement of AI technologies, creating uncertainty for actuaries attempting to implement AI-driven models within existing frameworks.

CONCLUSION

The integration of AI (ML) into mortality modeling presents both tremendous opportunities and significant challenges for the actuarial profession. As AI continues to reshape the landscape of healthcare and longevity, it is critical for actuaries to remain proactive in adapting their methodologies and practices, ensuring that they are equipped to navigate the evolving future of mortality forecasting. By embracing these innovations responsibly, the actuarial profession can play a pivotal role in making informed, equitable, and sustainable decisions in the face of rapidly improving life expectancy.

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