Lumaria

Health Incentive Program Report for Super-Life

2024 SOA Student Research Case Study

GRP Consulting team

- Alexander Gerlyand
- Mack Huang
- Jayden Ly
- Andre Wang
- Robert Zheng

SOCIETY OF ACTUARIES®

UNSW SYDNEY

Introduction

GRP has been tasked with improving Lumarian policyholder expected mortality for those who have purchased SuperLife's whole life and term insurance products through being paired with incentive programs. Lumaria as a country is rich with cultural heritage whilst maintaining modernity. It offers a temperate climate, world renowned natural landmarks. Lumaria's population has high literacy rates, an 18% smoking rate, and has access to universal healthcare. In this report, GRP aims to take advantage of Lumaria's unique features in the form of a 3 intervention Health Incentive Program to achieve the objectives below.

Objectives

The main objectives of the health incentive program are to:

- Incentivise healthy behaviours through participation in the program
- Decrease expected mortality
- Increase life insurance sales
- Improve product marketability and competitiveness
- Add economic value to SuperLife

The key metrics to measure the success of the program are profit, participation rate, impact on mortality (success rate) and surveys to see customer satisfaction. These metrics would be continuously monitored to ensure the Health Incentive Program is on track, and to inform SuperLife of how to adjust program parameters to ensure smooth operation into the future.

Program Design

Exploratory Data Analysis (EDA) has shown that leading causes of death within SuperLife's policyholders are cancer and cardiovascular disease (Figure 1.1). Therefore, the interventions chosen to make up the Health Incentive Program are targeted towards reducing the incidence of these conditions. These programs are:

1. Well-being app with fitness tracking incentives
2. Smoking cessation programs
3. Hiking group

Well-being app with Fitness Tracking Incentives

The Well-being app with Fitness tracking incentives aims to provide a convenient platform for policyholders to monitor and enhance their physical and mental well-being. Through features such as personalised fitness goals, activity tracking and actionable insights, the app encourages active engagement. Policyholders are incentivised to utilise fitness trackers to monitor and improve their physical activity levels through achieving health-related milestones, with rewards including cash-back incentives, supermarket vouchers and lottery schedule rewards. The accessibility and convenience of mobile apps for fitness tracking promote higher participation rates and increase in policyholders. Weekly motivational messages and notifications further encourage sustained engagement and goal achievement. By focussing on decreasing the risk of cardiovascular disease and mortality rates while improving overall health outcomes, the program offers tangible benefits to both individuals and insurers, fostering a mutually beneficial relationship built on promoting healthier lifestyle choices.

Smoking Cessation Program

The Smoking Cessation program offers a comprehensive platform for policyholders seeking to quit smoking, providing crucial resources and support tailored for individual needs. This program addresses the significant health concerns of cancer and cardiovascular disease among policyholders as well as the general population. EDA showed a significant difference in mortality upon smoking, making this an invaluable tool to improve the overall health of policyholders. Despite the smoking rate among the policyholders being a lower 6.31%, the projected increase in policyholders per year will attract those from the general population where a greater 18% are smokers. In addition to the health benefits such as reduction in risk of cardiovascular disease and cancer, the incentive for policyholders will also potentially reduce their long-term healthcare costs and improve their quality of life. The program also offers additional incentives to encourage participation such as access to support groups and discounts on health insurance premiums for non-smokers.

Hiking and Outdoor Activities Group

The Hiking and Outdoor Activities Group offers a platform for policyholders to engage in physical activities amidst Lumaria's Luminous Lake, Skyreach and Whispering Woods. This program's main objective is to improve policyholders' all round health with particular focus on cardiovascular and mental health. Studies have shown that simply the act of being in nature has clear health benefits of reduced stress and improved recovery times. Combining this with group physical activity creates a platform for policyholders to connect, forge new relationships, whilst increasing the level of incidental exercise to improve cardiovascular health. Furthermore, sightseeing and socialising aspects of these activities make policyholders likely to persist in the program over time, reducing mortality. SuperLife can also leverage Lumarian public holidays such as Super Luminova to organise larger events and competitions to reward policyholder participation. Participation in these groups can be recorded in the aforementioned Well-being app to claim rewards.

Applications of these interventions in other countries have shown to be cost-effective and in reducing the expected mortality while encouraging participation in the program due to the accessibility.

Marketability and Distribution

For SuperLife to fully benefit from the proposed Health Incentive Program, current and prospective policyholders must know the health benefits and cost savings they can provide. EDA has shown that Agents had the greatest proportion of existing sales (Figure 5.1), indicating that one key way for SuperLife to increase participation in the programs is to train agents to market the bundled Health Incentive Program to their existing and future clients.

However, international trends show a shift towards increased online interaction with consumers. Google reported that mobile queries containing "insurance near me" grew over 100% in the period 2017-19. A report from SageFrog Marketing Group also showed that 89% of consumers searched the internet for reviews before commencing any action. It is therefore evident that the Marketing department's resources should be invested into creating a transparent online presence, exhibiting SuperLife's commitment to improving policyholder and community health.

As a conclusion, SuperLife should start making a transition to creating a stronger online presence in the long term, as shifting consumer paradigms mean SuperLife must accommodate increased online interaction. However, to cater for the current climate where life insurance consumers prefer speaking to live agents, training agents to effectively communicate and promote the bundled programs is most appropriate.

Timeframe for evaluation

For the short-term, a 5 year timeframe would allow for sufficient observation of the initial participation rates, behaviour changes and monitoring of program rollout to be adjusted. For the long-term, a time frame of 20 years was chosen to complement the 20-year term insurance products. This allows for a comprehensive assessment of the program's impact on the policyholder mortality rates, cost effectiveness and overall value over the life of these policies.

Data and Data Limitations

All datasets were cleaned and EDA conducted to identify trends and outliers. The programs were modelled using data provided by SuperLife for Lumaria. The following analysis relied on data provided by SuperLife for Lumaraia. Before analysis and modelling was completed, the datasets underwent cleaning and exploratory data analysis (EDA). This was done to identify trends, patterns and potential outliers in the data.

Before analysing results, we must acknowledge the limitations associated with the data used in the modelling process.

1. **Limited data**
   Of the six classes of interest used in pricing (Figure 2.5) the twenty year term insurance pool, there were significantly fewer instances of policy holders classified as HS and MS, which would lead to higher standard error of mortality estimates.
2. **Homogeneity**
   The pairwise proportion plots between Underwriting risk and region showed that the data was highly homogenous. The top left and top right panel in Figure 3.1 showed that there was an equal proportion of each region within each underwriting class and the bottom two graphs conversely showed that there was an equal proportion of underwriting class within each region. The lack of discernible patterns within the dataset with respect to underwriting class and regions would complicate the task of identifying and engineering relevant features.
3. **Economics data**
   Inflation, overnight interest and spot rates are provided annually from 1962 to 2023. Limited data would lead to restrictions on the accuracy of projections. Although higher frequency data will be more volatile, it would manifest seasonality which can be captured by time series analysis. The dataset can be enhanced by incorporating a greater variety of economic metrics such as GDP and commodity prices which can help predict interest rates.
4. **Multiple States Transition Data**
   Mortality statistics can be derived for smokers and non smokers from the policy in force data set. However, it doesn't provide information or have a separate state for ex-smokers. Collecting data on smokers to quit smoking would help better quantify the mortality savings of our smoking cessation program.

Assumptions

Listed are the assumptions made which are most impactful to the proposed program's costs. Descriptions can be viewed in Appendix - Descriptions.

Assumption	Rationale and Analysis
Conservative investment growth rate	As a sizeable corporation, it would be expected that SuperLife has a diverse portfolio of investments available to earn interest on its excess capital. However, we assumed the investment rate was given by the risk-free 1 year spot rate as the conservative lower bound of such a portfolio, partially due to a lack of information of the economic landscape and accessibility of investments within Lumaria.

Prevalent decrements for T20 and SPWL	Single premium whole life policies were assumed not to have withdrawal decrement as withdrawal of a policyholder would not affect the profits that Superlife would incur. On the other hand, Term life insurance policies included withdrawal decrements as withdrawal will affect the level of premium income SuperLife. This would go on to affect the level of profit that pricing and expense models would incur.
Lapse rates	See estimation of lapse rates section in pricing .
Mortality curves of Lumarians	Even though insured individuals are at higher risk, the mortality trend with age should still exist.
Commissions and expenses	Figures from IAG and Allianz, leading insurance companies, offer good bases for competitive and fair expenses selection. Based on their revenue, policies sold, and expenses (Appendix - Expenses and Commissions Rationale), commissions per policy were: **80%** of first year premium, **5%** of proceeding premiums. Expenses per policy were: **200 USD** for the first year, and **25 USD** in following years.
Independent interventions	These assumptions were made to simplify calculations where the interaction effects between interventions are not accounted for.
Independent policyholders	Uniform impact for policyholders that derive benefits from intervention was assumed since the sample size was large enough.
Age-independent Mortality Reduction	The lower and upper bounds of intervention mortality reduction were given, thus we are able to apply these bounds to all ages.
Lapsed smoker mortality	A lapsed smoker refers to a policyholder who was once classed as a smoker and successfully quit smoking. Research has shown that the mortality of a smoker who quit is still greater than nonsmokers. However, it was also shown that mortality improves relative to individuals who were still smoking (BMJ 1999).
Exchange to USD	Since we are only given a single exchange rate, we must assume the exchange rate is pegged at this rate. All calculations were made in USD at this pegged exchange rate.
Participation rate	Based on standard economic theory, we assume that the participation in programs is directly proportional to the benefits provided by the intervention (S. Strang et al. 2016)
Policyholder youngest age	This was found from the dataset given and is realistically plausible.

Cessation program	Expenses of the smoking cessation program were incurred in the first year as effective programs typically last up to a year. (C. Mendelsohn, 2022)

Pricing/Costs

Profit was calculated on a per-policy basis. Zero-profit net premiums were calculated for policies issued in different years to individuals of different smoking status, underwriting class, and age using the equivalence principle. The zero-profit premiums were then increased by a loading dependent on the underwriting class to create profitable premiums. The loadings were computed based on the volatility of crude mortality estimates q_x using the sum of squares of standardised residuals Figure 8.2.

Mortality rates used for pricing varied with smoking status and underwriting class to account for individual risk and were calculated independently. Investment growth rates and discount rates varied with issue year to account for dynamic economic conditions. Through a conservative outlook, interest on investments used historical 1-year spot rates which are assumed to be risk free, and the discount rate was calculated as the overnight rate. An estimate of initial expense as well as ongoing expenses were based on research on other life insurance companies' cash flows, assuming the policy generated its own expenses for acquisition, maintenance and settlement, and assuming the company allocated other business-wide expenses such as rent to each policy.

The range of issue ages in the in-force dataset was 26-65, however it would be infeasible and computationally expensive to calculate a separate premium for each issue age. Premiums were calculated for each issue age band (26-35, 36-45, 46-50, 51-55, 56-65). Issue age bands were chosen so that there was an approximately equal number of observations in each bin (Figure 2.6). More bins were required towards higher ages due to the steep increase in mortality after age 60, and higher risk groups should be separately charged appropriate premiums to mitigate a possible inequitable access risk.

Aggregate profits on the last twenty years were estimated using before and after intervention, using a reduction in mortality after intervention computed on given mortality reduction bounds of 4.94% and 9.76%. The impact of the smoking cessation program was modelled across the entire range of cessation proportions, and mortality of lapsed smokers was estimated as the average of smokers and nonsmokers according to our assumption. Initial expenses were increased with the introduction of interventions based on given costs and research (Program). Smoker policies incurred expenses associated with the smoking cessation program. The aggregate profit was calculated by holding the premium constant with reduced mortalities and higher expenses across the current count of policyholders.

Aggregate future profits were calculated similarly, by first projecting the counts of policyholders by age, underwriting class, face amount, and smoker status. After finding that the number of newly issued policies to each underwriting class and smoker status followed a visibly linear trend, simple linear regressions were used on different types of policyholder to predict future counts. The linearity assumption was based on linear historical data (Figure 6.1), and holds intuitive validity as policyholder count would be expected to consist of both population and economic growth. Negative predictions were corrected to zero, in effect assuming that such a policyholder would cease to exist based on past trends. Again, the new profit was calculated by considering the reduction in mortality and the increase in expense.

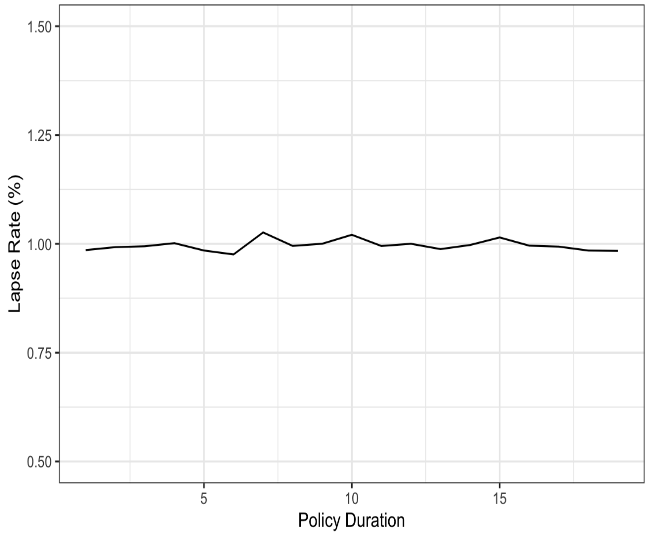
Projection of Interest Rates

Double exponential smoothing was used to project Lumeria's overnight interest rates for the next 20 years (Figure 9.1). The method relies on the assumption that the overnight interest rate can be decomposed into a long term average level as well as a linear trend component. Seasonality was ignored as it would introduce fluctuations which would unnecessarily complicate the analysis. Sensitivity testing as discussed in later sections will test the effect of varying the interest rates between these bands.

For pricing of the SPWL, double exponential smoothing assumes that the increasing linear trend from 2020 will persist indefinitely. As this is not a realistic assumption, we consider an alternative assumption that interest rates in the long term interest rates will level out. We used the most recent observation of overnight interest rate as our best estimate of the long term average (Figure 9.2). This is equivalent to saying the interest rate behaves as a random walk which was verified when fitting the best ARIMA model based on AIC and BIC. Instead of constructing confidence bands, upper and lower bounds were constructed using historical extremes.

Estimation of Lapse Rates

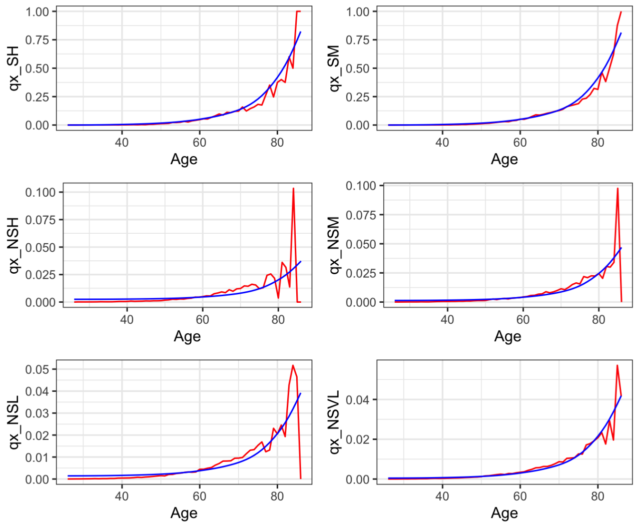
Policies that have to be renewed annually are subject to the risk of policy holders lapsing. Lapse rates for the 20 year level term (T20) insurance policy were calculated using the internal policies in-force data set. We assume that the probability of lapse depends on the duration of the policy which is defined as the number of years since issue year. For each duration, the lapse rate was computed to be the number of people lapsing during the year divided by the number of people at risk at the start of the year. Historically for the T20 policy, the lapse rates stayed relatively constant at approximately 1% for the 20 year policy term.



Although lapse rates have been historically constant, depending on how current and future customers respond to our interventions, there is a risk of an adverse shock in future lapse rates, which is addressed in our scenario testing.

Estimation of Mortality Rates for Different Subgroups

Heterogeneity in mortality amongst different subgroups would ultimately affect our pricing and underwriting of policies. The provided mortality rates are of the general population for the year 2010. However, we need mortality rates for a subset of the insured such as smokers and high underwriting risk individuals that our intervention is primarily targeting. Policy holders were classified into one of six possible strata determined by their smoking status and underwriting class and each of these stratum were associated with their own set of mortality rates. Accordingly, we calculated crude estimates of q_x using the in force dataset for each stratum defined in Figure 2.5.



As the in force policy data was right censored in the presence of withdrawals/lapses, crude estimates of mortality rates for each stratum was obtained using Kaplan Meier's Estimator and Cox Regression. Due to the limited data available for certain classes as discussed in data limitations, the relationship between crude estimates of q_x was jagged. In an attempt to reduce the variability of these estimates, they were graduated using the provided life table of Lumeria's general population in 2010 as reference. This ensured that the mortality curve was smooth and followed the same shape as the provided mortality rates. Although the maximum age at death in the in force dataset is 86, the parametric formula linking the provided reference mortalities and crude estimates from the dataset can be extrapolated to obtain mortality rates of higher ages. On the basis that our suggested intervention schemes reduce mortality and increase life expectancy, the mortality rates at ages above 86 will be needed in the scenario tests used for pricing.

	a	b
NSH	2.30e-3	3.10e-1
NSL	1.25e-3	3.37e-1
NSM	1.25e-3	3.37e-1
NSVL	2.61e-4	3.69e-1
SH	-4.08e-3	7.33
SM	-4.03e-3	7.25

$$\mathring{q}_x = a + b\hat{q}_x$$

The left hand side of the equation represents the graduated mortality rate whereas $\hat{q}_x$ represents the crude estimate. We assume that the mortality rates for each subset of insured individuals is a linear function of the general population's mortality rate. Parameters a and b was solved for using a least squares approach.

Key (risk)

SH: Smokers high	NSH: Non smokers high	NSM: Non smokers moderate
SM: Smokers moderate	NSL: Non smokers low	NSVL: Non smokers very low

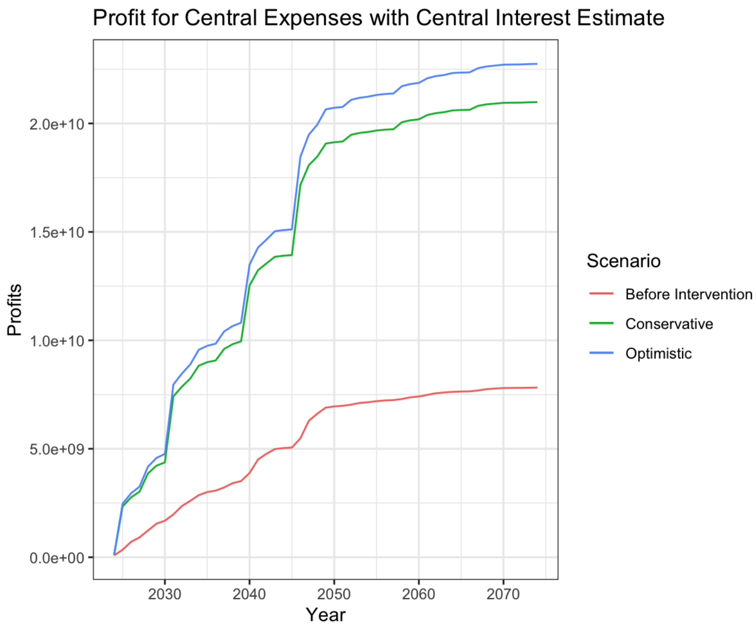
Past Twenty Years Mortality Savings

Below is a summary of the aggregate profits from 2004 to 2023 (inclusive) inflated to today using provided inflation rates, taking into account the increase in expenses due to the intervention and assuming the smoking cessation rate had a ten per cent success rate based on a study concerning a similar program (Mercha et al. 2023). We observed a 16 to 38 per cent increase in aggregate profits after the intervention based on the lower and upper bounds of the mortality savings assuming central expenses.

Expense Estimate	Before Intervention ($USD in billions)	After Intervention ($USD in billions) (conservative)	After Intervention ($USD in billions) (generous)
Optimistic	6.963	8.250	9.431
Central	7.014	8.157	9.687
Pessimistic	7.114	8.186	9.366

Future Economic Value

Below is a plot of the aggregate profits from 2024 up to Year t deflated to today based on our policyholder projections, central interest rate estimate, and central expenses, assuming a success rate of ten per cent for the smoking cessation rate based on the aforementioned study. As a result of the intervention, we observed a 17 per cent increase in profit over the first year, growing sharply to 214 per cent by 2028, 216 per cent by 2033, and 177 per cent by 2043. The rapid increases in aggregate profits were attributed to sharp declines in policy types that disproportionately affected post-intervention profits. Note the projections of policy and aggregate profits lose a great degree of certainty over longer time periods.



To optimise sales, aforementioned measures should frequently be monitored. Prices for existing policies should be used if estimates here are wrong. Prices should also be altered to meet an appropriate level of demand from new customers, supposing our projections are inaccurate.

Risk and Risk Mitigation Considerations

Quantitative Risk	Mitigation
Reinvestment risk related to investments into fixed income securities which are susceptible to interest rate fluctuations	Test the effects of adverse interest fluctuations on discounted profits Hedge against decreasing long term interest rates by buying interest rate options

Economic forecasts risk	Future forecasted rates of inflation and interest rates do not reflect true movements in variables impacting accuracy of the model
Expense risk relating to maintenance of incentives programs	Conducting cost-benefit analysis to evaluate effectiveness of different incentives programs, cost-plus process to ensure profits are maintained
Cost overrun risk where project costs deviate from actual experience	Establish contingency funds to address unexpected program costs and fluctuations in expenses.
Low participation rates in incentive programs - expected mortality and economics benefits will not be realised	Implement increased targeted market campaigns focusing on the distribution channels and educational initiatives to promote program awareness and encourage participation among policyholders.
Pandemic Risk: a pandemic may present an adverse change to the mortality of Lumarians	Sensitivity testing for extreme increases in mortality rate caused by pandemic

Likelihood and Severity risk matrix

Likelihood /Impact	Low Impact	Moderate Impact	High Impact
Unlikely			Pandemic Risk Labour Relations Risk Data Security Risk
Likely	Expense Risk	Long term interest rate risk Economic forecasts Cost Overrun risk Low Participation Rates	Competitor Risks
Highly Likely	Late/Incorrect Benefits Payment Incorrect Premium Collection		

Qualitative Risk	Mitigation
Regulatory changes	Compliance monitoring to stay informed about regulatory changes and ensure compliance with laws and regulations.
Negative Public Perception risk: If the program is perceived as exploiting users for their personal data or promoting unattainable body image standards.	Being transparent about privacy policies and data usage Emphasis on the program being to promote healthier lifestyles rather than a focus on physical appearance.
Inequitable access risk: Socioeconomic factors may affect	Implementing outreach programs and potential subsidies to make programs more accessible for everybody. Apps would have better UI and UX to

accessibility of programs to certain subsections of the population.	accommodate for people who are less technologically literate.

Sensitivity analysis

Due to a lack of understanding of SuperLife's expense structure, and external impacts listed in the Risk and Risk Mitigation Considerations section, a set of three estimates of expenses were used to calculate profits of SuperLife, representing the optimistic, pessimistic, and central estimates. Furthermore, the impact of each intervention on mortality had a degree of uncertainty and thus the upper and lower bounds of the impact were considered. Due to reinvestment risk, three scenarios of interest rates were also used. Finally, in mitigating model risk with regards to predictions on customer growth, lower and upper confidence bounds of 95% were further considered.

A range of estimated change in profits were calculated on intervention impacts if the intervention were introduced twenty years ago, with a figure of 15% increase in profit assuming the pessimistic expenses scenario.

In Figures 10.1, 10.2 and 10.3, 27 plots (81 projections) of profit were found for scenarios dependent on expense structure, mortality impact of intervention, interest rate and policyholder growth. The projections highlight that the intervention should outperform sales without the intervention.

In the most pessimistic scenario, the expected cumulative profits in 2028, 2033 and 2043 are 203.97%, 208.03%, and 170.64% more than the corresponding profit without intervention in that scenario. In the most optimistic scenario, the expected cumulative profits in 2028, 2033 and 2043 are 247.25%, 248.47%, and 206.95% more than the corresponding profit without intervention in that scenario. An unfavourable scenario we investigated was the exclusive underwriting of 20 year term policies to 35 year old smokers with a zero cessation rate, in which we observed an annual drop in profits of 9.16% due to the increased expenses (Figure 10.4).

Conclusion and Recommendations

Through our research and analysis, the potential for SuperLife's growth and development in Lumaria's health through our proposed Well-being app, smoking cessation and hiking groups is significant. By investing in these proactive measures, SuperLife stands to realise reduced healthcare costs, fewer insurance claims, and enhanced customer satisfaction, creating shared value within Lumaria.

Due to the quantitative risks and data limitations entailed in this report, we cannot be absolutely certain of the profits, economic value, and reduction in policyholder mortality that will be created for SuperLife through the proposed Health Incentive Program. To increase the likelihood of success in the future, regular maintenance must be implemented on the program design. Constant monitoring of key metrics of profit, policyholder mortality, customer satisfaction and participation rates will allow SuperLife to complete the actuarial control cycle, continually adjusting project parameters to cater for the ever-changing economic and consumer environment in which the company operates.

Appendix

Example Intervention Program Implementations and Cost Effectiveness

Intervention	Cost effectiveness
Well-being app and Fitness Tracking Incentive	ACHIEVE intervention cost approx A$77432. Cost per participant recruited was A$944. Incremental Cost-effectiveness ratio (ICER) for MET increase per person per week was $0.61; minute of sedentary time reduced per participant per day was A$5.15 and BMI unit loss per participant was A$763. The long-term cost effectiveness analysis indicated that if the intervention was scaled-up to all eligible Australians, approximately 265,095 participants would be recruited to the program at an intervention cost of A$107.4 million. **Health care cost savings were A$33.4 million.** Total HALYs gained were 2,709. The mean ICER was estimated at **A$27,297 per HALY** gained which is considered cost-effective in the Australian setting. Intervention considered cost-effective if resulting in ICER below A$50,000 per HALY gained in Australian context (Maple et al., 2022). Study to our knowledge to examine the cost-effectiveness of a commercial physical activity app (Carrot Rewards) over 5-year time horizon. Carrot Rewards had an ICER of **$11,113 CAD per QALY**, well below a $50,000 CAD per QALY willingness-to-pay (WTP) threshold. Subgroup analyses revealed that the app had lower ICERs for British Columbians, females, highly engaged users, and adults aged 35-64 yrs., and was dominant for older adults (65 + yrs). Probabilistic sensitivity analyses revealed varying parameter estimates predominantly resulted in ICERs below the WTP threshold (Rondina, 2021). **Financial incentives for physical activity are more effective during the payment period** when they are offered at a **constant rate** rather than an increasing or decreasing rate. Effectiveness dissipated shortly after the incentives were removed. Overall, for each $1 spent, participants in the constant incentives group logged 475.4 more steps than those in the increasing incentives group and 429.3 more steps than those in the decreasing incentives group (Chethan Bachireddy, 2019).
Smoking Cessation Program	The BSCI was cost-effective versus usual care with an incremental cost-effectiveness ratio (ICER) of £3145 per QALY (incremental costs: £165; incremental QALYs: 0.05). Integrated care was cost-effective versus SCC with an ICER of £6875 per QALY

	(incremental costs: £292; incremental QALYs: 0.04). The BSCI and IC were cost-effective in 89% and 83% of PSA iterations respectively. The main area of uncertainty related to relapse rates (Mattock et al., 2023). ICERs for SCPs for cancer patients average around \$4200 (median = \$3400) and ICERs for SCPs as part of a cancer screening program average around \$15,000 (median = \$11,000). These are incredibly “good investments” (i.e., gains in patient outcomes for relatively low extra cost) compared to almost anything in the oncology portfolio, especially new treatments (Hotch et al., 2023). **Interest in cessation treatment among people who smoke in a community-based multidisciplinary Thoracic Oncology Program.** Of 641 total respondents, the average age was 69 years (range: 32–95), 47% were men, 64% white, 34% black, and 17% college graduates. A total of 90% had ever smoked: 34% currently and 25% quit within the past year. Among the current smokers, 60% were very interested in quitting and 37% would participate in a cessation program. (Meadows Taylor, M. et al. 2021) **Factors associated with quitting among smoking cessation medication assisted smokers and ex smokers: A cross-sectional study in Australia** An observational online cross-sectional survey was conducted using a convenience sample of smokers and ex-smokers in Australia. A self-administered questionnaire was used to evaluate socio-demographic, psychological, smoking, and medication use characteristics. The Fagerstrom Test for Nicotine Dependence scale was used to assess the level of nicotine addiction. Logistic regression used to identify factors associated with smoking cessation. Of the 201 respondents, 33.3% had successfully quit smoking. (Mercha et al. 2023)
Hiking and Outdoor Activities Group	Davis (2017) Canada RCT , EQ-5D-3L patient: At 6 months:\$1,800/QALY, At 12 months:\$3,200/QALY, \$20,000 (CAD) cost-effective threshold The intervention consisted of an invitation, from a general practitioner, to participate in a 6-month walking-based, supervised exercise program with three 50-minute sessions per week. Of the patients invited to participate in the program, 79% were successfully recruited, and 86% of the participants in the exercise group completed the programme. Over 6 months, the mean treatment cost per patient in the exercise group was €41 more than "best care". The mean incremental QALY of intervention was

	0.132 (95% CI: 0.104–0.286). Each extra QALY gained by the exercise programme relative to best care cost €311 (95% CI, €143–€394). The cost effectiveness acceptability curves showed a 90% probability that the addition of the walking programme is the best strategy if the ceiling of inversion is €350/QALY. **Hiking** **A Low-Cost, Accessible Intervention to Promote Health Benefits** Literature demonstrates that simply being exposed to nature, even in passive ways, has clear benefits. For example, an early landmark study demonstrated that viewing nature through a hospital window decreased recovery time and pain medication requests, and increased general well-being of patients recovering from gallbladder surgery. (Mitten, D. et al. 2016) Researchers have found the benefits of simply spending time in forests, or forest bathing, to include (a) decreased systolic blood pressure,42 (b) decreased stress levels (measured through prefrontal cortex activity and salivary cortisol),43 (c) deactivated sympathetic nervous system (measured via urinary adrenaline and noradrenaline levels),44 and (d) strengthened immune system (measured via enhanced natural killer cell activity and intercellular anticancer proteins).45-47 Each of these studies compared forest and urban environments, finding significant differences in health-related effects between the 2 environments throughout the study period. (Mitten, D. et al. 2016)

Data Cleaning

In the Inforce Dataset, the "Online" factor for the Distribution Channels was not listed in the given key, however we treated Online as another distribution method. The variables were modified to match the inforce dataset key where

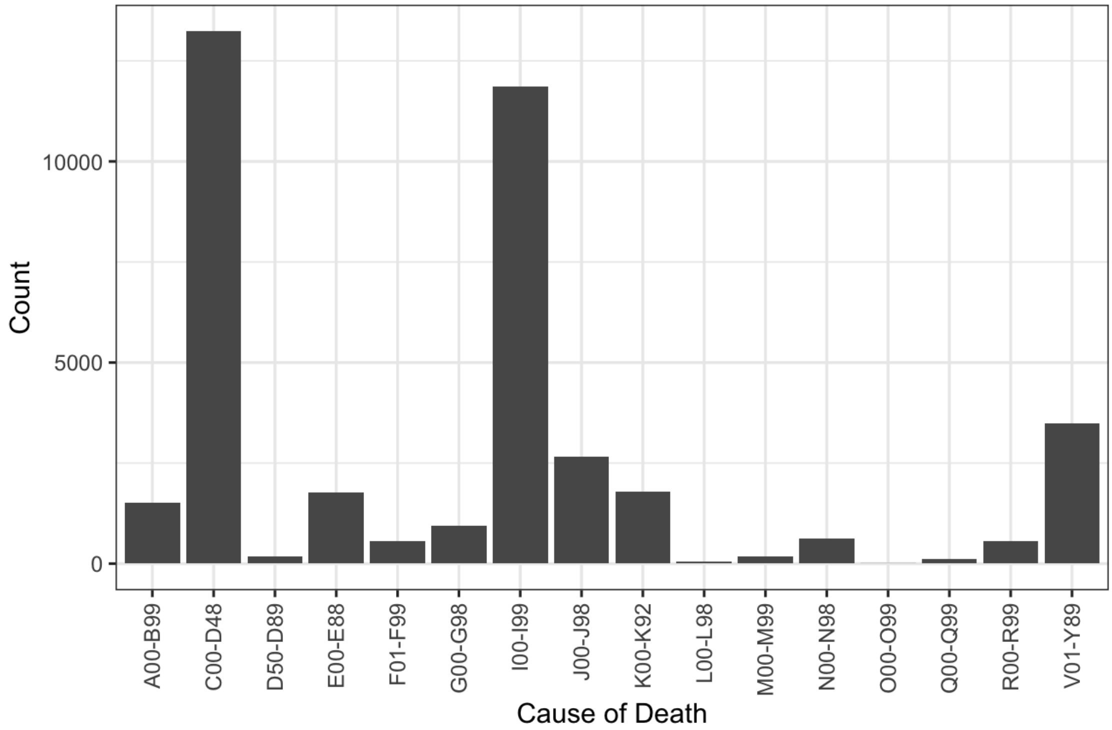
- The lapse Indicator originally had factors of 1, Y and NA and the Y's were converted to 1's
- The cause of death replaced blank factors with NAs
- The death and lapse indicator replaced the NAs with 0s and 1s

Extra columns were also added to calculate age at death, age at lapse and time where

- Age at death was calculated as **year of death - issue year + issue age**
- Age at lapse was calculated as **year of lapse - issue year + issue age**
- Time is defined as age at death or age at lapse or **2023 - issue year + issue age** (used for censoring with KM)

Exploratory Data Analysis

Figure 1.1: Main causes of death from inforce data



Predominant causes of death were analysed. Neoplasms (predominantly cancer), diseases of the circulatory system, and external causes of morbidity and mortality were shown to be most frequent.

- A, B: Certain infectious and parasitic diseases
- C-D48: Neoplasms (cancer)
- D50-D89: Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism
- E00-E88: Endocrine, nutritional and metabolic diseases
- F01-F99: Mental and behavioural disorders
- G00-G98: Diseases of the nervous system
- I00-I99: Diseases of the circulatory system
- J00-J98: Diseases of the respiratory system
- K00-K92: Diseases of the digestive system
- L00-L98: Diseases of the skin and subcutaneous tissue
- M00-M99: Diseases of the musculoskeletal system and connective tissue
- N00-N98: Diseases of the genitourinary system
- O00-O99: Pregnancy, childbirth and the puerperium
- Q00-Q99: Congenital malformations, deformations and chromosomal abnormalities
- R00-R99: Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified
- V01-Y89: External causes of morbidity and mortality (accidents, assault, etc)

Figure 2.1 Smoker Status Hypothesis Test

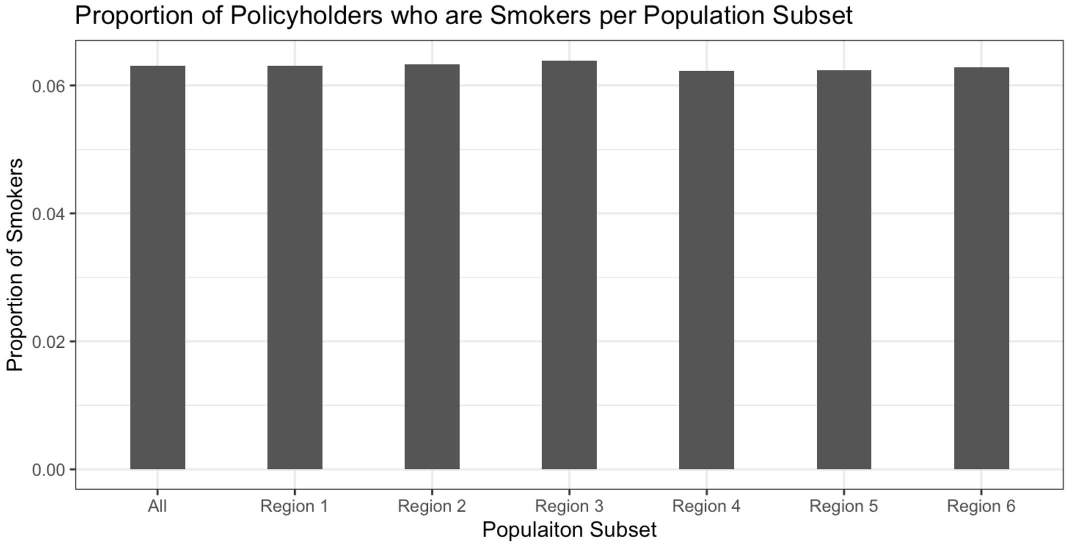
Hypothesis test for differences in mortality between smokers and non smokers

```
Call:
survdiff(formula = survival_obj ~ Smoker.Status, data = smoking_time)

                        N Observed Expected (O-E)^2/E (O-E)^2/V
Smoker.Status=NS 916842    26070    38221      3863     73052
Smoker.Status=S   61740    14306     2155     68494     73052

 Chisq= 73052  on 1 degrees of freedom, p= <2e-16
```

Figure 2.2 Distribution of Policyholders and Smoker Status



Hypothesis test said there’s a significant change in mortality when comparing smokers and non smokers

- the provided data on the schemes suggests that we have an up to 50% reduction in mortality when in effect

Small percentage of SuperLife’s policyholders were smokers

- but with the incentive program there are more people coming in from the general population, and the general population has a much higher proportion of smokers at 18%

Figure 2.3 KM Curves by Smoking Status

Survival curves were also made for smokers and non-smokers. It is evident that there is a difference in survival probability.

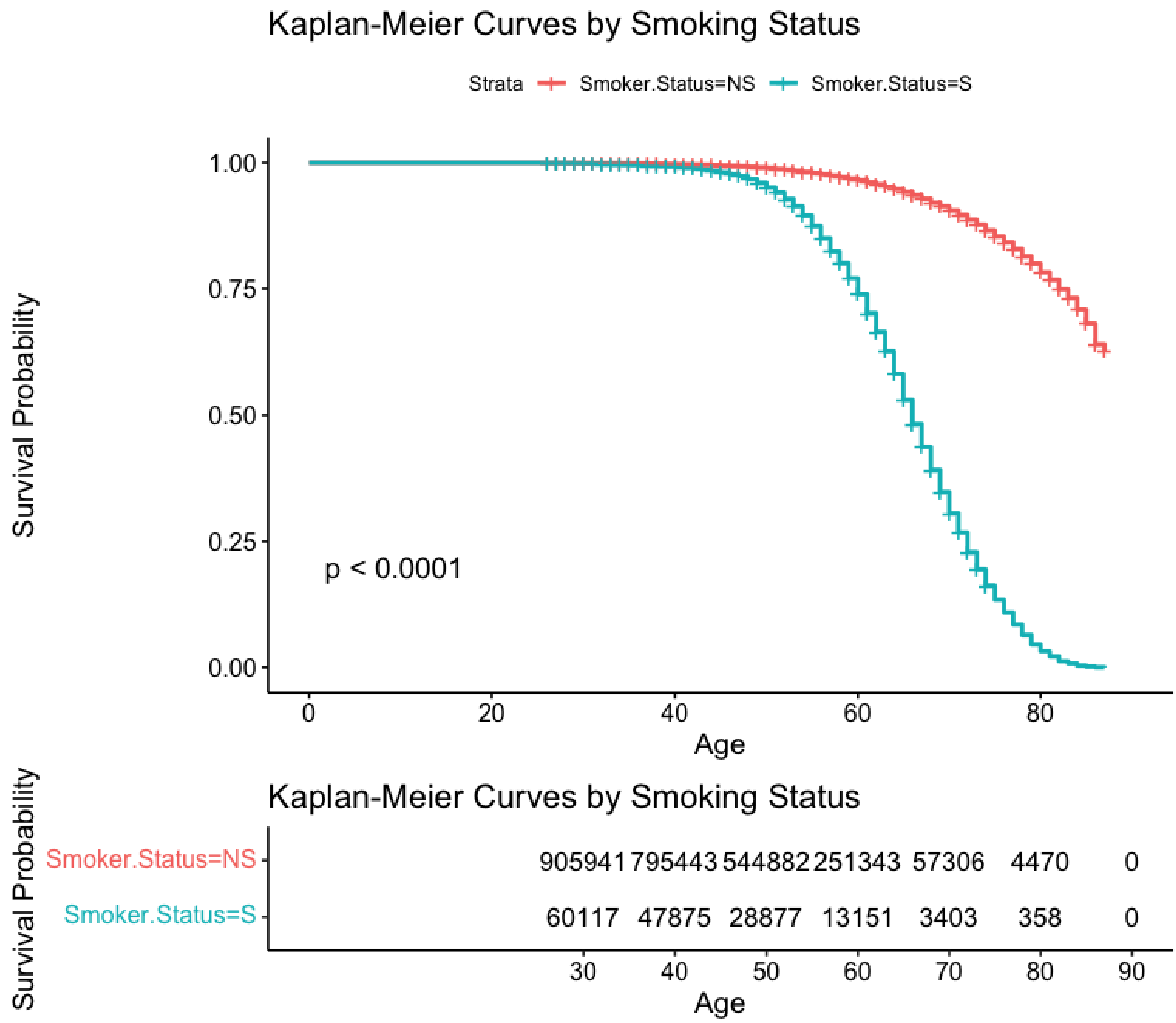


Figure 2.4 KM Curves by Smoking Status and Underwriting Class

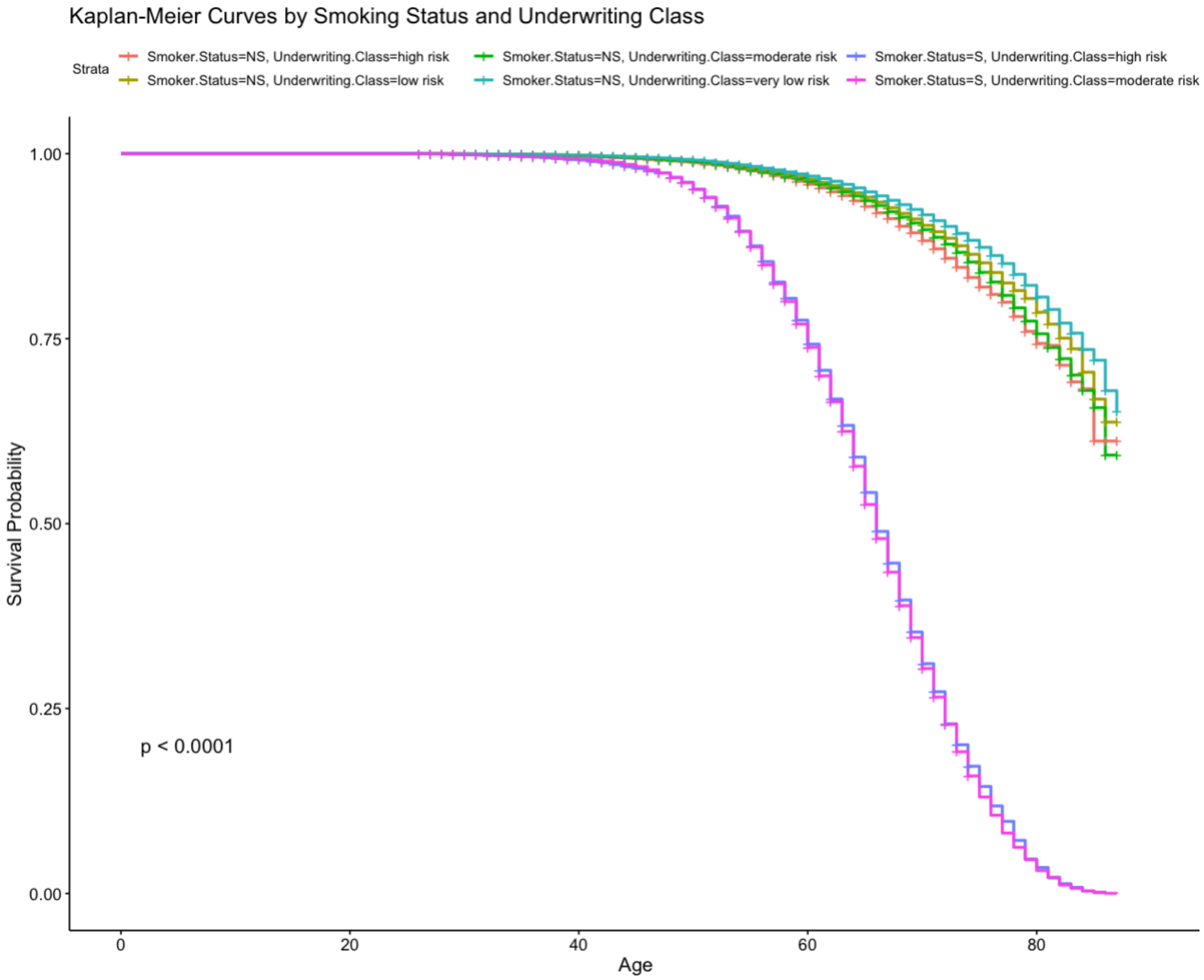


Figure 2.5 Distribution of Subgroups based on Smoker Status and Underwriting Class

Subgroup	Count
High Risk Non Smokers (NSH)	94 405
Low Risk Smokers (SL)	275 681
Moderate Risk Non Smokers (NSM)	188 917
Very Low Risk Non Smokers (NSVL)	357 839
High Risk Smokers (HS)	17 651
Moderate Risk Smokers (MS)	44 089

Figure 2.6 Number of Policyholders in each Age Bracket

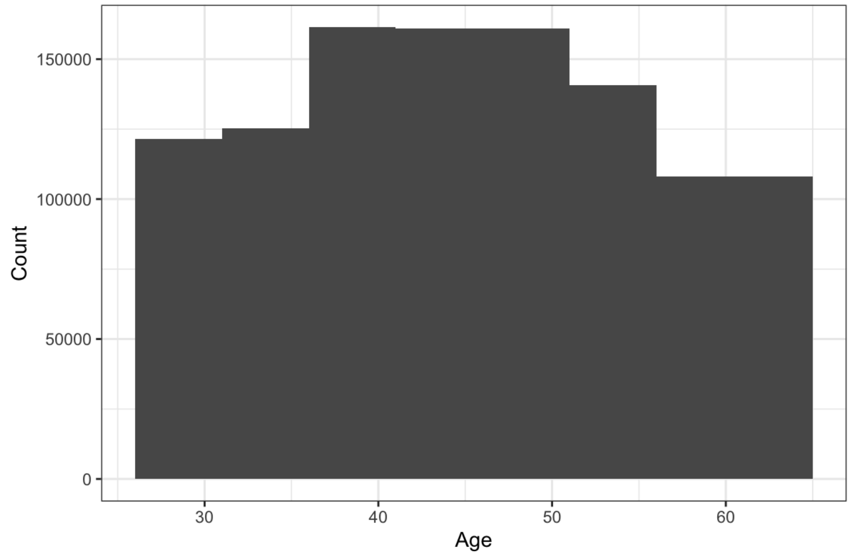
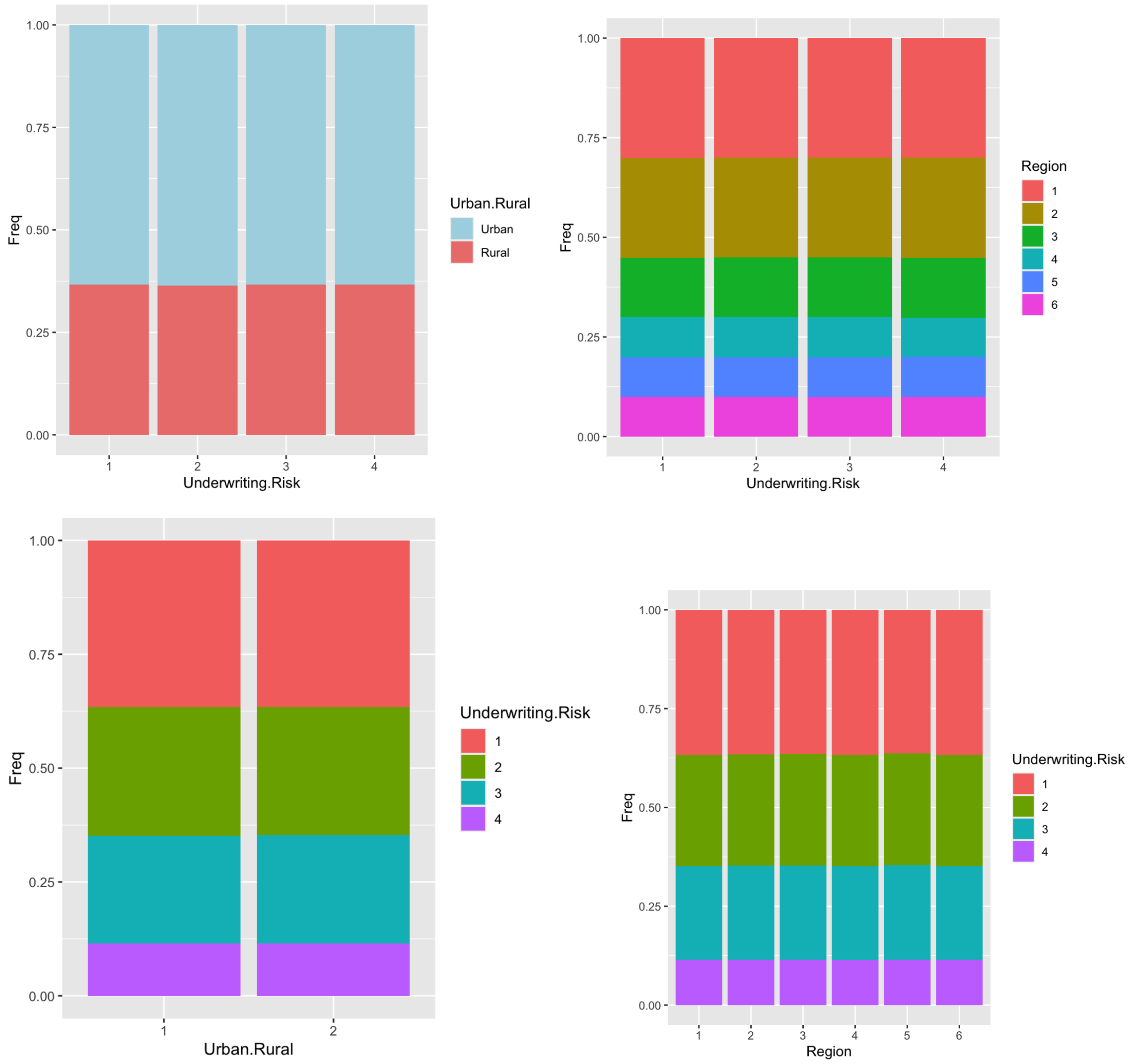


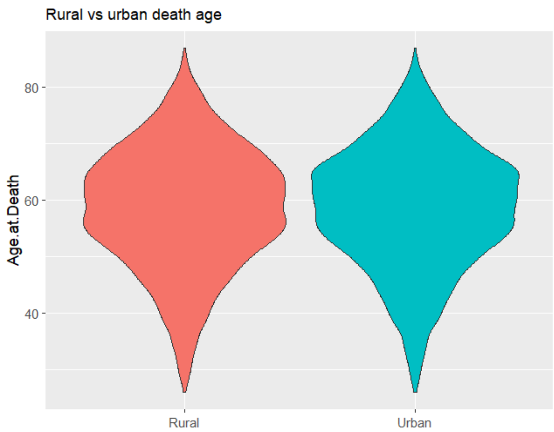
Figure 3.1 Underwriting Risk in Each Region

Analysis found no noticeable patterns in underwriting risk.

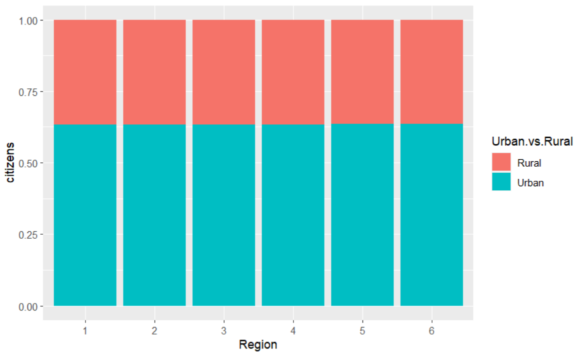


There were also no differences for rural and urban policyholders.

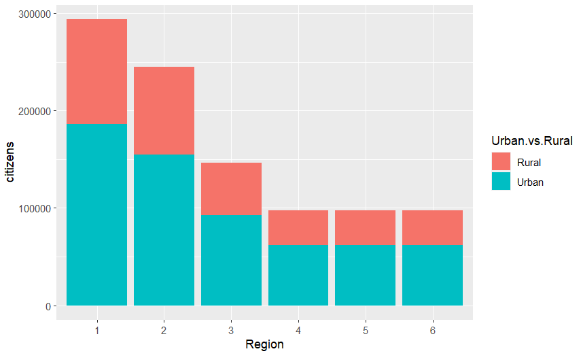
Figure 4.1 Urban vs Rural



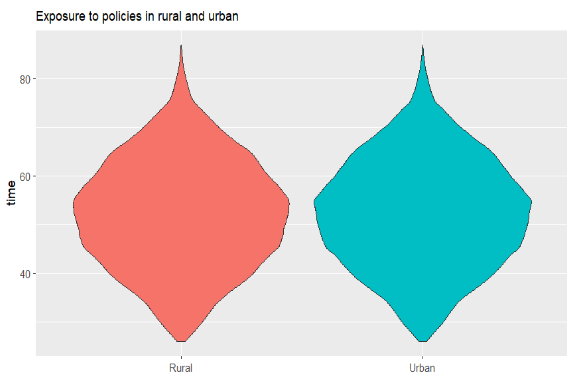
Rural and Urban death ages align with each other in terms of distribution with minor differences being that urban has a slightly greater number of deaths at a higher age.



The split of policyholders between rural and urban stays very consistent among regions.



The split of policyholders between rural and urban stays very consistent among regions. However there were more policyholders in regions 1, 2, and 3 when considering all 6 regions.



Exposure between the urban and rural policyholders shows almost identical distributions.

Figure 5.1 Distribution Channels

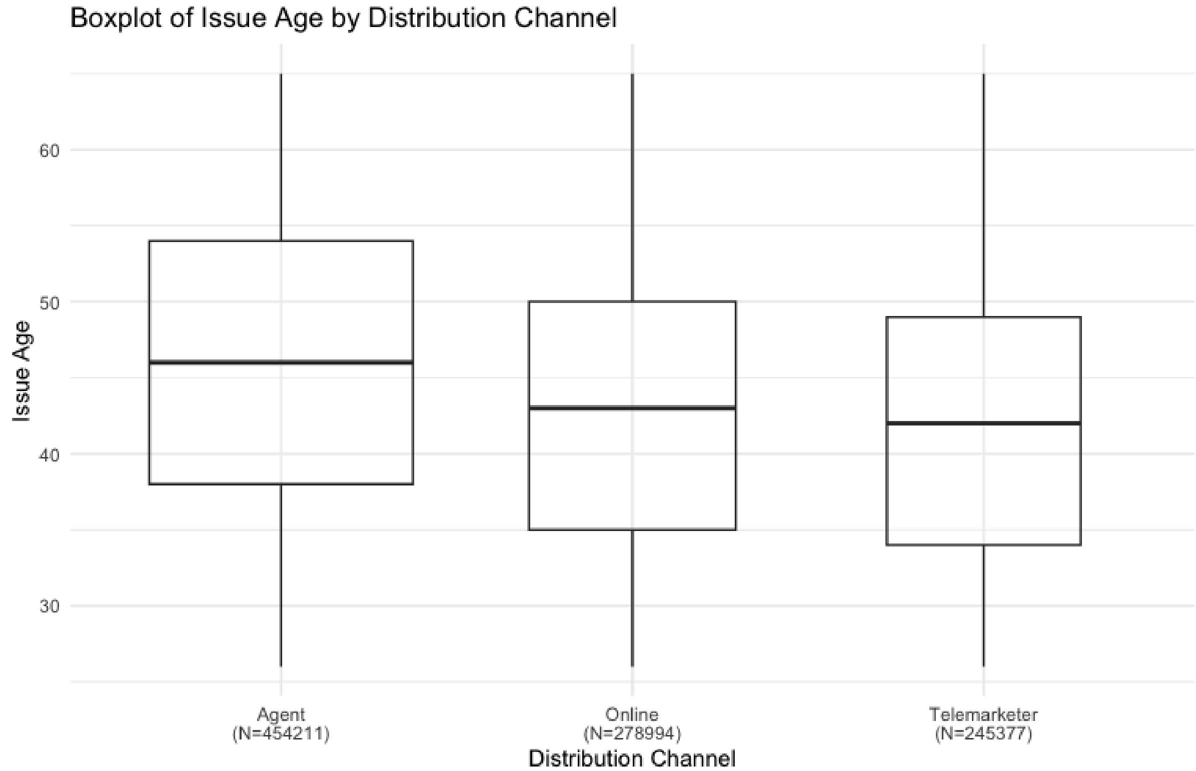


Figure 6.1 Investigation on the growth of policyholders each year:

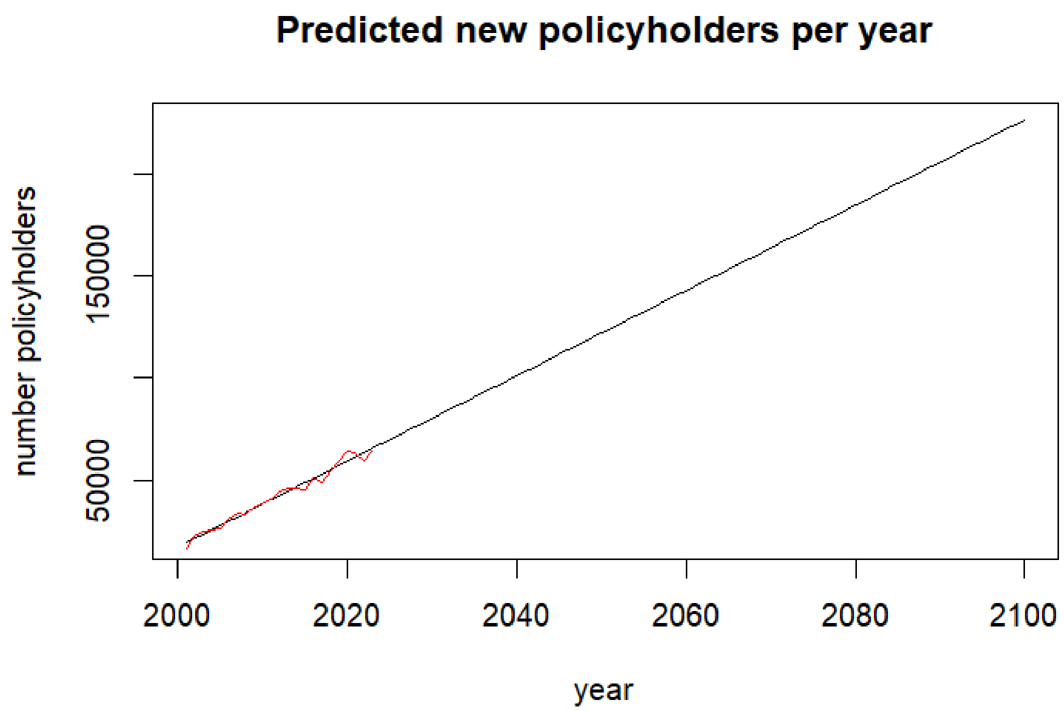


Figure 7.1 Counts of Policyholders

Counts of new customers entering different underwriting and smoking classes were found. It was appropriate to fit a linear model to project future incoming customers.

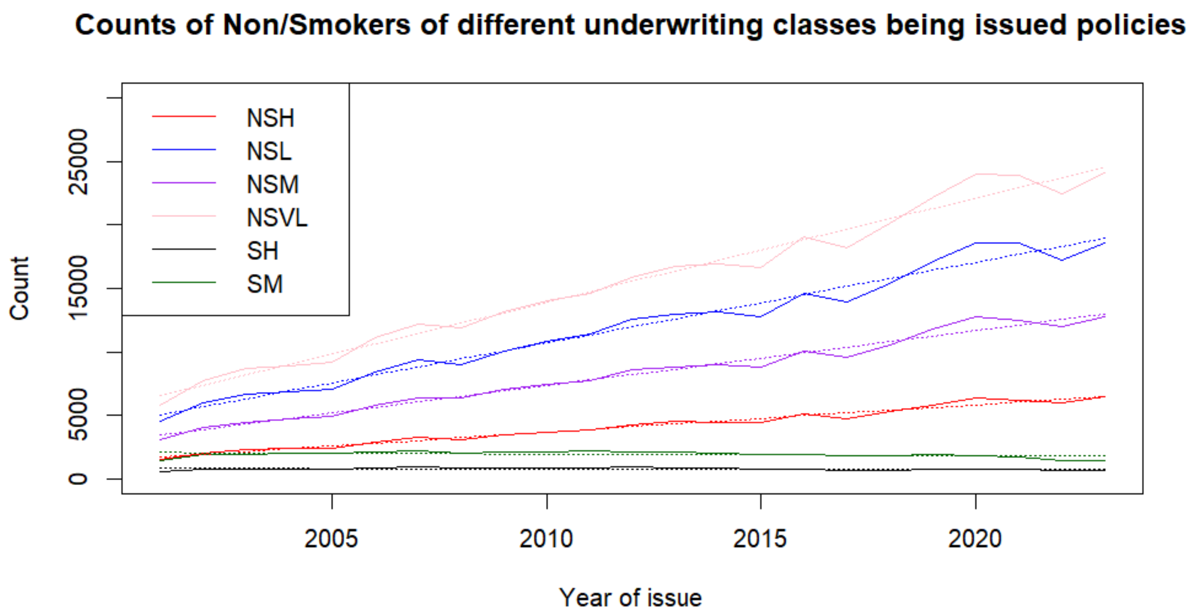
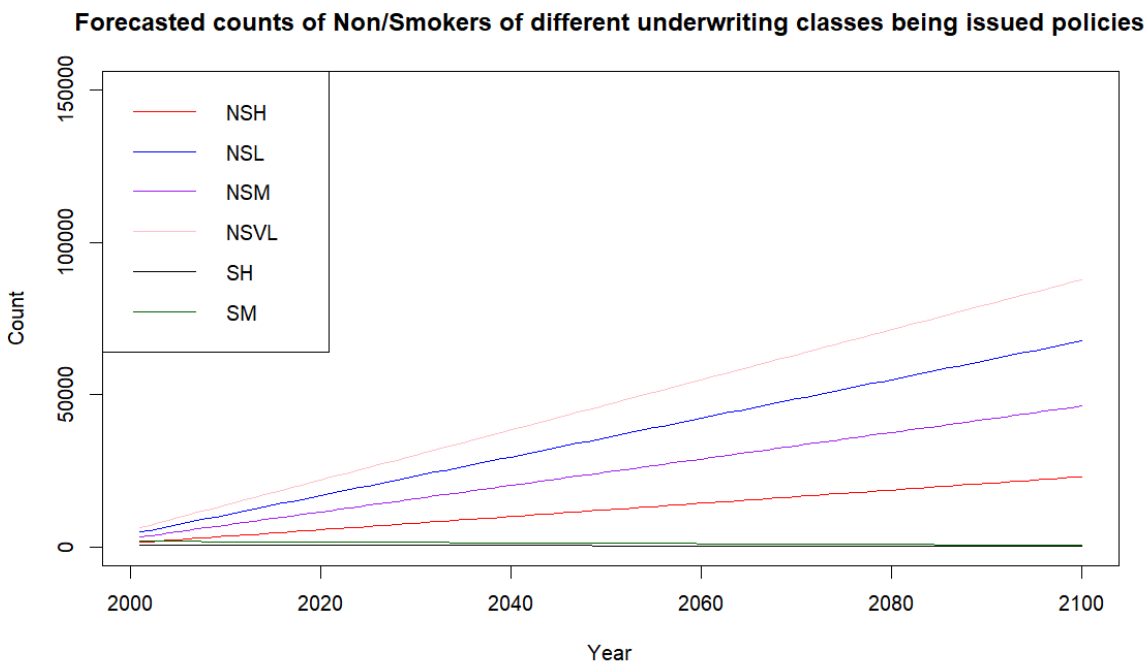


Figure 7.2 Forecasted Counts of Policyholders



Program Structures

Well-being App with Fitness Tracking

Program Requirements
1. Policyholders must be over 18 and a member of SuperLife. 2. Policyholders can participate in the following activities to be tracked using phones to earn points: a. *Walking*: Step count from phone can be translated into points b. *Hiking and Outdoor Activities*: GPS location can be used to verify the time spent in the outdoors to be translated into points c. *Cycling*: Kilometres spent cycling taken from third party apps such as Strava can be translated into points d. *Running*: Step count from running can be translated into points 3. Points can later be redeemed by policyholders in the form of cash rewards and the costs of these rewards are reflected in the expenses for the program.
Feedback Channels
Feedback section within app can be used to collect user information: - Collect customer data on how the app is used or the complaints that they might have about the programs incentives - Feedback will inform SuperLife on how policyholders perceive the programs and if they would recommend to friends or, - If they'd stay with the program into the future or, - How the program has impacted their fitness levels

Smoking Cessation Program

Program Requirements
1. Policyholders who are smokers and members of SuperLife will be able to access Smoking Cessation Programs 2. Smokers who successfully quit will be moved out of the smoking cessation program 3. If a policyholder is unable to quit smoking within a specified time frame, then they will be removed from the program
Feedback Channels
Survey of participants of the program on a monthly basis can indicate the efficacy of the program. - If the rate at which smokers are converted to non-smokers changes, then the program can be refreshed

Hiking and Outdoor Activity Groups

Program Requirements

1. Policyholders meet regularly with a SuperLife representative to participate in Hikes and Outdoor Activities   a. Policyholders can be split up in terms of skill level and preference for exercise intensity 2. Every Super Luminova, special promotions are in place where Policyholders participating in SuperLife Hiking and Outdoor Activities are given access to larger group activities organised by SuperLife (cost of this is expressed in the cost of the program) 3. Participation in these programs can be counted towards the Well-being and Fitness tracking to record activities and earn cash rewards
Feedback Channels
Weekly feedback from participating policyholders can be collected and used to adjust the program - Particular groups of policyholders could have their own personalised activities for their sessions to ensure the longevity of policyholder participation in the programs - Incentives could be revised in order to encourage greater participation from policyholders

Assumptions

Descriptions

Assumption	**Rationale and Analysis**
Conservative investment growth rate	Conservative investment growth rate assumed to be equal to the risk-free 1 year spot rate.
Prevalent decrements for T20 and SPWL	Assume that the only decrements for term policies are withdrawal and deaths. For single premium policies, only decrement is death.
Lapse rates	Lapse rates are constant for the duration of the policy. This was supported by our lapse rates estimates from the in force dataset.
Mortality curves of Lumarians	The shape of the mortality curves of Superlife's insured policyholders should follow that of the general population in 2010 provided by Superlife. Assume the mortality curves of different subsets of insured policy holders can be obtained by a linear transformation of the provided mortality curve.
Commissions and expenses	Payment of commissions and expenses over time could be appropriately based on figures from existing insurance companies.
Independence of intervention	The impacts of each intervention program were independent of each other, to ease calculations. Their impact was also assumed to be the same per

effect	policyholder, despite the possibility that specific individuals would benefit more from the intervention.
The mortality of lapsed smokers	The mortality of lapsed smokers lies between the mortality of smokers and nonsmokers.
Exchange to USD	Assume the exchange rate from Lumarian Crowns to USD is pegged at a single rate. All calculations were made in USD at this pegged exchange rate.
Participation rate	The participation rate is a function of benefits provided by the intervention.
Youngest Age	The youngest age of a person purchasing insurance was 26.

Expenses and Commission Rationale

Based on IAG reportedly having generated 7947 million AUD in gross revenue in the past half year, and commission expenses totalling 418 million AUD (IAG, 2024, p.6), the percentage of commission expense of gross revenue was about 6.04%. Zurich's insurance revenue of 68,757 million and fees and commissions expense of 2,547 million (Allianz, 2023, p.111-112) gave a percentage of 3.70%. Recognising that typically commissions are high for agents attracting new customers in the first year, and lower in following years, an **80%** commission on the first year premium of a policy and **5%** commission on proceeding premiums was used.

Furthermore IAG's underwriting costs of 646 million AUD across 730,000 policies (IAG, 2024, p.1) in the most recent half year implied approximately 884.93 AUD per policy. An upfront expense of **200 USD**, as well as ongoing costs of **25 USD** being paid over at least 20 years (for T20 and SPWL policies) was judged to be a realistic, competitive and appropriate structure of expenses.

Figure 8.1 Graduated Mortality Rates

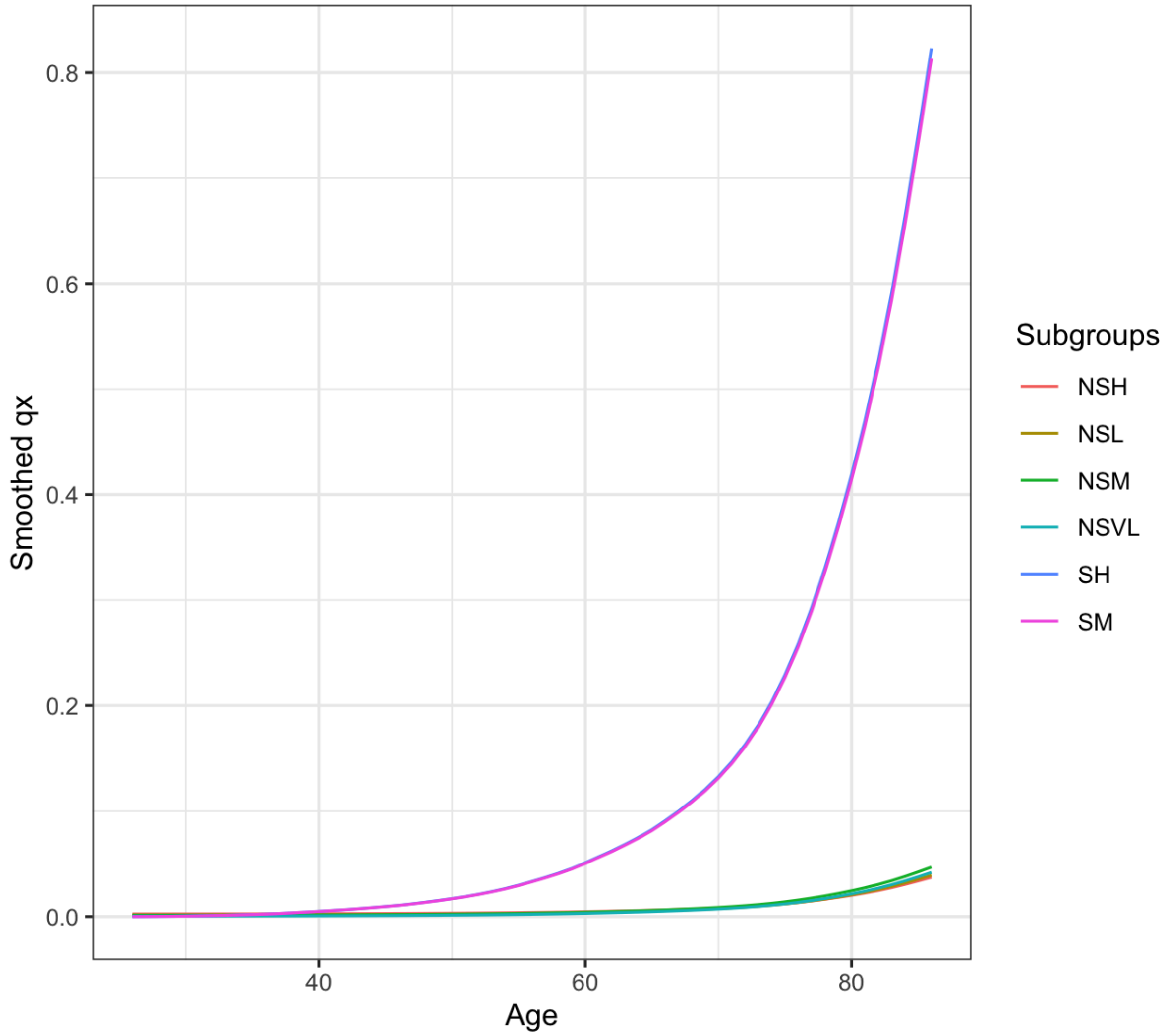
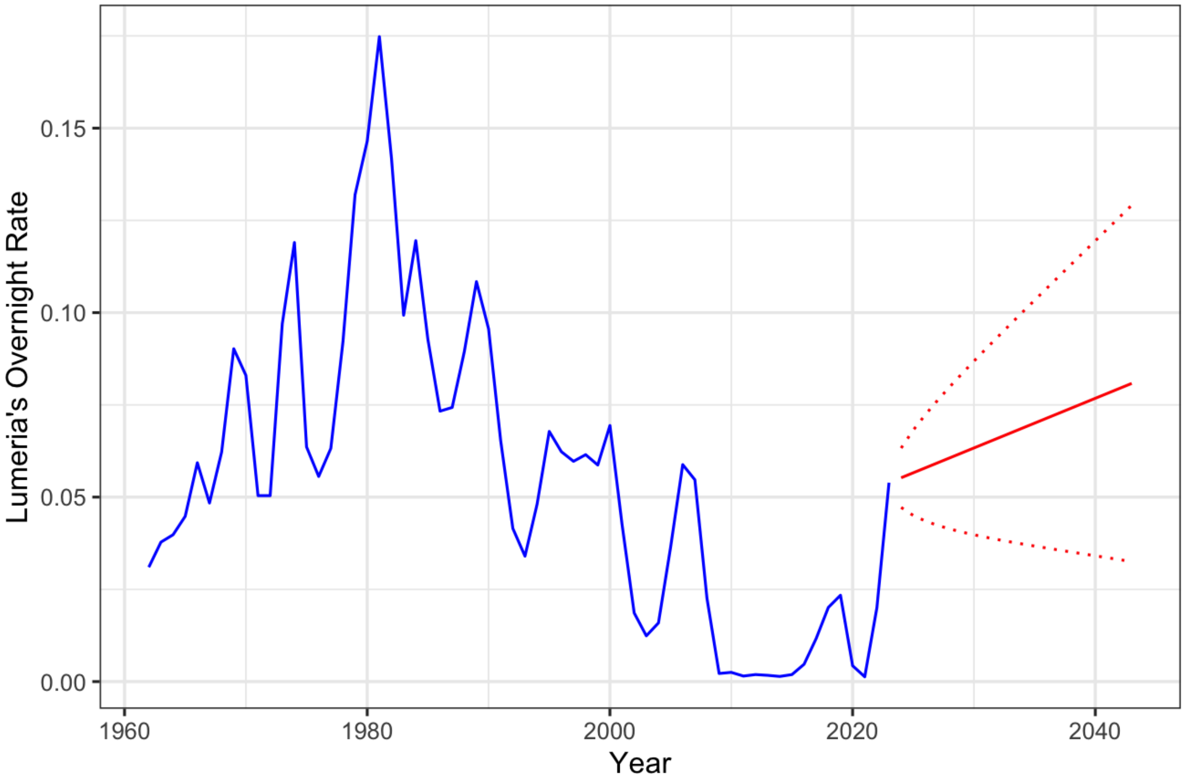


Figure 8.2 Volatility of Crude Mortality Estimates for Different Subgroups

Subgroup	Sum of Squares of Standardised Residual
SH	4.732105
SM	2.715302
NSH	128.4102
NSM	45.21062
NSL	4.732105
NSVL	2.715302

Figure 9.1 Projection of Overnight Interest Rates for Next 20 Years with Double Exponential Smoothing



Under the double exponential smoothing model, the h-step forecast is given by the equations:

$$Y[t+h] = a[t] + h \cdot b[t] \tag{1}$$

$$a[t] = \alpha Y[t] + (1-\alpha)(a[t-1] + b[t-1]) \tag{2}$$

$$b[t] = \beta(a[t] - a[t-1]) + (1-\beta)b[t-1] \tag{3}$$

where $a[t]$ denotes an estimate of the level of the time series at time t and $b[t]$ denotes an estimate of the slope or trend at time t. The smoothing parameters α and β were tuned by minimising the one step ahead squared prediction error.

Figure 9.2 Long term Overnight Interest Rate Level with Confidence Bands

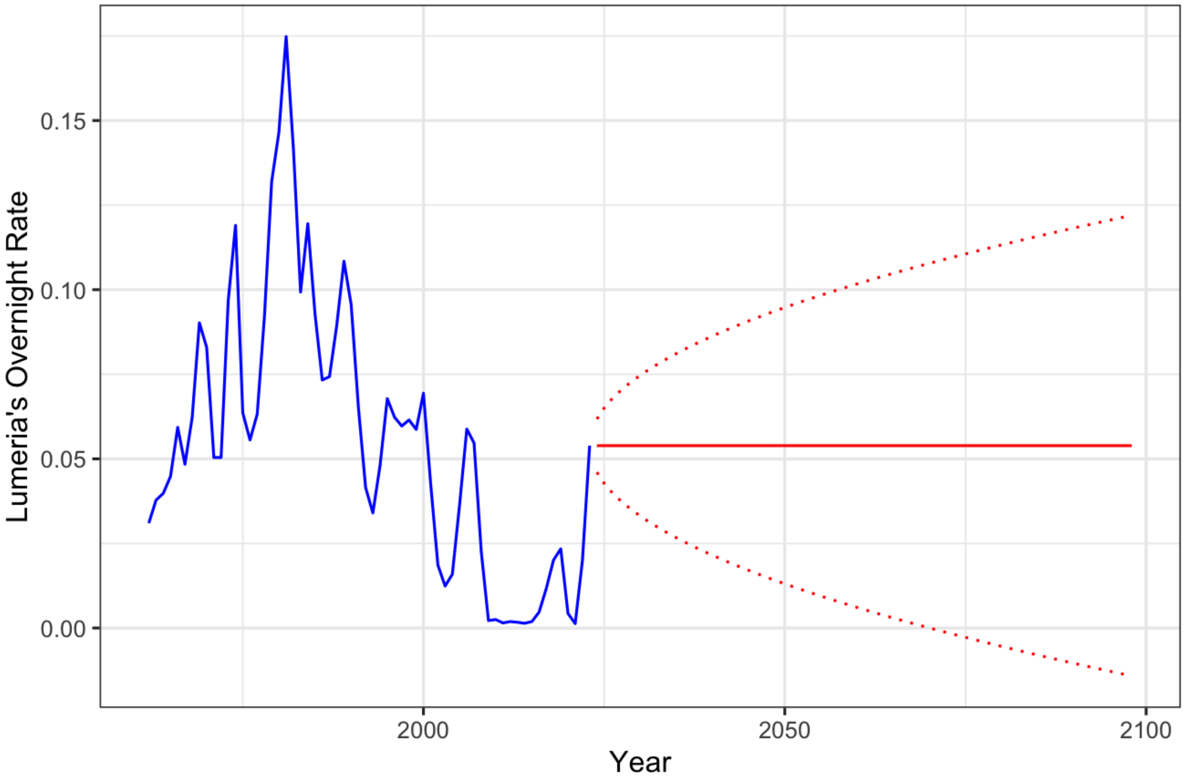


Figure 10.1 Scenario Testing for Profits (Central Policyholder Projections)

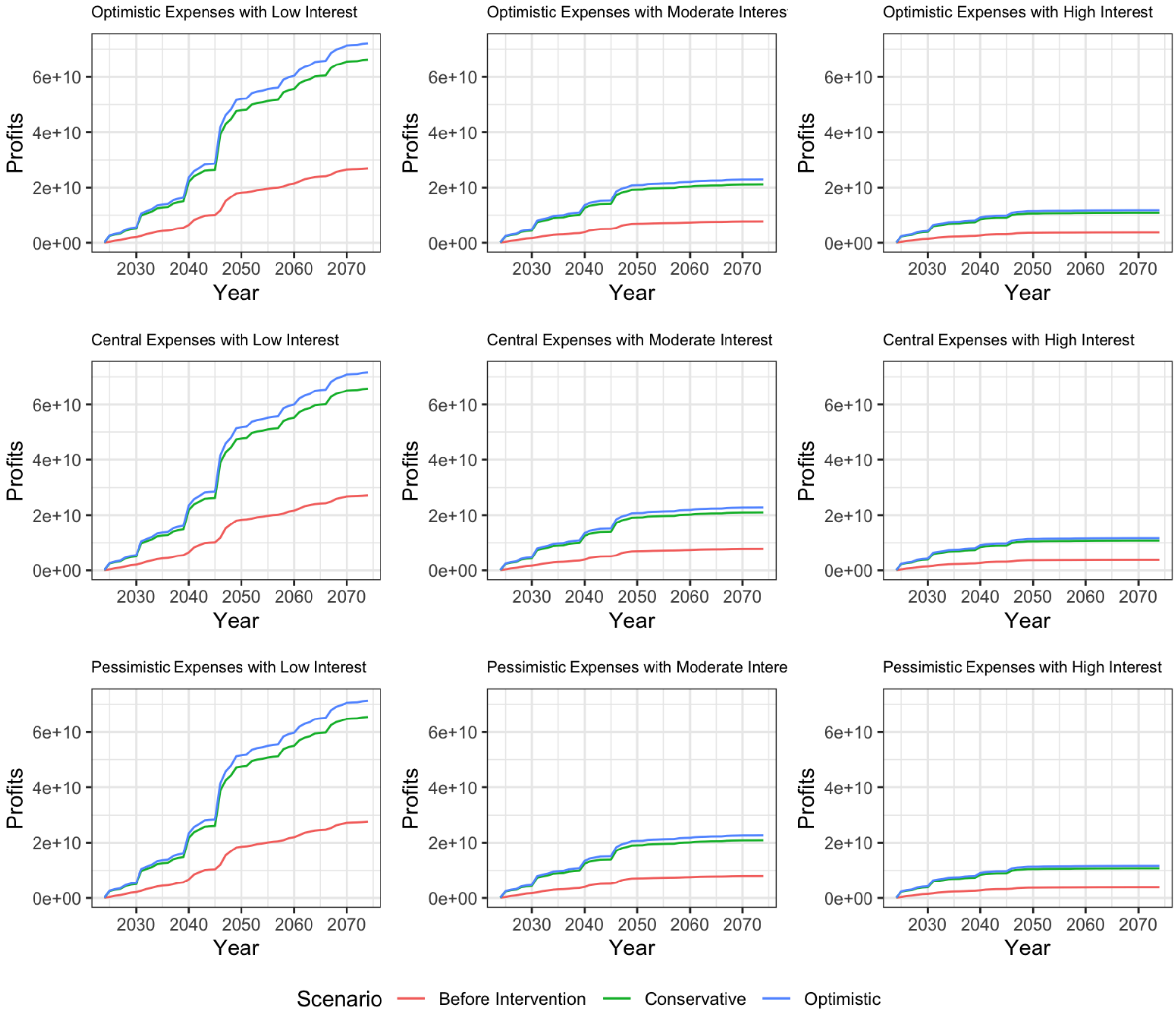


Figure 10.2 Scenario Testing for Profits (Conservative Policyholder Projections)

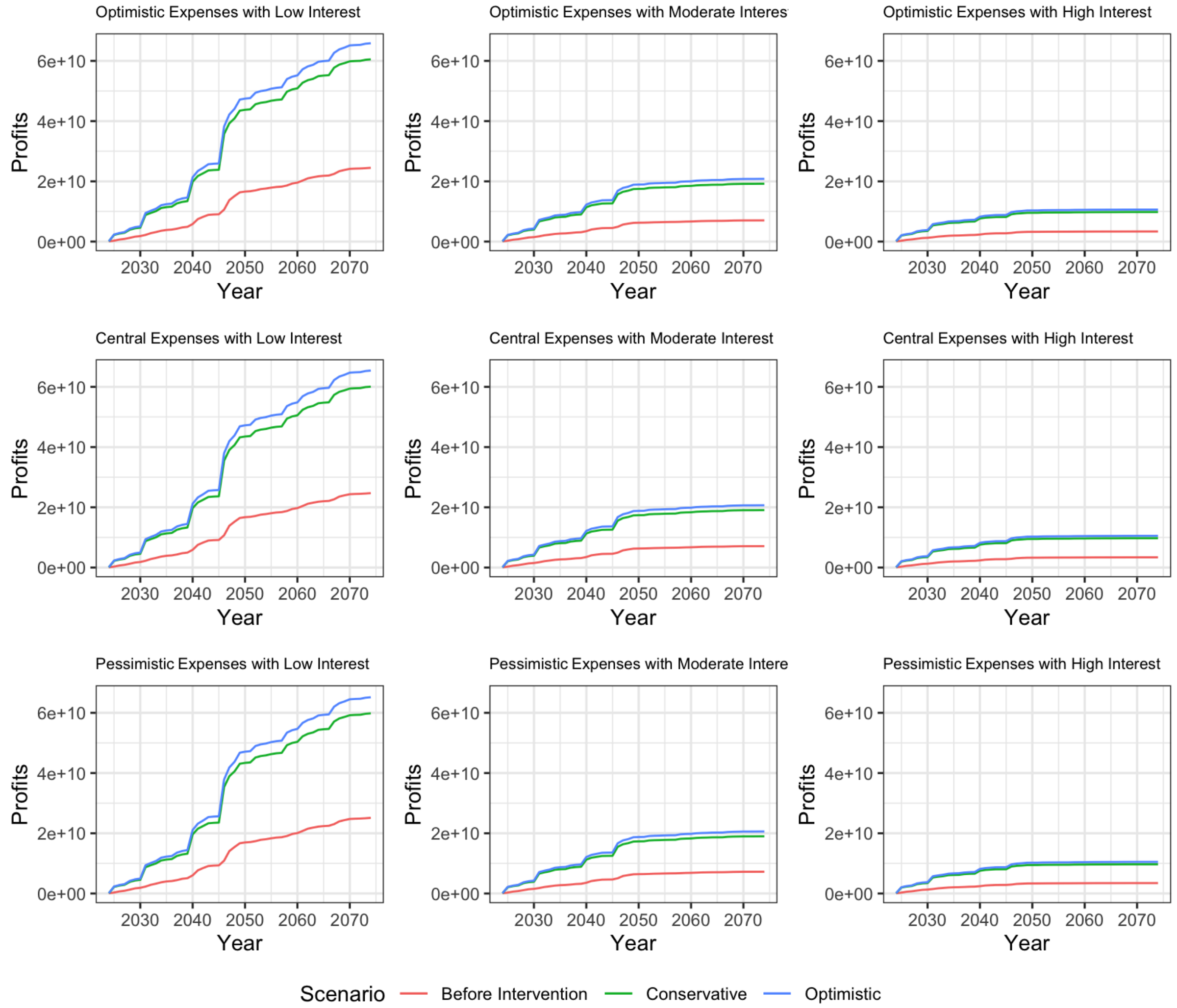


Figure 10.3 Scenario Testing for Profits (Optimistic Policyholder Projections)

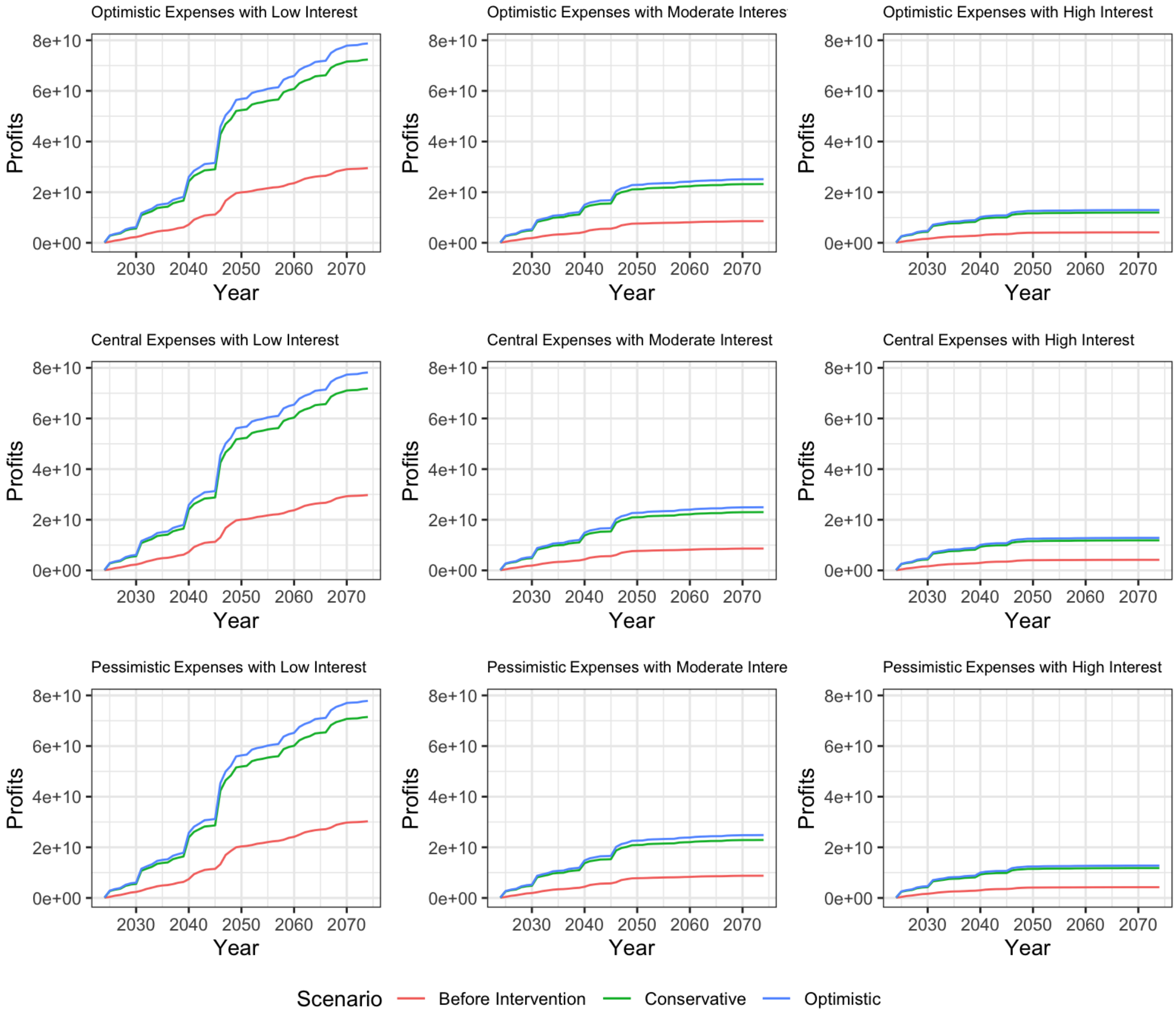


Figure 10.4: Scenario Testing Project Profits for T20 Policies of 35 year olds

References

- Allianz (2023) *Allianz: Annual report*, *Allianz.com*. Available at: https://www.allianz.com/en/investor_relations/results-reports/annual-reports.html (Accessed: 21 March 2024).
- Cost-effectiveness of physical activity programs and services for older adults: a scoping review (2023) National Library of Medicine. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10024893/ (Accessed: 04 March 2024).
- Chethan Bachireddy, M. (2019) Effect of different financial incentive structures on promoting physical activity among adults, JAMA Network Open. Available at: https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2748659 (Accessed: 04 March 2024).
- Google. (n.d.). Insights we uncovered in 2019 that will take you into 2020. [online] Available at: https://storage.googleapis.com/think/docs/think-with-google-2019-research-review.pdf (Accessed 19 Mar. 2024)
- Gusi, N. et al. (2008) Cost-utility of a walking programme for moderately depressed, obese, or overweight elderly women in primary care: A randomised controlled trial - BMC public health, BioMed Central. Available at: https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-8-231 (Accessed: 04 March 2024).
- Hawkins, N. (2024) *IAG announces 1H24 results*. Available at: https://www.iag.com.au/sites/default/files/Documents/Results%20&%20reports/IAG-announces-1H24-financial-results.pdf (Accessed: 22 March 2024).
- Hoch, J.S., Barr, H.K., Guggenbickler, A.M. and Dewa, C.S. (2022). Lessons from Cost-Effectiveness Analysis of Smoking Cessation Programs for Cancer Patients. Current Oncology, [online] 29(10), pp.6982–6991. doi:https://doi.org/10.3390/curroncol29100549. (Accessed: 04 March 2024)
- Maple, J.-L. et al. (2022) Economic evaluation of an incentive-based program to increase physical activity and reduce sedentary behaviour in middle-aged adults - BMC Health Services Research, BioMed Central. Available at: https://bmchealthservres.biomedcentral.com/articles/10.1186/s12913-022-08294-7 (Accessed: 04 March 2024).
- Meadows-Taylor, M., Ward, K.D., Chen, W., Faris, N.R., Fehnel, C., Ray, M.A., Ariganjoye, F., Berryman, C., Houston-Harris, C., McHugh, L.M., Pacheco, A. and Osarogiagbon, R.U. (2021). Interest in Cessation Treatment Among People Who Smoke in a Community-Based Multidisciplinary Thoracic Oncology Program. JTO Clinical and Research Reports, [online] 2(6), p.100182. doi:https://doi.org/10.1016/j.jtocrr.2021.100182. (Accessed: 20 March 2024)
- Mendelsohn, C. (2022) *Optimal use of smoking cessation pharmacotherapy*, *Australian Prescriber*. Available at: https://australianprescriber.tg.org.au/articles/optimal-use-of-smoking-cessation-pharmacotherapy.html#:~:text=14-,Adequate%20duration,least%2010%20weeks%20is%20recommended.&text=At%20the%20end%20of%20the,evidence%20does%20not%20support%20tapering.&text=Extending%20the%20course%20for%2012%E2%80%9318%20months%20may%20help%20prevent%20relapse. (Accessed: 22 March 2024).

- Mersha, A.G., Eftekhari, P., Kennedy, M. and Gould, G.S. (2023). Factors associated with quitting among smoking cessation medication-assisted smokers and ex-smokers: A cross-sectional study in Australia. Preventive Medicine Reports, 32, p.102168. doi:https://doi.org/10.1016/j.pmedr.2023.102168. (Accessed: 20 March 2024)
- Mitten, D., Overholt, J.R., Haynes, F.I., D'Amore, C.C. and Ady, J.C. (2016). Hiking: A Low-Cost, Accessible Intervention to Promote Health Benefits. American Journal of Lifestyle Medicine, 12(4), pp.302–310. doi:https://doi.org/10.1177/1559827616658229. (Accessed: 21 March 2024)
- Rondina, R. et al. (2021) Is it worth it? cost-effectiveness analysis of a commercial physical activity app - BMC public health, BioMed Central. Available at: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-021-11988-y (Accessed: 04 March 2024).
- S. Strang, S.Q. Park, T. Strombach, P. Kenning, Chapter 12 - Applied economics: The use of monetary incentives to modulate behavior, Editor(s): Bettina Studer, Stefan Knecht, Progress in Brain Research, Elsevier, Volume 229, 2016, Pages 285-301, ISSN 0079-6123, ISBN 9780444637017, https://doi.org/10.1016/bs.pbr.2016.06.010. (Accessed: 22 March 2024)
- Smokers who quit still die earlier than those who never smoked. (1999). BMJ : British Medical Journal, [online] 319(7213), p.806. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1174617/ (Accessed: 22 March 2024)
- Srivastav, A.K. (2019). Discount Rate vs Interest Rate. [online] WallStreetMojo. Available at: https://www.wallstreetmojo.com/discount-rate-vs-interest-rate/. (Accessed: 21 March 2024)
- The cost-effectiveness of tailored smoking cessation ... Available at: https://www.thelancet.com/journals/eclinm/article/PIIS2589-5370(23)00005-6/fulltext (Accessed: 04 March 2024).