

Transformative Horizons: Generative AI's Role in Medicine and Mortality Modeling

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INTRODUCTION

Generative AI has rapidly emerged as a transformative technology in the medical field, contributing to significant advancements in gene detection, AI-assisted surgeries, diagnostics, drug development, and cancer treatment. These breakthroughs not only enhance human longevity but also redefine the capabilities of modern medicine. This essay explores the successful applications of generative AI in healthcare, highlighting specific examples, their implications for human longevity, and the critical adjustments required in mortality modeling to reflect these advancements.

GENE DETECTION AND PRECISION MEDICINE

Generative AI has revolutionized genomics by enabling precise detection of genetic mutations and predispositions to diseases. Tools like Google DeepVariant use AI to analyze genomic sequences with unparalleled accuracy, identifying rare genetic disorders that were previously difficult to detect. For instance, the ability to detect BRCA mutations linked to breast and ovarian cancer has allowed high-risk individuals to pursue early interventions, significantly increasing survival rates. Such precision medicine approaches personalize treatments, optimizing effectiveness while minimizing side effects, thereby contributing to longer and healthier lives.

The implications for longevity are profound. Early detection of genetic predispositions enables proactive healthcare, allowing individuals to mitigate risks through lifestyle changes, targeted screenings, and preventive treatments. For mortality modeling, this trend necessitates incorporating genetic risk factors and their mitigation into predictive frameworks. Traditional models based on population averages may become less reliable as personalized medicine reshapes survival probabilities.

AI-ASSISTED SURGERIES

AI-powered robotic systems are transforming surgical practices by enhancing precision and reducing risks. The da Vinci Surgical System, for example, uses AI to assist surgeons in performing minimally invasive procedures with extreme accuracy. Generative AI algorithms predict potential complications in real time, enabling surgeons to adjust their techniques proactively. These advancements have proven particularly effective in complex procedures, such as neurosurgery and cardiac surgery, where precision is critical to patient survival.

The impact on longevity is significant. By reducing surgical complications and recovery times, AI-assisted surgeries improve survival rates and quality of life, particularly for older adults who are at higher risk during invasive procedures. Mortality modeling must adapt to reflect these improvements, accounting for lower post-surgical mortality rates and extended life expectancies due to successful interventions.

ADVANCED DIAGNOSTICS

Generative AI excels in diagnostic applications, leveraging deep learning to interpret medical imaging and detect diseases at early stages. Examples include:

- **Cancer Detection:** AI tools like IBM Watson Health analyze radiology scans to identify tumors with higher sensitivity than traditional methods. A study in *Nature* reported that Google's AI model outperformed radiologists in detecting breast cancer from mammograms, reducing false negatives by 9.4%. Early detection significantly enhances survival rates and reduces the need for aggressive treatments.
- **Rare Disease Identification:** AI platforms such as Face2Gene analyze facial features and genetic data to diagnose rare conditions like Noonan syndrome. These tools have accelerated diagnostic timelines, giving patients quicker access to life-saving treatments.

Improved diagnostics contribute directly to longevity by enabling early and accurate identification of life-threatening conditions. As diagnostic tools evolve, mortality models must incorporate early detection data to better predict survival outcomes and long-term health trajectories.

DRUG DEVELOPMENT

Generative AI is revolutionizing drug discovery by identifying promising compounds and optimizing trial designs. Companies like Insilico Medicine and Atomwise use AI to screen billions of molecules, significantly reducing the time and cost of bringing new drugs to market. A notable success story is AI's role in developing Baricitinib as a treatment for severe COVID-19 cases. Within months, AI algorithms identified the drug's potential, expediting its inclusion in clinical trials and approval processes.

AI-driven drug development impacts longevity by accelerating the availability of treatments for previously incurable diseases. Mortality models must adjust to reflect the potential for rapid medical breakthroughs, incorporating scenarios where new therapies extend survival for specific patient populations.

BREAKTHROUGHS IN CANCER TREATMENT

AI is at the forefront of personalized cancer therapies, combining genomics and real-time patient data to tailor treatment plans. Generative AI models predict tumor growth patterns and optimize radiation therapy protocols. For example, Tempus, an AI-driven platform, integrates clinical and molecular data to guide oncologists in selecting the most effective chemotherapy regimens. Additionally, CAR-T cell therapy—a cutting-edge cancer treatment—relies on AI to engineer immune cells that target specific cancer markers with precision.

The implications for longevity are profound. By personalizing cancer treatments, AI improves survival rates and reduces treatment-related morbidity. Actuarial models must account for these advancements, incorporating varying cancer survival rates based on the availability and effectiveness of AI-driven therapies.

PREDICTIVE HEALTHCARE ANALYTICS

AI algorithms analyze vast datasets to identify disease patterns, enabling early interventions. For example, deep learning models in oncology detect early-stage cancers from imaging data with unparalleled accuracy, significantly improving survival rates. AI tools have also been deployed to monitor chronic conditions such as diabetes and cardiovascular diseases. For instance, AI-powered predictive models assess risk factors, allowing physicians to intervene before complications arise.

Beyond detection, AI's capacity for real-time patient monitoring ensures proactive management of health. Tools such as wearable patches monitor vital signs like heart rate, oxygen saturation, and blood pressure continuously,

alerting healthcare providers to abnormalities. This level of personalization directly impacts life expectancy by reducing preventable deaths and hospitalizations. Incorporating these advancements into mortality models requires integrating predictive data streams that reflect disease onset and mitigation at an individual level.

LIFESTYLE AND WELLNESS OPTIMIZATION

Wearable AI devices are pivotal in promoting healthier lifestyles by tracking sleep patterns, activity levels, and caloric intake. Devices like Fitbit and Apple Watch collect comprehensive health metrics, delivering personalized recommendations to users. For instance, algorithms analyze exercise routines and suggest optimal intensity levels to improve cardiovascular health or weight management strategies tailored to individual needs.

AI-assisted dietary apps also analyze users' nutritional habits, offering meal plans that align with their health goals. By addressing lifestyle-related risks such as obesity and sedentary behavior, these tools contribute to the prevention of chronic diseases, significantly impacting longevity. Mortality modeling must consider the widespread adoption of such devices, integrating metrics that reflect improved lifestyle behaviors and their long-term effects on survival probabilities.

LONGEVITY AND MORTALITY MODELING

The advancements discussed above significantly influence human longevity, necessitating major changes in how mortality is modeled. Key considerations include:

- **Dynamic Mortality Trends:** Traditional mortality tables, which rely on historical data, may not adequately capture the rapid advancements driven by AI. For example, predictive analytics can alter population-level risk trajectories by detecting and addressing diseases earlier than previously possible. Dynamic models that integrate real-time healthcare data are essential for accurate predictions. Incorporating dynamic variables such as AI-prompted interventions ensures that mortality projections remain relevant in an era of rapid medical innovation.
- **Heterogeneity in Longevity Gains:** Disparities in access to AI-driven healthcare introduce variability in longevity outcomes. Individuals with access to advanced diagnostic tools and treatments may experience substantial gains, while others may not benefit equally. For instance, rural populations often lack the infrastructure to implement wearable technology or AI-based monitoring systems. Mortality models must incorporate socio-economic and geographic factors, highlighting the uneven distribution of longevity gains and their broader implications.
- **Integration of Non-Traditional Data Sources:** AI generates vast amounts of unstructured data, such as metrics from wearable devices, genomic information, and social determinants of health. Incorporating these diverse data sources into mortality models enhances predictive accuracy and provides insights into emerging longevity trends. For example, genomic data predicting disease susceptibility could refine actuarial assumptions on life expectancy, leading to more tailored insurance products.
- **Ethical and Privacy Considerations:** The use of sensitive health data raises ethical concerns about privacy and consent. As wearable devices and AI monitoring systems collect extensive personal data, adherence to regulations like GDPR and HIPAA becomes critical. Mortality modeling must balance the integration of AI-driven insights with strict data protection frameworks, ensuring public trust and compliance with ethical standards.
- **Extended Life Expectancy:** AI-driven healthcare innovations are likely to increase the prevalence of centenarians, shifting the distribution of survival probabilities. For example, AI tools that enhance cancer detection and management contribute to longer lifespans by reducing mortality from previously terminal illnesses. Actuarial models must reflect this trend by extending projections to account for an aging population with improved health spans.

BROADER IMPLICATIONS AND CHALLENGES

While generative AI holds immense potential for enhancing longevity, it also presents challenges:

- **Data Quality and Bias:** Ensuring high-quality, unbiased data is critical for accurate predictions. Models trained on non-representative datasets may perpetuate healthcare disparities, requiring rigorous validation and continuous improvement. For example, AI models used for diagnosing skin conditions may underperform on darker skin tones if the training data lacks diversity.
- **Regulatory Frameworks:** Adapting regulatory frameworks to govern AI applications in healthcare is essential. Collaboration among policymakers, technologists, and actuaries is necessary to establish ethical and practical guidelines that safeguard patient rights while fostering innovation.
- **Ethical Dilemmas:** The integration of AI into healthcare raises ethical questions about accountability and fairness. For instance, AI-driven recommendations for high-cost treatments might inadvertently disadvantage low-income patients. Clear guidelines and human oversight are crucial to ensuring equitable access to AI-driven advancements.

CONCLUSION

Generative AI stands at the forefront of a new era in healthcare and actuarial science, significantly enhancing human longevity and transforming mortality modeling. By embracing real-time analytics, addressing ethical considerations, and refining actuarial frameworks, the profession can navigate these advancements effectively. Harnessing AI responsibly ensures that extended longevity benefits society equitably while preserving the integrity of actuarial practices. These advancements not only improve patient outcomes but also hold the potential to extend human longevity significantly, transforming healthcare into a more precise, efficient, and equitable domain.

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