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Bridging the gap between medicine and insurance: How to leverage data, artificial intelligence, and neuroinformatics for insurance and financial risk management

ANITHA RAO | MARK WEINDLING | PAUL RIDGEWAY
LIZ KENNEDY | HARRIS A. EYRE | PAULO PINHO

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CONTENTS

RISKS

TECHNOLOGY

REGULATION

DEAR READER,

Welcome to edition 54 of the Capco Institute Journal of Financial Transformation.

In this edition we explore recent transformative developments in the insurance industry, through Capco's Global Insurance Survey of consumers in 13 key markets, which highlights that the future of insurance will be personalized, digitalized, and connected. Other important papers cover topics high on global corporate and political agendas, from ESG and climate change to artificial intelligence and regulation.

The insurance industry has been undergoing transformation in recent years, with insurers responding to the needs and expectation of tomorrow's customers, for products that were tailored, flexible, and available anytime, anyplace, and at a competitive price.

COVID-19 has accelerated such change, forcing insurers to immediately implement programs to ensure they can continue selling their products and services in digital environments without face-to-face interaction. New entrants have also spurred innovation, and are reshaping the competitive landscape, through digital transformation.

The contributions in this edition come from a range of world-class experts across industry and academia in our continued effort to curate the very best expertise, independent thinking and strategic insight for a future-focused financial services sector.

As ever, I hope you find the latest edition of the Capco Journal to be engaging and informative.

Thank you to all our contributors and thank you for reading.

Lance Levy, **Capco CEO**

BRIDGING THE GAP BETWEEN MEDICINE AND INSURANCE: HOW TO LEVERAGE DATA, ARTIFICIAL INTELLIGENCE, AND NEUROINFORMATICS FOR INSURANCE AND FINANCIAL RISK MANAGEMENT

ANITHA RAO | CEO and Founder, Neurocern, and Board-Certified Geriatric Neurologist, Department of Neurology, University of Toledo College of Medicine

MARK WEINDLING | Chief Technology Officer, Neurocern

PAUL RIDGEWAY | Strategy, Chief Financial Officer, Neurocern

LIZ KENNEDY | Project Manager, Neurocern

HARRIS A. EYRE | Chief Medical Officer, PRODEO, and Co-Lead, Neuroscience-inspired Policy Initiative, OECD

PAULO PINHO | Vice President and Medical Director of Innovation, Diameter Health

ABSTRACT

As the global population ages, neurological diseases such as Alzheimer's disease, stroke, and epilepsy will represent a top data attribute in disability and mortality predictive modeling. Clinical shortages of geriatric specialists globally have led to missed diagnoses and delays in care leading to untoward clinical and financial outcomes. Research has demonstrated a clear trickle-down impact in underwriting, latent mortality risk, and reserving for the aging population.

Advances in technology and artificial intelligence have given rise to innovative analytical modeling that have benefited both insurance and overall population health. This paper will discuss the application of a neurologically trained artificial intelligence data engine and case studies to provide understanding on how AI-enriched data insights can improve the quality, costs, and context of care.

1. CONNECTING THE DOTS: NEUROINFORMATICS, FINANCE, AND INSURANCE

The use of artificial intelligence (AI) has become pervasive in today's world, with new use cases and problems solved in nearly every discipline. Medicine is no different – the applications of AI in medicine have expanded significantly in the 21st century. For instance, application of computational methods to large datasets on human genomics have allowed researchers to better understand and trend data impacting diseases and genes [Obermeyer and Emanuel (2016)]. While much work has been done already, with applications out, clinicians and researchers alike are only beginning to understand AI's benefits and pitfalls.

The subject of our discussion for this article will be centered around one subtype of AI, an expert system. In its simplest form, an expert system emulates the decision-making capability of a human "expert", generally through a rule-

based process and primarily using "if-then" predicate logic. "Medical" expert systems are computer programs that guide clinicians and doctors in evaluating, triaging, diagnosing, and treating patients [Pac et al. (2021)].

Expert systems in medicine are especially impactful in reducing the time to diagnosis and in clinical instances where experts are needed for accurate diagnosis and treatment of niche diseases where availability of specialists and clinical acumen may be in short supply. While these expert systems use "human expert knowledge" to compute results, their use should never replace the value-add of seasoned medical experts who are constantly keeping current in their medical knowledge and possess the ability to apply qualitative reasoning based on deeper experience and understanding. This knowledge upkeep and ability to reason provides an additional layer of nuance to a diagnosis or understanding that an algorithm, with its limited inputs and fundamentally restricted logical description, is unable to match. Thus, a human being is an essential component of ensuring appropriate results and functioning [Pac et al. (2021)].

1.1 Population aging and considerations for insurance and financial services

The increased life expectancy and reduced fertility rates globally have shaped the demographics of society into a predominantly older and increasingly aging population [Rao and Eaton (2021)]. With a rise in population age comes a rise in the prevalence of neurological and cognitive conditions such as dementia, stroke, and epilepsy. Neurological diseases are the leading cause of disability globally [Alzheimer's Disease International (2020)] and the second leading cause of death [Alzheimer's Association (2020)]. Life reinsurance mortality analyses include neurological conditions in the top three paradigms in their financial and actuarial modeling with a clear trickle-down impact in underwriting, latent mortality risk, and reserving for the aging population. For instance, clinical severity and residua of a stroke will dictate the length of disability of an individual. This, in combination with other comorbidities, will impact mortality modeling.

With increasing population age, older adults will be also required to stay productive beyond traditional retirement age to sustain national and global economy viability [Smith et al. (2021)]. Neurological diseases can impact the productivity of older adults, thereby challenging economic security. Retirement and pension funding will undoubtedly be impacted by later retirement age, morbidity, and mortality from neurologic diseases [Smith et al. (2021), OECD (2021)].

Chronic neurological conditions can even influence the fraction of the GDP spent on healthcare and long-term care (care homes and nursing homes) and private sector pension funds [Bohk-Ewald and Rau (2017)]. For example, neurological conditions such as Alzheimer's and related dementias (ADRD) represent a sizable global public health conundrum in both developing and developed countries. There are approximately 50 million people living with dementia globally, and this number is expected to triple by 2050. The annual global total direct and indirect cost of dementia was estimated at U.S.$1 trillion in 2018, a figure expected to double by 2030 [Prince et al. (2015)]. To provide context and scale, if the global cost of dementia care represented the economy of a country, it would represent the 18th largest global economy – currently Saudi Arabia [Prince et al. (2015)].

1.2 Predictive analytics and claims modeling in the aging population

The insurance industry is only beginning to connect the dots between insurance and medicine. For example, while with respect to long-term care insurance (LTCI), neurological diseases constitute a plurality of total claims incidence, accurate data inputs are not in place to appropriately model morbidity. In a study funded by the Society of Actuaries, researchers from Neurocern and Milliman found that traditional parameters (gender, claim duration, and age) used by insurance actuaries to assess cost and utilization in LTCI did not actually predict variability in claim incidence across geographic areas [Rao and Eaton (2021)]. These findings impact modeling for other product lines that rely on these attributes for cost calculation and reserving assumptions, like retirement, pension, annuity, and life insurance. These same researchers identified other critical data elements that predicted claims incidence more accurately. For example, the study showed a modest correlation of 38% between clinical neurological specialist shortages and historical incidence of LTCI claims from years 2000 to 2017, highlighting how medical workforce shortages have trickle-down effects on the financial and insurance industries [Rao and Eaton (2021)]. Better data can help insurance companies stratify utilization risk, predict cause of claim, and estimate the duration of claims more accurately than the status quo.

1.3 Financial modeling and risk management

Underwriting based on incorrectly estimated mortality assumptions in older populations can result in premature benefit payout and longer duration [Bohk-Ewald and Rau (2021)]. The same applies to critical illness, where incorrectly underestimating the risk of certain conditions in older

age policyholders results in paying out benefits to more policyholders than initially budgeted for. Moreover, gaps in clinical documentation and clinician shortages can lead to misdiagnosis or lack of diagnosis; even the most detailed underwriters will miss conditions that are poorly documented in the electronic medical record. According to the Alzheimer's Association, at least 50% of cognitive impairment cases are undiagnosed or undocumented [Alzheimer's Association (2016)]. Furthermore, the severity of cognitive impairment (often used as a benefit eligibility trigger) may ultimately impact adjudication for critical illness and LTCI riders.

2. A NEED FOR MULTI-MODAL DATA PROCESSING AND NEUROLOGY-BASED AI-EXPERT SYSTEM

Digital technologies are employing biomarkers for neurologic conditions; wearables can detect gait cadence changes and identify Parkinson's disease and eye-tracking devices can identify early cognitive impairment [Kourtis et al. (2019)]. These technologies are experimental, albeit rapidly evolving. Currently, no one data element is the holy grail in this space and instead, should be acquired in multivariate fashion for decision support, risk stratification, and early diagnosis use cases. An overreliance on one data source risks a higher number of false positives and false negatives, whereas a multi-modal data processing technique using an expert-AI system can achieve higher accuracy and reproducibility in computation, financial modeling, and analytics.

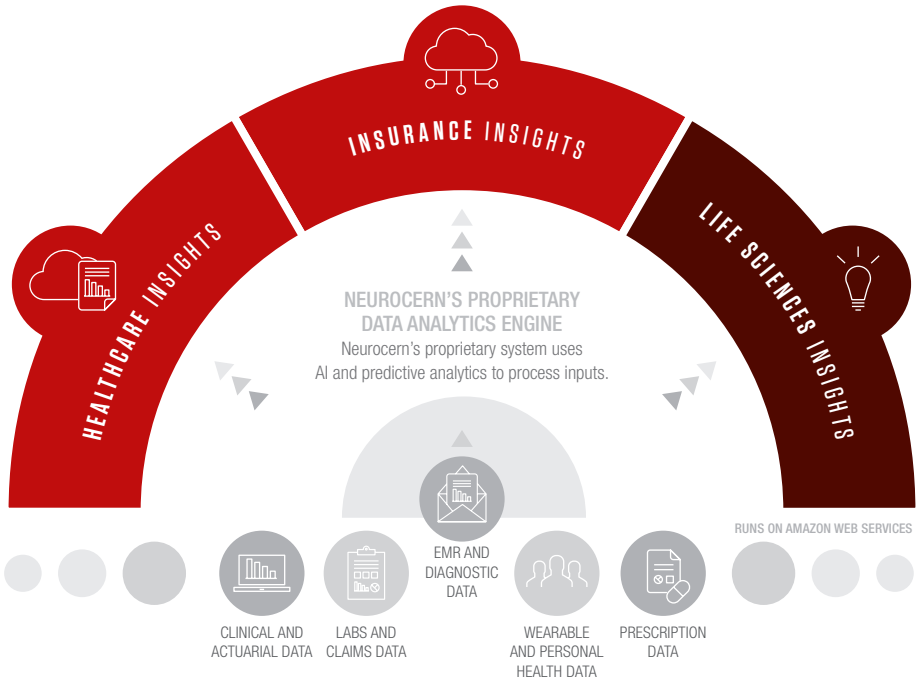
This paper will focus on the application of an expert system developed by Neurocern capable of leveraging data insights for financial and health outcomes to a specialty where clinician shortages abound. Despite increasing prevalence of neurological conditions in the aging population, the supply of neurologists and other geriatric mental health specialists is sparse [Dall et al. (2013)] and the supply is challenged to meet the demand [Rao and Eaton (2021)]. Patients often face challenges in accessing neurological care due to long wait times and lack of available experts in their area [Freeman et al. (2013)].

Data sources such as claims, prescriptions, health, and lifestyle data can be used in multivariate fashion to generate probabilistic risk scores, which can help insurance carriers identify risks in their populations and influence contextual care more easily and timelier (Figure 1).

2.1 The application of predictive analytics, AI, and informatics for financial outcomes

Making data-informed decisions in medicine can mean the difference between early diagnosis and treatment. By extension, data-driven decisions in insurance can translate

Figure 1: Expert AI-system for neurology and cognition



to mitigating risk and forecasting population outcomes more accurately. Sadly, both clinical medicine and insurance have datasets that are siloed and, therefore, not always optimized to glean insights.

Applying Neurocern's expert system that has been trained with clinical data to insurance and financial decisions can unlock meaningful population-level insights for organizations. Neurocern benefits from millions of claims data elements and a robust research reference dataset to generate data enrichment. This process can predict neurological conditions that are associated with high cost and utilization.

Not all analytics are created equal. Some predictive analytics vendors only scratch the surface, querying only known medical data to calculate financial risk. Sophisticated predictive analytics can go beyond this to find undiagnosed cases (second level analytics) that may result in additional financial benefit. Going a level further (third level analytics) allows for the accurate prediction of the total cost of care for an individual and a population.

We have laid out the following case studies to provide understanding on how data insights can improve the quality and context of care.

Case study 1: Cost of care – a new treatment for Alzheimer's disease

In 2021, pharmaceutical giant Biogen, announced the first ever treatment for Alzheimer's disease, a common neurological condition impacting over 50 million patients globally. This medication, Adacanumab, currently costs more than U.S.$50,000 per person per year. With varying life expectancy among Alzheimer's patients, projecting the financial cost of care can be challenging. Complicating the cost determination is the fact that Aducanumab is weight based and assumptions are based on a 74 kg average weight. Given global trends in obesity, U.S.$50,000 may underestimate the true financial burden of Adacanumab.

Cost is also driven by disease prevalence. Clinically, diagnostic sensitivity (premised on true positives in a particular population) for identifying mild cognitive impairment, and by proxy early dementia, among general medicine practitioners ranges from 14-61% [Van den Dungen et al. (2012)]. The same applies to false negatives [Bradford et al. (2009), Valcour et al. (2000)]. Given the narrow clinical indications for Adacanumab, over- and underdiagnosis may adversely impact cost assumptions.

Alzheimer's treatment cost of care implications for insurance and financial modeling

For the public and private sector in insurance, understanding disease prevalence, severity, and predicted life expectancy of those with clinical indications for treatment may help more accurately forecast reserves and allocate treatment costs to those patients that truly qualify for treatment.

To showcase the value of applying an AI expert system, Neurocern's Aducanumab Eligibility Analytics Model was applied to claims data to identify individuals truly eligible for treatment.

We provide two scenarios to illustrate the value (Table 1). In Scenario #1, traditional clinical workflow fraught with a high degree of false positives and false negatives and void of triaging of claim applications is modeled. In this scenario, 85% of claims are approved, resulting in a cost of care of U.S.$1.3 billion over five years for >30,000 potential claims in dataset. Scenario #2 showcases Neurocern's AI expert system's ability to enhance diagnostic accuracy. A triage score is computed to validate the veracity of the claims in terms of true positives, true negatives, false positives, and false negatives – this is

Table 1: 5-year savings model with artificial intelligence

	SCENARIO #1	SCENARIO #2 (with Neurocern AI)
Total cost of Aducanumab treatment per person per year*	U.S.$50,000	U.S.$50,000
Duration of treatment+	5 years	5 years
ABC Insurance Company cost per person per year (20% of total cost of treatment)¥	U.S.$10,000	U.S.$10,000
Percent of patients with cognitive concerns that meet eligibility criteria	85%	60%
Total eligible claims	30,572	30,572
Total cost over 5 years	U.S.$1.3B	U.S.$929M
Total savings over 5 years	--	**> $350M**

* Assumed average cost of $50,000 per person per year
\+ Assumed mean duration of treatment of 5 years
¥ Assumed estimated cost to ABC Insurance Company was 20% of the total cost of the drug

Figure 2: Delirium risk score and dashboard

premised on clinical data from an academic database (which also included brain autopsy findings), the current gold standard in diagnosis of Alzheimer's.

This research demonstrated Neurocern's ability to triage cognitive impairment more accurately, timely, and effectively than a general physician [Rao and Naryanaswamy (2018)]. With diagnostic accuracy, a truer eligibility rate of 60% for Aducanumab was derived after filtering out the false positive and false negatives. The five-year cost savings, as compared to standard of care, of employing the expert system exceeded U.S.$350 million – which represents a savings of approximately 33%.

As drug treatments emerge, their costs will dictate the importance of diagnostic accuracy; insurance carriers will want to identify those members truly eligible, both in terms of incidence and prevalence.

Case study 2: Digital claims transformation – life insurance with critical illness riders and long-term care riders

Delirium is an acute change in thinking, memory, and attention that develops over a short period of time and can be "reversible" with appropriate treatment in specific clinical scenarios [Tripathi and Vibha (2009)]. Diagnostic accuracy is important to carriers that offer critical illness riders and long-term care insurance to insureds suffering from irreversible cognitive impairment. When delirium occurs in patients with underlying Alzheimer's dementia or normal aging, the severity of the cognitive impairment appears worse. This results in false positive eligibility for benefit payout – a common occurrence in claims workflows. Moreover, patients with delirium have a two-fold increase in mortality, a 15-fold increase in walking dependence, and five-fold increase in nursing home placement according to published studies [Morandi et al (2014)]. This increase in both mortality and disability becomes especially relevant to life insurance carriers with critical illness riders, disability riders, and long-term insurance riders.

In 2020, Neurocern developed proprietary predictive analytics as part of their AI expert platform. In a digital claims processing pilot, Neurocern partnered with insurance carriers who cover over 1 million lives and have more than U.S.$50 billion in claims exposure. Claims for irreversible cognitive impairment were targeted with this AI expert system and compared against traditional claims processing workflows.

A claims triage risk score and a delirium risk score were computed using the expert system (Figure 2). To prevent sway and ascertain case-control accuracy, insurance third-party administrators (TPA) were blinded to the risk scores. Additionally, an independent medical advisory team reviewed the results from Neurocern's analytics. Neurocern showed a sensitivity of 94.7% (finding true positives) and specificity of 100% (finding true negatives) in this population. Both TPAs and insurance carriers failed to identify delirium in 28% of claims leading to the incorrect label of irreversible cognitive impairment in these claimants and downstream financial implications for patients through increased insurance premiums or inaccurate reserving.

To illustrate the cost impact of this tool (Table 2), if ABC long-term care insurance sees 1,000 cognitive impairment claims per month in their LTCI rider product and a payout of U.S.$6,500 per month is paid out as a benefit, accurately identifying cases of delirium in 28% of claimants by an expert system, could lead to over U.S.$1.7 million in savings per month.

Table 2: Savings from identifying claims accurately with artificial intelligence

DELIRIUM RISK SCORE	
Number of claims per month	1000
Claims with delirium	28%
Total claims with possible delirium per month	280
Total claims identified by Neurocern's AI-delirium model	265
Average monthly payout per insured	U.S.$6500
Potential savings per month of identifying delirium with Neurocern's AI platform	**U.S.$1.72 M**

3. CONCLUSION

Neurological diseases are one of the top three reasons for disability and represent a top condition in mortality assumptions globally. They are routinely diagnosed incorrectly, and this can lead to untoward clinical and financial outcomes. The COVID-19 pandemic has also spurred the incidence of neurological symptoms in at-risk conditions and may add to the overall cost of care [Taquet et al. (2021)]. Comprehensive data mining, contextually appropriate datasets, and multi-modal data processing with advanced analytics allows enterprise clients to find new insights that quantifiably improve clinical and financial outcomes. As illustrated in these case examples, neurological diseases can significantly impact reserving and outcomes for the aging population. Given new biopharmaceutical treatments on the horizon for neurological diseases, insurance carriers and financial risk managers will face new challenges. Employing predictive analytics and AI to understand cost drivers and overall morbidity and mortality for a block of business could prove to be a game-changer.

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