

# **IAALS - Articles**

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# IAALS - Articles 1/2

- IAALS – 001: [A synthetic model for Asset-Liability Management in life insurance, and analysis of the SCR with the standard formula](#)
- IAALS – 002: [Applying economic measures to lapse risk management with machine learning approaches](#)
- IAALS – 003: [On the Influence of Pathologies on Long-Term Care Needs: Evidence from Switzerland](#)
- IAALS – 004: [French private retirement reform : sensibility to new product options and creation of dedicated portfolio in low rates environment](#)
- IAALS – 005: [The IAIS Global Frameworks for Supervision of IAIGs Including ComFrame, ICS 2.0 and the Holistic Framework in Japan, the Unites States, and the Rest of the World](#)
- IAALS – 006: [Duration of Long-Term Care: Socio-Economic Drivers, Evolution and Type of Care Interactions](#)
- IAALS – 007: [Viability analysis of Brazilian Market for Universal Life](#)
- IAALS – 008: [Measuring longevity risk through a Neural Network Lee-Carter Model](#)
- IAALS – 009: [Le pragmatisme sous IFRS 17 - application à une société d'assurance mixte avec réassurance de contrats VFA](#)
- IAALS – 010: [Credibility Adjustment of the Lee-Carter Model for Small Population Mortality Projection](#)
- IAALS – 011: [Actuarial and Utility-Based Pricing of Long-Term Care Options Embedded in Life Annuities](#)
- IAALS – 012: [Wavelet-based feature-engineering for mortality projection](#)

## IAALS – Articles 2/2

- IAALS – 013: [Modeling Multi-Country Mortality Dependence by a Vine Copula](#)
- IAALS – 014: [Breast cancer calculator : a case of inclusive underwriting](#)
- IAALS – 015: [Statistical learning methods for mortality data correction in the absence of fertility data](#)
- IAALS – 016: [Biological Age Model, stepping towards Dynamic Underwriting](#)
- IAALS – 017: [Searching for liquidity premia due to uncertainty in dynamic policyholder's behavior: an IFRS17 oriented approach](#)
- IAALS – 018: [AI and Deep Learning apply to computer vision, document recognition and information retrieval](#)
- IAALS – 019: [Disability income claimant rehabilitation and other claim interventions: who are the selected few; and are these claimants more likely to return to work](#)
- IAALS – 020: [Mortality trends in developed countries: an analysis of the recent deceleration in mortality improvement](#)
- IAALS – 021: [Anticipate future pandemics age-pattern mortality: an application of antigenic imprinting principles](#)
- IAALS – 022: [Improving mortality information in middle-income countries](#)
- IAALS – 023: [An approximation to re-estimate the over-mortality occurred and not reported -missing persons- to face the possible claims: the Mexican case](#)
- IAALS/AFIR/PBSS – 001: [Modélisation prospective du risque Incapacité, proposition d'une approche combinant modèle bi-dimensionnel et algorithmes d'apprentissage](#)
- IAALS/PBSS – 001: [A Reverse Mortgage or An Annuity Product? Analysis on Money's Worth Ratio Considering the Value of Living](#)

# A synthetic model for Asset-Liability Management in life insurance, and analysis of the SCR with the standard formula

**Author(s):** Arturo Infante (AXA), Aurélien Alfonsi (UPMC), Adel Chenchali (Ponts Paritech)

**Abstract:** The aim of this paper is to introduce a synthetic ALM model that catches the main specificity of life insurance contracts. First, it keeps track of both market and book values to apply the regulatory profit-sharing rule. Second, it introduces a determination of the crediting rate to policyholders that is close to the practice and is a trade-off between the regulatory rate, a competitor rate and the available profits. Third, it considers an investment in bonds that enables to match a part of the cash outflow due to surrenders, while avoiding to store the trading history. We use this model to evaluate the Solvency Capital Requirement (SCR) with the standard formula and show that the choice of the interest rate model is important to get a meaningful model after the regulatory shocks on the interest rate. We discuss the different values of the SCR modules first in a framework with moderate interest rates using the shocks of the present legislation, and then we consider a low interest framework with the latest recommendation of the EIOPA on the shocks. In both cases, we illustrate the importance of matching cash-flows and its impact on the SCR.

# Applying economic measures to lapse risk management with machine learning approaches

**Author(s):** Pierrick Piette (Université Lyon 1), Stéphane Loisel (Université Lyon 1), Cheng-Hsien Jason Tsai (National Chengchi University)

**Abstract:** Modeling policyholders lapse behaviors is important to a life insurer since lapses affect pricing, reserving, profitability, liquidity, risk management, as well as the solvency of the insurer. Lapse risk is indeed the most significant life underwriting risk according to European Insurance and Occupational Pensions Authority's Quantitative Impact Study QIS5. In this paper, we introduce two advanced machine learning algorithms for lapse modeling. Then we evaluate the performance of different algorithms by means of classical statistical accuracy and profitability measure. Moreover, we adopt an innovative point of view on the lapse prediction problem that comes from churn management. We transform the classification problem into a regression question and then perform optimization, which is new for lapse risk management. We apply different algorithms to a large real-world insurance dataset. Our results show that XGBoost and SVM outperform CART and logistic regression, especially in terms of the economic validation metric. The optimization after transformation brings out significant and consistent increases in economic gains.

# On the Influence of Pathologies on Long-Term Care Needs: Evidence from Switzerland

**Author(s):** Aleksandr Shemendyuk (Université de Lausanne), Michel Fuino (University of Lausanne), Joël Wagner (UNIL)

**Abstract:** Population ageing is one of the major concerns for the current society. As a consequence, highly developed countries are facing a higher demand for long-term care (LTC). In this context, pathologies play an important role in determining LTC dependence (see, e.g., Biessy, 2016; Fuino and Wagner, 2018). In our paper, we study the influence of pathologies on the minutes of care required for institutionalized elderlies and investigate on the diverse multi-morbidity profiles. In particular, we investigate the impact of mental disorders, nervous system and musculoskeletal diseases, as well as diagnosed tumors, on the amount of delivered professional care. This approach allows us to design a cost structure per disease profile. Further, we analyze the effect of multi-morbidity on the mortality of dependent elderly. Our analysis is based on a novel longitudinal dataset, which provides information on 23 000 institutionalized elderly in Switzerland over a period of 20 years. Our results show that the number of minutes of care and, therefore, the costs are highly dependent on the individuals' pathology profile. Finally, we give insights on the relation between multi-morbidity and mortality.

# An experimental study of the demand for bundled longevity and health insurance products

**Author(s):** Cheng Wan (School of Risk and Actuarial Studies), Hazel Bateman (School of Risk and Actuarial Studies, The ARC Centre of Excellence in Population Ageing Research, UNSW Sydney), Katja Hanewald (School of Risk and Actuarial Studies, The ARC Centre of Excellence in Population Ageing Research, UNSW Sydney), Hamming Fang (Department of Economics, University of Pennsylvania School of Entrepreneurship and Management, ShanghaiTech University The ARC Centre of Excellence in Population Ageing Research, UNSW Sydney)

**Abstract:** We conduct an online experimental survey to elicit and analyse preferences for bundled longevity and health insurance products in China. Participants are asked to advise the allocation of retirement savings across a portfolio of life annuities, critical illness insurance, long-term care insurance, and a savings account for vignette households which differ by wealth and health. Participants also report reasons for allocation choices, exposure to health risks, and retirement planning experience and we collect a comprehensive array of covariates including preferences, financial competence and demographic, and socio-economic factors. The study provides empirical evidence of the interaction between longevity and health insurance products, the impact of having access to bundled annuity/critical illness/long-term care insurance products on the demand for longevity insurance, as well as insights about the preferences for product attributes. Overall, this research will inform the development of retirement products in China and other developing economies facing population ageing and incomplete insurance markets.

## French private retirement reform : sensibility to new product options and creation of dedicated portfolio in low rates environment

**Author(s):** Thibaut Gilliard (Addactis), Ancelin Cjaise (Addactis)

**Abstract:** A major shift has occurred in the French private retirement market, including professional pension schemes, due to the implementation of a new regulation (“Pacte” law). Starting from a multi-product context, these being inconsistent in payout possibilities, guarantees, options and transferability, mainly due to several incremental past policies (1994 and 2006 for the major ones), the considered law has created a common standardized canvas for the core product design: transferability, lump sum or annuities, reversion, technical rate for reserving... It has also stated that the assets covering these liabilities have to be put on ring-fenced funds. Currently, insurers manage most of these undertakings (alongside asset managers), and as such, retirement schemes are mutualised with other life products and in the Solvency II scope. Indeed, the French government has taken the opportunity to ease the transfer of these products to FRPS, the French IORP-compliant structure, creation of ring-fenced funds being one of the main drags. In this paper, we aim to provide insights on the risks and cost-benefit analysis on the creation of ring-fenced funds in this context: from existing products and common portfolio to new products (and new behaviours induced by the new product options) and separated portfolios, in negative rates and solvency downgrade environment.



# The IAIS Global Frameworks for Supervision of IAIGs Including ComFrame, ICS 2.0 and the Holistic Framework in Japan, the United States, and the Rest of the World

**Author(s):** Marc Slutzky (Milliman), Ito Kenjiro (Milliman)

**Abstract:** In November 2019, the International Association of Insurance Supervisors adopted a Global Framework for the Supervision of Internationally Active Insurance Groups (IAIGs). This includes revisions to ComFrame including the Insurance Core Principles (ICPs), ICS 2.0 and the Holistic Framework for mitigation of Systemic Risk. While ICS 2.0 will generally be applicable to IAIGs and will be monitored by supervisors rather than reported for a five-year testing period, the Japanese Financial Services Agency since 2017 has required all Japanese insurers to calculate required and available capital, and then publishes aggregate results. In the United States, due to its volatility and its effect on products that dominate the US market, the IAIS Market Value based approach to ICS has effectively been rejected by US insurance regulators who are developing their own Aggregation Method, a standard which is being designed and calibrated to be “outcome-equivalent” for ICS. This paper and presentation will present the current developments in the supervision of IAIGs noted above and their effects on the protection of policyholders and on the mitigation of systemic risk to the global financial system.

# Duration of Long-Term Care: Socio-Economic Drivers, Evolution and Type of Care Interactions

**Author(s):** Michel Fuino (UNIL), Joël Wagner (UNIL)

**Abstract:** The time spent in dependence and the type of care an elderly receives are the two main cost drivers of long-term care (LTC). We aim to provide a better understanding of the duration of care by using a comprehensive social insurance dataset covering the LTC needs in Switzerland over a 20-years-period and including 230 000 observations on dependent elderly. First, using the framework of survival analysis, we calculate Kaplan-Meier estimates for the care duration and derive the main explaining factors through econometric models when care is received at home and in an institution. Retaining only significant covariates, the final accelerated failure time models allow us to predict the duration for different profiles of elderly along their age, gender, region of residence, type of household composition, acuity level and pre-retirement income. Second, we study the interaction of care durations when care is provided at home and in an institution. While our data supports that for short at home care durations the time spent in institutional care is reduced, we find that both types of care are non-substitutes when the time spent at home has been longer. Under the latter regime, the time spent in institutional care remains at a constant level. Finally, given the longevity improvements over the period of observation, we analyze the impact of living longer on the time spent in dependence. Our results show that while the mean age at entry in dependence grows, the overall care duration does not significantly change. Given the expected increasing number of elderly in most developed countries, our study is relevant for government planning, budgeting social insurance schemes, estimating personal savings needs and calculating private insurance premiums.

## Viability analysis of Brazilian Market for Universal Life

**Author(s):** João Vinícius de França Carvalho (University of Sao Paulo), Mariana Ikeda (University of Sao Paulo)

**Abstract:** Universal Life (UL) is a widespread type of personal insurance in many countries around the world. Its design combines the protection of life insurance with the income provided by investment funds, through profit sharing, transparency of individual accounts and flexibility of premium contributions - its main attractiveness. Due to the absolute absence of local works on this subject and considering the lack of definition about the product regulation by the Brazilian Insurance authority, the objective of this work is to evaluate the viability of UL in Brazil from two perspectives: (i) from the individual point of view of contractors, considering different profiles of clients and investment scenarios, and; (ii) from a business perspective, verifying whether insurers see Universal Life advantages in their business. The results indicate that the insured would be better off buying UL than buying life insurance on the open market and investing the surplus in financial investments because of the product's hybrid characteristic and associated opportunity costs. From a business perspective, the results of profit testing suggest that there will be incentives to offer UL as long as the operation has a long-term duration. In addition, by conducting various sensitivity analyses by changing the company's mortality pattern, contract type, and investment profile, all results point to a similar way. Therefore, the Brazilian market for Universal Life is viable, and the findings are influenced by the context of higher interest rates relative to countries where UL is already widespread.

## Measuring longevity risk through a Neural Network Lee-Carter Model

**Author(s):** Mario Marino (Sapienza University of Rome), Susanna Levantesi (Sapienza University of Rome)

**Abstract:** One of the main challenges for life actuaries is adequately modeling and predicting the future mortality evolution. To this end, starting from the pivotal approach of the Lee-Carter model, several extensions and variants of this model have been proposed in literature. All of them essentially based on the ARIMA models in order to describe the future mortality trend. Recently, some research works have shown the suitability of machine and deep learning techniques to improve mortality modeling and, referring to forecasting, to obtain competitive and outperforming results compared to ARIMA models. The present work focuses on the application of a Recurrent Neural Network model, the Long Short-Term Memory (LSTM), in the framework of the Lee-Carter model. The LSTM model is designed to model and predict sequential data, such as time series, capturing hidden patterns within data and repeating them if significant. In mortality modeling, this means that the mortality rates predicted over time takes into account the hidden features of the past phenomenon not captured by an ARIMA model. We provide either a point forecast and a desired 3 interval prediction. The resulting mortality rates are then applied for longevity risk measurement purposes.

# Le pragmatisme sous IFRS 17 - application à une société d'assurance mixte avec réassurance de contrats VFA

**Author(s):** Pierre Kramer (CNP)

**Abstract:** Si la nouvelle norme IFRS 17 se distingue par une rupture franche avec le cadre propre à IFRS 4, elle se caractérise également par sa complexité. C'est ainsi que les différents acteurs concernés sont amenés à faire des choix méthodologiques divers ayant notamment trait à la maille de calcul des nouvelles métriques, à la sélection des différents modèles comptables, au traitement de la frontière des contrats et de la composante investissement, ou encore à la résolution de diverses sources de désadossement actif-passif. La mise en œuvre de ces principes ne peut se faire sans le recours à des solutions intelligibles et pragmatiques, permettant de favoriser la lisibilité de la communication financière tout en assurant par ailleurs la pertinence des informations communiquées. Sans se prétendre exhaustif, l'article présenté ici vise à fournir à la communauté actuarielle un certain nombre de pistes jugées crédibles à la fois du point de vue normatif et actuariel. Il est complété d'exemples concrets de critères pouvant être adoptés pour assurer la pertinence des approches présentées.

# Credibility Adjustment of the Lee-Carter Model for Small Population Mortality Projection

**Author(s):** Jean-Baptiste Coulomb (PSL), Yahia Salhi (ISFA, Université Claude Bernard), Pierre Thérond (ISFA, Université Claude Bernard)

**Abstract:** In this paper, we are interested in applying Bühlmann-Straub credibility to portfolios of small sizes in general. Our approach is part of the continuity of the parametric approach of Salhi et al. (2016). We have introduced the Bühlmann-Straub credibility into a Lee-Carter model in order to take into account the heterogeneity of 18 populations coming from the Human Mortality Database. The model remains relatively simple in order to avoid an over-parametrisation. We were focused more precisely on the trend risk, which is a component of the basis risk. The methodology used in this paper also allows us to improve the longevity forecasts and the appreciation of the associated risks. The model presented performs globally better than a Lee-Carter model without credibility.

# Actuarial and Utility-Based Pricing of Long-Term Care Options Embedded in Life Annuities

**Author(s):** Thorsten Sehner (UNI-ULM), Michel Fuino (UNIL), Joël Wagner (UNIL), An Chen (Ulm University)

**Abstract:** In most industrialized countries, one of the major societal challenges is the demographic change coming along with the aging of the population. The increasing life expectancy observed over the last decades underlines the importance to find ways to appropriately cover the financial needs of the elderly. A particular issue rises in the area of health, where sufficient care must be provided to a growing number of dependent (old) people in need of long-term care (LTC) services. In many markets, the offering of life insurance products incorporating care options and LTC insurance products is generally scarce. In our research, we therefore examine a life annuity product with an embedded care option potentially providing additional financial support to dependent persons. We evaluate state-dependent transition probabilities for elderly evolving from the autonomous state through dependency states till death using a semi-Markov framework. To determine the price of the care option, we apply two approaches: an objective actuarial pricing approach and a utility-based pricing approach. For the latter, we employ individual utility functions taking account of the policyholder's condition. We base our numerical studies on transition probability data from Switzerland recently developed in “Long-term care models and dependence probability tables by acuity level: New empirical evidence from Switzerland.” (Michel Fuino and Joël Wagner (2018)). Our findings give new and realistic insights into the nature, the utility and the performance of life annuity products proposing an embedded care option for tackling the financing of LTC needs.

## Wavelet-based feature-engineering for mortality projection

**Author(s):** Donatien Hainaut (UC LOUVAIN), Michel Denuit (UC LOUVAIN)

**Abstract:** The wavelet theory is a powerful tool for processing and compressing time-series or images. To summarize, the wavelet transform consists to project a signal on an orthonormal basis of functions. The sets of functions is chosen in order to provide a sparse representation of the initial time-series. In the first part of this article, we use wavelets for smoothing mortality curves. Mortality curves are projected into the space of Daubechies wavelets and we use a chi-square test for reducing the dimension of the curves by thresholding the smallest wavelet coefficients. In the second part, we study the evolution of wavelet coefficients for the Belgian population from 1950 till today. Next, we forecast the wavelet coefficients in order to predict the evolution of mortality and compare with alternative methods, like the Lee-Carter model.



# Modeling Multi-Country Mortality Dependence by a Vine Copula

**Author(s):** Masafumi Suzuki (PGF Life)

**Abstract:** Multi-country mortality dependence attracts the attention of insurers owning life insurance or annuity businesses across countries. When implementing a sophisticated enterprise risk management (ERM) program, it is crucial to model the structure of such dependence accurately, even though capital regulations, such as Solvency II and ICS, do not mandate a focus on geographical diversification. Elliptic and Archimedean copulas are often used as a tool of risk aggregation in advanced ERM. However, they cannot always flexibly capture complex tail dependence, especially under certain stressed situations. This study proposes modeling multi-country mortality dependence by a vine copula, which provides greater flexibility and efficiently characterizes the dependence structure. We demonstrate the usefulness of a vine copula using actual data. First, we use a Lee-Carter model to estimate the mortality rates of 13 countries (12 European countries and Australia). Subsequently, we use a vine copula to model the dependence among the time-varying mortality improvement parameters of each country. Consequently, we obtain a dependence structure resembling the actual geographical relationships, which is intuitively understandable. We also demonstrate that the vine copula is superior on some measures to other benchmark copulas. Finally, we conduct a simulation in a stressed environment and reveal that benchmark copulas underestimate the tail dependence of concentrated exposure. This study contributes to developing internal models for capital regulation.

[Back to the list](#)

## Breast cancer calculator : a case of inclusive underwriting

**Author(s):** Manuel Plisson (Scor)

**Abstract:** Anyone with a disability, handicap, critical or chronic illness or taking medication regularly is considered an "aggravated health risk". These people have the right to subscribe to an insurance policy. However, they may have to pay a higher premium than that applied to a "healthy" person. Extra-premiums are the term used to describe premiums paid by insured persons suffering from aggravated risk. These extra-premiums are intended to compensate the risk of excess mortality to which these people are exposed. In this memoir we will study the case of people with a history of breast cancer and wanted to be insured. The amount of the extra premium naturally varies according to certain "prognostic" variables, such as the age of the patient, the size of the tumor and more. The goal of this memoir is to evaluate the individualized extra-premium that will be requested at the time of underwriting the insurance policy. We must notice that "Breast Cancer" is a generic term that covers heterogeneous pathologies. Severity of breast cancer depends on various features that may be antagonists. That's why, in order to compute the extra-premium of a person with history of breast cancer, "Calculator" is necessary. This calculator will finally allow to an Inclusive Underwriting. In order to achieve this "Breast Cancer Calculator" project, we used data from the SEER database, which is the richest and most comprehensive cancer-specific database in the world. This database will be used to predict the probabilities of death of each person. In addition, in order to have the most accurate and consistent predictions, we used and compared the results and performance of a classical probabilistic model (Logistic Regression) and three Machine Learning models (XGBoost, GA2M and Random Forest). After selecting the most efficient and consistent model, we developed and implemented an actuarial model, which makes it possible to move from this probability of death (or excess mortality) to the final extra-premium.

[Back to the list](#)

# Statistical learning methods for mortality data correction in the absence of fertility data

**Author(s):** Alexandre Boumezoued (Milliman)

**Abstract:** It appeared recently that observations from censuses lead to major problems of reliability in estimates of general population mortality rates as implemented in practice, leading to mis-interpretation of the key mortality characteristics in the past decades, including false "cohort effects". In this context, we will detail new solutions regarding the construction of mortality tables. This talk will address:

- 1) briefly the possible strategies for mortality rate computation using birth by month data when available, based on the work by Richards (2008), Cairns, Blake, Dowd, Kessler (2016), Boumezoued (2017) and Boumezoued, Hoffmann, Jeunesse (2018, 2019), as well as the recent Human Mortality Database Version 6 update.
- 2) in details two new statistical learning methods to compute a corrected mortality table when fertility data is not available.

The first proposed method for 2) relies on a penalized optimization procedure that balances corrected table smoothness and the bias of resulting estimates, based on an appropriate correction indicator. The second method relies on Neural Networks. For both 5 methods, cross-validation and back-testing results will be shown on countries for which fertility data is available, and the output results will be presented in the form of corrected mortality tables for around 20 other countries of the Human Mortality Database for which fertility data past series are not available.

## Biological Age Model, stepping towards Dynamic Underwriting

**Author(s):** Antoine Thibault (Scor)

**Abstract:** In 2018, SCOR Global Life issued the first Mortality and Critical Illness risk model based on individual activity levels as tracked through wearables, called Biological Health Model (BAM). Since 2019, this model has already been successfully implemented and embedded in Protection products design and pricing with 3 insurers in China, Malaysia and Taiwan, alongside new customer engagement, prevention platforms and related apps. The approach now starts getting traction in Europe as well. On top of enabling far better client interaction, this program as a whole paves the way towards a more tailored approach through dynamic risk measurement and Life&Health insurance offering. This paper will present the comprehensive BAM approach, from actuarial and medical risk modelling to product and services design. It will also provide details on the recent developments of the algorithm considering further alternative biometric and activity variables such as resting heart rate, sleep patterns, BMI, VO2Max, thanks to a strategic and scientific partnership with GARMIN. Finally, the paper will provide real and recent experience data on the Asian developments. BAM is the first individualized continuous risk modelling approach applied in real life protection products. On top of the unquestionable scientific interest, the Internet of Things and Big Data dimensions, it also addresses key questions around the shift of role of insurers towards becoming more prevention and intervention service providers, Data privacy and its use for the good of our customers.

[Back to the list](#)

# Searching for liquidity premia due to uncertainty in dynamic policyholder's behavior: an IFRS17 oriented approach

**Author(s):** Jaume Belles Sampera (Universitat Barcelona), Miguel Santolino (Universitat Barcelona)

**Abstract:** The forthcoming international accounting principles for insurance contracts (IFRS17) forces affected companies to face several challenges. A big one is to decide which discount rates will use the company to compute contractual service margins of their insurance contracts. Liquidity risk of future fulfilment cash flows is one of the aspects allowed by IFRS17 principles to be taken into account when determining those discount rates. Typically, insurance companies project part of liability's liquidity risk by means of incorporating lapse rates in their cash flows. Nevertheless, uncertainty in those lapse rates is not frequently considered. The goal of this paper is trying to incorporate this uncertainty in the discount rates through adding spreads linked to these possible deviations from the expected policyholder's behavior. These spreads are going to be quantified by relating the evolution of consumer's behavioral indices provided by external sources (such as governmental statistical institutions) with the evolution of sectorial lapse rates.

# AI and Deep Learning apply to computer vision, document recognition and information retrieval

**Author(s):** Romain Meridoux (CNP)

**Abstract:** The e-beneficiaire.cnp.fr platform enables the CNP Assurances group to manage online the claims of beneficiaries of a contract. A number of supporting documents are requested from the beneficiary to investigate his file: bank account statement, identity card, death certificate ... We developed a Deep Learning-based approach to automate this process to improve the customer experience, facilitate the work of claims managers and make the process faster and more robust. We have developed several API allowing: - to identify the type of document sent by the beneficiary - to extract the information necessary for the investigation of the file We use Transfer Learning approaches and models such as Mask-RCNN and Faster-RCNN for document classification. For Optical Character Recognition (OCR), we have an approach based on a convolutional neural network to which we add a network of LSTM-type recurrent neurons. All our AI-API are industrialized on a GPU platform. By way of example, the reading API of bank account statement processed more than 80,000 copies in one year with an accuracy of 99.9%, a recall score of 98% and an average execution time of 4 seconds.

# Disability income claimant rehabilitation and other claim interventions: who are the selected few; and are these claimants more likely to return to work

**Author(s):** Landi Du Toit (University of Cape Town)

**Abstract:** Long term disability income (DI) claims account for a significant portion of life insurance companies' risk product liabilities. The annuity type benefits offered by these products, typically paid until a policyholder reaches retirement age, dies or returns to work, results in liabilities of a long-term nature often with experience other than originally assumed. It is thus crucial for insurance companies to manage the incidence as well as terminations of these claims. Group DI claims, incurred over 20 years, by one of the largest insurers in South Africa, were analysed, considering the case management information available to identify claimant intervention. Six claim factors, in addition to claim intervention, were identified as significantly correlated to return to work (RTW). In this paper we consider the composition of intervened claimants according to these significant RTW claim factors. This was done in order to highlight any intervention selection. In addition, the impact of intervention regardless of selection is presented.

# Mortality trends in developed countries: an analysis of the recent deceleration in mortality improvement

**Author(s):** Steve Haberman (Cass Business School)

**Abstract:** Many researchers have reported a slowing down in the upward trend in life expectancy in countries like UK and US since around 2010. The reported studies have focused on aggregate measures like life expectancy at birth or at an adult age like 20: this approach lacks granularity and makes it difficult to understand what is happening at individual ages and the implications for mortality rates. Mortality rates play a key part in the actuarial/demographic assumptions for pension plan adequacy, annuity pricing and reserving, and population projections. Our objective is to look more deeply at the underlying trends in age and gender specific mortality rates and mortality improvement rates across a range of developed countries. The results should be of interest to policy makers, to private and public funded pension schemes and to insurance and reinsurance companies involved in annuity markets.



# Anticipate future pandemics age-pattern mortality: an application of antigenic imprinting principles

**Author(s):** Marine Habart (Axa)

**Abstract:** Influenza pandemics have been the worst catastrophes in terms of human losses during the last two centuries. For instance, the 1918 Spanish flu killed more than 50 million people, higher than the First World War. Pandemics represent the biggest catastrophic risk for life insurers, with impacts on both assets (possible recession, share price volatility, ...) and liabilities sides (death, disability, ...). But more than that, pandemics are a matter of public interest. A valuable information from both insurer and public policies standpoints, during pandemic event, is the age-pattern of the deaths. This information would allow the insurer to manage the risk depending on its portfolio structure. But it can also orientate public mitigation strategies. For long time, no fully satisfactory theory emerged to explain the "W" shape of 1918 Pandemic mortality distribution, where the young adults (aged 20 to 40) were also significantly affected. This paper aims to explore a promising explanation: the Antigenic Imprinting principle according to which the vulnerability of an individual depends on his past exposure to viruses. A whole framework has been developed, from the building of a world-wide, prospective, epidemiological, to the implementation of the antigenic imprinting principle within the lethality module. Main conclusions are shared and can be of great interest for both insurers and general population awareness.

## Improving mortality information in middle-income countries

**Author(s):** Marine Habart (Axa)

**Abstract:** Much of the world's future mortality trends is predicated on what will happen outside of Western countries. However, little is known about historical trends in survival in Africa, Latin America and Asia due to fragmentary and poor-quality data. Recent improvements in the coverage, if not the reliability, of demographic information suggest that it might be possible to get a sense of the level and trends of broad mortality indicators in parts of these regions. Through a collaboration between researchers at the University of California, Berkeley, and at AXA, an effort has been undertaken to evaluate the nature of data quality issues and the adjustments required to produce accurate life tables in two populations selected as case studies (Hong Kong and Mexico). Expanding the Human Mortality Database methods, the gold standard for mortality estimation, we show how this approach has proved useful to document trends in the death rates in these two countries and, by extension, in other countries with similar statistical information. We also show how these mortality series can be used by actuaries to assess variations in biometrical risks and for mortality improvement models, and how the data limitations identified through the study may affect such assessments.

# An approximation to re-estimate the over-mortality occurred and not reported -missing persons- to face the possible claims: the Mexican case

**Author(s):** José Eliud Silva Urrutia (Anáhuac University Mexico)

**Abstract:** In Mexico the problem of missing persons increases every year. In fact, official statistics suggest that, in 2019, this figure exceeds 40 thousand. There are several implications for insured missing persons, because their vital status is unknown and the affected beneficiaries can't claim the respective insured sum because of the absence of the required death certificates. The exact number of missing persons with life insurance is unknown, however the Mexican Association of Insurance Companies (AMIS in Spanish) reports an increasing trend of homicides in the life insured population. A typical situation is to find missing persons as corpses in clandestine graves. There is also an excess demand of forensic services, which causes severe delays in corpse identification and issue of death certificates. The objective of this paper is to re-estimate the over-mortality assuming that missing people are death. To do that, hierarchical time series are used to forecast and then smoothing by segments is employed for re-estimation. The estimate are based on real data from the AMIS and the Mexican government ministry. The new estimates suggest the necessity to constitute a new reserve to face the possible new claims from beneficiaries of the insured missing persons. According with the estimates, the main changes appear around the called accident hump.

# Modélisation prospective du risque Incapacité : proposition d'une approche combinant modèle bi-dimensionnel et algorithmes d'apprentissage

**Author(s):** Fatoumata Ndoye (Fixage)

**Abstract:** Le coût du risque arrêt de travail augmente depuis un certain nombre d'années. Cette hausse est notamment expliquée par les risques psychosociaux. Cet article modélise le taux de prescription d'arrêts de travail grâce à un modèle dont les fondamentaux sont identiques à celui du modèle de LEE CARTER. Ce modèle prend en compte trois composantes : l'année, la tranche d'âge atteint et l'origine de la prescription de l'arrêt de travail. Les algorithmes d'intelligence artificielle permettront d'objectiver la corrélation entre les composantes et le nombre de paramètres à estimer. La première partie de l'article consiste en une analyse des risques incapacité/invalidité. Nous parlerons des tendances nationales constatées sur ce risque depuis une dizaine d'années. Dans la deuxième partie de l'article, nous décrivons le modèle utilisé, dont l'estimation des paramètres sera faite en utilisant les algorithmes de Machine Learning et les données nationales. L'utilisation des résultats de nos modèles dans l'estimation, le pilotage et le suivi du risque arrêt de travail (dans un cadre ORSA en particulier et la détermination des actions de prévention) est étudiée dans la troisième et dernière partie.

# A Reverse Mortgage or An Annuity Product? Analysis on Money's Worth Ratio Considering the Value of Living

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