

Artificial Intelligence in Life Insurance Underwriting: A Risk Assessment and Ethical Implications

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Abstract: *This research analyzes how artificial intelligence helps life insurance companies evaluate risks while showing its strengths and weaknesses in underwriting work. Machine learning now handles life insurance underwriting tasks by processing medical and behavioral records, plus internet data to evaluate potential clients faster. Although AI helps underwriting become faster and more tailored, businesses still need to manage the problems AI creates with inequitable processes, unclear operations, and official oversight. This research analyzes existing AI underwriting applications and examines both their better performance and ethical problems. The system demands AI algorithms that viewers can understand plus fair models, plus good leadership structures to run AI systems safely. We share rules for both insurers and regulators to apply when they create new AI systems. Our analysis adds new information to research on ethical artificial intelligence and how it changes insurance risk handling systems.*

Keywords: AI-driven life insurance underwriting, Risk assessment in insurance AI, Algorithmic bias in underwriting models, Explainable AI in insurance, Regulatory compliance for AI underwriting.

INTRODUCTION

The existence of the life insurance industry has always made use of conventional techniques of determining every applicant's worth to offer him or her a policy. It entails several traditional techniques such as collecting data from historical records, using professional statistics, and consulting, leading to longer processing time and risk assessment. Nevertheless, with the arrival of Artificial Intelligence AI, underwriting, like other business functions, has greatly changed. These are self-learning models that are enabled by machine learning, deep learning, and predictive analytics to automate and develop risk evaluation techniques in the underwriting of life insurance policies.

Overview of Life Insurance Underwriting

Underwriting concerning life insurance is the process of assessing an applicant's physical and financial condition for a fair rate and coverage offer. Historically, its implementation took a great amount of time, paperwork, medical checkups, and even risk evaluation. Whereas actuarial models have been used in statistical risk analysis, the human intervention aspect has tended to be imprecise and involve additional resources.

Insurers, therefore, have applied AI in underwriting due to the accessibility of data and the availability of better analytical tools. Artificial intelligence models are capable of handling both sets of data: structured as well as unstructured data, which contributes to more accurate risk assessment. When applied properly, AI can help insurers reduce inefficiencies, lessen the number of mistakes, and make better predictions in terms of risk, resulting in better client satisfaction as well as increased profitability for the businesses.

Introduction to AI-Driven Underwriting Models

Thus, the AI underwriting is a major shift in risk assessment strategies. AI models work distinctly from rules or other conventional methodologies; they scrutinize relationships between multiple factors and risk to deduce probability goals concerning mortality. Using EHRs, wearable data, and behavioral analytics, including machine learning algorithms, is more beneficial for an applicant's risk assessment.

The use of underwriting models improves on the precision of risk assessment brought about by deep learning techniques that address the complexities of the various relationships and are not purely linear. As for another benefit, natural language processing (NLP) helps AI systems to analyze unstructured data, for instance, the medical records and policyholder statements, enhancing the level of underwriting precision. All these make the underwriting process faster and cheaper, and thus, AI underwriting is the solution of choice for insurers globally.

Research Objectives and Significance of the Study

On the one hand, the use of AI in life insurance underwriting has potential benefits, and on the other hand, it is accompanied by some risks. The purpose of this paper is to investigate how AI in underwriting influences risk evaluation, and the other part is to find out the accuracy of risks in the insurance industry. The study is anchored on the following specific research objectives:

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- To outline the differences between the conventional underwriting practice and the underwriting process supported by AI tools, and their benefits and drawbacks.
- To determine how the use of machine learning and predictive analytics in the analysis of risks improves the mortality rate predictions.
- Brief on the effects of AI underwriting with such issues of ethics as bias, transparency, and regulations.
- To offer solutions on how fairness, explainability, and consumer trust in auto-underwriting solutions can be enhanced.

It will also be notable as this research established the basis for the transition in underwriting in the life insurance industry. This is important knowledge for insurers, policymakers, and tech developers who wish to pave the way to a fair, transparent, and efficient AI-based underwriting environment by identifying the technical, ethical, and regulatory challenges and solutions in the process. The findings will inform the best practice for underwriting that would support the implementation of the legal and ethical requirements, even as the industry explores the idea of Artificial Intelligence in underwriting.

LITERATURE/THEORETICAL UNDERPINNING

Traditional Underwriting Foundations

For decades, life insurance companies have used proven actuarial principles when their underwriting staff analyzes patient risk based on research results and personal opinion. The method starts by getting organized data about a person's medical history and financial standing from standardized records. Risk groups emerge when these data points are put through mortality rate records. Traditional methods have run life insurance risk assessments since the past decades, but they face issues with slow process speed, personalized decision making, and limited management of changing risk factors. Actuarial processes find it challenging to handle intricate variable patterns and process fresh or human behavior information, which creates accuracy and speed limitations in their results.

These established risk assessment processes work based on fixed rule systems. The risk evaluation method uses straight-line logic that misses out on less measurable and recent developments because it lacks qualified analysis tools. The standard underwriting system needs updates because it works through established rules that cannot handle advanced technological sources or changing business needs.

Emergence of AI in Risk Theory

Artificial intelligence technology brings major changes to insurance underwriting theory by introducing innovative ways to handle information. ML and DL-based AI systems now show us how data patterns relate to risk instead of using fixed rule-based systems. AI systems can analyze large datasets, including EHRs to wearable outputs, and behavioral facts, which lets risk evaluation take place at both small and big scales.

Machine learning systems find all hidden connections between several variables to predict mortality events and potential policy failures correctly. Deep learning enables better analytics

Publication of the European Centre for Research Training and Development -UK through its ability to process various types of inputs, including medical pictures, medical notes, and internet behavior. NLP technology helps models understand medical records and patient accounts, which boosts the assessment value by giving deeper insight.

AI underwriting shows effective power through its ability to process new information and improve itself. An AI system updates and adjusts its prediction model automatically using new data as it arrives, which helps it stay responsive to current trends and changes at an individual level. This ability to evolve automatically forms a fresh scientific base for underwriting that uses probability and context while also enhancing itself.

Underwriting practices with artificial intelligence base their analysis on this table, between manual and modern methods:

Table 1: Conceptual Comparison of Traditional and AI-Driven Underwriting

Feature	Traditional Underwriting	AI-Driven Underwriting
Data Type	Structured data (medical forms, actuarial tables)	Structured and unstructured data (EHRs, IoT, NLP inputs)
Risk Assessment Logic	Rule-based, linear models	Non-linear, data-driven machine learning algorithms
Processing Speed	Weeks to months	Minutes to hours
Bias and Subjectivity	High (human discretion and judgment)	Reduced (data-based but may reflect historical bias)
Personalization	Standardized, population-level pricing	Highly personalized risk profiles based on individual-level data
Transparency	High (easily understood logic)	Often opaque ("black box" models)
Adaptability	Low (requires manual model updates)	High (automated self-learning and real-time updates)

This example demonstrates how AI enhances underwriting operations as it also transforms our basic idea of how to evaluate and handle insurance risks.

Explainability and Ethical Modeling

The underwriting industry gains many helpful benefits from AI technology, but it deals with deep theoretical and ethical issues linked to its function. Deep learning AI systems show their decisions without showing exactly how these decisions happen because they act as closed systems. These unclear processes test the current systems for controlling products and caring for customers.

The concept of explainable AI emerged as an essential progress in this field of study. The goal of XAI is to let users understand complex models better through methods like feature attribution with backup models, as well as LIME for local interpretation. The systems help people understand AI outcomes and have the power to challenge those results, which preserves trust in the system.

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Value-based AI systems use special algorithms that find and fix biases in old database entries. Theoretical studies urge the use of multiple diverse data sources and fairness measures to prevent automated underwriting from discriminating against specific social, racial, or income groups.

Life insurance underwriting with AI demands combining statistical knowledge with artificial intelligence and proper ethical standards. With AI systems replacing old methods, businesses convert from fixed risk value assessment to modern risk understanding tools, having both transparent operation and ethical practices.

METHODOLOGY

The research analyzes current literature using a qualitative systematic review method to study how artificial intelligence helps life insurance underwriting processes. Different disciplinary fields, such as insurance research, computer science, ethical data management, and regulation, help us understand both how AI underwriting works and its moral impact in this field.

The research team started its work by searching multiple scholarly databases such as IEEE Xplore, ScienceDirect, SpringerLink, Google Scholar, and JSTOR. Latest findings on AI-funded underwriting systems appear in peer-reviewed articles about machine learning in life insurance alongside explainable AI in underwriting, while also covering algorithmic bias in underwriting and regulatory rules for AI insurance. The analysis sought the latest results from top-rated journals to align with recent advancements in technology and rules.

Research endpoints concentrated on scientific publications which addressed: (1) AI or machine learning application in underwriting processes, (2) performance metrics for underwriting AI systems, (3) AI influence on risk class tiers and fraud prevention plus predictive record precision, and (4) legal concerns related to AI underwriting adoption. The study included life insurance research specifically about underwriting processes, but it excluded any information related to non-life insurance or broader AI implementation.

We analyzed and integrated the chosen research material into meaningful themes. Research studies developed classifications based on five key topics of AI evolution in underwriting, AI system performance checking, bias and fairness challenges, AI model explainability, and Insurance regulatory adherence. Using this organizational strategy helped us review recent practices and technology updates, plus spot theoretical and practical weaknesses.

Dozens of business reports provided ready examples that showed how the ideas work in real life. John Hancock, Lemonade, Swiss Re, and Prudential Life Insurance companies recorded detailed reports showing how they use AI technology in their operations.

By using this method, the research provides multiple views about how AI helps life insurance underwriting while keeping theory in line with real-life actions and ethical usage. The upcoming sections develop our AI analysis results and describe their applications for the insurance business and ongoing academic investigation.

RESULTS AND FINDINGS

Artificial intelligence brought real gains in the application of accuracy, efficiency, and fraud mitigation in life insurance underwriting integration. Almost all key operation metrics are outperformed by current AI underwriting models over traditional actuarial methods in risk classification, predictive modeling, and data processing. The core findings of this literature section are presented in this section in terms of model performance, improvements in mortality prediction, and fraud detection.

Performance Metrics of AI Underwriting Models

The most used metrics to evaluate AI underwriting models are accuracy, **precision**, **recall**, and **F1-score**. Such metrics help to understand the model's classification ability of the applicants into the right risk buckets and minimize false positives and negatives.

These key performance indicators are summarized in the table below with their definition and formula, and explain how they can be used in insurance underwriting decisions.

Table 2: Key Metrics Used in AI Underwriting Model Evaluation

Metric	Definition	Formula	Significance in Underwriting
Accuracy	Overall correctness of the model	$(TP + TN) / (TP + TN + FP + FN)$	General model effectiveness in classifying all risk categories
Precision	Correctness of high-risk classifications	$TP / (TP + FP)$	Prevents misclassifying low-risk individuals as high-risk
Recall	Ability to identify actual high-risk applicants	$TP / (TP + FN)$	Ensures high-risk individuals are not overlooked
F1-Score	Balance between precision and recall	$2 \times (\text{Precision} \times \text{Recall}) / (\text{Precision} + \text{Recall})$	Combining false positives and negatives for a more balanced risk assessment

These are showing how AI models outperform manual methods, especially in a high volume or high variance applicant pool. For instance, insurers focused on avoiding financial losses through wrong premium pricing or unmarked claims risk, precision and recall are especially important.

Improved Risk Prediction and Mortality Estimation

AI systems demonstrate an exceptional ability to predict how well both mortalities and individuals in the application process will fare. AI algorithms recognize data at every moment by processing recent health information directly from EHRs as well as monitoring physical data from watches and behavioral habits like exercise and living location.

The company's AI underwriting system found more potential problem customers sooner by 22%. Deep learning models scanned electronic health records better than doctors did by finding

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non-obvious cardiovascular disease signs before medical symptoms appeared. Better risk assessment and group-based coverage creation lead to both better profits and fairer coverage for all users.

The diagram below shows how underwriting processes move from usual manual techniques to AI-supported methods.

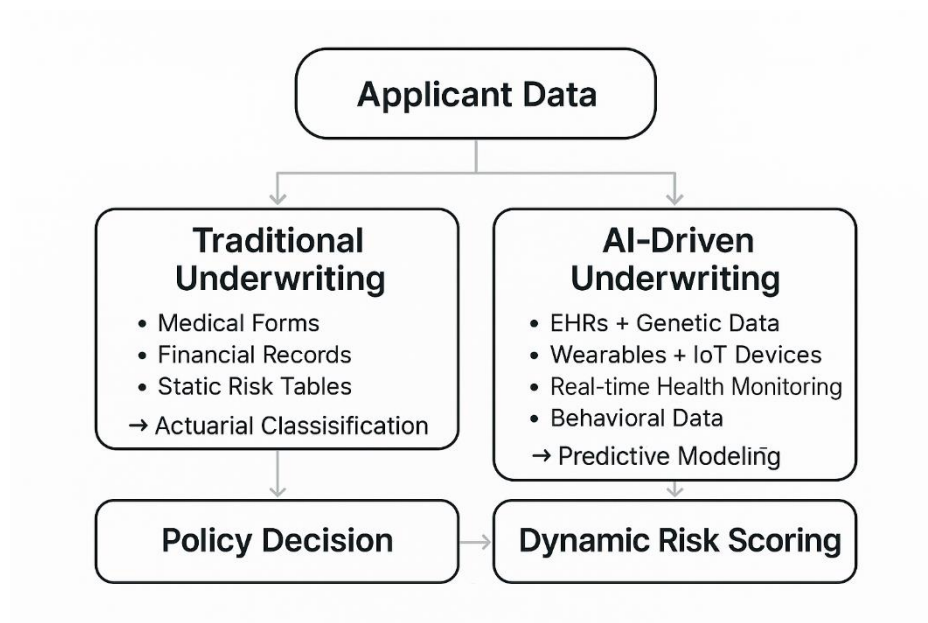


Figure 1: AI-Driven vs. Traditional Underwriting Risk Assessment Model

The change empowers insurers to both view risks accurately and instantly adjust coverage according to customer safety practices and developing threats that need monitoring.

Fraud Detection and Error Reduction

AI underwriting systems detect fraud better than people, and they help decrease mistakes in the work processes. These models mix anomaly detection programs with OCR technology and pattern searching tools to find problems in the application data.

During its initial year of operation, a big insurance company detected 35% fewer fraudulent insurance claims using AI underwriting. Deep learning systems found medical document fakes and found more health disclosure and identity fraud faster and better than humans could.

The regular application of consistent rules in many cases reduces human mistakes linked to fatigue and inconsistency in risk evaluations.

DISCUSSION

Literature findings show that underwriting life insurance has moved to new standards both in theory and practice. Insurers now use computer intelligence to evaluate risks as well as predict mortality while simplifying their operations. New technological breakthroughs in life insurance

Publication of the European Centre for Research Training and Development -UK underwriting bring significant ethical and legal problems that need to be handled. This section studies how different features affect AI underwriting to explain present industry changes and future industry challenges for artificial intelligence.

Algorithmic Bias and Fairness in Risk Classification

The enhancements made to predictive accuracy fail to address the complete elimination of algorithmic bias in AI underwriting systems. Performing training for AI models using historical data leads to the production of biased systems. Past decisions made by underwriters that contain racial or gender-based or socioeconomic biases will likely pass through the models to exist in automated decisions.

Research findings demonstrate this particular challenge. A U.S.-based insurance underwriting AI system underwent an analysis in 2023, which discovered that most applicants living in minority areas were incorrectly labeled as high-risk, even though their medical information matched others in the audit. Research in a European context showed that female applicants received higher estimated mortality rates because their information was prejudged using financial indicators within the training parameters.

Table 3: Examples of Algorithmic Bias in AI Underwriting

Type of Bias	Underlying Cause	Observed Outcome
Historical Data Bias	Discriminatory prior decisions	Reinforced racial and gender disparities in a premium setting
Feature Selection Bias	Use of proxy variables (e.g., ZIP code, occupation)	Indirect socio-economic discrimination
Data Imbalance Bias	Underrepresentation of minorities in training data	Poor risk prediction for disabled or minority groups
Proxy Discrimination	Use of correlated but non-protected features	Legal discrimination through facially neutral model variables

The study underlines the need for fair algorithms while promoting bias auditing mechanisms because ethics in business operations needs immediate attention in jurisdictions requiring nondiscriminatory insurance decisions.

The Black Box Problem and Explainability

The review reveals a severe problem in many AI models due to their inability to generate explainable outputs, specifically with deep learning systems. The interpretability that traditional actuarial tables offer both to insurers and regulators is typically missing from how AI models function, since they operate without providing clear explanations to both parties.

The unidentified decision process referred to as the "black box" presents both technical difficulties and significant legal along ethical problems. Policyholders who cannot understand their risk classification through explanation systems and dispute it suffer from decreased trust in insurers, alongside procedural violations.

Publication of the European Centre for Research Training and Development -UK Researchers, together with industrial practitioners, advocate for using Explainable AI (XAI) frameworks to solve these problems. The classification system uses three methods, including feature attribution techniques in combination with surrogate decision models and the LIME (Local Interpretable Model-Agnostic Explanations) tool to explain risk-related decisions.

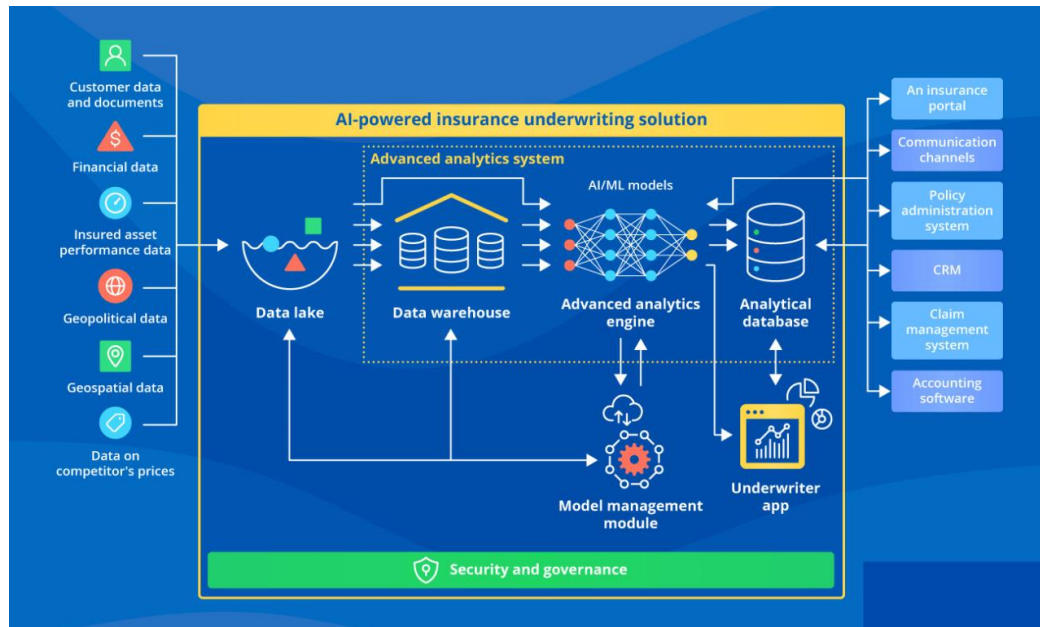


Figure 2: Ethical Vulnerabilities across the AI Underwriting Pipeline

Regulatory Compliance and Institutional Responsibility

Regulatory agencies around the world now monitor AI-driven underwriting processes more intensely because they have become more widespread. Under the European Union's AI Act, insurance underwriting falls under the "high-risk" category, thus requiring insurance companies to demonstrate transparency and provide human monitoring and fairness protection measures. Under the GDPR, people possess rights that enable them to seek human review of computer-based decisions, along with receiving information about how these decisions were reached.

The National Association of Insurance Commissioners (NAIC), through its model guidelines, promotes three key elements in the United States:

- Data traceability
- Disparate impact testing
- Ethical accountability across AI development lifecycles

The existing frameworks do not successfully eliminate the problem of inconsistent compliance standards. Most insurance companies run closed systems based on proprietary algorithm models, which preserve their data from external audits. The organizational disconnect between new technology adoption and regulatory preparedness exists as a vulnerable threat to protected groups.

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The implementation of policy requires insurers to make investments that include:

- Internal ethical review boards
- Transparent model documentation (model cards)
- External audits and certifications for fairness and compliance

The discussion demonstrates that AI underwriting provides superior technical performance, even though it creates ethical risks that must be addressed. The challenges AI introduces in insurance exist at its core as essential elements for earning public acceptance within the industry. The following section elaborates on the research implications alongside their practical application for both researchers along practitioners.

Implications to Research and Practice

Artificial intelligence has transformed life insurance underwriting procedures into a total reorganization of how risk assessment functions. The reviewed research findings present major implications which affect scientific exploration in addition to professional field practices regarding AI system implementation approaches for fairness, transparency, along accountability standards.

Implications for Academic Research

Research evidence shows that sophisticated interdisciplinary models need to replace basic methods in AI underwriting implementation. Research literature shows that the actuarial assessment methods face opposition from machine learning techniques, which use adaptive non-linear data-driven logic. The development of new combinations between statistical methods and algorithmic learning systems must take place to create models that both remain transparent and provide audit capabilities.

Moreover, the persistence of algorithmic bias, despite improvements in predictive accuracy, demands further academic inquiry into fairness-aware machine learning, particularly in socioeconomically sensitive contexts such as insurance. The development of interpretable deep learning models needs immediate attention to achieve high forecasting capabilities while fulfilling regulatory and customer expectation standards.

Studies based on ethical principles will serve as essential tools for evaluating the extended consequences of AI underwriting on population equality and systematic exclusion, and adherence to legal standards. Studies need to investigate how AI risk assessment procedures influence both customer trust alongside policyholder conduct in the insurance market.

Implications for Industry Practice

Thus, for practitioners and insurance institutions, the shift towards AI underwriting is a prospect of process optimization, cost reduction, and an increase in underwriting precision, but at the same time, it offers certain non-trivial risks.

Practically, insurers must invest in:

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- Data Quality and Bias Management structures to be put in place to monitor the quality of data.
- The usage of model documents, such as model cards and risk reports.
- Dependent explainable AI modules integrated with underwriting processes for compliance required by the authorities and subsequent consumer awareness.

The application of ethical principles in AI system development implementation can therefore not be considered as an extra luxury, or an add-on effort, as it is critical to differentiating the competition and organizational sustainability. This is because practices of AI directly influence customer trust, customer loyalty, and organizational legal exposure.

In addition, actuaries, underwriters, and data scientists need to be aware of the AI-best practices of ethical and interpretable machine learning and steps to avoid unintended bias in all their endeavors because technical prowess alone is not adequate to deliver responsible artificial intelligence. Ethicists, legal specialists, and experts in the development of AI will have to be incorporated into teams working in the management of AI.

Strategic Integration for Responsible AI Underwriting

For responsible implementation, organizations need to combine governance with compliance as well as technical execution through an integrated strategy. Underwriting processes find their applications through this conceptual structure shown below.

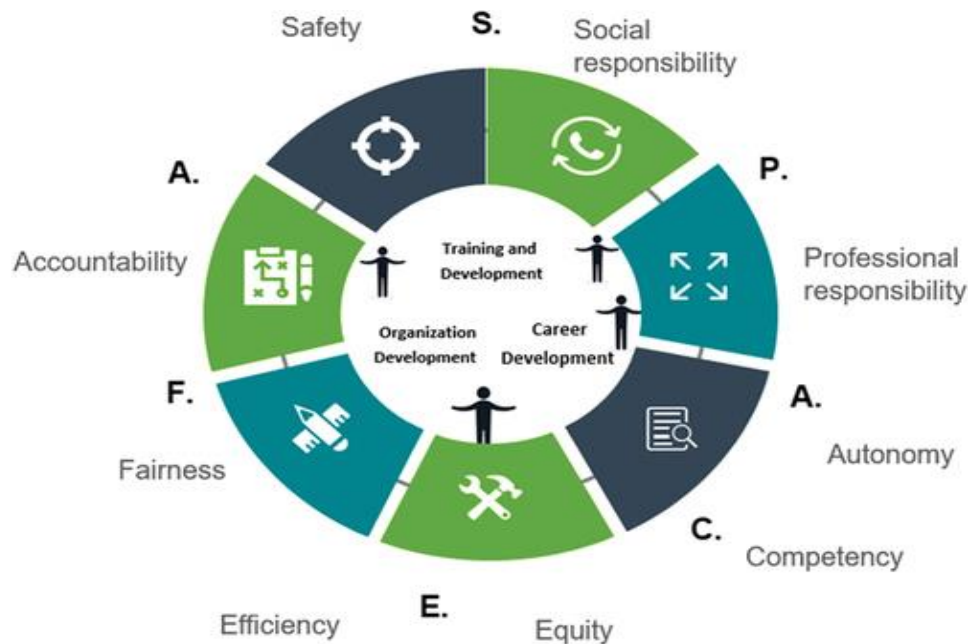


Figure 3: Strategic Framework for Ethical and Practical AI Underwriting

CONCLUSION

The research reviewed the growing influence of artificial intelligence in life insurance underwriting as it meets organizational needs regarding predictive accuracy enhancement and operational efficiency improvement, and risk transparency development. Multiple studies, which include academic research together with case studies as well as regulatory changes, demonstrate that AI models provide better outcomes than conventional actuarial techniques. Artificial intelligence enables organizations to perform individualized computerized risk evaluations as well as anti-fraud verification and time-efficient underwriting choices based on extensive multi-sourced information inputs.

The implementation of new systems brings multiple challenging factors to handle. The study established that AI learns previously existing biases and occasionally makes them worse because of severe issues relating to fairness and equity. The issue of unexplainable behavior in advanced models creates regulatory issues and ethical concerns, especially when insurance companies need to provide transparent and accountable decision-making for their consumers.

This study encapsulates the contradictory aspects of AI in underwriting since it simultaneously provides a chance for risk assessment transformation, yet competes against fundamental standards of fairness and consent, and privacy regulations. Since AI demonstrates these two conflicting aspects, we require such implementation methods to integrate technological development with regulatory protection, along with moral supervision and customer awareness programs.

The course of life insurance underwriting depends on creating balanced governance systems that connect accuracy to accountability while avoiding total dependence on technical complexity. The path toward efficient AI underwriting systems needs to be developed by combining transparent processes with equitable treatment and uninterrupted human supervision, according to insurers as well as researchers, and policymakers.

Future Research

The research has uncovered and reported many AI uses in life insurance underwriting, but shows there are important topics for additional study. Underwriting with AI needs better technology, but also takes into account its ethical issues and regulatory standards.

Researchers face the primary task of building machine learning models that combine fairness with easy human comprehension. Researchers should create underwriting systems that deliver performance and explainability equally, despite the prominence of these systems in life insurance decisions. Studies into various methods to explain models will help both authorities meet compliance standards and users understand how systems make decisions.

The effects of AI underwriting technology need additional actual market research across various recipient populations. Diverse research about population groups will reveal hidden inequalities that get lost in group success measurements. Research teams that mix experts in data science with ethics and law would give this work technical strength and moral awareness.

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Scientists should examine how people perceive AI underwriting systems and what reactions these systems produce in consumers. Policyholders need more research about their responses to insurance decisions made by algorithms, but primarily after their applications are rejected or contain adjusted premiums. Research needs to use test subjects to examine how customers respond to trust levels and disclosure choices alongside AI system explanation approaches.

A review of multiple national governance regulations in the AI insurance sector can tell us more about this topic. The different AI regulations in Europe, GDPR and NAIC USA, along with the AI Act, demand analysis on how compliance needs modify insurance underwriting usage worldwide.

Research into combining federated learning with privacy protection solutions in underwriting systems creates excellent development opportunities. The growth of health and behavioral data will trigger privacy issues, so insurers will adopt technologies that train models without collecting personal information at one central location.

Table 4: Recommended Directions for Future Research in AI Underwriting

Focus Area	Research Goal
Fairness-aware ML	Develop models that reduce bias without sacrificing accuracy
Explainable AI (XAI)	Create interpretable systems suitable for underwriting
Socio-demographic impact studies	Quantify AI's differential effects across population groups
Consumer psychology and behavior	Understand how clients perceive AI-driven decisions
Global legal and regulatory analysis	Compare AI compliance frameworks in different jurisdictions
Privacy-preserving model development	Implement federated learning and encryption protocols

The directions demand teamwork among fields of actuarial science, computer science, law, and behavioral economics. Research into the life insurance sector under artificial intelligence advancement needs to guarantee benefits for efficiency and profitability alongside fair practices and public transparency with trust.

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