

The Role of AI in Extending Human Longevity and the Implications for Mortality Modeling

Niranjan Rajendran, B.Sc. (Hons)

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INTRODUCTION

Technological advances have consistently pushed the boundaries of human life expectancy. Each medical leap has lengthened and improved human lives, from the discovery of penicillin to the deployment of new surgical techniques. In recent years, a rapidly evolving wave of innovations in artificial intelligence (AI) has begun to reshape how we approach medicine and our fundamental understanding of human health and survival. This essay explores how AI might extend human longevity and discusses the implications for modeling future mortality and survival, particularly from an actuarial perspective.

AI'S POTENTIAL TO IMPROVE HUMAN LONGEVITY

EARLY DETECTION AND PERSONALIZED TREATMENTS

One of the most powerful applications of AI in healthcare involves its capability for early disease detection and the identification of patient-specific treatment plans. By analyzing large datasets from medical records, wearable health devices, and genomic databases, AI systems can sift through terabytes of information and detect subtle patterns that human clinicians might overlook. For example, machine learning models now enable healthcare providers to spot the earliest signs of conditions like cancer or cardiovascular disease based on complex biomarkers and imaging data. Earlier diagnosis leads directly to a higher chance of successful intervention, which can extend both lifespan and health span.

Furthermore, AI-driven therapies go beyond basic disease detection. Precision medicine enabled by AI tailors interventions based on an individual's genetic profile, lifestyle factors, and environmental context. Recent breakthroughs in predictive analytics have demonstrated the possibility of forecasting disease risk and progression, allowing physicians to adjust treatment plans in real time. As these technologies improve, they hold the potential to transform once-fatal diseases into chronic conditions, substantially impacting mortality rates and reshaping life expectancy across different populations.

DRUG DISCOVERY AND BIOTECHNOLOGY

Drug discovery is another area in which AI has shown promise. Traditional development processes for pharmaceuticals can require a decade of testing and billions of dollars in investment. In contrast, AI algorithms can comb through existing databases of compounds and proteins to identify promising therapeutic targets more efficiently. This accelerates the identification of potential drug candidates, shortens the timeline of preclinical testing, and increases the likelihood of finding effective treatments.

Within the biotechnology sphere, AI has aided in the development of customized interventions such as CRISPR-based gene editing and cell-based therapies. AI helps accelerate the trial-and-error process needed to refine these

complex therapeutic approaches. As a result, new treatments may reach patients faster and address previously intractable health conditions, potentially reducing mortality from genetic disorders and chronic diseases.

LIFESTYLE AND BEHAVIORAL INTERVENTIONS

While biomedical applications draw much of the spotlight, AI-driven lifestyle, and behavioral interventions also hold significant potential. Wearable devices, smartphone apps, and virtual coaching systems powered by AI can support sustained behavior change monitoring everything from daily physical activity levels to sleep patterns. By offering personalized feedback and motivation, AI-based platforms can help individuals adhere to health regimens designed for the long term. Over time, these interventions may reduce the risk of preventable conditions such as obesity, Type 2 diabetes, and hypertension, further contributing to improvements in population-level longevity.

IMPLICATIONS FOR FUTURE MORTALITY AND SURVIVAL MODELING

RETHINKING TRADITIONAL ACTUARIAL ASSUMPTIONS

Actuarial models have traditionally relied on historical mortality data to forecast future survival rates and life expectancies. As AI-driven medical innovations start to influence morbidity and mortality on a mass scale, these historical trends may no longer adequately predict the future. If AI significantly extends both average and healthy lifespans, actuaries will need to adapt their models to avoid underestimating survival rates. For the life insurance industry, underestimating future lifespans can result in premium mispricing and inadequate reserves.

However, the path to longevity increases is not straightforward or uniform. The pace of adoption varies by region and socioeconomic factors, which can widen gaps in mortality improvement across populations. Traditional actuarial models often incorporate conservative estimates of future mortality improvements based on past trends. But if we see a rapid, AI-driven decline in disease prevalence or a surge in the standard of care, these estimates could fall short. New models may need to incorporate a range of possible AI adoption scenarios, adjusting for disparities in healthcare access, varying regulatory environments, and shifts in human behavior.

NEED FOR ALTERNATIVE SCENARIOS

Instead of relying on a single best estimate of future mortality changes, the actuarial field may increasingly consider alternative scenario analyses.

These scenarios could address variables such as:

- **Speed of AI Integration into Healthcare:** A scenario might consider a full-scale integration of AI in healthcare, where drug discovery and personalized treatments revolutionize chronic disease management. Conversely, a more conservative scenario would assume AI remains limited to specific areas, such as diagnosing certain cancers.
- **Regulatory and Ethical Concerns:** Policy and ethical constraints could slow down the adoption of AI-driven therapies. Alternatively, an environment with fewer regulatory hurdles could accelerate AI adoption significantly.
- **Socioeconomic Disparities:** The uneven availability of AI-based healthcare solutions could generate divergent mortality patterns between high-income and lower-income populations.

By embracing these scenarios, actuaries, insurers, and policymakers can better understand the range of possible outcomes for mortality over the next five, 10, or 20 years, improving the resilience of financial systems that depend on accurate forecasts.

BEHAVIORAL SHIFTS AND THEIR EFFECT ON ACTUARIAL MODELING

Beyond direct medical interventions, an extension of healthy lifespans resulting from AI-based preventive and wellness strategies may inspire broader lifestyle changes. As individuals live longer and maintain good health into older ages, they may alter how they plan for retirement, approach insurance coverage, and weigh financial and personal risks.

For instance, if AI-driven systems help older adults remain independent longer, there could be an increased demand for long-term care insurance products that cover advanced ages but might pay out later, given improvements in healthy life expectancy. Alternatively, seniors may choose to continue working or contributing to society in some capacity, leading to shifts in saving and consumption patterns. Each of these possibilities necessitates new modeling strategies that incorporate shifting timelines and behaviors.

INDUSTRY IMPLICATIONS: LIFE INSURANCE, ANNUITIES, AND PENSIONS

PRICING AND RESERVES

As AI extends longevity, both the life insurance and annuity industries could face significant pressure to reevaluate their underwriting guidelines. Premiums for life insurance products have historically been based on well-established mortality tables. If healthier and longer-living individuals dominate the insured pool, insurers might need to reduce premiums in competitive markets or amend underwriting criteria. Conversely, if certain populations experience more rapid benefits from AI-based therapies, insurers must carefully account for selection effects that may lead to anti-selection if these individuals seek coverage at standard rates.

For annuity providers, the longevity risk grows even more prominent. If people consistently live longer than anticipated, annuity reserves could prove insufficient over time, threatening solvency. Consequently, more dynamic reserve modeling that can adapt annually to emerging data on AI-driven longevity improvements will become necessary.

PRODUCT INNOVATION

The life and health insurance industries will likely respond to AI-driven longevity trends with innovative product offerings. New coverage types might include incentives for policyholders who engage with AI-based health monitoring devices or adjust premiums based on real-time data. Employers may design pension plans that reward active health monitoring and AI-driven preventive care. While these new product lines present revenue opportunities, they also introduce additional complexity and regulatory considerations.

CONCLUSION

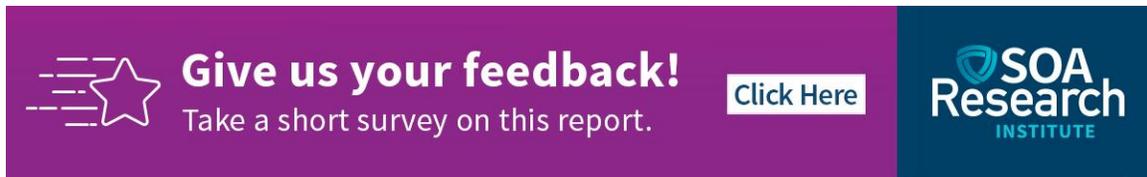
Artificial intelligence has already begun to reshape the landscape of healthcare, and its potential to extend human longevity is both exciting and disruptive. From early disease detection to personalized treatments and real-time behavioral interventions, AI may drive a transformative wave of mortality improvement in the coming years. However, the impact will likely be uneven across different populations, and the magnitude and timing of these changes remain uncertain.

For actuaries, insurance companies, and policymakers, this uncertainty represents both a challenge and an opportunity. Traditional mortality models, which rely heavily on past data, may lose accuracy in predicting a future shaped by new and rapidly evolving AI applications. Scenario-based modeling that accounts for varying rates of AI adoption and regulatory environments becomes essential. Moreover, changing behaviors and social structures brought about by longer, healthier lives may require entirely new assumptions about consumer choices, financial planning, and product design.

Ultimately, AI's potential to increase human longevity demands proactive adaptation in actuarial science and risk management. By embracing flexible modeling techniques and integrating cutting-edge research, the actuarial community can help ensure that the life insurance, annuity, and pension sectors remain robust in an era where rapidly improving health outcomes could alter life expectancies in ways never seen before.



Niranjan Rajendran, B.Sc. (Hons) in Finance and Insurance Mathematics, Actuarial Trainee at Allianz Life Insurance Lanka Ltd. He can be reached at rajandranniranjan3@gmail.com.



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