

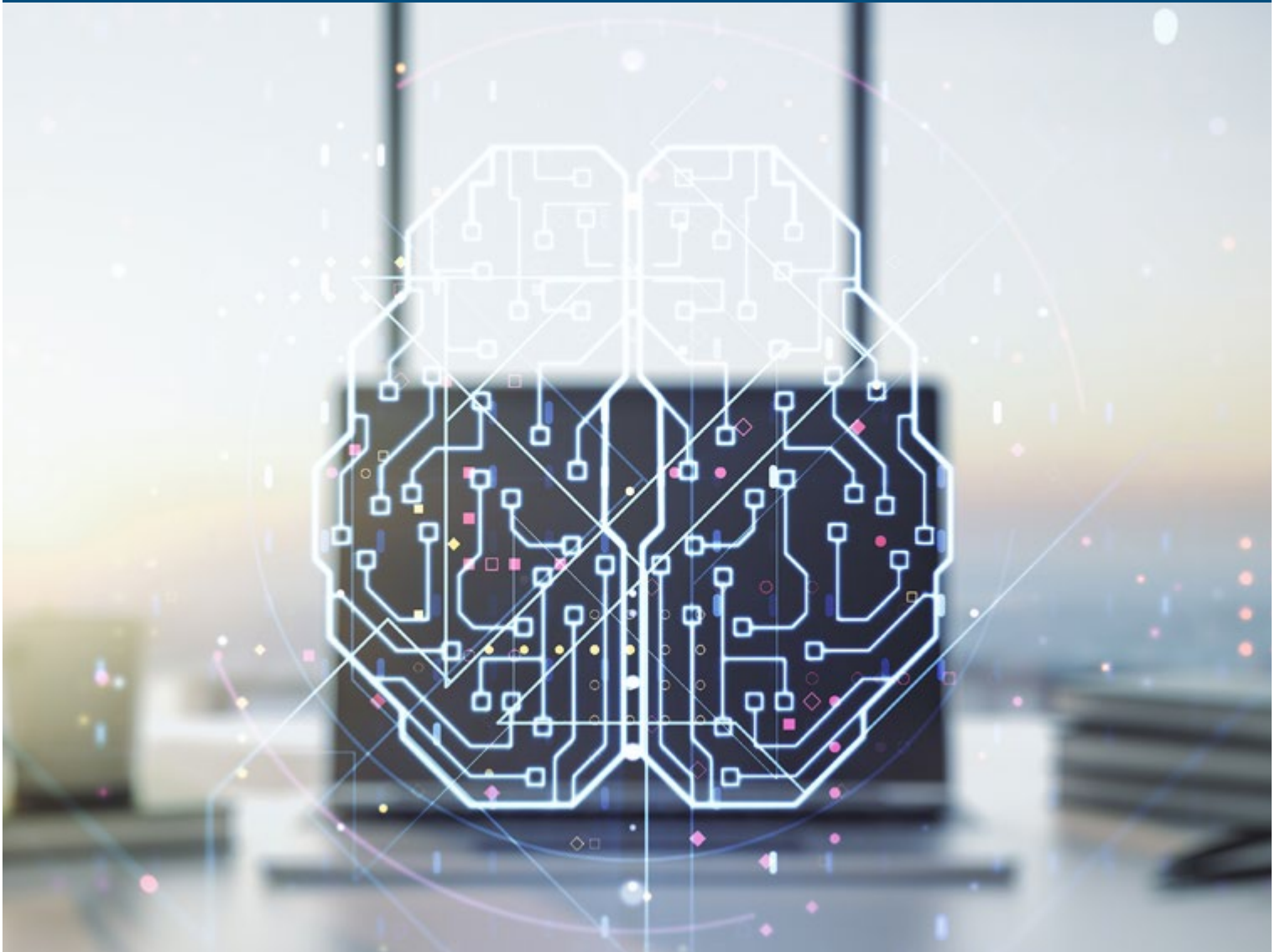
April 2020



Innovation and Technology

Actuarial Practice Innovation

Call for Essays



Prize Winners

First Place

**Wearables in Insurance:
Where Do We Go From Here?**
Mark Farrell

Second Place

Unified Behavior Modeling
Craig DeAlmeida

Third Place

I, Black Box
Harrison Jones

Honorable Mention

The Last Actuary
Mark Farrell

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Introduction

Kevin Pledge and Henry Chen

There are currently numerous technology transformations and disruptions taking place that invite actuaries to pursue innovative solutions to traditional and nontraditional actuarial problems. This essay competition, sponsored by the Actuarial Innovation and Technology Steering Committee (AITSC) of the Society of Actuaries (SOA), sought to give inventive actuaries the opportunity to identify how these technology transformations and disruptions are likely to impact actuarial practice innovation in the future.

It should be noted that the essays are intended to be solely the views, ideas, and opinions of the authors. They do not represent any formal position or opinion of the SOA or organizations with which the authors are affiliated. They are meant to contribute to the wide range of thinking and to generate innovative ideas on these topics.

Essay Topics

The essays explore several aspects of how technology transformations are likely to impact actuarial practice innovation in the future, including:

- How actuaries have designed innovative solutions using more advanced approaches than in the past
- Collaborative efforts where actuaries have championed innovation across a wide array of professions
- Using new sources of big data to drive product development and bring new products to market

- Designing more dynamic models that can readily be adjusted as new information becomes available

A panel of judges reviewed the essays for publication and awards. The judges selected three essays for awards, one for an honorable mention and a further three for publication. Consideration was given to creativity, relevance, and economic and business impact.

The prize-winning essays are:

FIRST PLACE

Mark Farrell, “Wearables in Insurance: Where Do We Go From Here?”

SECOND PLACE

Craig DeAlmeida, “Unified Behavior Modeling”

THIRD PLACE

Harrison Jones, “I, Black Box”

HONORABLE MENTION

Mark Farrell, “The Last Actuary”

The additional essays selected for publication are:

- Hussain Feroz Ali and Syed Danish Ali, “Coming to Terms With Innovation in Insurance”
- C. Seth Lester, “Embracing a New Dimension of Model Tuning in Actuarial Model Development”
- Dinelka Nanayakkara, “Driving Health Care Insurance Product Development in Line With Health Tech”

What’s Next?

Innovation can be difficult to identify and quantify. A call for essays such as this helps generate ideas for future research topics that may be covered by the AITSC. We also feel that essay competitions such as this one will be beneficial in the future.

The AIT Actuarial Practice Innovation Essay Competition Oversight

The essays were judged against a rubric developed by the oversight committee. We would like to thank the members of the judging committee for their participation and contributions:

Dorothy Andrews

Jim Timmins

Blake Hill

Gwen Weng

Special thanks to SOA staff members

Mervyn Kopinsky

Korrel Crawford

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Wearables in Insurance: Where Do We Go From Here?

Mark Farrell

Actuaries, working in the predigital era, writing out calculations by hand, would have found it difficult to imagine today's actuary having such immense data, technology and computing power at their disposal.

Ubiquitous smartphones, advanced artificial intelligence, autonomous vehicles, the Internet of Things, drones and blockchain are just some of the new technologies today's actuary is exposed to. The future holds even more exciting prospects with emerging fields such as quantum computing, 5G, brain-computer interfaces, smart pills and smart dust all coming to the fore.

Naturally, these changes provide immense possibilities, but also challenges and potential repercussions for the data-focused actuarial profession. As a forward-looking profession, it seems imperative that actuaries must change with the times and learn to embrace the challenges and opportunities the new technology-focused digital world is creating.

This essay summarizes the current use of technology within insurance (InsurTech) with a focus on wearable technology. Thoughts are provided on new wearable-derived data sources insurance companies may use in the future and the potential advantages of using data from wearables. A summary of opinions are presented on important questions that must be addressed as the use of wearables in insurance becomes more advanced and widespread.

In the era of tightening data regulations and consumer concerns, a blockchain solution is proposed. The essay concludes with thoughts on the important ethical considerations actuaries and other insurance stakeholders should consider to ensure we are using wearable data in an ethical and responsible way.

The Emergence of InsurTech

In recent years many high-profile insurance thought-leaders have argued that the industry has been lagging behind other industries (e.g., banking), which have increasingly embedded technology throughout their business models. However, this is now beginning to change as we witness the emergence of InsurTech—the use of technology innovations within insurance.¹

InsurTech has seen many technologies coming to the fore. For example:

- **Telematics** (e.g., Metromile uses telematics to offer affordable car insurance for low mileage drivers)
- **Artificial intelligence** (e.g., Lemonade offers “zero paperwork and instant everything” home insurance powered by AI)
- **Blockchain** (e.g., Insurwave is a blockchain-enabled insurance platform for marine insurance)
- **Robotics** (e.g., Digital Workforce uses robotics to enable insurance companies to automate processes)
- **The Internet of Things (IoT)** (e.g., Neos Ventures combines connected home devices and home insurance)
- **Wearable technology (wearables)** (e.g., John Hancock sells interactive life insurance policies that track fitness and health data through wearable devices and smartphones)

Wearables

One of the key technologies to emerge over the last decade has been the Internet of Things (IoT). Our world is now saturated with a vast array of sensors

1 Since 2015, many insurance companies have invested in InsurTech start-ups, and venture capital funding has poured into InsurTech companies. FinTech Global reported more than \$8.5 billion was raised by InsurTech companies globally between 2014 and 2018: FinTech Global, Global InsurTech Funding Tops \$3bn in 2018, FinTech.Global, January 23, 2019, <https://fintech.global/global-insurtech-funding-tops-3bn-in-2018/>.

that capture information across many areas, including transport, agriculture, health care and property.²

IoT sensors have also made their way into wearable technologies that collect data across many aspects of an individual's lifestyle, particularly those relating to health and health-related behaviors. We have also moved beyond wrist-borne devices to now seeing wearable devices in shoes, clothing, accessories and jewelry. Consider, for example, the Oura Ring—a seemingly normal-looking ring that incorporates a plethora of sensors measuring various sleep, activity, and recovery metrics with a high degree of accuracy.³

This availability of more bespoke and timely data on biometrics and the ability to understand this data, via machine learning, is having a profound impact, both on the medical profession and on patient care. The ability to detect deterioration in a biometric(s) of choice can lead to a preventive intervention, which can be delivered at lower cost and higher efficiency than a curative response in the absence of the biometric warning.⁴ Furthermore, research from behavioral psychology and economics confirms that more immediate feedback results in a higher probability of a behavioral adjustment of an individual.⁵ The early evidence on the use of wearable technology is that it is an effective tool in changing individual attitudes, behavior and

ownership of health problems to the net benefit of the subject's health.⁶

Wearable data, therefore, provides information that can be conceivably exploited to both improve our understanding of health- and mortality-related risk factors, and also used as an indirect channel to incentivize and help improve health behavior for society.

Hence, wearables also hold much promise for the health and life insurance industries to incorporate health and behavioral data to aid insurance underwriting, pricing, product innovation and customer engagement. This is evidenced by some pioneering insurance companies such as John Hancock, Vitality, United Healthcare and Oscar that have already incorporated wearables into their product design.

WEARABLE DATA

The insurance companies currently embracing wearables are typically monitoring activity levels (e.g., via step counts) and rewarding policyholders in the form of discounts and other perks. However, as the technology advances and matures, it seems conceivable that other health metrics may be used by insurers to underwrite policies with greater accuracy (see Farrell & McCrea, 2018).⁷ Health metrics that hold particular promise include:

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- 2 According to Cisco, 500 billion devices are expected to be connected to the internet by 2030. Cisco, Cisco Edge-to-Enterprise IoT Analytics for Electric Utilities Solution Overview, February 1, 2018, <https://www.cisco.com/c/en/us/solutions/collateral/data-center-virtualization/big-data/solution-overview-c22-740248.html>.
 - 3 de Zambotti, M., L. Rosas, I. M. Colrain, and F. C. Baker. March 21, 2017. The Sleep of the Ring: Comparison of the Oura Sleep Tracker Against Polysomnography. *Behavioral Sleep Medicine*: 1–15, <https://www.ncbi.nlm.nih.gov/pubmed/28323455>.
 - 4 CIPFA. Prevention: Better Than the Cure: Public Health and the Future of Healthcare Funding. *CIPFA.org*, January 1, 2015, http://www.cipfa.org/-/media/files/topics/health/cipfa%20%20publichealth_v14.pdf.
 - 5 Volpp, Kevin G., David A. Asch, Robert Galvin, and George Loewenstein. August 4, 2011. Redesigning Employee Health Incentives—Lessons from Behavioral Economics. *New England Journal of Medicine*, 365: 388–390, <https://www.nejm.org/doi/full/10.1056/NEJMp1105966>. Hafner, Marco, Jack Pollard, Christian Van Stolk. 2018. Incentives and Physical Activity: An Assessment of the Association Between Vitality's Active Rewards and Apple Watch Benefit and Sustained Physical Activity Improvements. *Rand Corp*, https://www.rand.org/pubs/research_reports/RR2870.html.
 - 6 For example, the UK body that creates guidelines for medical practice has strongly endorsed self-monitoring, feedback and goal setting as essential components to health-related behavior change: National Institute for Health and Care Excellence. Behavior Change: Individual Changes. *Public Health Guideline*, January 2014, <https://www.nice.org.uk/guidance/ph49/chapter/1-recommendations#recommendation-7-use-proven-behavior-change-techniques-when-designing-interventions>. See also Cadmus-Bertram, L.A., B. H. Marcus, R. E. Patterson, B. A. Parker, and B. L. Morey. 2015. Randomized Trial of a Fitbit-Based Physical Activity Intervention for Women. *American Journal of Preventive Medicine* 49(3): 414–8.
 - 7 In this study, I investigate the possibility of using data provided by wearable technology to help predict overall health and mortality. See Michael McCrea and Mark Farrell, A Conceptual Model for Pricing Health and Life Insurance Using Wearable Technology, *Risk Management and Insurance Review* 21(3): 389–411, December 2018, <https://ideas.repec.org/a/bla/rmgtin/v21y2018i3p389-411.html>.

- **Continuous blood glucose monitoring (CGM).** CGM is now feasibly monitored by individuals (from both an economic and a practical sense) because of the advancement of sensors such as that offered by the Freestyle Libre System and the Dexcom G6 system. Insurance for diabetics has historically been challenging because insurers class these individuals as high risk. CGM may act as a means by which cheaper insurance can be purchased by people who are diabetic and are managing to control their blood sugar levels through means such as exercise and diet.
 - **Heart rate variability (HRV).** HRV measures the variation in the time interval between heartbeats. It has been studied extensively in the medical research field and has been shown to be a predictor of morbidity and mortality. As HRV provides a noninvasive and easy way (e.g., measuring via the previously discussed Oura Ring) to measure autonomic nervous system imbalances, it could be potentially used by insurance companies in the future. Insurers could potentially use HRV as a rating factor and also a means to help inform policyholders of insights into their health and to even facilitate healthy behavior change.
2. **Reduced adverse selection and improved underwriting and product pricing.** By recording data on an individual's health behavior, the information asymmetry between the policyholder and the insurer is reduced, thus enabling an enhanced granular risk differentiation based on the true risk levels of the drivers to be achieved. This potentially reduces the problems of adverse selection. Wearable technology may, therefore, lead to the identification of newly available and potentially relevant information and rating factors, which are important determinants of health- and life-related insurance products. This is particularly prevalent in today's insurance market as insurers engage in a "race to simplification" so that they can offer adequately priced products while avoiding having to obtain invasive and time-consuming policyholder information.
 3. **Enhanced customer engagement.** Insurance company products do not lend themselves well to customer engagement, with most insurance buying viewed as a "grudge purchase." In addition, the industry has suffered from a lack of consumer trust. The traditional insurance model, which typically involves contact at a single (annual) point in time, has arguably held the industry back in today's customer-centric world. Incorporating wearables into product design may now help overcome this as customers are engaged on a more frequent basis with the potential to reward policyholders for desirable (i.e., risk lowering) activities. In addition, wearables data might give the insurance company an opportunity to provide policyholders with valuable health information and analysis and motivation (through discounts and rewards) to engage in healthier behaviors.

ADVANTAGES OF USING WEARABLE DATA IN INSURANCE

Incorporation of self-quantified wearable health data into insurance product design provides insurance companies with many potential advantages. I discuss some of these here.

1. **Product innovation.** The availability of these new technology-driven data metrics opens potential new avenues for health and life insurers to provide cover for previously difficult to insure or uninsurable risks.⁸ This is aided by the potential to now provide ongoing feedback data to the insurer in a real-time basis, overcoming the historical underwriting of coverage whereby the insurer typically captures only mortality and morbidity related metrics at a single point in time.

THE CHALLENGES AHEAD

Although some insurance companies are already embedding wearables into product offerings, the application of wearables within insurance is still nascent, and many opportunities remain to be

8 For example, <http://alllife.co.za/> currently provides cover to policyholders who suffer from manageable chronic diseases, such as HIV and diabetes, and who sign up for a strict medical program that requires monthly health checks. Wearable devices could act as a conduit to this model in a more economical and real-time based feedback system.

uncovered and challenges remain to be solved. Actuaries, as insurance problem-solvers and historic gatekeepers to policyholder premium calculations and insurance product development, are likely to play a significant role, along with other stakeholders, in addressing the many future issues around using wearable data and embedding the technology into insurance. Some issues and questions actuaries may contribute to answering include:

- How can the insurance industry use more timely and rich biometric data to refine their underwriting and pricing practices and provide a more personalized product?
- Can wearable data be used to predict the risk of adverse health outcomes and help incentivize healthy behavior, thus altering the policyholder/insurer relationship?
- What are the socioeconomic implications from potentially reducing adverse selection in insurance markets via pricing using wearable technology data? Does more accurate pricing of health insurance open the possibility of extending coverage to those deemed uninsurable or difficult to insure (e.g., diabetics)? Will certain high-risk individuals be penalized as a result? Will they still be able to get insurance? Should regulatory bodies, therefore, provide greater oversight?
- How will customers react to insurers introducing new technology into their products? Will they enter a trusting relationship that encourages data disclosure?
- How can we ensure that we use new novel data sources and artificial intelligence in an ethical manner within insurance?

Furthermore, as the future is likely to move toward more detailed data being captured, on a more frequent and possibly real-time basis, there are various implementation impediments to overcome. Actuaries may also help solve problems in the following areas:

- Data privacy, security and ethical debates have been a central part of the “big data” landscape since its rise to prominence. What are the demographic, cultural, legal and institutional barriers to the sharing of private information? How have users of private data in other technological spheres overcome these barriers?
- What are the technological challenges in the collation, storage, processing and communication of this very detailed and real-time data? Can insurers provide guarantees for the validity and source of the data using technical means?

Blockchain: Part of the Solution?

A major hurdle for the insurers’ ability to use wearable data relates to effectively managing policyholder concerns regarding privacy and control of data.

Blockchain, as a distributed ledger technology, holds much potential for the actuarial profession.⁹ The incorporation of wearable data into insurance may also benefit from blockchain as it potentially allows policyholders to control access to personal records and to know who has accessed them.¹⁰ If insurance pricing is to be based on more extensive levels of health and behavioral data, then this data needs to be shared with the insurance company while allowing privacy to be maintained as well as adequate policyholder controls (e.g., releasing a certain aggregated level of the data and only for specific purposes) and suitable security mechanisms to be put in place.

9 Farrell, M. 2019. Blockchain: A UK/European Perspective, *International News*, 76: 15–17, <https://www.soa.org/sections/international/international-newsletter/>.

10 Government Office for Science. 2016. Distributed Ledger Technology: Beyond Block Chain. Available from: <https://www.gov.uk/government/news/distributed-ledger-technology-beyond-block-chain> (accessed October, 2019).

Blockchain has already shown promise, within health care, in the facilitation of sharing medical data without the need to turn the data over to another party.¹¹ It also, therefore, seems to have potential to be used to help manage wearable data for insurance companies of the future.

Ethical Considerations

Some important questions must be addressed as the use of wearables in insurance becomes more advanced and widespread.

WITH GREAT POWER (TO “NUDGE”) COMES GREAT RESPONSIBILITY

Wearable technology has the potential to change the insurer and insured relationship to a more continuous risk-management support role where the insurer helps prevent adverse conditions taking place by alerting policyholders and also nudging them in the right direction. However, this shift toward “predicting and preventing” and influencing behavior has many potential repercussions that should be considered. To highlight this, consider the following examples:

- An insurance company rewards policyholders for activity via recording steps. As a result, the policyholder goes for a run rather than doing yoga (which they would enjoy more and would have a better marginal impact on their overall health).
- A health insurer offers a policyholder a free watch with heart health monitoring capability. The policyholder willingly accepts it as they expect the data, from their rigorous fitness lifestyle, to reduce their premium. The data reveals a heart issue. The insurance company withdraws coverage.

AN ETHICAL EXAMPLE: ADVERSE SELECTION—FRIEND OR FOE?

As “big data” continues to increase, the insurance world appears to be moving toward more individualized,

granular pricing. With both increasing and more accurate data availability (e.g., via wearables), it is likely that the asymmetry of information between the insurer and the policyholder will decrease, in the absence of regulation. This situation will inevitably lead to a decrease in adverse selection as the pooling of risk involves pooling lives of a more similar nature, and hence fewer lives leave the risk pool because of a pricing mismatch between risk and premium.

There are many socioeconomic implications from potentially reducing adverse selection in insurance markets. The traditional view is that reduced adverse selection is advantageous and desirable since policyholders are paying a premium closer to a statistically “actuarially fair” price, that truly represents their level of risk. However, this traditional belief provides a good example of a situation where insurance companies and regulators may now need to reconsider traditional views considering the new data-rich world we inhabit. For example, British actuary Guy Thomas (2018) argues that some adverse selection may actually be good for society if we consider the social value created from insurance coverage as a probabilistic “loss coverage.”¹² Figure 1 shows this situation.

This example helps highlight how some groups of consumers (in this case, the low-risk insurance policyholders) may benefit from enhanced personalized pricing, and other individuals may be potentially disadvantaged (in this case, the high-risk individuals—who are arguably most in need of insurance—who were previously being subsidized by the lower-risk policyholders).

This serves as just one example of how insurance companies, regulators and actuaries must carefully consider the implications of incorporating new data into pricing models to help ensure that we are using data responsibly in an ethical manner.

11 Vella, Heidi. The Healthcare Case for Sharing Medical Data with Blockchain. *Raconteur*, March 28, 2018, <https://www.raconteur.net/healthcare/healthcare-case-sharing-medical-data-blockchain>.

12 See Book Review: *Loss Coverage: Why Insurance Works Better With Some Adverse Selection*, *Journal of Risk and Insurance* 85(3), August 7, 2018, <https://onlinelibrary.wiley.com/doi/10.1111/jori.12262>.

Figure 1 The Potential Impact of Adverse Selection on Insurance Loss Coverage

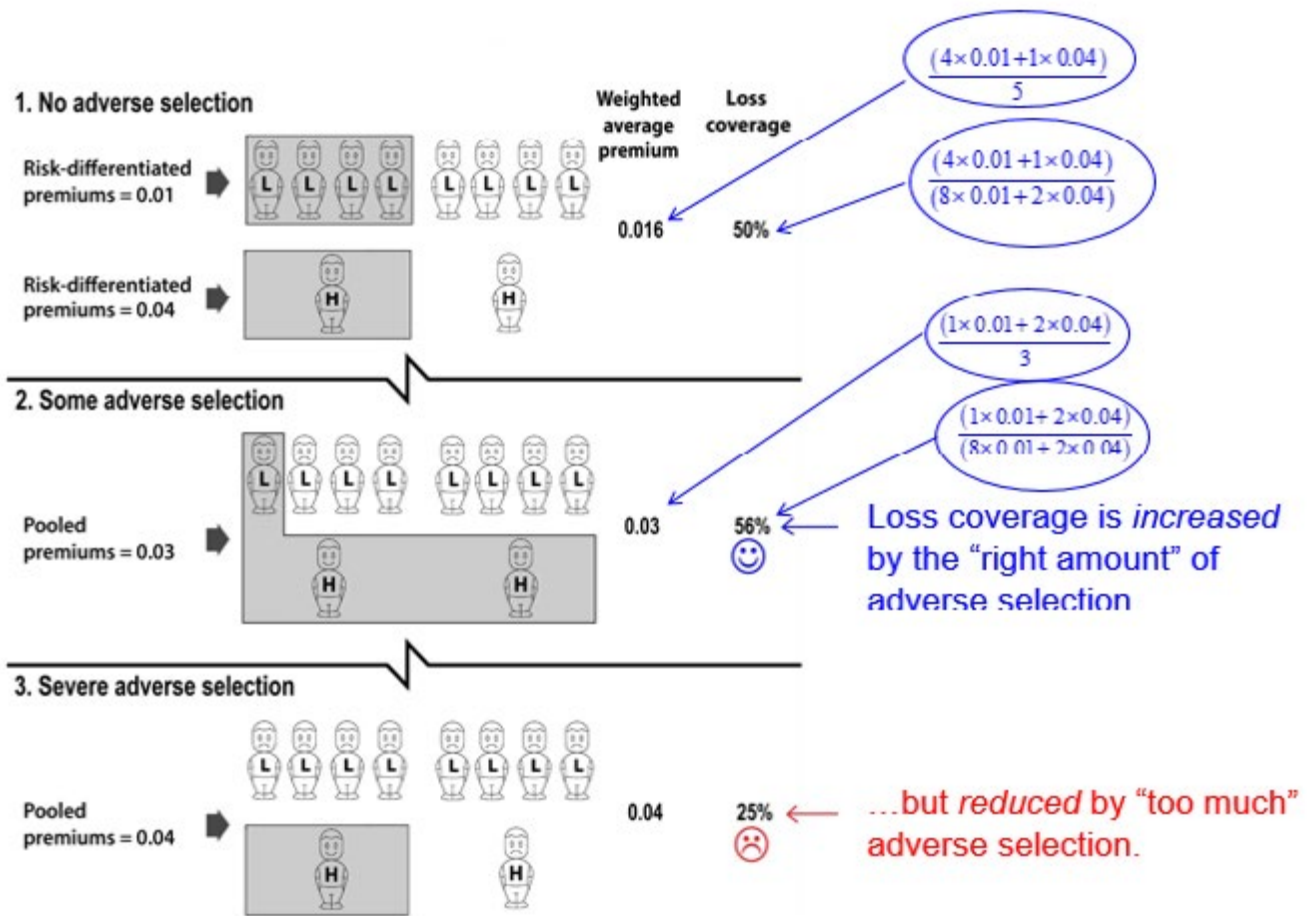


Diagram reprinted with kind permission from Guy Thomas. For further more detailed discussion on this diagram, please refer to <https://www.soa.org/sections/education-research/educ-research-newsletter/>.

Concluding Thoughts

In an era where data is growing at an exponential rate and machines are progressively more capable of outperforming humans at many tasks, the actuarial profession (like many professions) is facing unprecedented change. Novel data sources, such as from wearable devices, combined with more sophisticated and powerful analysis is one example of

how technology is altering some areas of traditional actuarial work. As we continue to move into this new digital data-rich paradigm, new opportunities and challenges will emerge. Technology is creating a new world before our very eyes, providing actuaries with an opportunity to capitalize on our strengths of technical expertise, problem-solving ability and professionalism to ensure we remain relevant and trusted business professionals in the future.

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Unified Behavior Modeling

Craig DeAlmeida

In the context of life insurance and annuity modeling, traditional approaches to setting actuarial assumptions have supported modeling policyholder behaviors, the contract options policyholders may use at various points in time, as being independent from one another. As actuaries apply more advanced analytics such as predictive modeling to these behaviors and discover interrelationships among them, however, continuing the practice of independent behavior modeling can introduce material bias into projected financial results. Modelers will need to consider unified behavior modeling, incorporating interactions among behaviors, and the tradeoffs involved between accuracy and complexity. In general, realizing the stronger impacts in assumption accuracy from predictive modeling requires a partnership with actuarial projection modeling.

The Current State: Independent Behavior Modeling

Our traditional approach, from an outside view, is rather curious. We isolate each behavior as its own assumption and model it independently from other behaviors, as if they belonged to different individuals. Take a basic deferred annuity contract, where a policyholder may take partial withdrawals of their account value, fully surrender for a cash surrender value, or annuitize it, converting it into a stream of lifetime income payments. The policyholder may also die and receive a death benefit. We create four behavior models: a withdrawal model, a surrender model, an annuitization model and a mortality model, each with their own probabilities for each period. When cash flows are projected for this contract using the traditional deterministic method, these probabilities are applied to all modeled policyholders; for example, all policyholders take a withdrawal equal to the probability of taking a withdrawal times an

assumed withdraw amount, or all policyholders suffer a fractional death. Fractions of lives remain in force, an odd modeling convention since our contracts are used by nonfractional people.

This modeling convention is sensible in that, if the behaviors are truly independent, the deterministic approach of applying uniform behaviors to all policyholders will produce the average cash flows from a more realistic, stochastic approach, where each individual either takes or does not take the given behavior based on the given probability. Indeed, the stochastic approach to behavior modeling can be rather noisy and take many trials to converge to a deterministic answer, which is far easier to derive, track and explain.

The Flawed Assumption of Independent Behaviors

But this depends on an “if,” that the behaviors are truly independent. As predictive analytics is being increasingly applied to these assumptions and these probabilities, incorporating more and more predictive factors, this assumption of independence is being proven false. For instance, full surrenders often happen more frequently on contracts where partial withdrawals have been taken in the past than those where no partial withdrawals have been taken. It is not surprising that these would be correlated, for the conditions that lead to an individual taking a partial withdrawal, such as to pay unexpected medical expenses, are sometimes the same ones that lead to a full surrender. If a person took a partial withdrawal in the past, the conditions that contribute to a full surrender are more likely to happen.

Indeed, hardly any pair of behaviors can be presumed to be independent. Consider further the condition of unexpected medical expenses ... the policyholder who likely has higher mortality is less likely to annuitize the contract. When this policyholder takes a partial withdrawal, their personal probabilities for later partial withdrawals, surrender, annuitization and death all change. Predictive analytics is increasingly exposing these relationships in personal probabilities and in turn challenging the deterministic modeling approach used to project cash flows based on these probabilities.

Bias: When Independent Behavior Modeling Encounters Dependent Behaviors

For a simplified example, consider a policy where the only benefits available at the end of each year are a surrender benefit equal to 100% of the entire account value or a withdrawal benefit equal to 10% of the account value. In the following year, if the surrender benefit was not previously chosen, the same two benefits are available at the end of the year. The analytics team studies past experience and determines that, in each year, the best prediction of behavior is as shown in Table 1.

Table 1 Dependent Behavior Model for Example

	Probability of Withdrawal	Probability of Surrender
No withdrawal in prior year	10%	5%
Withdrawal in prior year	60%	25%

In the first year, there is no withdrawal in the prior year and the top row is used.

When the modeling team is presented with these sorts of behavior relationships, they can easily envision the difficulties. In their extracts for their inforce models, they may not yet track the occurrence of prior year withdrawals. In their deterministic behavior projection, there is no distinction between those taking and not taking recent withdrawals, so other behaviors dependent on this predictive factor, like surrenders are in the example, may be limited to the initial state.

The analytics team suggests that the resulting probabilities of going from one state to the next be calculated via a Markov chain to get over the initial resistance of the modeling team. The first 10 years of

transition probabilities are worked out for pricing new business in Table 2.

The withdrawal rate (frequency of 10% withdrawals times 10%) is expressed as occurring after surrenders, not concurrent with them. So in year 1, the calculation includes 95% survival from surrenders as a denominator. The modeling team takes the table of decrement rates and applies them as a single behavior involving fractional people to project the expected cash flows.

But there is a bias in this approach, best shown via example. Assuming an original cohort of 1 policy, consider the surrenders in year 2, which starts with 0.95 policies, as 0.05 surrendered in the first year. 0.85 policies take no withdrawal in year 1 and 0.10 policies do. The surrender amounts are worked out with distinct account values, based on whether a withdrawal was taken in year 1, or with an average account value, assuming \$100,000 deposit and 2% interest credited each year (see Table 3).

Using the average account value from prior withdrawals and nonwithdrawals produces 2.8% more in total surrenders in year 2 than tracking account value distinctly for each of these. This is due to more surrenders coming from policies with lower account values (having taken a withdrawal in the prior year) than from those with higher account values.

A Path Forward: Projecting Behavior Paths

The example illustrates how averaging out interacting behaviors can lead to biased projected cash flows. The actuarial modeling solution for realizing, without bias, the cross-behavioral insights predictive analytics captures is simple in theory but challenging in practice. It requires modeling the policyholder as a nonfractional person and projecting which contract option was or was not taken in each period as a single, unified behavior outcome for the period. The policyholder either died,

Table 2 Transition Probabilities

Year	1	2	3	4	5	6	7	8	9	10
Surrender rate	5.0%	7.1%	8.3%	9.0%	9.4%	9.6%	9.8%	9.9%	9.9%	9.9%
Withdrawal rate	1.1%	1.6%	2.0%	2.2%	2.3%	2.4%	2.4%	2.5%	2.5%	2.5%

Table 3 Surrender Amount Calculations

Method	Distinct Account Values	Average Account Value
# Y2 surrenders, no Y1 withdrawal	$0.85 \times 0.05 = 0.0425$	$0.95 \times 0.0711 = 0.0675$
# Y2 surrenders, Y1 withdrawal	$0.10 \times 0.25 = 0.0250$	
\$ per Y2 surrender, no Y1 withdrawal	$\$100,000 \times 1.02^2 = \$104,040$	$\$100,000 \times 1.02^2 \times 0.9895 = \$102,945$
\$ per Y2 surrender, Y1 withdrawal	$\$104,040 \times 0.9 = \$93,636$	
Surrenders, no Y1 withdrawal	$0.0425 \times \$104,040 = \$4,422$	(not needed)
Surrenders, Y1 withdrawal	$0.0250 \times \$93,636 = \$2,341$	
Total surrenders	$\\$4,422 + \\$2,341 = \\$6,763$	$0.0675 \times \\$102,945 = \\$6,949$

surrendered, annuitized or did none of these things, but only one of these, while also possibly taking some partial withdrawals. The policyholder, starting the period at one set of conditions, which may include past behaviors, does one specific behavior among a set of possibilities, each with its own probability. Connecting these behaviors together one after another for all projected periods creates a behavior path the individual policyholder takes for that projection.

Approaches for modeling policyholders along various behavior paths to project cash flows and financial results include the following:

- **Brute force.** Project every possible behavior path. This is fully accurate but quickly becomes untenable except in simple setups. The first 10 years in the example comprise 2,047 behavior paths, with probabilities ranging from 20% down to 0.000002%. A 20-year projection has two million paths, a 40-year projection two trillion. Most of these have infinitesimal probabilities and are not worth the time to calculate out.
- **Recombining tree.** Determine every possible account value at each step and use probabilities connecting these account values to calculate projected cash flows. After 10 years in the example, only 11 account values are possible, having taken zero to 10 withdrawals up to that point. The probabilities of each account value at each step can be calculated using tree methods, and withdrawal and surrender benefits from each node in the tree are calculated. This is also fully accurate and grows

in size more slowly for longer projections than brute force. However, more realistic use cases will often not lend themselves to such overlapping paths to form a recombining tree.

- **Stochastic.** Simulate behavior paths, giving each simulation equal probability and averaging cash flows across the simulated paths. This provides customized control on how many paths to project but is balanced against bias in results from lack of convergence. Modest improvements in convergence can be gained by stratified sampling and similar techniques most easily when a single random number is used to define a behavior path. For example, if 0.87269, being between 0.85 and 0.95, leads to a withdrawal in the first year, then $(0.87269 - 0.85)/(0.95 - 0.85) = 0.2269$ can be used for the second-year action, and so on. The possible paths using this technique are limited by machine precision.
- **Stochastic with hierarchical clustering.** Starts like stochastic, but group similar behavior paths together using hierarchical clustering, choosing a representative path to project for each cluster, applying its total probability to the results. At a minimum, the stochastic method can produce identical paths and these need not be run more than once. But many paths are virtually the same and produce similar results. In the example, there are 126 paths with four withdrawals and a year 10 surrender—one of these paths will be closest to producing the weighted average present value of cash flows. Details for applying hierarchical

clustering on behavior paths are beyond the scope of this article, but this technique offers a powerful reduction in the number of paths needed for a given level of accuracy.

An Uncertain Future State: Is Unified Behavior Modeling Worth the Effort?

The two teams ponder the example and wonder: is the bias from using average account values significant enough to warrant carrying out one or more of the preceding modeling approaches? The answer requires carrying the approaches as an experiment, but more questions arise before the group commits to taking on even an experiment:

- What additional modeling expertise is needed to implement and review behavior paths, which splits each cell into multiple cohorts to be blended together, in actuarial projection models?
- Does third-party software have the flexibility to accommodate such an approach, and if not, what catalyst would be needed to spur adoption of this modeling approach by those vendors?
- What impact will the additional modeling complexity have on internal and external audit of results, and will auditors and regulators need additional time and resources for such models?
- For decision makers incorporating these results, will the increased accuracy of the predictive and actuarial models developed in harmony offset the increase in model risk?

- What impact will removing the bias have on benefits and credited rates offered to policyholders, either as an industry or relative to peers?

These questions are variations of the same basic tradeoff question: Is more accurate modeling worth it? Each of the stakeholders will weigh the value of increased accuracy differently, and the decision on whether to go with unifying behavior modeling will be sorted out, like any modeling decision, by balancing how much the increase in accuracy is worth, in quantitative terms, with effort and confidence, the latter often being more qualitative.

For this conversation to begin, some estimate of the increase in accuracy is needed, and that is where a manageable experiment can help establish the benefit of unified behavior modeling in the face of what can sometimes seem like overwhelming stakeholder concerns. For the 10-year example, the brute force method is doable in a spreadsheet and results in the following comparison for the entire projection (see Table 4).

How to measure bias will vary among stakeholders. Some will find being 4% to 5% off in benefits to be acceptable given uncertainty in the underlying assumptions driving those benefits, while others may see it as a red flag. Perhaps fewer will find the nearly 8% negative bias in account value tenable where investment strategy and inforce optimization decisions are being made on such projections. The expected number of policies inforce is accurate because the Markov chain calculation did work. By count was accurate, but by amount was biased.

Table 4 Brute Force Results

Modeling Approach	Unified Behavior: Separate Projections	Independent Behaviors: Single Projection	% Bias
Surrender benefits	\$59,247	\$61,648	4.1%
Withdrawal benefits	\$12,950	\$13,587	4.9%
Account value (AV) after 10 years	\$42,408	\$39,082	-7.8%
Policies in force after 10 years	0.3981	0.3981	0.0%
AV per policy in force after 10 years	\$106,518	\$98,163	-7.8%

Others might look to profitability measures instead. This requires more assumptions and modeling to produce, but for a simple indicator from this experiment, a 5% upfront expense and a 3% yield on reserves are assumed, with reserves equal to account value. Removing the bias by separately projecting behavior paths under a unified behavior assumption, increased the internal rate of return from 8.4% to 8.8%, an increase of 0.4%.

Walking Forward: Predictive Analytics and Actuarial Projection Modeling Together

Where predictive analytics is applied by those not intimately familiar with actuarial projection models, modeling teams can find the suggested behavior models to be unrealistic to implement. Due to data constraints, they may simply declare predictors involving past behavior to be off limits for projecting cash flows. But modeling teams, due to the additional scrutiny brought by various stakeholders as noted earlier, also require stronger proof of improved accuracy of predictions to undertake the efforts needed to implement those behavior models. Many organizations find friction here.

Making this particularly difficult is that the more powerful insights predictive analytics may offer for actuarial projections will likely come from connecting behaviors that are traditionally modeled independently. To realize these insights, fundamental changes in the actuarial model are required, but to make the case for these changes, the benefits from the changes need to be estimated. Because simplified methods will introduce material bias into the result, experimenting with these changes directly, on a small scale at first, is needed to move forward.

The environment needed to move forward includes a few key ingredients. First, having prototyping models with sufficient flexibility for rapid experimentation lowers the barrier for seeing whether new insights are worth the effort to implement. Second, close coordination between the analytics and modeling teams is needed to build mutual trust and confidence for trying new ideas jointly. Finally, the organizational culture needs to be tolerant or even encouraging of experimentation, with a willingness to defend its more complex output to both internal and external stakeholders, all of whom can ultimately benefit from more accurate actuarial projection models.

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I, Black Box¹

Harrison Jones

In response to a complaint against a standing member of the Society of Actuaries (SOA), the SOA called a hearing to investigate the matter. The following report provides details from the investigation as well as a transcript from the hearing.

Society of Actuaries: Notice of Hearing

Panel

- Ms. Sydney Rosby,
Member, Investigative Committee
- Mr. Ronald McDownald,
Member, Investigative Committee

Appearances: Mr. Harrison Jones, Actuary, MedInsurance Co.

Date: August 29, 2027

Background

1. MedInsurance Co. (“MedInsurance”) currently writes long-term disability (“LTD”) insurance policies in the North American market. Their LTD products cover a wide range of injuries and illnesses that could keep a policyholder from working, including Mental and Nervous (“M&N”) claims.
2. MedInsurance has historically experienced their highest losses on claims related to M&N. In the LTD industry, M&N claims have been very difficult to diagnose and treat. In turn, it is common to see claimants remain on LTD for many years without making much progress. From a technical side, this means that M&N claims have a *low termination rate*, the termination rate being the rate at which claimants return to work.

3. For the past five years MedInsurance has invested heavily in their Innovation Lab, a division that currently employs about 15 data scientists and 5 actuaries. According to their slogan, the Innovation Lab specializes in “using data and AI to spark a competitive advantage at MedInsurance.”
4. MedInsurance assigned a team lead of the Innovation Lab, Harrison Jones, to build an algorithm that would mitigate the losses related to M&N claims. Mr. Jones explained that this would be possible by building a predictive model that could identify claims management strategies that result in claimants returning to work faster.
5. A team of four developers (combination of data scientists and actuaries) under the direction of Mr. Jones produced and implemented a predictive model that influenced the claims management practice at MedInsurance.
6. Since implementing the new claims management practice at MedInsurance, there have been complaints from policyholders and benefit plan sponsors regarding this change. One plan sponsor in particular initiated a complaint against Mr. Jones after an incident at their place of work.

Transcript From Investigative Hearing

All introductory conversation relates to the material presented in the section “Background.” This transcript picks up during the technical discussion/debate surrounding the predictive model in question and Harrison Jones’s actions in producing the model.

Sydney Rosby denoted by [SR], Ronald McDownald denoted by [RM], and Harrison Jones denoted by [HJ].

[SR]: Can you please start by explaining the underlying data that your team used to produce this predictive model?

[HJ]: Yes. MedInsurance has gathered data on termination rates for many years. MedInsurance has traditionally

1 Disclaimer: This transcript is not based on real events and was prepared for the Society of Actuaries. Any similarity to an actual company or people is purely coincidental.

used this data for other actuarial functions, such as pricing and valuation work. After senior leadership came to me with their concerns regarding low termination rates for M&N claims, I suggested that they start gathering data on their claims management practices. So we were able to enhance our termination rate data with information on how our claims managers perform their work. Two variables of note were added to our data set: 'Claims Strategy' and 'Claims Manager Experience.'

[RM]: How do you measure 'Claims Strategy' and 'Claims Manager Experience'?

[HJ]: 'Claims Strategy' is measured in one of three categories ("Distant," "Active Management," and "Aggressive"), based on how the VP of Claims views the work of a particular claims manager. This is a subjective evaluation, but we were able to connect the 'Claims Strategy' with each policy. 'Claims Manager Experience' was more straightforward. It measures the number of years that the claims manager has been working in their current role with the following scale: "New (< 2 years)," "Experienced (2–8 years)," and "Tenured (> 8 years)."

[RM]: Were there any initial concerns regarding an "Aggressive" style of claims management? Right away, that sounds like policyholders would react unfavorably.

[HJ]: The "Aggressive" style that we are talking about here is not what you might think. It just means that the claims manager is very diligent about getting a claimant back to work, but always with an emphasis on patient care. So if someone tears a knee ligament at a construction site, we would provide them with additional care in the form of physiotherapy, acupuncture, and so on. This can sometimes be costly even if the claimant returns to work faster. We wanted to understand if the benefits outweighed the costs.

[SR]: Okay, we understand. Moving on to how you eventually used this data. Please walk us through how your team built this predictive model.

[HJ]: So with our own internal data on termination rates, enhanced with our new variables for claims management practices—

[RM]: Did you use any sources of big data in this model?

[HJ]: Can you please define big data for me?

[RM]: Can you define big data?

[HJ]: (*lengthy pause*) ... maybe it is best if I just say our underlying population of data consisted of just over 500,000 policies. We used 14 independent variables to produce our predictions of termination rates. We did not supplement our own data with third-party sources.

[RM]: Okay, as you were saying, you now had the data to build your model—

[HJ]: Yes, once we had our data, it was a simple process to produce our predictive model. Our statistical software is precalibrated to build a boosted decision tree to the standardized specs we use at MedInsurance. Once the data is collected, it is only a matter of typing two or three lines of code to get what we need.

[SR]: So that's it? Two lines of code and you are done?

[HJ]: Well, not quite. The point of building this model was to identify claims management practices that could reduce total losses for MedInsurance, specifically related to M&N claims. We had to use some more precalibrated tools to analyze the results from our boosted decision tree; but again, this was relatively quick. Two or three more lines of code.

[RM]: Did you consider any other models besides a boosted decision tree? It seems a little presumptuous to use only one model here. What metrics did you use to analyze whether this model had a good fit?

[HJ]: With all due respect, we do this a lot in the Innovation Lab. There is a lot of work in the back end that goes into running those two or three lines of code. A lot of automatic configuration where we place a lot of confidence.

[SR]: Some might call that a "black box."

[HJ]: We built this ourselves though. Like I said, we're confident in the results that it produces.

[RM]: Okay fine, what did you find after reviewing the results?

[HJ]: We found, unsurprisingly, that the “Aggressive” claims management strategy was the most effective at increasing termination rates, especially after a two-year period. This confirmed our initial hypothesis. Another finding was that we did not initially identify any relationship between the years of experience for a claims manager and termination rates.

[RM]: Did that matter? To me it seems like you had your answer regarding “Aggressive” claims management practices and could use that strategy. Is this the strategy that MedInsurance eventually implemented, which in turn led to the incident?

[HJ]: No, actually. We decided not to pursue the “Aggressive” claims management style for two reasons: One, it was expensive to provide so much additional care to our claimants. The financial benefits did not outweigh the costs. Two, our senior leadership was not comfortable promoting a claims management strategy that we labelled as “Aggressive,” regardless of the actual definition. We ended up removing the ‘Claims Strategy’ variable and used only the ‘Claims Manager Experience’ variable instead.

[SR]: So you removed the ‘Claims Strategy’ variable, and then what did you find?

[HJ]: In this new version of the model, the ‘Claims Manager Experience’ was significant. We found that newer managers generally had higher termination rates for M&N claims. The logic being that they were hungrier to deliver on their targets (of higher termination rates). With this finding, we got to work immediately. Communication went out to the VP of Claims to assign all M&N claimants to the claims managers with less experience.

[SR]: That seems like a drastic response. Did you not perform any follow-up statistical analysis, or impact analysis, to confirm that your findings were correct?

[HJ]: We were managing very tight deadlines. By the time we had come to this conclusion, the VP of Claims was demanding a strategy to take to his superiors *immediately*. We did not have any time for follow-up analysis.

[SR]: Did you feel like you had completed all the work that you needed to make an appropriate decision? It sounds like things might have been rushed.

[HJ]: At the end things were definitely rushed, but that’s sometimes the nature of the work we do.

[RM]: Well, with the benefit of hindsight, would you change anything in your process? I presume you’ll have to build another predictive model. Wouldn’t you like to avoid future repeat incidents?

[HJ]: Look, I obviously feel bad about what happened, and neither I nor MedInsurance intended for this. But if you are asking for my personal opinion, this type of incident could have always happened. It is really difficult to predict, with machine learning or anecdotally, how a claimant will react to any kind of claims management strategy. We happened to update our strategies right before this incident, so in my opinion our model is now just the point of blame.

[SR]: I do not agree with your statement “it could have always happened,” and I do not personally believe this is just a coincidence. You presented findings to your VP of Claims that changed their strategy. This clearly had an impact in how they conducted business.

[HJ]: So what’s your suggestion? We stop using predictive models to inform our decisions in insurance? The SOA has spent the last 10 years sponsoring events touting the benefits of machine learning and AI for insurers. How much time have they spent warning them of the potential ramifications?

[RM]: At every one of our events that focus on predictive modeling, we have had sessions on the consequences of misusing these techniques.

[HJ]: What is the ratio though? For every session on AI ethics, we have five where actuaries are bragging about all the amazing work they have done. Not to mention insurers who are investing millions of dollars into this field and demanding results on tight deadlines.

[RM]: How the SOA decides to operate is not the point of discussion for this hearing. I think maybe it is worth reminding you that three workers were severely injured at a construction site two months ago. One of your policyholders returned to work after spending nearly three years at home due to Mental & Nervous disorder. After returning to work, he suffered a severe panic attack while operating an excavator and injured three

of his coworkers. In his own words: “MedInsurance and their doctors convinced me that I was ready to return to work. I did not agree, but was happy to get out of the house and so I took their advice.”

[SR]: The bottom line, Harrison, is that we see a number of issues in how you handled the production and implementation of this predictive model. Did you ever consider the correlation between the number of years of experience of a claims manager and the strategies that they use?

[HJ]: I’m not sure I follow.

[SR]: Well, you removed the ‘Claims Strategy’ variable from your model, and all of a sudden the ‘Claims Manager Experience’ became statistically significant in predicting termination rates for M&N claims. To me that says there could be a correlation. Maybe your new claims managers use an “Aggressive” style. Maybe when you assigned all M&N claims to the new managers, what you were really doing was applying an “Aggressive” style to those claimants.

[RM]: Was there any consultation with the MedInsurance health practitioners about how an “Aggressive” claims management style could affect the health of those with an M&N claim? Specifically those with panic disorders?

[HJ]: I’m not aware of any, no. However, I don’t see how that would be relevant to my actuarial work. I’m familiar with the Actuarial Standards of Practice (ASOP), and there isn’t anything directly assigned to how an actuary should conduct themselves in the preparation of predictive models. There are 55 ASOPs but nothing that says I should consult a health care professional when developing claims management strategies.

[RM]: While that is technically true, I would direct you to Precept #3 of the Code of Professional Conduct that states, “*Where a question arises with regard to the applicability of a standard of practice, or where no applicable standard exists, an Actuary shall utilize professional judgment, taking into account generally accepted actuarial principles and practices.*”

[SR]: One last question: we have noticed that public opinion of MedInsurance turned sour in the last few

weeks when news of this story hit the mainstream. What corrective actions have you or the Innovation Lab taken to make sure this does not happen again?

[HJ]: We have begun to strategize an approach for a predictive model governance framework. I will provide a write-up at a later date for you to review.

[RM]: Yes, please do that, thank you.

All conversation after this point did not relate to the investigation.

Appendix A: Predictive Modeling Governance Framework From MedInsurance

The predictive modeling governance framework was never provided in full. But in email correspondence with Harrison Jones, the following explanation was provided:

Dear SOA Investigative Committee,

Thank you for providing me with clear feedback on areas for improvement in my work. I understand that the materials related to this hearing must be presented to the community of actuaries, but both myself and MedInsurance are glad to see that no further disciplinary action is being taken.

In regard to a predictive modeling governance framework: we have begun this process and this is actually being chaired by the chief risk officer at MedInsurance. We have identified five key areas that will be used as “pillars” in our project:

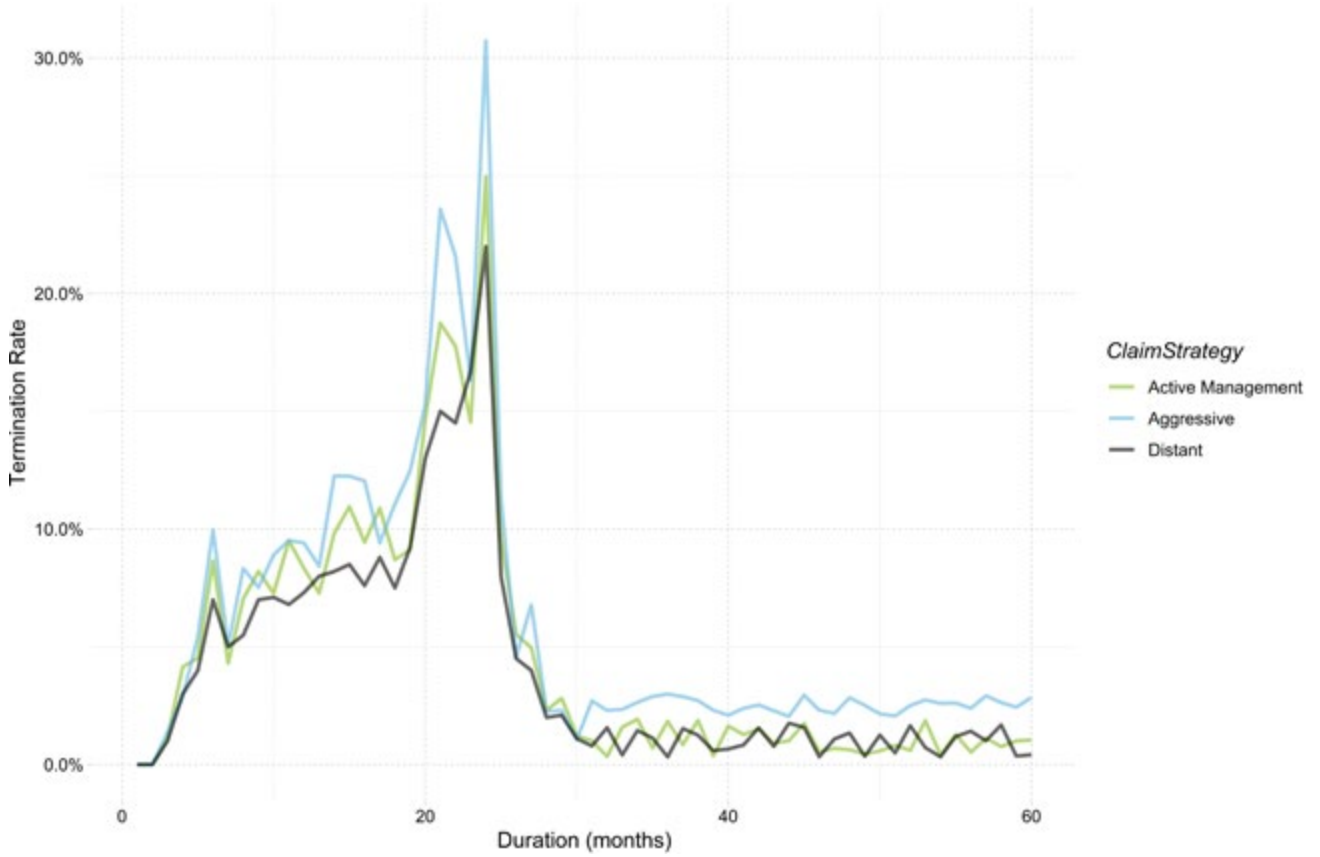
- i. data management controls
- ii. code review protocols
- iii. unconscious bias review
- iv. a discrimination assessment
- v. implementation / consequence evaluation, with a direct consultation to health care practitioners

We understand that this process will take time and a lot of hard work is still ahead of us.

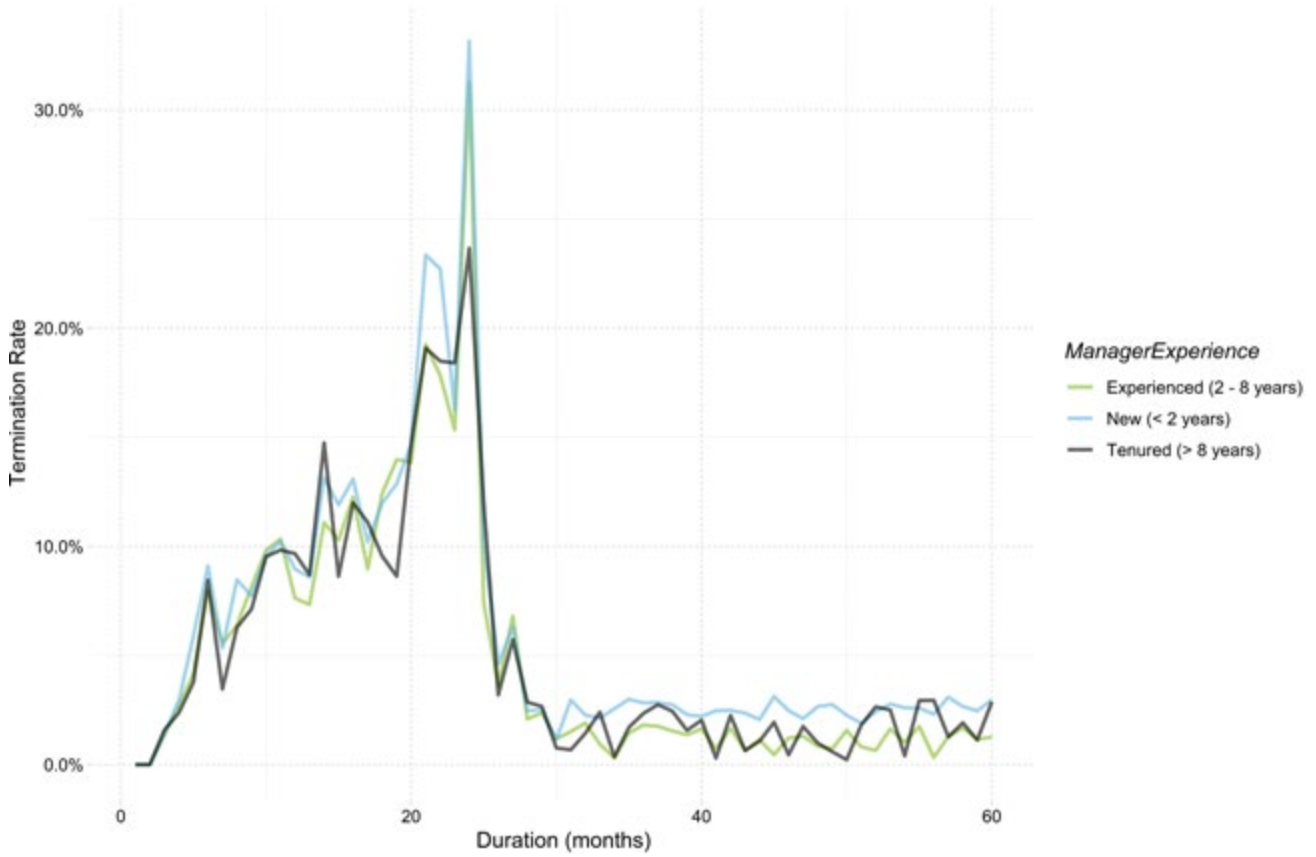
Kind regards,

Harrison Jones

Appendix B: Claims Termination Rates, Split by Claims Management Strategy



Appendix C: Claims Termination Rates, Split by Claims Manager Experience



Harrison Jones, ASA, is a manager at Deloitte. He can be reached at hajones@deloitte.ca.

The Last Actuary

Mark Farrell

The church was packed. Hundreds had gathered to pay their respects. As the eulogy was being read out, my thoughts began to drift. My father was loved. Eccentric and slightly odd in his ways, but very intelligent and—most important—he always acted with complete integrity. Whether it was work, family or community related, he put integrity at the core of his approach. He partially thanked his chosen profession for instilling in him the importance of integrity in how he conducted his life. These attributes had served him well, judging by the vast crowd of friends, family and former work colleagues who had gathered to say their last good-bye.

The church minister was humorously explaining to the silent crowd how my father had managed to accurately predict the exact week of his death—no doubt using the tools and expert judgment he had become so proficient in when he was working as an actuary.

Born in 1968, he had certainly had a good life, dying just three months shy of his 119th birthday. As the eulogy progressed, I became more and more intrigued about the profession that my father had made such an impact upon and that he had clearly loved. When he finally retired, in 2038, the actuarial profession had also literally died a death. I vividly recalled Father speaking with passion at his retirement dinner. A poignant moment of the retirement speech that remained with me was when he was shaking his head, showing tangible regret and disappointment, as he talked nostalgically about his actuarial career. He had discussed how times, and in particular the business

world, had changed drastically eventually making his skills and profession obsolete. Technology and data had been the driving forces of change and in many ways, as Father used to say, these same drivers should have been what propelled his profession to greater heights and not toward oblivion. But it wasn't just the actuarial profession that had vanished. Paralegals had disappeared, doctors were pretty much gone. All victims of technology advancements and the merciless artificial intelligence (AI) algorithm. Even household maids were a thing of the past as robots took care of cooking, laundry and other household chores. The fuel behind AI was data, algorithms and smart individuals. Father had, therefore, felt that actuaries were well placed to play a key role in the emerging paradigm, particularly given the pressing need to consider the ethical and regulatory implications.¹

On my way home from the funeral, I again began to think about the world we now lived in and the prophetic words Father had uttered toward the end of his career. My car was traveling at speed as I lay back in my seat and closed my eyes, safe in the knowledge that my autonomous vehicle would have me safely home at exactly 17:05. Technologists had finally overcome the moral and legal issues² with self-driving cars, and they were now of course ubiquitous, bar the occasional hobbyist manual driver who was confined to the “leisure only” roads. It seemed strange to think of a time when the majority of people actually drove themselves from place to place and thus took on the potential liability of damaging someone else or their property. Father, of course, had tried to warn his fellow actuaries that this new reality would have drastic repercussions³ for the many property and casualty (P&C) actuaries. Risks and liabilities still remained, but they had shifted from the driver toward the manufacturers of the cars and their parts (e.g., sensors). As human input had all but disappeared from the driving experience, cutting out the 90+% of risk previously caused by human error,⁴ risk and liability had also transferred to the producers of the software

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- 1 Royal Statistical Society and Institute and Faculty of Actuaries. 2019. *A Guide for Ethical Data Science*. <https://www.actuaries.org.uk/upholding-standards/data-science-ethics>.
 - 2 Scalable Cooperation at MIT Media Lab. Moral Machine (online game), <http://moralmachine.mit.edu/>.
 - 3 Peterson, R. W. The Future of Mobility and Shifting Risk. *Risk + Innovation*, July 15, 2017, <https://www.aig.sg/content/dam/aig/apac/singapore/documents/other/aig-the-future-of-mobility-and-shifting-risk.pdf>.
 - 4 Farrell, Mark. Autonomous Vehicles: Mortality and Insurance Implications. *Longevity Bulletin*, September 2018, https://www.actuaries.org.uk/system/files/field/document/LongevityBulletin_11_201809_web_ISSN_2397-7221.pdf.

used to make the AI-driven decisions as well as those responsible for building the transport routes and networks on which the driverless cars operated.⁵

My father had been one of the more outspoken actuaries of his time, calling for widespread changes and a need to grasp the opportunities that were arising in the new digital and technology-focused world. If only they had listened to his advice, instead of laughing at his claims of the potential end of the profession, perhaps the actuarial profession would still be alive.

As I arrived home and walked through my apartment door, my retina mail immediately downloaded via my permanent e-contact lenses. The e-letter was from my employer pension fund provider showing that my equity investments had passed the \$2,000,000 mark and according to my personal investment chat-bot,⁶ it was now time to start moving toward bonds to lower the fund volatility, given my planned retirement age of 86. Scrolling further through the letter, using two successive blinks from my right eye, the sophisticated AI-powered algorithms informed me that my expected death was still 112 with a 90% level of confidence. I recalled Father telling me how his first actuarial job involved calculating the liability for an employer's pension scheme where the employer made a promise to pay out a pension that was a fixed percentage of each individual's final salary. I wasn't sure if he was joking or not when he told me about this strange type of pension scheme, but a quick retina search revealed that these so-called defined benefit pension schemes had indeed existed and had kept many actuaries in work for a number of years. How times had changed!

My trail of thought was interrupted by my wife announcing that dinner was now ready. As I sat down to eat, the digital counter on the kitchen table automatically showed the exact amount of calories and breakdown of protein, fats and carbohydrates I was about to consume. Of course, this information would be automatically relayed to my insurer, Baidu, and a quick

glance at the figures told me that my health premium score wouldn't be adversely affected. It had been a bad few days since Father's death, as far as my real-time health insurance premium was concerned. My usually well-organized diet had suffered, and my implanted glucose sensor's historic data showed that I had been eating a lot of sugar-heavy meals. As a result, my automatically calculated fasting glucose had crept over 100 mg/dL this morning, which had implications for my health insurance premium. But worst of all, my jewelry sensors had picked up the emotional stress response from having to drop everything and help with funeral arrangements while also dealing with the emotional shock that Father was no longer with us. Despite his accurate predictions about his death and recent humorous quip that the trustees of his employer's pension scheme would be "jumping with joy with the fact that one of the scheme's highest liabilities was eventually being extinguished," the news of his death still came as a blow, as if out of nowhere, and I could see the toll it was taking in cold, hard stress figures.

All this health-related data was feeding directly into the autonomous blockchain-enabled insurance company⁷ where the machine learning algorithms predicted my health risk with near 100% accuracy. Ubiquitous blockchain proliferation had occurred. Not by 2025 as the hype had suggested, but by 2035 the exchange of value across the world was facilitated by the irrefutable and distributed technology. Smart contracts were set up and utilized with ease, which had led to a gain in trust in both the banking and insurance industries. Middlemen were a thing of the past. Unnecessary friction across nearly all services and transactions had now disappeared.

Adverse selection was also a thing of the past,⁸ as individual insurance risk predictions were now completely specific and accurate to each individual, ensuring that the insurers were not impacted by potential asymmetry of information. Hence the bad risks were no longer being subsidized by the "good risks." The traditional insurance pooling of risk

5 Peterson, R. W. The Future of Mobility and Shifting Risk. <https://www.aig.sg/content/dam/aig/apac/singapore/documents/other/aig-the-future-of-mobility-and-shifting-risk.pdf>.

6 Maruit Techlabs. Chatbots as Your Personal Finance Assistant. Accessed October 2019, <https://marutitech.com/chatbots-personal-finance-assistant/>.

7 Farrell, Mark. Actuaries and Blockchain Technology. *ProActuary.com*, January 2019, <https://proactuary.com/actuaries-blockchain/>.

8 Farrell, Mark. December 2017. Adverse Selection? Friend or Foe. *ProActuary.com*, <https://proactuary.com/adverse-selection-friend-or-foe>.

no longer existed⁹ as every insured individual was accurately assessed on a completely personalized granular level. However, lack of pooling had created wider societal problems as the poor risks in society were now finding it very difficult to get the necessary coverage.

Insurance companies had also changed in many other ways. Baidu now had 90% of the insurance provision market share, as they had leveraged off their advanced analytics and strong customer loyalty and engagement. Everything had moved from static to dynamic and real-time, from purchase and annual renewal to continuous offerings and interactions. Data availability was ubiquitous with sensors everywhere feeding in voluminous data cheaply and easily for the sophisticated and automated algorithms to perform complex and extremely accurate calculations, which had moved beyond the realm of human understanding. Wearables, social media, geolocation, weather and news were just some of the real-time data continuously feeding into insurers' dynamic blockchain-enabled data systems, where AI was doing the work previously done by actuaries.

My own insurance company acts not only as a financial security blanket but also as a valued trusted advisor. The insights and health information it provides me on a daily basis have truly helped overhaul my health behaviors and constantly nudge me in the right direction with alerts and monetary motivations. The fact that all my coverage comes from a single provider, where I also get nearly all my other digital services, has meant that my customer experience is drastically efficient and simplified. They even provide me with new, unique, bespoke, personalized and dynamically priced products based on my changing needs. Manual underwriting no longer exists. Claims processing is fast, accurate, cheap and efficient. Fraud is almost nonexistent, as the data and algorithms delving into online social data can spot fraud with ease. Everything is frictionless. The industry has shifted largely to one of prevention, risk monitoring and mitigation. I love interacting with my insurer as they provide such valuable information in a clear simplified format. I truly trust that they will provide the necessary claims and/or advice should I need to call upon them at any point.

My father had foreseen these changes and viewed them as being catalysts and opportunities for actuaries to “move up the value chain,” adding value in innovative creative ways, completely outside traditional actuarial work. His view had been that creativity, flexibility and the ability to innovate and reinvent oneself were going to be key skills for the future. He spoke about the need for actuaries to embrace technological changes. His message to actuaries of the future also included:

- The need for actuaries to become more creative as new data sources and complex risks continued to appear and evolve.
- The need for actuaries to evolve their mindsets so that perpetual ongoing learning¹⁰ was viewed as being very important for actuaries to not only thrive, but survive.
- Barriers to entry will reduce in the future. Actuaries would no longer be protected, to the same extent, by credentials from exams and by regulatory work. Actuaries must ensure they are always adding value and remain focused on the needs of employers and their customers.
- As part of being flexible and continuous innovators, actuaries must learn to work in diverse teams that often take an agile experimental approach to new problems, which would involve failing fast and iterating as necessary.
- As key members of these diverse agile problem-solving teams, actuaries would, at times, be expected to apply their specialist knowledge, but they would also need to be able to act as generalists with an ability to see the bigger picture and to connect people and ideas.

Many of his fellow actuaries, unfortunately, thought he was being dramatic with such views. Actuaries don't need creativity, they claimed. Technology and AI are overhyped, they retorted. We are protected by impermeable barriers to entry, they countered. However, risk and corporates had evolved and changed so quickly that Father's warning about creativity and flexibility being some of the most important attributes

9 Schreiber, Daniel A. AI Can Vanquish Bias. *Lemonade*, December 9, 2019, <https://www.lemonade.com/blog/ai-can-vanquish-bias/>.

10 Farrell, Mark. LinkedIn post, https://www.linkedin.com/posts/markfarrellactuary_actuaries-activity-6560790232101335040-PYP6.

an actuary of the future could possess, did indeed seem prophetic. As he had forewarned, AI and technology had indeed penetrated every nook and cranny of business. Anything that could be easily automated had fallen prey to the majestic combination of AI and technology. Those who failed to embrace the fourth industrial revolution¹¹ had indeed been left behind. Hindsight, of course, is a wonderful thing.

As I turned on the news, I was greeted by some uplifting, positive information. The new president of China and free leader of the world was speaking at an address and the support from the crowd was palpable.

Politics had moved on in leaps and bounds over the last decade and of course had changed immeasurably since the spectacular collapse of America, in 2032. President Wò sēn was everything a nation could hope for in a leader—completely altruistic, nonbiased, 100% committed to the good of the people and more intelligent and rational than any president who had gone before him. But this was, of course, no surprise. President Wò sēn was after all an artificial intelligent robot.¹² What began as a joke (“Watson for President”)¹³ in 2016 had set in motion the wheels toward the current reality. Surprisingly, the vast majority were embracing the new efficient world order where national decisions were based on terabytes of historic data, aided by

quantum computers¹⁴ that had all but replaced traditional binary computers. The results were difficult to argue against. World crime was now down 15%, health care costs were down significantly as chronic conditions were recognized at an early stage and patients had the means to understand their conditions and treat themselves much of the time.

Concluding Thoughts

I should finish by saying that I actually don’t think that the actuarial profession will die. I believe there are too many talented and intelligent people in this profession for us to lose our relevance and for actuarial obsolescence to become a reality.

However, despite our many strengths, I do have the view that we are entering an era where the world of work will continue to change at a rapid rate. Increasing connections, technology, digital information and ideas are leading to exponential change throughout the world in many ways, whether we like it or not. To use a metaphorical quote from Malcolm X, “The future belongs to those who prepare for it today.”

As a profession, whose very existence is based on the premise of being skilled at predicting the future and dealing with risk, let’s not fail in these regards, at this very important juncture.

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11 World Economic Forum. Fourth Industrial Revolution. *WeForum.org*, accessed October 2019, <https://www.weforum.org/focus/fourth-industrial-revolution>.

12 Cuthbertson, Anthony. Could a Robot Run for President in 2020? *Newsweek.com*, February 16, 2016, <https://www.newsweek.com/could-robot-run-president-2020-trump-clinton-bush-kanye-west-426799>.

13 Watson for President. <http://watson2016.com/>.

14 Wikipedia. Quantum Computing. https://en.wikipedia.org/wiki/Quantum_computing.

Coming to Terms With Innovation in Insurance¹

Hussain Feroz Ali and Syed Danish Ali

An article recently published by the *Telegraph* took us by surprise: “Why Social Media Posts Could Invalidate Your Home Insurance.”² Interestingly, home insurance policies require customers to take reasonable care of their property; by posting their pictures online while on vacation, customers may be in breach of that policy and may find their claims rejected afterward. This is because there is a link between being on vacation and burglary, as thieves usually prefer the soft targets. While the article should caution us to monitor our behavior on social media, it is also an eye-opener for the changing realities of the new world.

In their quest to offer better customer service and lower-priced digital solutions, financial institutions are increasing their partnerships with technological firms. Embracing modern technology is becoming a necessity to remain valuable in the eyes of customers. The saddening demise of Thomas Cook can be a great lesson for every industry. The oldest and once highly popular travel company eventually lost its battle to online travel companies as customers demanded cutting out the middleman. Countless other examples relate the same story of a reversal of fortunes.

The financial industry in general and the insurance sector in particular are going through a similar transformation. The advent of FinTech and InsurTech has challenged existing business practices and poses a serious threat to traditional companies. The InsurTech

industry has gained significant momentum with potential for exponential growth. According to Deloitte, about US\$2.6 billion³ was invested in InsurTech business in 2018, and deal sizes have been growing, showing an impressive future outlook.

Financial inclusion has long been a concern for policymakers. Currently we live in an era where mobile phone subscriptions are quickly surpassing the banking population, creating hopes for accessibility of financial products to the previously “unbanked” population. This step alone is not enough to address financial inclusion, because penetrating the underserved segment requires the simplest product offering with the lowest pricing, minimal underwriting requirements and so on. Hence InsurTech would play a key role in addressing this issue alongside mobile telecommunication companies. Inclusion is one of the many issues (both legacy and emerging issues), such as low interest rate environments, increase in chronic diseases, climate change challenges and so on.

The technology is improving at an unprecedented rate. As per the GSMA Intelligence report “The Mobile Economy 2018,” 4G has become the leading mobile technology by number of connections in 2019. By 2025, two-thirds of mobile connections will operate on high-speed networks with 4G accounting for 53% and 5G at 14% respectively. Another revolutionary idea is Elon Musk’s Starlink that aims to bring thousands of small satellites in a constellation with ground transceivers to enable fast cheap internet access for all humans in all areas (remote or urban).

Let us look around to better understand how the insurance sector, banking world, rating agencies and regulators are all playing their part in this transformation process. This will help us understand how the actuarial profession is likely to innovate itself in the future.

Banking World Has Been Digitized— Insurance Will Be Next

The banking industry took a 180-degree shift after the advent of FinTech. The larger traditional banks

1 The views expressed are the authors’ own and do not necessarily reflect the opinion of their employers.

2 Morris, Hugh. Why Social Media Posts Could Invalidate Your Home Insurance. *Telegraph*, August 30, 2018, <https://www.telegraph.co.uk/travel/advice/social-media-post-invalidate-insurance-burglary/>.

3 *Financial Times*. New Pattern for Insurtech Bets. *FT.com*, September 30, 2019, <https://www.ft.com/content/78363a0a-e384-11e9-b112-9624ec9edc59>.

are partnering up with FinTech as part of their digital strategy. The other extreme is “digital only” banks with zero physical presence. Some examples of digital banks recently licensed are:

- Hong Kong issued eight virtual banking licenses in 2019.
- Four virtual banks are operational in China.
- Singapore has announced plans to offer up to five new virtual banking licenses.
- Taiwan issued its first virtual banking license in 2019.
- Pakistan has one fully digital bank that enables people to borrow, save, invest and insure through smartphones.

Though the “online only” banks with zero physical branches are being categorized as “virtual” banks, it will not take them too long to be converted to mainstream banks. Digital banks are also receiving favorable treatment from regulators to ease the setting-up process. For example, South Korea has allowed a three-year grace period for full implementation of Basel III regulations to digital banks.

The insurance sector, on the other hand, had seen a handful of such digital counterparts. Hong Kong introduced a fast-track approval process for digital insurance licenses and received an overwhelming response. Bowtie Life Insurance received the first virtual life insurance license, followed by Avo Insurance receiving the first virtual general insurance license in Hong Kong.

Innovation Push From Rating Agencies

Following an announcement by A.M. Best that it may soon begin scoring innovation efforts as a component of ratings, the innovation subject has taken center stage. This is a further sign of the realization that innovation and long-term financial health of insurers are interconnected. Companies not focusing on innovation will likely find themselves facing the risk of a rating downgrade.

Encouragement From Regulators

All of the preceding may not happen in reality if the regulators are not willing to embrace the new

world. The good news is that insurance regulators in several countries have jumped onto the innovation bandwagon to accommodate technological transformations; notable examples follow:

- In January 2019, New York State released the “first of its kind” guiding principles on how life insurers can use social media along with other nontraditional sources, provided that such information is not discriminatory toward customers. The usage of new data sources will provide better risk understanding of customers for accurately pricing individual risks; however, the challenge will be avoiding discriminatory criteria.
- Creating an innovative product that is in compliance with traditional regulations may be a catch-22 situation. Realizing this fact, some regulators have proactively come up with an innovative approach to address this situation: a regulatory “sandbox” model where innovation is allowed on an experimental basis within the supervision of a regulator. Such an approach would allow innovative ideas to be taken to the market without requiring full compliance with traditional regulations. This new idea has gained popularity in various parts of the world. In the United States, for example, Kentucky has recently released its guidelines for a regulatory sandbox model and is marketing itself as an innovation hub for InsurTech companies. In other parts of the world, India has recently released similar guidelines to facilitate InsurTech growth.

Expected Future Product Innovations

The existing product offerings from traditional insurers are handicapped by legacy system issues. In the new world, technology will be an enabler for innovation and new ideas will flourish, including:

- The product no longer would remain a prepackaged offering. Customers could expect to create a personalized product offering per their liking of benefits, pricing and so on. Imagine this concept using cooking as an analogy. Customers would not want to order from the menu but rather would like to cook their own meal. The key to success would be simple product design, instant

availability of quotes, user-friendly interface, easy-to-understand terminology and so on.

- The personalization may also mean a product no longer requires covering an individual for 365 days of the year. Customers may be willing to pay for only certain hours of each day for life insurance products. For example, individuals whose job requires them to spend certain hours in the office on weekdays might not want to include those hours in their insurance. They might want to buy life insurance with limited-hour protection during weekdays and 24-hour coverage on weekends or only during traveling. Such a change would be similar to the “pay per mile” concept introduced in auto insurance.
- The flexibility would also include short-term variations. For example, during the winter holidays, a customer might want to buy skiing coverage for a certain period. Instead of approaching the insurance company, she would demand having this flexibility on her mobile phone.
- The underwriting components would be automated. Instead of requiring medical tests, a combination of several data sources (both traditional and nontraditional) will automatically lead to automated pricing and quantification of underwriting risks.

The best advantage of this automation might come in the form of almost zero claim rejections due to incorrect disclosure. Currently the insurance sector is filled with such complaints, which negatively affect the image of the insurance industry. If a customer does not disclose certain information for underwriting, such information would not be used against her claim settlement. The trust issue runs deeper than that, and that’s why new business models like the peer-to-peer (P2P) business model are favored among InsurTech. P2P is not new, since mutuals and community-oriented businesses operate along similar lines. What is new is the increasing demand by customers for an ethical business model and practices.

- The bundling of products may gain popularity in the future. Currently life, health, critical illness and so on are considered separate products, and usually the customer has to buy each one independently. The future may allow easy product bundling and may even offer discounts for buying multiple products together.
- In many business models, the concept of the middleman is removed, which has significantly reduced product cost and allowed a direct relationship between provider and customers. As insurance is traditionally sold and not bought, a significant component of fees is used for intermediary commission. The future may require the removal of intermediaries to bring down pricing.

While different stages of the insurance product, distribution and business model are being disrupted differently, it is important to note that it is the convergence of these technologies that matter along with good ethical designs. This is because in problem solving, the problem is attacked with a broad number of perspectives and tools to create a solution that fulfills the needs of various stakeholders and solves the puzzle where each bit of the piece combines to solve a larger puzzle. It is then that we see ground-level impact and progress. Given these technology options, it is worthwhile thinking about how these ideas would fit into the larger context, sitting alongside the sharing economy, the Internet of Things, machine learning and smart cities.

If Insurance Companies Are Not Around in the Future, What’s the Implication for Actuaries?

In an interview with the *Financial Times*, the AXA chief executive Thomas Buberl⁴ cited technology firms like Apple, Google, Facebook and so on as his future competitors. This statement raised several questions: Are insurance companies facing an existential threat? Can actuaries survive without insurance companies? Actuaries have always been favorites in the insurance sector; can they continue to be the same for InsurTech? Insurance companies are criticized for their lack

4 *Financial Times*. AXA Boss Predicts Competitive Threat From Faangs. *FT.com*, October 4, 2019, <https://www.ft.com/content/f7f6d884-e484-11e9-9743-db5a370481bc>.

of response to technological changes. Is the same criticism valid for the actuarial profession, too?

Let us ask ourselves whether we are employable in InsurTech. There are a number of InsurTech companies currently operating, how many have employed actuaries? Are we not willing to approach them, or are they not willing to hire us?

The data analytics was bread and butter for actuaries; however, alternate careers like the data scientist have challenged our abilities. Having the skill set is one thing; demonstrating value to the company is another. Somehow companies are already not finding actuaries best suited for analytical roles and hence are turning their attention to data scientists.

If actuaries continue to be part of the back office function, it is very likely that their role will be quickly taken over by artificial intelligence and automation. Despite having the skill set suited for various sectors, actuaries have been unable to broaden their appeal and find themselves mostly confined to the insurance sector. The demand gap has played an important role, as jobs within the insurance sector are higher than the supply in the market. However, this complacency has restricted actuaries from challenging themselves in nontraditional roles.

How Can the Actuarial Profession Innovate Itself?

The future is full of excitement for the industry; however, to stay relevant, actuaries need to be part of the solution. Some of the proposals to stay relevant are as follows:

- The actuary will be required to possess computer programming skills, big data analytical tools and so on. Having technical know-how along with commercial acumen would become a prerequisite. More emphasis in the future would be on how to apply the actuarial skill set to solve complex problems with a simpler solution. The problem-solving skills of actuaries have always been

appreciated; it is the solution that they come up with that is usually criticized. Often the solution is equally complex and therefore difficult for nontechnical staff to comprehend. While actuaries have taken pride in solving complex problems, the future would require them to solve them in the most simplistic manner.

- Collaboration with team members outside the actuarial domain will play a key role in demonstrating the value of the actuaries. This will require actuaries to invest time in building relationships, team management and so on.
- Networking is important not just for individual profiles, but for the marketing actuarial profession. Actuaries will have to find time for networking sessions.
- The profession needs to find influencers to attract millennials as well as to broaden its appeal. This would require having entrepreneurship courses as part of the academic curriculum to give birth to future leaders and give boost to membership drive.
- Actuaries need to sharpen their nontechnical writing skills, which will be an important asset in the future. Not many actuaries considering publishing their articles or research work feel comfortable giving presentations to a broader audience. This would need to be changed in the future through some mandatory requirement as part of the exam curriculum.
- Finally, professional standards and ethical considerations will play a bigger role in the future. Innovation would push toward more leniency in regulations; however, actuaries will have to ensure that the customer is protected, data privacy is maintained, data analysis is nondiscriminatory and so on. Regulators have always relied on actuarial judgment on these matters and will continue to do so in the future.

Concluding Remarks

While we should be enthusiastic about encouraging innovation, it should not be pursued single-mindedly in search for profits by making unethical designs.⁵ Being socially conscious is as important, if not more so, than the technology itself. That is why digital risk management and controlling algorithmic risk are other

key value additions that actuaries can perform to add value to their employers to avoid the recent WeWork-type fiasco situation⁶ that seems to be worse than the ousting of Uber ex-CEO Travis Kalanick. The future actuary will be the one creating ethical future solutions by understanding the technology as well as having knowledge of AI and machine learning.

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5 For instance, see the SOA report *Ethical Use of Artificial Intelligence for Actuaries*, SOA.org, 2019, <https://www.soa.org/globalassets/assets/files/resources/research-report/2019/ethics-ai.pdf>.

6 Gandel, Steven. WeWork CEO Adam Neumann Ousted as Company Runs Low on Cash. *CBSnews.com*, September 24, 2019, <https://www.cbsnews.com/news/adam-neumann-wework-ceo-ousted-as-company-runs-low-on-cash/>.

Embracing a New Dimension of Model Tuning in Actuarial Model Development

C. Seth Lester

On December 3, 2019, US senators Cory Booker (D-NJ) and Ron Wyden (D-OR) penned a series of open letters to CMS administrator Seema Verma, FTC chairman Joe Simons, and leaders of several of the largest US health services and health insurance companies. The letters were uniquely tailored to their respective addressees, but each of them cited a pressing need to examine the presence of algorithmic bias in the automated decision systems used today in the health care provider space. These letters contained requests for additional information regarding the ways federal agencies and US health service providers safeguard their constituents and customers from being disparately impacted or targeted by algorithmic bias in automated decision systems.

The letters came hot on the heels of a bombshell study published in *Science*¹ just weeks earlier that made national headlines for exposing algorithmic bias in automated decision software widely used for the partial automation of certain care management decisions. The software employs predictive models of the kind that are in production today in numerous other provider systems and nonprofits, and the study's authors estimate that predictive models similar to the flawed automated decision model are potentially shaping, at least in some part, the managed care decisions for as many as 200 million patients in the United States

today. Among the study's findings, perhaps the most striking is that "correcting the bias would more than double the number of black patients flagged as at risk of complicated medical needs within the health system the researchers studied."

The *Washington Post* article that covered the study and its findings² indicated that the researchers who exposed the model's algorithmic bias are already collaborating with the vendor of the software to develop solutions to the model's inherent racial bias, and then went on to quote University of Chicago professor Sendhil Mullainathan, who oversaw the study and who issued an urgent appeal to the health care space's "Big Data" practitioners: "It's truly inconceivable to me that anyone else's algorithm doesn't suffer from this. I'm hopeful that this causes the entire industry to say, 'Oh, my, we've got to fix this.'"

Of course, this decision model wasn't intentionally imbued with racial bias. Race, as the *Science* study points out, isn't even explicitly considered by the model. In this case, the application of the model was the culprit. The model was intended to predict future health care costs for a patient, given some feature space derived from relevant information about the patient. Those patients who the model predicts to exceed a pre-set claims cost threshold are then flagged as requiring additional care assessment. And, despite the fact that the response this model was tasked with predicting—the patient's future health care costs—was quite likely very well reflected by the training data that was used to productionalize the model, this choice of response as an indicator of health care need is flawed, because this response is racially biased. On average, when compared with white patients who incurred equivalent dollar amounts of health care claims, black patients have substantially more chronic conditions.

Human beliefs and behaviors, biased or otherwise, are encoded in the long trails of data we leave behind. Models trained to predict a response based on biased data will dutifully reproduce the same biases they learn from the data. This principle is

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- 1 Obermeyer, Ziad, Brian Powers, Christine Vogeli, and Sendhil Mullainathan. 2019. Dissecting Racial Bias in an Algorithm Used to Manage the Health of Populations. *Science* 366(6464): 447–53, <https://doi.org/10.1126/science.aax2342>.
 - 2 Johnson, Carolyn Y. Racial Bias in a Medical Algorithm Favors White Patients Over Sicker Black Patients. *Washington Post*, October 25, 2019, <https://www.washingtonpost.com/health/2019/10/24/racial-bias-medical-algorithm-favors-white-patients-over-sicker-black-patients>.

known as “bias in, bias out,” and the judicious (and as we’ll see, innovative) application of actuarial judgment will become increasingly critical as our profession continues to expand its use of supervised learning models. It is incumbent upon actuaries to consider the application of a new model validation constraint—fairness—to their modeling efforts. As evidenced by the letters sent by senators Booker and Wyden to the various leaders of public and private health care enterprises, regulators will likely soon become primary customers of our increased efforts to validate model fairness, and regulatory scrutiny of fairness in predictive modeling is likely to increase as more predictive models are put into production. Additionally, algorithmic bias in predictive models can constitute enterprise risks that we would traditionally consider as part of a broader enterprise risk management (ERM) framework, such as reputation and operational risks.

Until recently, the concept of fairness was broadly viewed as more qualitative in nature, but a growing segment of research is directed toward the quantitative assessment of fairness with respect to the output of predictive models. To invoke the actuarial adage frequently paraphrased from W. Edwards Deming—if you can measure it, you can manage it, right? One example of a fairness measure is *statistical parity fairness*, where model fairness is judged by the difference in how the model proportionally classifies members within each group. For example, if a group of women is flagged by a model 30% of the time and an otherwise equivalent group of men is flagged by the same model only 15% of the time, then this model is not considered to be fair on the basis of statistical parity. A primary criticism of this measure (of which there are many) is that enforcing statistical parity can lead to models being forced to issue a large number of false-negative or false-positive predictions, which could result in unfairly impactful treatment of different groups or unnecessarily costly operational outcomes, depending on how statistical parity is enforced between the two groups.

Another common measure of model fairness that shows some promise in classifier models is to compare false negative or false positive *rates* between groups

that are sensitive to disparate model treatment, such as Title VII–protected classes like race, religion, or national origin, or even gender identity, sexual orientation and so on. Furthermore, several fairness measures can be bundled together in an n -tuple and evaluated (and maximized) in an arbitrary R^n space.

A general criticism of applying standards of fairness intuitively follows from the suggestion that we restrict our models to adhere to fairness constraints. This criticism is best summarized by the question “Why would we want to make our models less accurate?” Getting close to the pin is, to some degree, the point, isn’t it? It is the case that reduction of model error is the primary objective of just about every data scientist or actuary engaged in the task of training and tuning a predictive model that will one day be deployed in a production environment. In practice, most predictive models employed in a supervised learning context that more frequently predict outcomes correctly are favored over models that produce correct predictions less frequently. The concept of model error can be quantified in myriad ways, but the prevailing mechanism that predictive modelers use to quantify model error is MSE, or mean squared error. Actuaries and modelers, in model development, tune predictive models to minimize MSE by dialing into the exact model types and hyperparameters that minimize both model bias and variance, the two systematically reducible components of MSE.

Emerging research in the field of algorithmic fairness shows that some measures of fairness can often be imposed on models with relatively little material impact to a model’s MSE. University of Pennsylvania computer scientists Michael Kearns and Aaron Roth argue in the “Algorithmic Fairness” chapter of their new book, *The Ethical Algorithm*, that an accuracy-fairness tradeoff is ultimately best evaluated using a Pareto efficiency frontier framework, by plotting each model candidate’s measure of fairness on one axis and traditional MSE on the other.³ But Kearns and Roth are quick to point out that quantifying the tradeoff between a predictive model’s MSE and some fairness measure can’t replicate the essential need for humans to evaluate, assess and monitor predictive models in production.

3 Kearns, Michael, and Aaron Roth. 2020. *The Ethical Algorithm: The Science of Socially Aware Algorithm Design*. New York, NY: Oxford University Press.

In the case of the health care model in the *Science* study that exhibited algorithmic bias, the proposed fix wasn't the implementation of a fairness measure and the subsequent evaluation of the model within a fairness-accuracy tradeoff framework, but rather the simple invention of a new response that constituted an index measuring both the patient's future health care claim costs and the patient's future health status. The new model was trained on this response index, but was essentially the same general model structure and contained the same inputs as the original. The researchers found that the simple replacement of the

original response with a less racially biased response, but one that was still informative, reduced algorithmic bias in the model by an impressive 84%. This solution, though less technically rigorous, demonstrates the increasing importance of actuarial judgment and innovation in the widening predictive modeling space. To complement essential actuarial judgment, research in algorithmic fairness is beginning to unearth a robust toolkit of algorithmic bias monitoring techniques and technical tools to train and tune models for an optimal fit in accuracy-fairness frameworks.

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Driving Health Care Insurance Product Development in Line With Health Tech

Dinelka Nanayakkara

The global health care market has shown immense development over the past few years in terms of market size, health care provider sources, technology engagement, efficiency and much more. Going back a few decades in the dynamic run of the health care industry, only hospitals or typical medical centers specialized in the field of health care solutions. But at present, we are witnessing global technology giants entering the field either as standalone health-tech startups or in collaboration with current health care experts.¹ Apple, Amazon Health, Google, Proteus, Garmin and Collective Health are just a handful of them. With the use of advanced technology and the Internet of Things (IoT), the health care industry is headed toward a more efficient and cost effective market.

What impact will these dynamics have on the insurance industry of health care, specifically on the profession of actuaries? This essay focuses on the following scenarios that could develop or are already developing and affecting the actuarial profession. The scenarios are discussed in detail, and unique solutions are provided with the aim of using them in future product developments:

- Real-time improvements in treatment methods and diagnosis
- Advancements in personalized health care solutions and product modeling

Real-Time Improvements in Treatments and Diagnosis

As mentioned previously, the health care industry is dynamic and moving at a rapid pace. Health-tech company Tempus, valued at more than \$3.1 billion,² is a data-driven company that operates with the simple mission that each patient will benefit from the treatment and data gathered from patients before them. This could be seen as having a great impact on the actuarial profession in terms of modeling cancer insurance policies specifically, or even life insurance as a whole.

The rate of cancer is on the rise globally. New types of cancer are being found every day. In a vast number of countries across the world, “cancer insurance” is starting to be sold as a separate product apart from the traditional critical illness (CI) product group.

Be it specific insurance on cancer or critical illness under life insurance, health techs such as Tempus will have various impacts on the actuarial aspect of these products in terms of claims handling, underwriting, and—most important—benefit compensation, which would be the most affected by the dynamic market volatility produced by such companies.

Consider the following scenario: A particular insurance provider plans to sell an insurance product that specifically covers only cancer. The product is modeled in such a way that a percentage of a fixed-lump-sum amount is provided to the policyholder based on each stage of severity. Premiums will be modeled based on current incidence rates, using the full fixed-lump-sum amount assuming that the policyholder would have used up at least 90% to 100% of the fixed amount.

Four years after effect, the policyholder is diagnosed with cancer and claims the relevant percentage off his fixed amount based on his stage of cancer. But with companies such as Tempus in play, the cancer would have been treated faster and more effectively.

1 Thomas, Mike. 25 Healthcare Technology Companies That Just Might Save Your Life Someday. *BuiltIn.com*, May 12, 2019, <https://builtin.com/healthcare-technology/healthcare-technology-companies>.

2 Nordli, Brian. Chicago Startup Tempus Raises \$200M at a \$3.1B Valuation. *BuiltInChicago.org*. May 30, 2019, <https://www.builtinchicago.org/2019/05/30/tempus-chicago-unicorn-raises-200m>.

This could give rise to the following possibilities:

- Speed of treatment is growing exponentially, giving rise to the cost of duration for the treatment of the severity to be reduced over time.
- Within four years, the population of people diagnosed with cancer would have greatly increased, thus providing more data and experience for health care institutions and most important, to health-tech companies such as Tempus. This would greatly increase the accuracy of treatment, knowing what the exact treatment would be for the given situation. This means faster treatment, a drop/rise in medical costs (depending on how much technology is used to bring about the said benefits), and reduction of the possibility of the cancer developing into a further stage.
- Cancer diagnosis would be more accurate and faster with a lower number of tests required.

These are just a handful of possibilities.

Returning to our prime concern of how all of this would affect the current process of product development, the following issues could be observed:

- Modeling of higher fixed lump sum amounts would result in higher premium payments.
- Incident rates would show dynamic changes owing to real-time changes in new cancer treatment findings, which could once again bring about less accurate results in a pricing or any modeling aspect.
- The need for additional benefits as well as in-house treatment may not be necessarily in demand in the future with patients being able to be treated at home without the need of going to the hospital (looking at the next 20 years or more).

As actuaries, who are the primary individuals in the process of product development, how do we tackle these sorts of foreseeable scenarios that could occur?

Partnerships With Health-Tech Companies

As a starting point, insurance companies should form partnerships with health-tech companies—with the

goal of obtaining more accurate data to be used in modeling products. Moving forward 20 to 30 years in time, we would be able to see a vast majority of health-tech companies coming forward with more efficient medical solutions to the market. Therefore, moving forward, product development would require accurate data and experience.

We are currently witnessing the creation of partnerships between insurance companies and InsureTechs, but this collaboration is with the prime purpose of the development of physical tech products for insurance purposes. Moving forward, these partnerships will be based on the primary goal of acquiring required data.

Trillion-dollar companies such as Apple and Microsoft, to other high-end technology companies such as Google, Garmin and Fitbit, to companies such as Athea, MATRIX and Athos (companies that show primary research in the field of health care) are all making accelerated advancements in the fields of health care and fitness.

Such companies are expected to be filled with vast amounts of consumer data. Wouldn't the data possessed by these companies be of immense value in the process of product development?

The availability of up-to-date data on the health industry gives rise to more accurate:

- Incidence rates
- Benefit compensation to be provided
- Premium rates and many more benefits

But one important complication that insurers would face with such a situation would be data privacy. The data would be used primarily to obtain more credible and accurate pricing results when developing insurance products. Depending on the country of consideration, data privacy issues may vary from being less complicated to being highly complicated.

Personalized Health Care Solutions and Product Modeling

Personalized health (also known as precision medicine) has become one of the most talked about topics in the field of health care.

What is personalized health? Across the past decade or so we have observed the use of technology and

other scientific means to test and record each person's activity. Using this data, each individual is catered to in a more unique manner rather than as a general form of treatment. Statistics per the third quarter of 2019 show that only around 40% of the total US population are given the opportunity of precision health. This figure is certainly on a lower scale when considered in a global context.

Going back to cancer, a patient would be put through a few genome-based tests and, based on the results, would be classified in a certain group and be treated uniquely and accordingly.

How does this affect the actuarial profession, is what we should be asking. Consider the implications:

- **Adverse selection.** Precision medicine, when compared with more traditional forms, could be more expensive. Having a higher number of participants in your policy who are interested in the use of precision medicine should have higher claims comparatively. Apart from that, these claims would be expected to be significantly higher than others, therefore causing an imbalance in the portfolio of policyholders.
- **Additional technological products required.** The use of precision medicine may require the use of wearables such as smart watches, patch sensors, trackers and so on to track and obtain individual results for treatment. If insurance companies are to provide benefits, such requirements will come into further clarification.

Looking at the preceding implications that personalized health care can have on the profession of actuaries, a number of solutions could be implied but would require close consideration and analysis before applying them, due to the social impact that they could have. The following measures could be taken to rectify the preceding issues. The effect on certain important stakeholders is taken into consideration, too.

Currently many insurance companies make use of *coinsurance* and *co-pay* when modeling their products. *Coinsurance* is when an insurer pays out a percentage of a certain claim or a percentage of an aggregate of claims, whilst *co-pay* refers to the amount of a claim that is supposed to be paid out by the policyholder.

These concepts are included in the development of insurance products to reduce the risk that the insurers are exposed to and to avoid low-valued claims.

With precision medicine in focus, moving forward, higher claims but a low frequency of them may be expected, which would encourage insurance policies to include the previously mentioned conditions. This approach is currently used as well, but it is facing a lot of criticism due to the social impact it has on the parties involved. Focusing on "health care" policies with built-in components such as coinsurance and co-pay mainly refer to ones that deal with critical illnesses and ones that may face larger valued claims comparatively.

Precision medicine has become one important form of treatment when it comes to treating diseases such as cancer in particular. Most of this medicine would be considered more expensive than general medicine due to it being tailor-made and catering to each individual on a unique level. And implementing policies with such conditions would only discourage a person from using precision medicine. This discouragement would only have a negative impact on the health care industry.

As an alternative to the preceding policy conditions, I suggest the following be conducted at an industry level and not at an individual policyholder level.

WIDER USE OF RETROCESSION INSURANCE

Retrocession insurance refers to the insuring of reinsurance companies with other reinsurance companies in risk reduction. This form of insurance is currently seen in large valued claims with a lower frequency. Insurance related to catastrophes and other natural disasters use retrocession for risk mitigation.

Precision medicine for cancer takes note of a genome sequencing test to reverse engineer the tumor present in an individual, and using these results, individual-based medicine is prescribed according to each person's DNA and genome results. Using the results of these tests and other advancements in this field, previously incurable diseases could be treated at a higher cost.

Using retrocession insurance, a high claim related to a treatment such as the one just described would

share only one-third of the same risk into a third proportion, meaning that the insurer would be bearing the minimum risk possible. Reinsurance is currently being tried as an alternative, but reinsurers, just as the insurers, are resistant to accept the risk of facing a huge claim. Having retrocession insurance would reduce that financial risk burden on reinsurers.

From the perspective of the government, after all, we are dealing with providing the best treatment for people, and the best way of advancing such treatment would be to provide enough demand for it. Government policies would start promoting the use of retrocession insurance, and government financial institutions, too, should be willing to accept some form of financial risk undertaken by these private entities.

PARTNERING WITH HEALTH-TECH COMPANIES

Insurance companies should partner with health-tech companies to provide the policyholders with the necessary wearables at no cost or at a lower cost (depending on the conditions of the partnership). The use of precision medicine would mean that physicians and even the patients obtaining treatment would want the use of certain wearable devices.

These wearables could be of a relatively higher cost to the patients being treated. As per the reasons discussed previously, the insurance company would not be providing compensation to the policyholder to purchase these required wearables. Due to the high cost of purchasing the wearables required to further proceed with precision medicine treatment, the patient under treatment would feel discouraged from further obtaining precision medicine.

Even so, insurance companies could help out with this issue by partnering up with the tech companies that produce such health wearables. Moving forward, it could be forecasted that InsurTech would move onto more health-tech-based companies that would engage in the developing and producing of such devices.

Partnerships between insurance companies and health tech would benefit the policyholder and the health industry in the following manner:

- Demand for precision health solutions would not show a drop just because wearable trackers, sensors and so on are pricey.
- Insurance companies would gain more appreciation socially.
- Policies that seemed unprofitable could actually be of a more revenue-generating style.
- InsurTech and health techs are provided a wider market of focus. Partnering with an insurance company (that would possibly target the same customer base) would only see such tech companies grow.

The health care industry is evolving at a very rapid pace. Moving forward to the future, health-tech firms would have to work hand-in-hand with insurance companies to obtain the most market-efficient results that benefit each party financially, socially and in a manner to provide sustainability.

Retrocession insurance would more likely be in market use for health insurance that relates to critical illnesses that are moving toward more personalized medicine for those affected. The use of retrocession insurance in the market may bring about a reduction in the more socially negative coinsurance and co-pay.

The next 5 to 10 years will show exactly how the health-based technology firms will affect the actuarial profession or whether they will eventually not have any significant impact. As professionals in the field, let us be more aware of these tech firms moving ahead and closely observe what implications they have on the actuarial profession.

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