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SuperLife: Healthy Program Initiatives

UNSW AUSTRALIA

SOCIETY OF ACTUARIES

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Executive Summary

Lumarian Consulting Group (LCG) presents a set of proposed life insurance and health incentive programs tailored for SuperLife's policyholders. These programs leverage data-driven insights and ethical considerations to incentivize healthy behaviors, reduce mortality rates, boost life insurance sales, enhance product competitiveness, and drive economic value for SuperLife.

Our proposal provides distinct life insurance offerings for a wide range of policyholders. For our 20-year term (T20) product, we introduce a smoking cessation program for eligible smokers under the age of 40, as well as, a general health screening intervention for eligible non-smokers under the age of 45. These programs have the incentive of reduced premiums upon engagement with the intervention. For our whole life (WL) product, we introduce a healthy heart screening intervention for eligible non-smokers over 45 with the incentive of a cash-back.

To ensure that our interventions generate economic value and are sustainable over long time horizons, we have determined the mortality savings of the offerings had they been implemented 20 years ago and explored the profitability and economic value of the two T20 offerings over the next 20 years, and the WL offering across 20-year, 40-year and 60-year time horizons. Additionally, extensive stress testing on a few of our key assumptions has been performed and comprehensive risk mitigation strategies and ethical considerations have been made, to ensure that our offerings continue to align with SuperLife's primary goals during adverse scenarios.

Program Design

Figure 1 details the decision flows that dictate which consumer demographic aligns with one of three specific bundled products which includes the intervention, incentivization program, policy type and face value. Depending on the characteristics of the policyholder, such as age and smoking status, they may be eligible for one of the three bundles. The subsequent section outlines each program, their incentives for participation, key features and evaluation timelines.

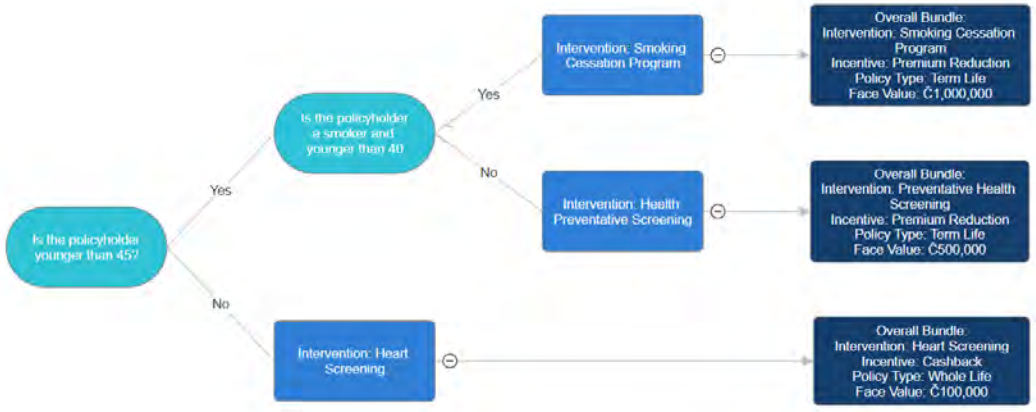

Figure 1: SuperLife's Health Program Bundles

20 Year Term Life Insurance with Smoking Cessation Program

This product bundle will be issued to smokers 40 years old or younger with a smoking cessation program and a 20-year term life insurance product of Č1m sum insured. The smoking cessation program will provide participants with resources, including support groups. The program's average mortality can be reduced by 46.26% given the smoker quits (see Appendix A1).

LCG has identified smokers as a key underrepresented demographic, given smokers comprise only 6.3% of SuperLife's policies compared to 18% of Lumaria's population, with this number falling to just 3.8% for policies written in the last five years, as seen in Figure 2. This presents an opportunity to greatly improve health outcomes, reduce mortality and add economic value. For this reason, smokers under the age of 40 who purchase a policy with a sum insured of Č1m, will be eligible to participate in a smoking cessation program. Due to the observed increase in mortality for smokers after age 40 within our in-force data, as well as, empirical evidence demonstrating that smoking cessation at ages below 40 have a mortality reduction of up to 90% of the excess risk from smoking (Thomson et al. 2022)[11] and smokers aged below 40 have higher attempt and success rates of quitting (Kim. Y, Lee. J & Cho. W, 2021)[5] participants must be aged under 40 to be eligible. However, due to the high upfront costs associated with the program (see Appendix A2), a face value of Č1m is required to be eligible for the program.

Data	Non-smoker	Smoker
SuperLife In-force Policyholders	93.7%	6.3%
SuperLife In-force Policyholders for Policies Written in Last Five Years	96.2%	3.8%
Lumarian Population	82%	18%

Figure 2: Proportion Of Smokers For SuperLife's In-force Policies And The General Population

To incentivize program participation, LCG recommends introducing premium reductions to policyholders who participate in the program, whereby policyholders under the age of 30 will be given a 2% discount, policyholders between the ages of 30-34 a 5% discount, and policyholders between the ages of 35-40 an 8% discount. These premium discounts are targeted incentives that encourage policyholders to engage with healthy behaviours that otherwise would not be recognized in pricing decisions. LCG recommends premium reductions over alternate incentives due to ease of implementation, low operational costs, clear and direct relationship in encouraging program participation and high confidence in projecting economic value added. The size of the eligible discount increasing with age has been decided according to our goal of increasing the sales and competitiveness of SuperLife's life insurance offerings, given the higher profitability at ages 30-40 had these stepped reductions not been implemented (see Appendix B), as well as, our expectation of Lumaria's population to age (see Appendix C4).

<u>20 Year Term Life Insurance with General Health Screening Program</u>

Our proposed T20 life insurance offering for non-smokers under 45 includes the general health screening intervention with a sum insured of Č500,000. This non-specific health intervention acts as a preventative measure to reduce mortality of otherwise healthy individuals. As with our other T20 life program, reduced premiums will act as an incentive to encourage participation with the condition of engaging with the preventative screening every two years.

With a program catered to young smokers established, another program catered for young non-smokers would diversify the target markets. External research into incentives for preventative screening found estimates of 23% reductions in mortality rates, demonstrating a reduction greater than the 5-10% range provided in our intervention data, and resulting in our conservative expected mortality reduction of 8% (McCracken et al., 2024)[10]. Due to the upfront costs of this measure, policyholders will be required to have a face value of Č500,000 to be eligible.

Similar to our T20 Smoker offering, policyholders who engage with this program will be eligible for premium reductions. Those aged 30 or under are eligible for a 3% premium reduction, and

those aged between 31-45, 5%. This rewards healthy behaviours that would otherwise not be priced into life insurance products, with the size of this reduction being consistent with the profitability and competitiveness of the product.

Whole Life Insurance with Heart Health Screening

Our proposed WL insurance offering would be aimed at non-smokers older than 45 through a heart screening program with a sum insured of Č100,000. The program consists of regular screenings for cholesterol levels and blood pressure, with cash-backs incentives conditional on program engagement every two years.

In-force policy data shows 31.30% of deaths amongst policyholders occurring due to heart-related issues (see Figure 3), with these deaths being more common among WL policyholders (see Appendix A3). Moreover, research found that heart-screening initiatives were especially recommended for those over 45. (Department of Health and Aged Care, 2023)[8]. Further external research found an 11% reduction in all-cause mortality from just cardiovascular screenings (Lindholt et al., 2023)[7]. Hence, LCG adopted a conservative expected mortality reduction of 8%.

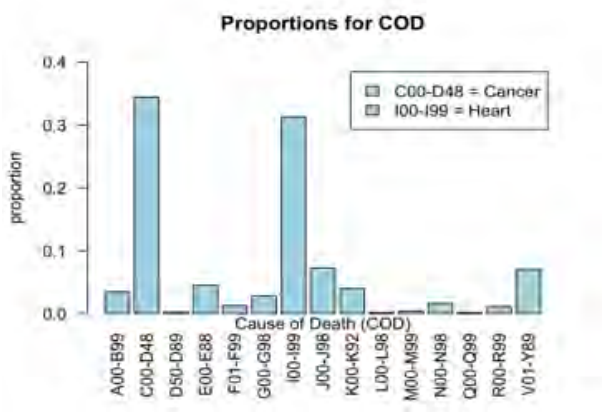

Figure 3: Cause of Death Among In-force Policyholders

As the upfront costs of this offering are not as high as the T20 offerings, this product will be available to those with a sum insured of Č100,000 to target lower socioeconomic individuals with a lower upfront premium for WL insurance. Policyholders who participate with the program will be awarded a cash-back of 2% of the initial lump sum premium upon death. This is to incentivize healthy preventative measures that induce mortality reductions.

Other Program Features

In addition to the program features designed to encourage policyholders to participate in programs that induce mortality reduction, LCG has proposed a range of measures to ensure the competitiveness and marketability of these life insurance offerings.

Entitled Issue Ages: We recommend a restriction on entitled issue ages to individuals aged 26 to 65. This assumption was established from SuperLife's in-force data only pertaining to issue ages ranging from 26 to 65. Furthermore, programs would be less effective at reducing mortality and risk not being profitable outside of these ranges.

Distribution Channels: The popular distribution channels for each policy type is an essential consideration in maximizing product competitiveness and marketability. Appendix A4 shows the distribution channel for each insurance product expected as percentage of sales. We recommend an increase in online marketing for all three products, particularly T20 products, due to the increase in online sales in the last five years to 49.8% of all policies (see Appendix A4). Additionally, we recommend that SuperLife trains agents to convey the benefits of their WL insurance offerings, as it continues to be the most popular distribution channel for WL.

Evaluation of the Program

Our short-term and long-term timeframes for evaluating the program have been formulated based on SuperLife's primary goals, as well as any potential risks and ethical considerations.

Our short-term timeframe aims to address the primary goals of encouraging healthy behaviours, boosting life insurance sales and improving product competitiveness, as well as key risks that we have identified (see Figure 8), whereas the long-term timeframe aims to address SuperLife's goals of reducing mortality and adding economic value, and reassesses the key risks that we have identified. A five-year horizon was chosen to have enough data and experience to draw accurate conclusions without the risk of investing heavily into a program that doesn't align with our objectives.

The short-term time frame ensures that the program which achieves SuperLife's objectives of incentivizing healthy behaviours, is a differentiated life insurance offering within the Lumarian life insurance market that is marketed well and is profitable and financially feasible for the remainder of the program. Additionally, the key risks and ethical issues that LCG have identified for this program will be assessed, and corresponding risk mitigation measures will be implemented if necessary. As this is a key time to ensure successful implementation of the proposed life insurance offerings, monthly monitoring of new business and in-force claims will be done, with appropriate pricing adjustments made if necessary. Additionally, to ensure that SuperLife administers these interventions and incentives in a transparent manner, quarterly policyholder surveys will be conducted, as well as a platform where policyholders can share their feedback at any point in time.

Beyond this short-term horizon, the objectives of reducing mortality and adding economic value to SuperLife will also be assessed. Added economic value determined by our pricing models over 20-year, 40-year and 60-year time horizons will be monitored on an annual basis, with premium adjustments (i.e. revision of premium reductions and cash-backs) made if necessary. To ensure the continued success and sustainability of the proposed life insurance offerings, quarterly monitoring of new business and in-force claims will be done, with appropriate pricing adjustments made if necessary. Furthermore, risks and ethical considerations will be regularly reviewed and corresponding mitigation strategies will be actioned where appropriate. To ensure that SuperLife continues to remain ethical in their operations, the quarterly policyholder surveys and feedback platforms will continue to be maintained and monitored.

Pricing and Costs

Mortality Savings from Proposed Programs

Across the three proposed offerings, LCG has determined that there would have been immense savings from reduced mortality costs had the program been implemented for the past 20 years, as seen in Figure 4. Appendix B1 outlines the process for determining mortality savings.

Policy Bundle	Expected Mortality Costs	Actual Mortality Costs	Mortality Savings	% Mortality Savings
T20 Smoker	$68,474,316.20	$84,000,000.00	$15,525,683.80	18.48%
T20 Non Smoker	$431,156,938.47	$519,500,000.00	$88,343,061.53	17.01%
SPWL Non Smoker	$165,207,340.14	$188,000,000.00	$22,792,659.86	12.12%

Figure 4: SuperLife's Mortality Savings If The Program Had Been Implemented 20 Years Ago

T20 Smoker Bundle: Our T20 Smoker Package would have provided over Č15m, or 18.48%, in mortality savings, as seen in Figure 4. These large savings are due to the immense mortality

improvements seen in younger individuals who successfully quit smoking. Indeed, we see that the mortality improvements through ages are variable (see Appendix B3). It is important to note that the variability in savings at issue ages are a result of many factors such as the variability in actual mortality experience when compared to expected mortality experience or modelling errors. It is important to consider this limitation within the context of the pricing section.

T20 Non-Smoker Bundle: Our T20 Non-Smoker Package would have provided over Č88m, or 17.01%, in mortality savings (see Figure 4). The mortality savings are evenly distributed over all age groups with slight variabilities at older age groups due to deviations from expected mortality improvements (see Appendix B4).

SPWL Non-Smoker Bundle: For the Whole Life Non-Smoker Package, we estimate total mortality savings of over Č22m, or 12.12%, as depicted in Figure 4. Similar to the T20 Non-Smoker Package, the mortality savings are fairly evenly distributed over all age groups with slight deviations due to the variability of actual mortality experience in relation to the expected mortality experience (see Appendix B5).

Economic Value Added From Proposed Program

When determining the added economic value of our proposed programs, our team projected sample portfolios of new sales in the year 2025 that follows the same composition of policies at each issue age as the overall book over the past 20 years (see Appendix B2). Added economic value from our bundles is calculated by the difference between the net present value of the portfolio with our proposed program and the net present value of the portfolio without the program. This portfolio of new sales is projected over suitable time frames such as 20 years for 20-year term policies and 20, 40 and 60 years for whole life policies.

Policy Bundle	Projected Time Frame (Years)	PV of Profits W/out Program	PV of Profits W Program	Added Economic Value From Program	% Increase in Profitability
T20 Smoker (Over 20 Years)	20	$597,988.14	$678,023.94	$80,035.80	13.4%
T20 Non Smoker (Over 20 Years)	20	$189,854.80	$204,314.94	$14,460.13	7.6%
SPWL Non Smoker (Over 20 Years)	20	$1,799,214.48	$1,806,431.42	$7,216.94	0.4%
	40	$673,681.02	$713,589.34	$39,908.33	5.9%
	60	$445,073.03	$467,703.39	$22,630.36	5.1%

Figure 5: SuperLife's Economic Value Added Over Appropriate Timelines

T20 Non-Smoker Bundle: Over a 20-year timeline, our T20 bundle with the preventative screening program has an added economic value of 7.62%, equivalent to over Č14,000 for every 100 policy bundles sold. Each issue age of our portfolio provides added economic value with the largest increases occurring at younger ages due to a smaller premium reduction at ages under 30. However, after ages 30, the added economic value increases from 4% at issue age 31 to 7.3% at issue age 45, demonstrating the improved profitability for older ages (see Appendix B6).

T20 Smoker Bundle: Over a 20-year time horizon, our T20 bundle with the smoking cessation program has an added economic value of 13.38%, equivalent to over Č80,000 for every 100 policy bundles sold. The largest increases in economic value occur at older ages of each premium reduction segment. For example, for the premium reduction of 2% between ages 25-30, the largest added economic value occurs at age 30. This is the same for ages 31-35 and ages 36-40, in line with our expectations (see Appendix B7).

SPWL Non-Smoker Bundle: For our whole life policy bundle, we projected our sample portfolio over 3 different time frames, that is, 20-year, 40-year and 60-year. Over a 20-year period, our

initial portfolio has a 0.40% added economic value, with ages less than 55 having lost economic value, due to the cost benefits of mortality reductions not yet exceeding the intervention expenses and cash-backs, and ages greater than 55 having small added economic value. However, after a 40-year projection, we see an added economic value of 5.92%, with all age issue segments being profitable. Over the 60-year projection, our model suggests that the program provides 5.08% of added economic value. Over both 40 and 60-years, our projections indicate that issue ages 50-65 will be the most profitable (see Appendix B8).

Pricing Strategy: Proposed Pricing Changes

Given the characteristics of our policyholders relative to the wider Lumarian population, as well as, our own projections for Lumaria's population, as seen in Appendix C4, we have introduced a range of pricing changes that aim to create the most economic value for Lumaria, whilst still maintaining ethical decision making. Indeed, the premium discounts we provide to those that engage with the smoking cessation program depend on the age of the policyholder as covered in program design, with those under the age of 30 receiving a 2% discount, those under the age of 35 a 5% discount, and those under the age of 40 an 8% discount. Similarly, the premium discounts we provide to those that engage with the preventative screening program depend on the age of the policyholder, with those under the age of 30 receiving a 3% discount and those under the age of 45 receiving a 5% premium discount. Individuals engaging with the heart screening program are provided with a 1.5% premium discount to their lump sum whole life premium paid at the beginning of the policy.

Our pricing model projecting these pricing changes over suitable timeframes indicates increases in profitability despite reductions in premium and cash-back schemes. Thus, the proposed pricing changes optimize sales through added financial incentives and improve the profitability of policies on a per policy and aggregate basis. Furthermore, premium reductions to incentivize healthy behaviors and ultimately lower mortality whilst adding economic value reflects LCG and SuperLife's focus to consider ethical objectives beyond just profit maximization.

Assumptions

Assumption Detail	Justification
Program Design (Intervention) – *High Level Importance*	
Intervention Expense: Upfront Costs: - Č 30 for T20 Non-Smoker - Č 2000 for T20 Smoker - Č 120 for WL Non-Smoker	Initial implementation cost partially covered by Universal Health Care (UHC) based on Medicare system. All periodic costs after for preventative screenings covered by UHC (see Appendix A2).
Expected Mortality Reduction: - 8% for T20 Non-Smoker - 17.5% adjusted to quit rate for T20 Smoker - 8% for WL Non-Smoker	Based on internal intervention data adjusted to external research. Preventative screening programs chosen with external research (McCracken et al., 2024)[10] & (Lindholt et al., 2023)[7]. Smoking mortality chosen with quit rate with research (Thomson et al. 2022)[11] & (Kim. Y, Lee. J & Cho. W, 2021)[5].
Data – *Low Level Importance*	
Expected Mortality Reduction: Gender variable ignored	No external research found to indicate significant mortality reduction differences between men and women for any proposed intervention.

Pricing (Expenses) – *High Level Importance*	
Upfront Expense: Č 100 initial expense plus 10% of premium	Level Premium Term Life Insurance Issue Cost Assumption (Birdsall, M., Strommen, S. and Hartman, B, 2020)[1]
Variable/Per Year Expense: Č 50	Assumption of Maintenance Cost (Birdsall, M., Strommen, S. and Hartman, B, 2020)[1]
Commission Expense: 29.8% of total premium for term-life and 10% for whole life	Utilised in-force data to determine proportion of policies which were sold through an intermediary: 40.8% . Used an assumption of 70% Commission for 1st year and 10% every year after (Principle-Based Reserves Simplified Methods)[1] - Total T20 Average Commission Expense for 1st year (40.8% x 70%) - Total T20 Average Commission Expense for every year after (40.8% x 10%) - Total SPWL Average Commission Expense: 10% (Leimberg, 2024)[3]
Reserves and Capital – *Medium Level Importance*	
Reserves Per Death Benefit Year 0: 0.8 per 1000 Year 1: 0.3 per 1000	Initial assumptions based off *Understanding Actuarial Management – Chapter 13* (Bellis et al., 2010)[9]
Capital Per Death Benefit: 0.01 per Death Benefit	Initial assumptions based off *Understanding Actuarial Management – Chapter 13* (Bellis et al., 2010)[9]
Mortality – *High Level Importance*	
Mortality Tables	Original mortality table, UK smoking and non-smoking mortality tables and loading factor based on in-force experience used (see Appendix C1).
Lapse Rate – *Medium Level Importance*	
Lapse Rate SPWL: No lapse rate	Single Premium Whole Life
Lapse Rate T20: Modelled From Inforce Data	Modelled from In-force Data, Utilised as Baseline for all T20 Policies (see Appendix C2)
Market Rates – *High Level Importance*	
Investment Rate: 2.97%	Used an ARIMA(0,1,1) Model (see Appendix C3).
Discount Rate: 5.5%	Standard Assumption (IBC Global)[10] and Actuarial Judgement
Miscellaneous – *Low Level Importance*	
Population Projections	Used Current Population Distribution Data and Mortality Table (see Appendix C4). Assumed no net migration due to limited data available.
Passive Smoking: Ignored	Limited Data Availability

Figure 6: Summary of Assumptions Made

Risk and Mitigation

Outlined below is a Risk Categorization and Definition (RCD) analysis that explores the main risks to be considered in both implementation and maintenance phases.

Quantitative Risk	Explanation	Mitigation

Interest / Inflation Rate Fluctuation	Market Risk: Economic downturn, high inflation or Black Swan events like COVID-19 could drastically alter the time value of money.	Further improvement of model and reserving measures. Also, could consider reinsurance to hedge market risk.
Overestimated Mortality Reduction	Modelling Risk: Claim reduction when realized may not be as effective as modelled	Invest in reinsurance to hedge the potential risk of mortality variability. Reduce premium reductions and cash-back incentives if necessary.
Underestimated Intervention Cost	Modelling Risk: Intervention program costs may be higher, leading to underpriced premiums	Identify external parties for programs and lock-in contracts (or discounts) for policyholders. Subsidizing costs through Universal Health Care should also be considered if possible.
Qualitative Risk	**Explanation**	**Mitigation**
Regional Disparity	Geographical Risk: Inadequate accessibility of intervention programs across all 12 regions of Lumaria.	More precise data on geographics and confirmation of facilities that will offer particular programs in each region. Exploring offline methods for administering some programs.
Reputational Risk	Marketing: Inadequate marketing could incur that the programs are gimmicks to draw profit.	Increase transparency with public on program goals and ethical corporate social responsibility engagement.
Moral Hazard	External: Policyholders may falsely undertake programs for premium reduction.	Implementing verification processes between program-offering facilities and SuperLife.

Figure 7: RCD Analysis For Our Main Risks

Risk Matrix

The most significant of these risks are shown in the corresponding risk matrix seen in Figure 8. These are pivotal factors in variables of likelihood and severity that will need ongoing monitoring to ensure continual program effectiveness and improvement.

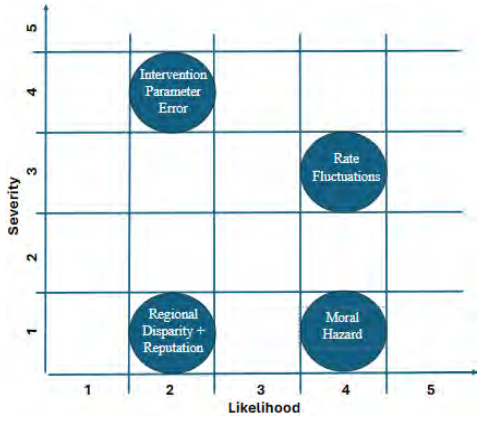

Figure 8: Risk Matrix

Sensitivity Analysis

Selected quantifiable risks of variable mortality reduction and intervention costs, implicit to our program design, were measured in sensitivity analysis to manage profitability forecasts. Sensitivity analysis leveraged the same processes as seen in Appendix B2, but with different underlying assumptions.

The T20 Smokers Package is highly volatile to changes in mortality and intervention expense parameters and hence have less stable profits, as seen in Figure 9. The extremities of our parameters either reducing profitability by 19.32% or increasing profitability by 46.16%. With investment rate and variable expense measures however, it is profitable across all measures (see Figures 10 and 11). Monitoring and control are required with this particular package with respect to parameter predictors and black swan events that cause drastic change.

T20 Smoker	Mortality Reduction				
Intervention Expense ⬇	12.5%	15%	17.5%	20%	22.5%
1500	-2.60%	9.56%	21.75%	33.94%	46.16%
1750	-6.78%	5.38%	17.56%	29.76%	41.98%
2000	-10.96%	1.2%	**13.38%**	25.58%	37.80%
2250	-15.14%	-2.98%	9.20%	21.40%	33.62%
2500	-19.32%	-7.16%	5.02%	17.22%	29.44%

Investment Rate	2%	2.50%	**2.97%**	3.50%	4%
Increase in Profitability	7.81%	10.68%	**13.38%**	16.43%	19.30%

Variable Expense p.a.	20.00	35.00	**50.00**	65.00	80.00	120.00
Increase in Profitability	18.90%	16.14%	**13.38%**	10.63%	7.87%	0.51%

Figures 9, 10 & 11: T20 Smoker Intervention, Market Rate & Variable Cost

T20 Non-Smoker	Mortality Reduction				
Intervention Expense ⬇	6.0%	7%	8.0%	9%	10.0%
20	-1.12%	3.51%	8.14%	12.78%	17.41%
25	-1.38%	3.25%	7.88%	12.51%	17.15%
30	-1.64%	3.0%	**7.62%**	12.25%	16.88%
35	-1.91%	2.72%	7.35%	11.99%	16.62%
40	-2.17%	2.46%	7.09%	11.72%	16.36%

Investment Rate	2%	2.50%	**2.97%**	3.50%	4%
Increase in Profitability	1.65%	4.72%	**7.62%**	10.88%	13.95%

Variable Expense p.a.	30.00	40.00	**50.00**	60.00	70.00	100.00
Increase in Profitability	19.24%	13.43%	**7.62%**	1.81%	-4.01%	-21.44%

Figures 12, 13 & 14: Intervention, Market Rate & Variable Cost

In comparison, non-smoker term contracts are more stable to changes in mortality and intervention expenses (see Figure 12). Variable expenses, however, have a more pronounced impact on profitability, as depicted in Figure 14 with losses on higher ranges.

WL Non-Smoker	Mortality Reduction				
Intervention Expense ⬇	6.0%	7%	8.0%	9%	10.0%
90	1.47%	3.61%	5.76%	7.92%	10.11%
100	1.25%	3.38%	5.53%	7.70%	9.88%
120	0.08%	2.93%	**5.08%**	7.25%	9.43%
180	-0.55%	1.59%	3.74%	5.90%	8.09%
240	-1.90%	0.24%	2.39%	4.55%	6.74%

Investment Rate	2%	2.50%	**2.97%**	3.50%	4%
Increase in Profitability	5.00%	5.04%	**5.08%**	5.13%	5.17%

Variable Expense p.a.	30.00	40.00	**50.00**	60.00	70.00	100.00
Increase in Profitability	11.47%	8.28%	**5.08%**	1.89%	-1.30%	-10.88%

Figures 15, 16 & 17: Whole Life Intervention, Market Rate & Variable Cost

As seen in Figures 15-17, the WL Non-Smoker Package has the most stable profits, with profits in nearly all simulated scenarios of intervention. Large increases to variable expense pose a large risk which will require mitigation techniques discussed above.

The sensitivity analysis suggests there is a strong degree of certainty that the WL Non-Smoker Program will increase profit in comparison to those without intervention. The T20 Non-Smoker Program is also almost certainly a beneficial program with only concerns in extremities of expense and mortality. The T20 Smoker Program is still beneficial, however, has greater profit variability. The differential of the benefits is extended by our focus on different face value cases, where lower socio-economic classes face greater mortality improvements through healthcare programs and gives more assurance to our models.

Empirical evidence from various studies indicates that our programs would have almost certainly reduced mortality over the past two decades. Notably, smoking cessation, particularly of ages below 35, has shown the most significant impact, by reducing relative mortality risk upwards of 50% in studies (Thomson et al., 2022)[11]. While effectiveness decreases on subsequent decades

due to prior smoking exposure, there remains a notable impact of over 30%. Additionally, screenings have been associated with empirical estimates for mortality reduction, with regular preventative screenings at approximately 23% (McCracken et al., 2024)[10] and cardiovascular screenings around 11% (Lindholt et al., 2023)[7]. Ultimately, against these measured results, our model takes more conservative parameters and increases the viability of its effectiveness over the last 20 years with adequate risk mitigation and monitoring.

It is important to consider the ethical framework in delivering truthful and professional products to consumers and this, in conjunction with reputational outlook needs to be consistently monitored with ongoing data collected by Superlife after the introduction of proposed programs. Continual transparency with clients who undertake any of the three programs is paramount and accommodating these clients with their respective promised premium reductions alongside the overall initiative in ethical goals of improving general health and mortality levels needs to be ensured through mitigations over time. To ensure that SuperLife continues to remain ethical in their operations, we have suggested quarterly policyholder surveys, as well as, a platform for feedback at any time.

Data Limitations

Data Limitation	Impact on Analysis
Intervention Program	
Approximate per capita cost is not standardised to annual cost. It ranges from per incentive, per screening, per participant, and other.	Have to make assumptions on frequency of incentives, screening, etc. This may lead to under/over evaluation of costs by significant amounts.
In-force Dataset and Encyclopedia	
Extreme drop in the policy count for age 56+ as it accounts for only 9.98%, whereas its 20.69% in the encyclopedia for age bracket 25-65.	The older population is understated, however the population statistics of the country shows an aging population in the next 20 years, thus, with limited knowledge, many assumptions will be challenged.
100% of all 56+ smoker has a claim (i.e. death), whereas only 4% of non-smokers have a claim	This significant difference will make it challenging to incorporate such information in the mortality tables for smokers vs non-smokers.
Missing data on premium amount for each policy, salary of policy holders, expense rates and commission rates	Assumptions are made for these variables. Again, all these variables are directly related to profitability and will result in a degree of error.
External Research Data	
Percent of smokers wanting to stop smoking for different age brackets	Adjustment factors are used to fit to the given demographics of Lumaria and the smoking cessation plan (Truth Initiative, 2018)[12].
Screening interventions are covered by healthcare.	Lower bound of costs chosen from the given range in the intervention. Scenario testing done for other costs.
Economic Data	
Inflation rate was higher than the interest rate, ie Negative real rate	We removed specific outliers for inflation to get more stable results and a positive real interest rate.

Figure 18: Data Limitations and Impacts

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Appendices

Appendix A: Program Design

A1: Mortality Reductions Through Smoking Cessation Across Different Ages

Age Bucket	Ages	Age Distribution	Avg Mortality	Avg Mortality Rate Reduction w Quit Rate
26-30	28	4.67%	50%	18.50%
31-35	33	4.66%	47.50%	17.58%
36-40	38	4.65%	45%	16.65%
41-45	43	4.64%	42.50%	19.13%
46-50	48	4.62%	40%	18.00%
51-55	53	4.60%	37.50%	16.88%
56-60	58	4.58%	35%	15.75%
61-65	63	4.55%	32.50%	14.63%

Age Bucket	Avg Mortality Rate Improvement
26-44	46.26%
45-65	36%

Age	Age Proportion	Smoking Proportion	Age*Smoke	Adjusted smoking rate
18-25	14.15%	5.30%	0.75%	1.50%
26-44	30.91%	12.60%	3.90%	7.77%
45-65	27.31%	14.90%	4.07%	8.11%
66+	3.78%	8.30%	0.31%	0.63%
			9.03%	18.00%

Age Group	26-65
Smoking %	15.88%

A key finding was the underrepresentation of Lumaria's smokers from age 26-65 (estimated to be 15.88%) compared to SuperLife's proportion of smokers in the in-force policy dataset (6.31%). Based on the population's age distribution and smoking distribution, ages 26-44 has 7.77% and ages 45-65 has 8.11% of smokers, making both age groups viable targets as a key area for instilling health behaviour and growth. However, external research indicated that younger years between quitting before 44 has better mortality reduction with approximately 90% of excess risk from smoking reduced. This mortality reduction decreases by 24% after 45 and, similarly, younger ages of 25 to 39 have a higher attempt and success rate of quitting, becoming a more viable target market.

Source: Kim. Y, Lee. J & Cho. W, 2021 & Lindholt et al., 2023

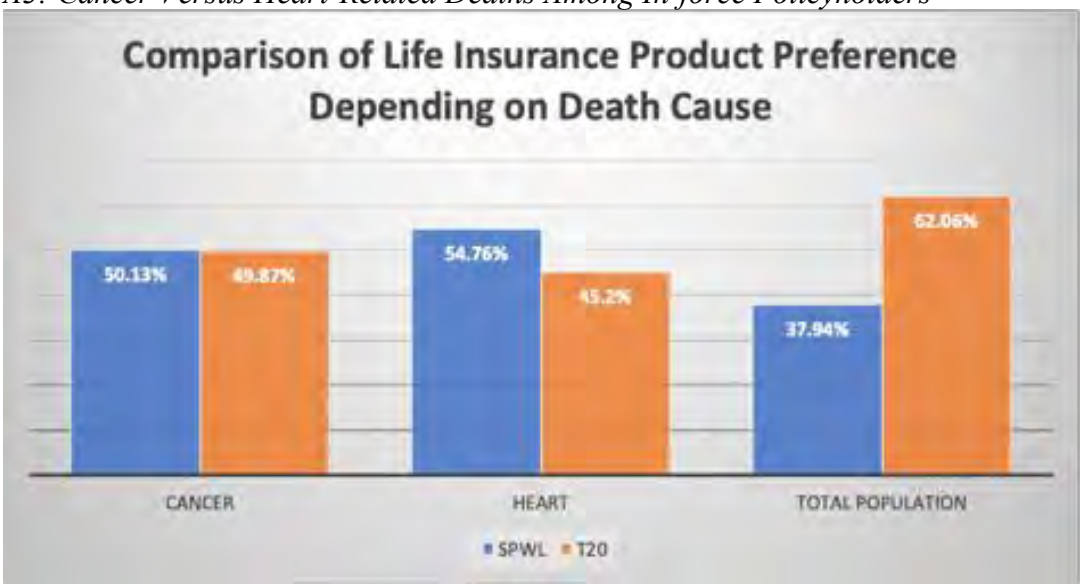
A2: Program Expenses

Program	Initial Expense per Policyholder
Smoking Cessation	Č2000
Preventative Health Screening	Č30
Heart Health Screening	Č120

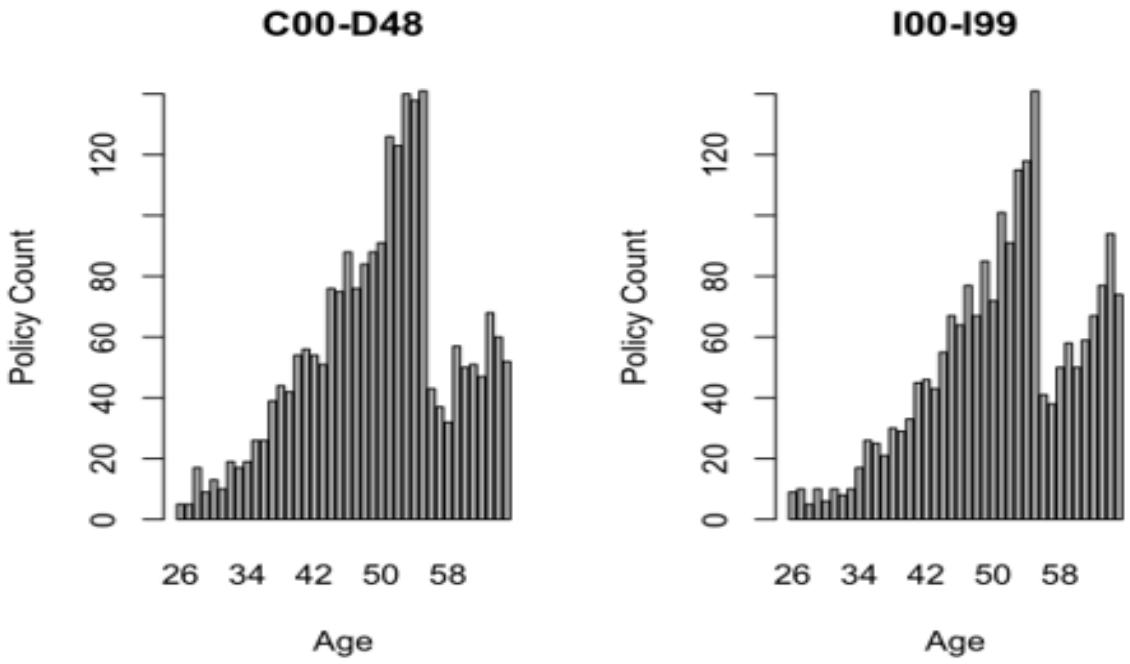
The encyclopedia states that the Lumarian population is covered by universal health care (UHC). Medicare is used as a basis UHC scheme to determine the corresponding costs covered by SuperLife and UHC. Further potential interventions were reduced to ones which would be partially or fully covered by UHC. All screening programs require periodic costs every two years and smoking cessation is assumed to be paid in one upfront cost per policyholder. Periodic costs every two years would be assumed to be paid for preventative screenings by the UHC except for initial implementation costs and acquisition per policyholder. Further external research found smoking cessation not to be fully covered by UHC for intensive care which resulted in an estimated expected initial cost of Č2000 per policyholder.

Source: Department of Health and Human Services, 2023 & U.S. Centers for Medicare and Medicaid Services, 2022

A3: Cancer Versus Heart-Related Deaths Among In-force Policyholders



The following figure shows that while an approximately even amount of cancer deaths are from WL and T20 policyholders, more heart disease deaths occur among WL policyholders. As heart-related deaths is the second leading cause of death among policyholders and the greatest among policyholders over the age of 45, as seen below, LCG decided to introduce the healthy heart intervention for eligible WL policyholders over the age of 45.



A4: Distribution Channels Percentage of Sales for SuperLife by Insurance Product for the Whole In-force Book and for Policies Written in the Past 5 Years

Whole Book:

		Distribution Channel		
		Agent	Online	Telemarketing
Insurance Product	T20	30.8%	34.6%	34.6%
	SPWL	72.0%	18.5%	9.5%

Past 5 Years:

		Distribution Channel		
		Agent	Online	Telemarketing
Insurance Product	T20	25.0%	49.8%	25.2%
	SPWL	69.9%	20.0%	10.1%

We see an increasing use of the online distribution channel, hence why this is a particular area of focus for marketing our offerings. However, agents continue to be an important distribution channel for SPWL new business, hence why LCG finds it essential that SuperLife trains agents to effectively communicate the benefits of these life insurance offerings to potential policyholders.

A5: Other Exploratory Data Analysis

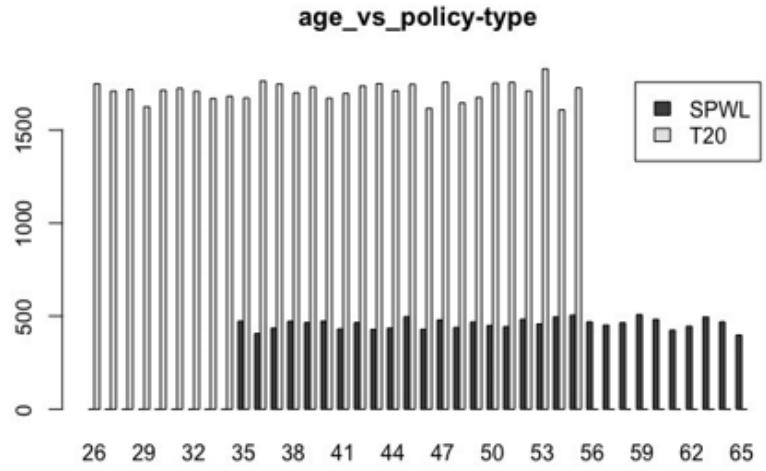


Figure shows the number of policies across all ages based on their policy type. It is observed that T20 policies are purchased by individuals 56 and below where as whole life are 35 and above.

```
age_vs_ptype <- table(superlife_data$Policy.type,superlife_data$Issue.age)
barplot(age_vs_ptype,beside = T,
        legend = rownames(age_vs_ptype), main = "age_vs_policy-type")
```

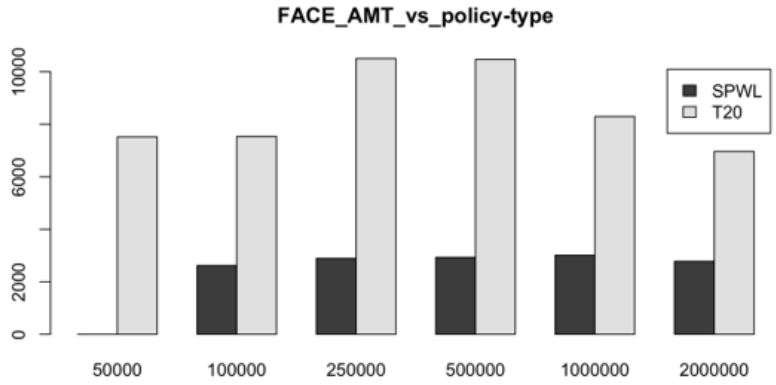
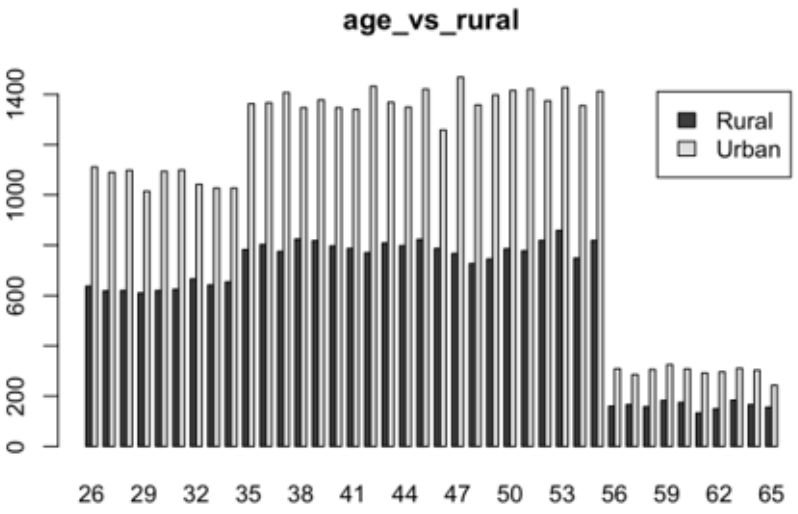


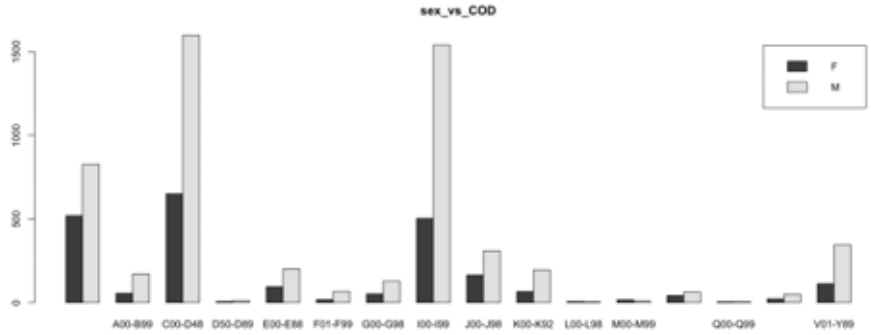
Figure shows the number of policies for the two policy types broken down into groups of face amount.

```
FACE_AMT_vs_ptype <- table(superlife_data$Policy.type,superlife_data$Face.amount)
barplot(FACE_AMT_vs_ptype,beside = T,
        legend = rownames(FACE_AMT_vs_ptype), main = "FACE_AMT_vs_policy-type")
```



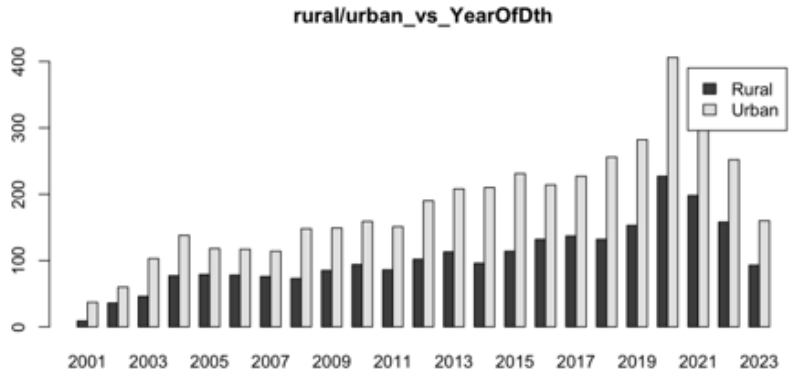
Count of policies from rural or urban region for all ages.

```
age_vs_ru <- table(superlife_data$Urban.vs.Rural,superlife_data$Issue.age)
barplot(age_vs_ru,beside = T,legend = rownames(age_vs_ru), main = "age_vs_rural")
```



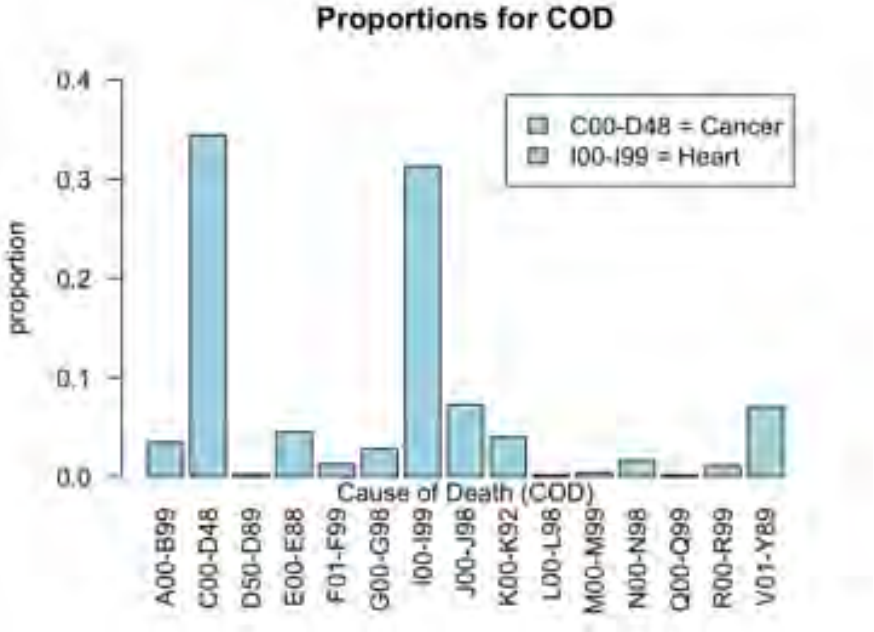
Cause of death vs gender of the policy holders.

```
sex_vs_COD <- table(superlife_data$Sex,superlife_data$Cause.of.Death)
barplot(sex_vs_COD,beside = T,legend = rownames(sex_vs_COD), main = "sex_vs_COD")
```



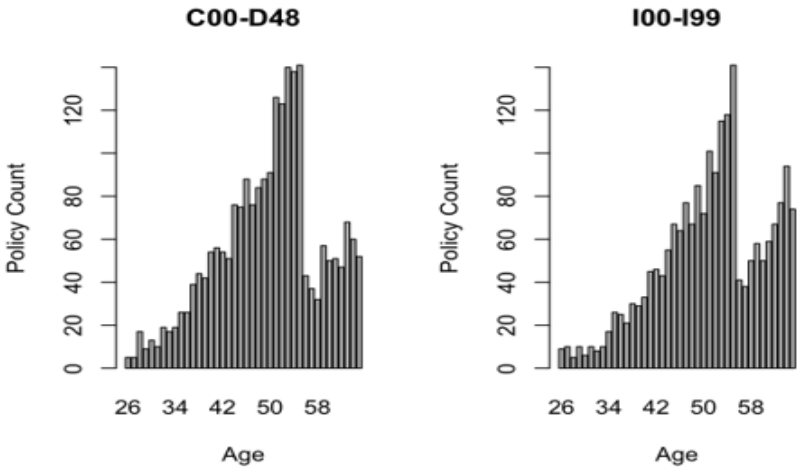
Count for the year of death for policy holders living in rural vs urban regions.

```
ru_vs_YOD <- table(superlife_data$Urban.vs.Rural,superlife_data$Year.of.Death)
barplot(ru_vs_YOD,beside = T,legend = rownames(ru_vs_YOD)
        , main = "rural/urban_vs_YearOfDth")
```



Proportion for the cause of death. It is observed that cancer and heart related problems have the highest proportion for cause of death.

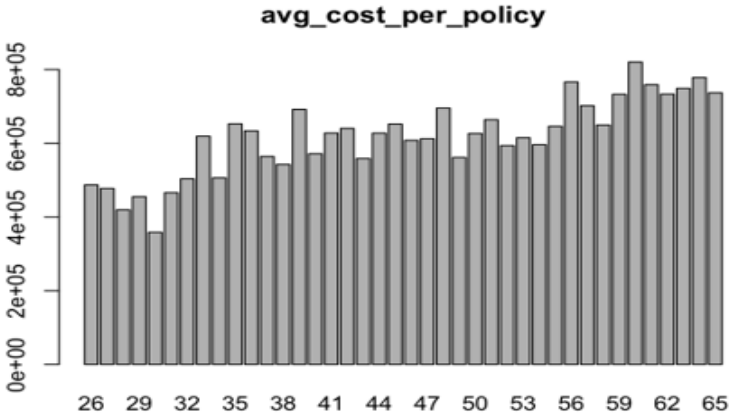
```
COD_prop_tab <- superlife_data %>%
  filter(Cause.of.Death != "")
COD_prop <- prop.table(table(COD_prop_tab$Cause.of.Death))
barplot(COD_prop,las = 2,ylim = c(0,0.4),main = "Proportions for COD"
        , xlab = "", ylab = "proportion",
        legend.text = c("C00-D48 = Cancer", "I00-I99 = Heart"),
        col = "lightblue")
mtext(text = "Cause of Death (COD)", side = 1)
```



Distribution for policy count for cancer and heart related cause of death across all ages.

```
COD_vs_AGE <- table(superlife_data$Cause.of.Death,superlife_data$Issue.age)

par(mfrow = c(1, 2))
barplot(COD_vs_AGE[3,],main = rownames(COD_vs_AGE)[3],
        xlab = "Age", ylab = "Policy Count")
barplot(COD_vs_AGE[8,],main = rownames(COD_vs_AGE)[8],
        xlab = "Age", ylab = "Policy Count")
```



Average cost per policy across all ages. The figure shows an increasing trend. In alignment with expectation as the older the person gets, we expect more severe and frequent claims.

```
Mortality_exp <- superlife_data %>%
  filter(Death.indicator == "1") %>%
  group_by(Issue.age) %>%
  summarise(policy_count = n(),claim_payouts = sum(Face.amount),
            avg_cost_per_policy = sum(Face.amount)/n())
barplot(Mortality_exp$avg_cost_per_policy,
        main = "avg_cost_per_policy", names = Mortality_exp$Issue.age)
```

Appendix B: Pricing and Costs

Appendix B1: Mortality Savings Macro Code

Explanation: By utilising the in-force data, we simulated through all the mortality experiences at each issue age over the past 20 years, starting from 2004. This required us to find the different possible mortality years experienced over each different policy type. For example, for an individual aged 35, who was issued a T20 policy in year 2014, they would have only experienced at most 10 years of their policy, thus we simulate the expected mortality cost of 10 years. We do this for each age issue for each of our policy bundles, in accordance with our Figure 1. The final expected mortality costs at each age issue is then returned utilising the macro below. This is then subtracted from the actual mortality costs at each age issue for the given policy type as found in the in-force dataset to obtain the mortality savings.

```
Sub Mortality_Experience()
Dim i As Double
   For i = 1 To 20 'Loops across past twenty years'
   Range("$E$4").Value = Range("$F$" & i + 56) 'entering in age'
   Range("$H$3").Value = Range("$M$" & i + 56) 'inputting face value'
   Range("$S$" & i + 56) = Range("$AT$28").Value 'inputting expected mortality cost into table'
   Next i
End Sub
```

Appendix B2: Deriving Economic Value

Our process to derive the economic value of our process is as follows. To start off, we have to determine what the premium is for the policy to obtain a net present value of 0. This is done using the solver function in Excel. After this, we apply a 20% premium loading to obtain our estimated premium if we were not implementing our program. We also obtain the net present value as a proxy for profits obtained under this policy type. We then implement the mortality improvements and intervention costs into our Excel model to create a new model that includes the benefits and costs of our intervention program. We apply the premiums obtained from the previous policy types, however also applying the premium discounts we offer as financial incentives. We then loop through each issue age, as each issue age has different premium discounts as well as different mortality improvement, to obtain the net present value at each issue age. The difference between the net present value we just calculated with the intervention program and the net present value without the intervention program is used as a measure for the added economic value. We utilise the composition of the original book to perform a weighted sum on the economic value at each issue age to obtain an average economic value for each policy sold. This is multiplied by 100 for our final metric of added economic value per 100 policies sold.

```
Sub Automate_Premium_Finder()
    Dim target As Double
    target = Range("$B$29").Value 'Solver Target'
    Dim i As Double
    For i = 1 To 20 'Loop Through 20 age issues, changes when using for SPWL or T20 Smoker'
    Range("$E$4").Value = Range("$F$" & i + 56)  'Loops through age issues'
    SolverReset 'solver inputs
    SolverOptions Assumenonneg:=False
    SolverOk SetCell:="$C$25", MaxMinVal:=3, ValueOf:=target, ByChange:="$H$3", Engine:=1, EngineDesc:="GRG Nonlinear"
    SolverSolve UserFinish:=True
    Range("$L$" & i + 56) = Range("$H$3").Value 'places final premium into table'
    Next i
End Sub
Sub Automate_NPV_With_Loading()
    Dim i As Double
    For i = 1 To 20
    Range("$E$4").Value = Range("$F$" & i + 56) 'input ages'
    Range("$H$3").Value = Range("$M$" & i + 56) 'inputs premium'
    Range("$N$" & i + 56) = Range("$C$25").Value 'places final net present value into table'
    Next i
End Sub
Sub Automate_NPV_With_Intervention()
    Dim i As Double
    For i = 1 To 20
    Range("$E$4").Value = Range("$F$" & i + 56) 'input ages'
    Range("$H$3").Value = Range("$P$" & i + 56) 'inputs premium'
    Range("$Q$" & i + 56) = Range("$C$25").Value 'places final net present value into table'
    Next i
End Sub

Sub Automate_NPV_With_Reduce()
    Dim i As Double
    For i = 1 To 20
    Range("$E$4").Value = Range("$F$" & i + 56) 'input ages'
    Range("$H$3").Value = Range("$P$" & i + 56) 'inputs premium'
    Range("$Q$" & i + 56) = Range("$C$25").Value 'places final net present value into table'
    Next i
End Sub
```

Appendix B3: Mortality Savings T20 Non-Smoker Bundle

Issue Age	Expected Mortality Costs	Actual Mortality Costs	Mortality Savings	Proportion Savings
26	$ 13,388,293.12	$ 18,500,000.00	$ 5,111,706.88	27.63%
27	$ 13,713,591.51	$ 22,500,000.00	$ 8,786,408.49	39.05%
28	$ 14,147,280.58	$ 15,000,000.00	$ 852,719.42	5.68%
29	$ 14,674,539.07	$ 19,500,000.00	$ 4,825,460.93	24.75%
30	$ 15,193,379.81	$ 17,500,000.00	$ 2,306,620.19	13.18%
31	$ 16,041,492.43	$ 19,500,000.00	$ 3,458,507.57	17.74%
32	$ 16,769,169.09	$ 22,000,000.00	$ 5,230,830.91	23.78%
33	$ 17,509,555.01	$ 21,500,000.00	$ 3,990,441.99	18.56%
34	$ 18,605,606.44	$ 24,000,000.00	$ 5,394,191.56	22.48%
35	$ 19,730,679.46	$ 24,000,000.00	$ 4,269,320.54	17.79%
36	$ 21,833,270.87	$ 26,000,000.00	$ 4,166,729.13	16.03%
37	$ 22,636,312.49	$ 23,500,000.00	$ 863,687.51	3.68%
38	$ 23,976,328.76	$ 35,500,000.00	$ 11,523,671.24	32.46%
39	$ 25,096,556.48	$ 30,000,000.00	$ 4,903,443.52	16.34%
40	$ 26,789,103.04	$ 41,500,000.00	$ 14,710,896.96	35.45%
41	$ 27,349,773.06	$ 30,000,000.00	$ 2,650,226.94	8.83%
42	$ 29,324,945.47	$ 27,500,000.00	$ (1,824,945.47)	-6.64%
43	$ 30,067,866.52	$ 33,000,000.00	$ 2,932,133.48	8.89%
44	$ 31,286,232.07	$ 31,000,000.00	$ (286,232.07)	-0.92%
45	$ 33,022,758.19	$ 37,500,000.00	$ 4,477,241.81	11.94%
Total	$ 431,156,938.47	$ 519,500,000.00	$ 88,343,061.53	17.01%

Appendix B4: Mortality Savings T20 Smoker Bundle

Issue Age	Expected Mortality Costs	Actual Mortality Costs	Mortality Savings	Proportion Savings
26	$ 3,260,673.46	$ 5,000,000.00	$ 1,739,326.54	34.79%
27	$ 3,486,410.51	$ 5,000,000.00	$ 1,513,589.49	30.27%
28	$ 3,670,324.28	$ 7,000,000.00	$ 3,329,675.72	47.57%
29	$ 3,831,459.52	$ 5,000,000.00	$ 1,168,540.48	23.37%
30	$ 3,867,130.01	$ 7,000,000.00	$ 3,132,869.99	44.76%
31	$ 4,174,983.24	$ 2,000,000.00	$ (2,174,983.24)	-108.75%
32	$ 4,155,613.32	$ 9,000,000.00	$ 4,844,386.68	53.83%
33	$ 4,296,176.04	$ 5,000,000.00	$ 703,823.96	14.08%
34	$ 4,381,604.54	$ 6,000,000.00	$ 1,618,395.46	26.97%
35	$ 4,329,966.18	$ 5,000,000.00	$ 670,033.82	13.40%
36	$ 4,477,269.84	$ 5,000,000.00	$ 522,730.16	10.45%
37	$ 5,362,739.42	$ 4,000,000.00	$ (1,362,739.42)	-34.07%
38	$ 6,340,386.75	$ 5,000,000.00	$ (1,340,386.75)	-26.81%
39	$ 6,313,394.67	$ 5,000,000.00	$ (1,313,394.67)	-26.27%
40	$ 6,526,184.42	$ 9,000,000.00	$ 2,473,815.58	27.49%
Total	$ 68,474,316.20	$ 84,000,000.00	$ 15,525,683.80	18.48%

Appendix B5: Mortality Savings SPWL Non-Smoker Bundle

Issue Age	Expected Mortality Costs	Actual Mortality Costs	Mortality Savings	Proportion Savings
46	($3,950,734.48)	$ 3,900,000.00	$ (50,734.48)	-1.30%
47	($4,149,765.83)	$ 4,800,000.00	$ 650,234.17	13.55%
48	($4,201,309.89)	$ 5,000,000.00	$ 798,690.11	15.97%
49	($4,486,215.70)	$ 7,500,000.00	$ 3,013,784.30	40.18%
50	($4,522,314.96)	$ 5,700,000.00	$ 1,177,685.04	20.66%
51	($4,970,038.89)	$ 8,500,000.00	$ 3,529,961.11	41.53%
52	($4,998,719.05)	$ 5,900,000.00	$ 901,280.95	15.28%
53	($5,781,837.76)	$ 8,200,000.00	$ 2,418,162.24	29.49%
54	($6,107,879.49)	$ 6,600,000.00	$ 492,120.51	7.46%
55	($6,853,869.56)	$ 8,600,000.00	$ 1,746,130.44	20.30%
56	($7,042,926.89)	$ 7,800,000.00	$ 757,073.11	9.71%
57	($8,603,356.73)	$ 11,200,000.00	$ 2,596,643.27	23.18%
58	($8,585,448.29)	$ 9,300,000.00	$ 714,551.71	7.68%
59	($9,917,694.80)	$ 9,800,000.00	$ (117,694.80)	-1.20%
60	($10,654,309.66)	$ 12,100,000.00	$ 1,445,690.34	11.95%
61	($12,313,693.27)	$ 12,500,000.00	$ 186,306.73	1.49%
62	($12,216,202.73)	$ 12,800,000.00	$ 583,797.27	4.56%
63	($14,355,720.89)	$ 16,100,000.00	$ 1,744,279.11	10.83%
64	($15,014,494.83)	$ 15,500,000.00	$ 485,505.17	3.13%
65	($16,480,806.44)	$ 16,200,000.00	$ (280,806.44)	-1.73%
Total	$ (165,207,340.14)	$ 188,000,000.00	$ 22,792,659.86	12.12%

Appendix B6: T20 Non-Smoker - Granular Results Over 20 Years

As referenced in the main body of the report, our T20 Non-Smoker Bundle is most profitable at younger age groups, due to the smaller premium reduction. However, at older ages larger premium reductions reduce the overall profitability. The mortality improvements at older ages are significantly higher, resulting in the increase in added economic value from 3.97% at age 30 to 7.29% at age 45.

	After 20 Years				
Issue Age	Composition of Book	PV of Profits W/out Program	PV of Profits W Program	Added Economic Value From Program	Percentage Profits
26	6.31%	$1,055.95	$1,200.90	$144.95	13.73%
27	5.86%	$1,118.54	$1,277.23	$158.69	14.19%
28	5.78%	$1,189.03	$1,363.20	$174.17	14.65%
29	5.61%	$1,268.10	$1,459.63	$191.53	15.10%
30	5.44%	$1,356.43	$1,567.36	$210.93	15.55%
31	5.38%	$1,454.11	$1,511.88	$57.77	3.97%
32	5.20%	$1,562.19	$1,630.69	$68.50	4.38%
33	4.95%	$1,648.32	$1,725.55	$77.23	4.69%
34	4.81%	$1,741.97	$1,828.70	$86.73	4.98%
35	4.75%	$1,844.27	$1,941.38	$97.11	5.27%
36	4.92%	$1,955.96	$2,064.39	$108.43	5.54%
37	4.79%	$2,057.56	$2,176.45	$118.89	5.78%
38	4.74%	$2,164.77	$2,294.69	$129.92	6.00%
39	4.59%	$2,278.34	$2,419.93	$141.59	6.21%
40	4.54%	$2,399.98	$2,554.05	$154.07	6.42%
41	4.55%	$2,529.29	$2,696.60	$167.31	6.61%
42	4.54%	$2,666.76	$2,848.08	$181.32	6.80%
43	4.39%	$2,812.54	$3,008.67	$196.13	6.97%
44	4.49%	$2,966.92	$3,178.66	$211.74	7.14%
45	4.36%	$3,130.56	$3,358.74	$228.18	7.29%
	Aggregate Total Profits Per 100 Policies Sold	$ 189,854.80	$ 204,314.94	$ 14,460.13	7.62%

Appendix B7: T20 Smoker - Granular Results Over 20 Years

Over a 20 year projection, the T20 Smoker Bundle is profitable at all ages, increasing at each age segment of premium reduction. That is, between ages 26-30, 31-35 and 36-40 all have the largest percentage profitability or largest percent added economic value at the older ages of the segment. Furthermore, unlike T20 Non-Smoker, the profitability increases at each age. For example, whereas T20 Non-Smoker bundle was less profitable at age 45, our Smoker bundle is most profitable at age 40.

After 20 Years					
Issue Age	Composition of Book	PV of Profits W/out Program	PV of Profits W Program	Added Economic Value From Program	Percentage Profits
26	8.68%	$3,259.39	$3,413.89	$154.50	4.74%
27	8.77%	$3,474.45	$3,779.72	$305.27	8.79%
28	8.65%	$3,716.60	$4,191.70	$475.10	12.78%
29	8.17%	$3,988.13	$4,653.70	$665.57	16.69%
30	8.14%	$4,291.20	$5,169.39	$878.19	20.46%
31	7.86%	$4,626.21	$4,912.42	$286.21	6.19%
32	6.60%	$4,996.60	$5,476.26	$479.66	9.60%
33	6.57%	$5,626.63	$6,431.31	$804.68	14.30%
34	6.73%	$6,332.46	$7,499.77	$1,167.31	18.43%
35	5.06%	$7,124.40	$8,697.25	$1,572.85	22.08%
36	5.60%	$8,011.90	$8,603.64	$591.74	7.39%
37	5.16%	$9,111.79	$10,062.54	$950.75	10.43%
38	5.09%	$10,328.48	$11,672.60	$1,344.12	13.01%
39	4.94%	$11,673.37	$13,448.62	$1,775.25	15.21%
40	3.99%	$13,167.53	$15,417.67	$2,250.14	17.09%
	Aggregate Total Profits Per 100 Policies Sold	$ 597,988.14	$ 678,023.94	$80,035.80	13.38%

Appendix B8: Whole Life Non Smoker - Granular Results Over 20, 40 and 60 Years

Over 20 Years					
Issue Age	Composition of Book	PV of Profits W/out Program	PV of Profits W Program	Added Economic Value From Program	Percentage Profits
46	5.24%	$ 13,659.63	$13,539.06	($120.57)	-0.88%
47	5.19%	$ 14,126.52	$14,015.53	($110.99)	-0.79%
48	5.15%	$ 14,590.80	$14,490.55	($100.25)	-0.69%
49	4.99%	$ 15,060.58	$14,972.29	($88.29)	-0.59%
50	5.19%	$ 15,515.36	$15,440.64	($74.72)	-0.48%
51	5.11%	$ 15,959.26	$15,899.83	($59.43)	-0.37%
52	5.22%	$ 16,498.53	$16,448.41	($50.12)	-0.30%
53	5.17%	$ 17,039.89	$17,006.64	($33.25)	-0.20%
54	5.21%	$ 17,575.07	$17,560.93	($14.14)	-0.08%
55	4.96%	$ 18,099.07	$18,106.54	$7.47	0.04%
56	5.02%	$ 18,606.30	$18,638.14	$31.84	0.17%
57	4.90%	$ 19,090.60	$19,153.41	$62.81	0.33%
58	5.04%	$ 19,545.98	$19,643.67	$97.69	0.50%
59	4.95%	$ 19,966.97	$20,103.61	$136.64	0.68%
60	4.89%	$ 20,349.26	$20,528.88	$179.62	0.88%
61	4.82%	$ 20,688.02	$20,914.73	$226.71	1.10%
62	4.76%	$ 20,976.41	$21,254.54	$278.13	1.33%
63	4.73%	$ 21,207.65	$21,541.52	$333.87	1.57%
64	4.72%	$ 21,374.55	$21,768.42	$393.87	1.84%
65	4.75%	$ 21,475.10	$21,932.66	$457.56	2.13%
	Aggregate Total Profits Per 100 Policies Sold	$ 1,799,214.48	$ 1,806,431.42	$ 7,216.94	0.40%

Over 40 Years					
Issue Age	Composition of Book	PV of Profits W/out Program	PV of Profits W Program	Added Economic Value From Program	Percentage Profits
46	5.24%	$ 7,670.88	$7,919.44	$248.56	3.24%
47	5.19%	$ 7,634.60	$7,913.39	$278.79	3.65%
48	5.15%	$ 7,571.33	$7,879.88	$308.55	4.08%
49	4.99%	$ 7,492.77	$7,829.91	$337.14	4.50%
50	5.19%	$ 7,382.78	$7,746.93	$364.15	4.93%
51	5.11%	$ 7,256.36	$7,645.03	$388.67	5.36%
52	5.22%	$ 7,027.57	$7,438.62	$411.05	5.85%
53	5.17%	$ 6,817.47	$7,250.24	$432.77	6.35%
54	5.21%	$ 6,621.83	$7,070.71	$448.88	6.78%
55	4.96%	$ 6,446.04	$6,905.18	$459.14	7.12%
56	5.02%	$ 6,296.47	$6,760.02	$463.55	7.36%
57	4.90%	$ 6,186.27	$6,651.24	$464.97	7.52%
58	5.04%	$ 6,111.66	$6,573.39	$461.73	7.55%
59	4.95%	$ 6,075.84	$6,530.45	$454.61	7.48%
60	4.89%	$ 6,079.44	$6,523.81	$444.37	7.31%
61	4.82%	$ 6,122.92	$6,554.98	$432.06	7.06%
62	4.76%	$ 6,205.89	$6,624.72	$418.83	6.75%
63	4.73%	$ 6,325.89	$6,731.42	$405.53	6.41%
64	4.72%	$ 6,480.07	$6,873.00	$392.93	6.06%
65	4.75%	$ 6,665.13	$7,046.70	$381.57	5.72%
	Aggregate Total Profits Per 100 Policies Sold	$ 673,681.02	$ 713,589.34	$ 39,908.33	5.92%

Over 60 Years					
Issue Age	Composition of Book	PV of Profits W/out Program	PV of Profits W Program	Added Economic Value From Program	
46	5.24%	$ 2,961.47	$3,136.96	$175.49	5.93%
47	5.19%	$ 3,084.68	$3,262.53	$177.85	5.77%
48	5.15%	$ 3,210.91	$3,391.65	$180.74	5.63%
49	4.99%	$ 3,342.03	$3,522.31	$180.28	5.39%
50	5.19%	$ 3,475.04	$3,657.81	$182.77	5.26%
51	5.11%	$ 3,611.28	$3,797.96	$186.68	5.17%
52	5.22%	$ 3,750.96	$3,941.80	$190.84	5.09%
53	5.17%	$ 3,912.43	$4,112.02	$199.59	5.10%
54	5.21%	$ 4,079.77	$4,287.99	$208.22	5.10%
55	4.96%	$ 4,252.92	$4,469.45	$216.53	5.09%
56	5.02%	$ 4,431.83	$4,656.22	$224.39	5.06%
57	4.90%	$ 4,626.51	$4,860.84	$234.33	5.06%
58	5.04%	$ 4,828.71	$5,072.80	$244.09	5.05%
59	4.95%	$ 5,038.65	$5,292.25	$253.60	5.03%
60	4.89%	$ 5,256.09	$5,518.79	$262.70	5.00%
61	4.82%	$ 5,481.30	$5,752.67	$271.37	4.95%
62	4.76%	$ 5,714.92	$5,994.58	$279.66	4.89%
63	4.73%	$ 5,957.14	$6,244.68	$287.54	4.83%
64	4.72%	$6,208.32	$6,503.27	$294.95	4.75%
65	4.75%	$ 6,468.59	$6,770.45	$301.86	4.67%
	Aggregate Total Profits Per 100 Policies Sold	$ 445,073.03	$ 467,703.39	$ 22,630.36	5.08%

Appendix C: Assumptions

Appendix C1: Mortality Tables for Smokers and Non-Smokers

Smoker and Non-Smoker Mortality Tables were constructed for our policyholders. First we considered the proportion of smokers at each age group for a comparable country (given the relatively similar life expectancies and mortality trends), the United States. From there we use the fact that 11.5% of the US's population are smokers versus 18% of Lumaria's population (Center for Disease Control and Prevention, 2023), giving us a scaler that we use to adjust to find the approximate proportion of smokers at each of these age groups in Lumaria (see below). For each age group, we assumed smoking proportion to be uniform across every age within the group.

Proportion of Smokers in the United States	11.5%
Porportion of Smokers in Lumaria	18%
Scaler	1.57

Age Group	Proportion of Smoker (US)	Proportion of Smoker (Lumaria)
18-24	5.3%	8.3%
25-44	12.6%	19.7%
45-64	14.9%	23.3%
65-120	8.3%	13.0%

From there, we found mortality tables for male smokers, female smoker, male non-smokers and female non-smokers for the United Kingdom (Benjamin, B., and R. Michaelson, 1988), another comparable country. By approximating an equal proportion of males and females for each group, we condensed this into a smoker mortality table and a non-smoker mortality table. By considering the ratio of the mortality at each age between non-smokers and smokers, this gave us a mortality adjustment for non-smokers.

Using the approximated percentage of smokers at each age, the relative mortality of smokers and non-smokers at each age, and the Lumarian mortality table for the total population, we were able to derive mortality tables for both smokers and non-smokers, as per the equation: $q = q_s p_s + q_{ns} p_{ns} = q_s p_s + r q_s (1 - p_s) = q_{ns}(r p_s + 1 - p_s)$, where q is the overall mortality rate at a given age, q_s is the mortality rate for smokers at that age, q_{ns} is the mortality rate for non-smokers at that age, p_s is the proportion of smokers at that age, p_{ns} is the proportion of non-smokers at that age, and r is the mortality improvement of non-smokers versus smokers.

However, comparing these population-level mortality tables against our in-force data, we noticed some discrepancies that we had to address through loading factors, namely that smokers had a much worse mortality at all ages, especially, ages 45 and older. For this reason, we applied mortality loadings to develop an estimate for the smoker mortality table for SuperLife's policyholders.

The final mortality table for SuperLife's smokers and non-smokers is shown below:

Age	qx (Non-smokers)	qx (Smokers)
0	0.003547	0.003547
1	0.000337	0.000337
2	0.000240	0.000240
3	0.000180	0.000180
4	0.000158	0.000158
5	0.000147	0.000147
6	0.000138	0.000138
7	0.000129	0.000129
8	0.000126	0.000126
9	0.000125	0.000125
10	0.000137	0.000137
11	0.000145	0.000145
12	0.000161	0.000161
13	0.000181	0.000181
14	0.000217	0.000217
15	0.000263	0.000373
16	0.000315	0.000456
17	0.000376	0.000548
18	0.000407	0.000605
19	0.000441	0.000663
20	0.000476	0.000719
21	0.000499	0.000764
22	0.000516	0.000805
23	0.000517	0.000828
24	0.000519	0.000838
25	0.000488	0.000834
26	0.000498	0.000852
27	0.000511	0.000874
28	0.000525	0.000898
29	0.000543	0.000929
30	0.000570	0.000975
31	0.000602	0.001030
32	0.000635	0.001085
33	0.000675	0.001154
34	0.000717	0.001226
35	0.000766	0.001310
36	0.000833	0.001425

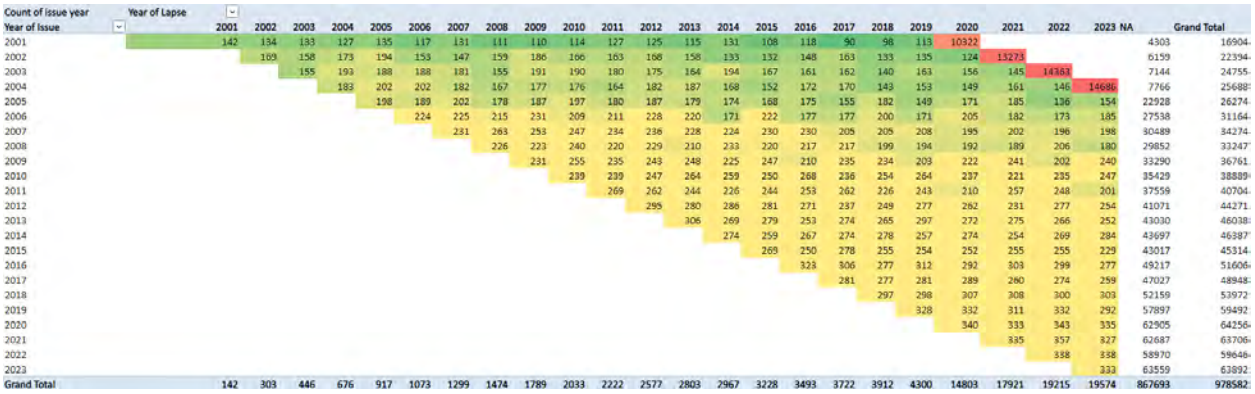
37	0.000911	0.001558
38	0.000992	0.001696
39	0.001075	0.001839
40	0.001173	0.002005
41	0.001270	0.002171
42	0.001380	0.002360
43	0.001499	0.002563
44	0.001629	0.002785
45	0.001728	0.002955
46	0.001875	0.003262
47	0.002056	0.003577
48	0.002247	0.003910
49	0.002457	0.004275
50	0.002682	0.004667
51	0.002941	0.005118
52	0.002090	0.009404
53	0.002300	0.010351
54	0.002540	0.011429
55	0.002811	0.012650
56	0.002462	0.016003
57	0.002703	0.017570
58	0.002968	0.019294
59	0.003286	0.021359
60	0.003625	0.023561
61	0.003962	0.025752
62	0.004333	0.028164
63	0.004728	0.030730
64	0.005167	0.033586
65	0.007555	0.049105
66	0.008276	0.053791
67	0.009042	0.058776
68	0.009906	0.064387
69	0.010879	0.070712
70	0.011993	0.077955
71	0.009786	0.109699
72	0.010878	0.121945
73	0.012179	0.136531
74	0.013680	0.153350

75	0.015403	0.172668
76	0.017394	0.194984
77	0.019620	0.219936
78	0.022097	0.247703
79	0.024800	0.278011
80	0.027772	0.311327
81	0.031116	0.348809
82	0.034873	0.390926
83	0.039110	0.438426
84	0.043688	0.489739
85	0.048471	0.543359
86	0.061251	0.551260
87	0.067685	0.609169
88	0.074775	0.672977
89	0.082615	0.743538
90	0.090402	0.813621
91	0.117530	0.763945
92	0.128011	0.832074
93	0.138841	0.902464
94	0.150460	0.977988
95	0.162410	1.055665
96	0.175066	1.137931
97	0.188465	1.225020
98	0.202111	1.313719
99	0.216371	1.406414
100	0.230728	1.499731
101	0.244850	1.591524
102	0.259309	1.685510
103	0.274022	1.781140
104	0.288892	1.877800
105	0.303827	1.974876
106	0.318841	2.072466
107	0.333962	2.170754
108	0.687915	0.000000
109	0.717620	0.000000
110	0.752108	0.000000
111	0.786407	0.000000
112	0.820477	0.000000

113	0.854275	0.000000
114	0.887760	0.000000
115	0.921073	0.000000
116	0.954387	0.000000
117	0.987700	0.000000
118	1.021014	0.000000
119	1.149310	0.000000

Appendix C2: Lapse Rates

The lapse rate assumption we used was the empirical lapse rate from our in-force T20 policies (note that there is the assumption of no lapse for WL policies). The following figure shows the number of lapses every year for policies issued in every year.



Count of issue year	Year of Lapse																								
Year of Issue	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	NA	Grand Total
2001	142	134	133	127	135	117	131	111	110	114	127	125	115	131	108	118	90	98	113	10322				4303	16904
2002		169	158	173	194	153	147	159	186	166	163	168	158	133	132	148	163	133	135	124	13273			6159	22394
2003			155	193	188	188	181	155	191	190	180	175	164	194	167	161	162	140	163	156	145	14383		7144	24755
2004				183	202	202	182	167	177	176	164	182	187	168	152	172	170	143	153	149	161	146	14686	7766	25688
2005					198	189	202	178	187	197	180	187	179	174	168	175	155	182	149	171	185	136	154	22928	26274
2006						224	225	215	231	209	211	228	220	171	222	177	177	200	171	205	182	173	185	27538	31164
2007							231	263	253	247	234	236	228	224	230	230	205	205	208	195	202	196	198	30489	34274
2008								226	223	240	220	229	210	233	220	217	217	199	194	192	189	206	180	29852	33247
2009									231	255	235	243	248	225	247	210	235	234	203	222	241	202	240	33290	36761
2010										239	239	247	264	259	250	268	236	254	264	237	221	235	247	35429	38889
2011											269	262	244	226	244	253	262	226	243	210	257	248	201	37559	40704
2012												295	280	286	281	271	237	249	277	282	231	277	254	41071	44271
2013													306	269	279	253	274	265	297	272	275	266	252	43030	46038
2014														274	259	267	274	278	257	274	254	269	284	43697	46387
2015															269	250	278	255	254	252	255	255	229	43017	45314
2016																323	306	277	312	292	303	299	277	49217	51606
2017																	281	277	281	289	280	274	259	47027	48848
2018																		297	298	307	308	300	303	52159	53972
2019																			328	332	311	332	292	57897	59492
2020																				340	333	343	335	62905	64256
2021																					335	357	327	62687	63706
2022																						338	338	58970	59646
2023																							333	63559	63892
Grand Total	142	303	446	676	917	1073	1299	1474	1789	2033	2222	2577	2803	2967	3228	3493	3722	3912	4300	14803	17921	19215	19574	867693	978582

Using this data, we obtain the following lapse rates assumption for T20 policies:

Year	Lapse Rate
1	0.61%
2	0.62%
3	0.62%
4	0.62%
5	0.61%
6	0.61%
7	0.64%
8	0.62%
9	0.62%
10	0.64%
11	0.62%
12	0.62%
13	0.61%
14	0.61%
15	0.62%
16	0.61%
17	0.60%
18	0.59%
19	0.59%
20	58.66%

Appendix C3: Interest Rate Projection

We have determined an estimate for the future interest rate using an ARIMA time series model. This was done by first considering the given 1-year risk free annual spot rates for 1962-2023, adjusting for outliers using the tso function in R (outliers were 1983, 1987 and 2023). The auto.arima function in R was then used to fit an ARIMA time series model and project the 1-year risk free annual spot rates for the next 60 years. The ARIMA(0,1,1) model was selected, and the projected 1-year risk free annual spot rate for the each of next 60 years was projected to be 2.97%. See below for a snippet of the code used.

```
# Read the data from CSV file
data <- read_excel("srcsc-2024-lumaria-economic-data.xlsx")

#Convert to time series object
ts_data <- ts(data$`1-yr Risk Free Annual Spot Rate`, start = min(data$Year),
              end = max(data$Year), frequency = 1)

# Detect outliers
outliers <- tso(ts_data, types = c("AO", "LS", "TC"), maxit.iloop = 10)
ts_data_adj <- ts_data
ts_data_adj[outliers$outliers$ind] <- ts_data_adj[outliers$outliers$ind] -
  outliers$outliers$coefhat

# Visualize the data
plot(ts_data_adj, main = "Spot Rate Over Time",
     xlab = "Year",
     ylab = "Spot Rate")

# Fit ARIMA model
arima_model <- auto.arima(ts_data_adj, d = d, D = 0, max.p = 3, max.q = 3,
                          seasonal = FALSE)

# Summary of the ARIMA model
summary(arima_model)

# Forecast interest rates for the next 60 years
forecast_values <- forecast(arima_model, h = 60)

print(forecast_values)
```

Appendix C4: Population Projection

To have confidence in our hypothesis that Lumaria would experience the phenomenon of an aging population over the duration of it's programs, we developed a crude procedure to project the population in 20 years time, as well as, the population distribution across all ages.

This was done by considering the Lumarian mortality table and the distribution of ages given in the Encyclopedia. The distribution at each specific age within an age group was then determined by considering a hypothetical cohort at the start age, and using the mortality rates to obtain relative population proportions at each age within the group. This gave us an estimate for the current population distribution at every age, and ultimately the population at every age, using the total Lumarian population. Considering a 20 year time horizon, we were able to use the Lumarian mortality table to project the future population at every age 20 and older, adopting the assumption that Lumaria has no net migration. To obtain an approximation for the population below 20, we used the same relative proportions of population at ages below 20 to population of age 20. From this, we obtained a projection for the population and population distribution, as seen below.

Age Group	Current Population	Proportion	Population in 20 Years	Proportion in 20 Years
0-14	18,415,532	20%	13,596,513	7%
15-24	16,573,979	18%	12,236,861	6%
25-54	42,355,723	46%	42,399,278	21%
55-64	11,049,319	12%	13,215,720	7%
65-120	3,683,106	4%	18,972,887	9%
Total	92,077,659	100%	100,421,368	100%

While this projection method has made several major assumptions, it clearly confirms the future trend of an aging population in Lumaria, a consideration that impacted our life insurance offerings and program design.