Rare5 Consulting:

SuperLife's Health Incentive Program Proposal

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1. Objectives

SuperLife is one of the main life insurance carriers in the country of Lumaria. In the last 23 years, SuperLife has sold two life insurance products: single-premium whole life insurance (SPWL) and 20-year term life insurance (T20). The company is looking to build a health incentive program that aims to achieve its objectives of:

- Incentivising healthy behaviours through active participation in the program,
- Decreasing expected mortality,
- Increasing life insurance sales,
- Improving product marketability and competitiveness and,
- Adding economic value to the company.

In this report, we have proposed a health incentive program that consists of three main phases: *Gamifying Health*, a *Smoking Cessation Program* and *Holistic Prevention and Educational Programs*. Through the implementation of the programs, we are confident that SuperLife will achieve all five objectives.

2. Program Design

As mentioned previously, the program will consist of three pillars: *Gamifying Health*, Smoking *Cessation Program* and *Holistic Prevention and Educational Programs*.

Gamifying Health

The first part of our proposed health incentive program is to Gamify Health. This consists of creating a points-based incentives program that allows individuals to receive cash at the end of the calendar year if they achieve enough points. The points will be gained if individuals participate in healthy behaviours every day including sleeping seven hours, being outside during daylight hours for over 180 minutes, or achieving 10,000 steps. To ensure individuals are actively participating in healthy behaviours, the number of points rewarded for each activity will depend on the time commitment. For example, the points associated with spending 3 hours outside during the day will be higher than the points for achieving 10,000 steps. As a way of encouraging the development of positive habits, bonus points will be awarded to policyholders who continue to achieve over 90% of their daily goals for an extended duration (up to 50 years after the first goal was achieved). A breakdown of how points will be rewarded can be found in Appendix A.1. The goals that individuals are required to reach are also designed to ensure trackability; the harder it is to track, the less points associated to the goal.

A new customer-centric app will provide a colourful and captivating overview of their own health. Front and centre on the dashboard we will display three rings for the three daily goals so that policyholders can track their progress towards living a healthier life each day in real time

(outer ring - sun, middle ring - walk, inner ring - sleep). Moreover, as part of the app the user can opt-in to receiving notifications in the form of gentle reminders when they are getting close to meeting their goals or positive messages of encouragement when there is a significant deterioration. Leveraging sophisticated machine learning algorithms, users will be able to view data trends in the palm of their hands and discover new strategies on how to keep improving. We believe the app will assist customers to become more active whilst improving their sleep quality.

The program will be available to all participants. Research finds by gamifying health, it incentivises individuals to participate in easy healthy behaviours that can significantly improve their wellbeing (Mitesh, et al., 2019). The approach is also marketable and makes the life insurance products sold by SuperLife more attractive compared to other insurance programs. By rewarding healthy behaviours, policyholders would not only be more engaged with their life insurance policy, but also find value in the short-term rewards making them less likely to lapse on their policy. This will improve SuperLife's ability to retain its customers whilst also improving mortality.

Smoking Cessation Program

The smoking cessation program will be centred around helping smokers to stop smoking permanently. Through analysing SuperLife's policyholder experience, we have found that whilst only 6.3% of SuperLife's customers are smokers, 35.4% of all deaths recorded were due to smoking. Besides being a main contributor to population mortality, smoking also has follow-on effects, and can contribute to other diseases that would also eventually increase mortality (Qin, 2020). Circulatory System Diseases are more prevalent among smokers (Gallucci, et al., 2020) and is also the second highest cause of death of SuperLife's policyholders. Therefore, by implementing a smoking cessation program, the expected mortality for smokers is likely to greatly decrease.

It has been proven that subsidising smoking cessation treatment increases the chances of successful long-term abstinence, and that full-coverage intervention do not offer any significant benefits for quitting rates compared to partial-coverage (van den Brand, et al., 2017). Therefore, SuperLife will partially subsidise its policyholder's treatments. The program outline as well coverage cost detail is explained in Appendix A.2. Individuals that require additional support outside the program will need to pay out-of-pocket, however, the cessation program will ensure individuals are provided guidance on how to find additional resources.

Holistic Prevention and Educational Programs

The last aspect of the health program we propose is focusing on holistic prevention. One of the most effective ways to treat most diseases and ensure longevity of an individual's health, ceteris paribus, is concentrating on preventative measures.

Within the provided in-force dataset, the top five causes of death were:

- Neoplasms (Tumours/Cancer): 33% of all deaths
- Circulatory System Diseases: 30% of all deaths
- External Reasons (e.g. public accidents, intentional self-harm): 8.8% of all deaths
- Respiratory System Diseases: 6.7% of all deaths
- Digestive System Diseases: 4.6% of all deaths

Therefore, to help reduce mortality of existing policyholders, we have considered four main programs which directly aim to target the top 5 causes of deaths. These are:

- *Cancer Prevention Initiative.* As shown above, neoplasms (i.e. cancer/tumours) were the highest cause of death amongst policyholders. By educating individuals on this topic, we aim to reduce the number of deaths relating to cancer.
- *Educational Workshops.* Learning how to live a healthy lifestyle is a common preventative measure that many health professionals recommend, noting it helps reduce the chance of developing diseases in the future. This may include encouraging healthy eating habits and doing exercise.
- *Safety Campaigns:* This campaign aims to target the third highest cause of death for policyholders, which was noted to be accidents.
- *Annual Health Check-ups*: This campaign intends to allow policyholders to discover any new diseases in the early stages, such that treatment can be arranged before it is too late.

The program will involve campaigns in the form of workshops, reminder emails and community outreach. In the case of workshops, these will be advertised first to policyholders but is also open to the public. If non-policyholders are interested, they will need to provide their contact details. Therefore, the program will not only reduce the expected mortality of policyholders but will also have reputational benefits allowing SuperLife to gain exposure and attract new customers.

3. Performance Metrics

In addition to creating a health incentive program, we also emphasise the importance of monitoring the program to ensure that it is achieving the desired response. The short-term and long-term metrics that should be monitored are outlined below.

Short Term (0- 10 years):

- Compare actual vs expected mortality improvements due to the program every 5 years. This will signal if assumptions need to be updated due to the mortality improvement experience being more optimistic or pessimistic than anticipated.
- Monitor engagement rates of each incentive program separately. Engagement rates can showcase which incentive programs are attracting more customers and are more efficient.

- Periodically review the percentage of new policies written and ensure it is in line with expectations. Lower rates may indicate potential deficiencies within the program.
- Monitor lapse rates to ensure that they are not significantly increasing due to the implementation of the program.
- Engage with customers for feedback (through surveys) on all three programs to help shape further improvements. This can help improve the program to better suit policyholders' needs.

Long Term (10-20 years)

- All the short-term metrics should also be used for long term. However, due to having experience data with a longer time horizon, findings should be more robust.
- Comparing actual vs expected mortality improvements due to the program every 10 years will provide a more wholistic picture. After 11 years, it is expected that the mortality improvements of the programs are fully realised. This analysis will assist in showcasing how effective the program is by checking whether savings have aligned with our forecasts.
- Compare expected profit gained with actual profit gained. Review all assumptions in pricing.

4. Assumptions

The pricing of the insurance policies for both SPWL and T20 are dependent on several assumptions. These are summarised below. For a more detailed analysis of each assumption, please refer to Appendix B.

- A lapse rate of 2% for T20 policies was set. This was based on historical information using the most recent 10 years. It was found that lapse rates were relatively consistent around 2% for all years, and all policy durations (Appendix B.1).
- Based on Lumaria Historical Inflation and Interest rates between 1962 and 2023, an investment rate of 8% and discount rate of 11% was calculated (Appendix B.2).
- Cost of incentives per policyholder was dependent on the 'Interventions Data' provided by SuperLife's product team. The midpoint of the range was chosen to be the best estimate for costs and mortality improvement. Whilst we expect that costs will decrease as the program matures; we have assumed inflation will counteract the decrease.

Intervention Name	Costs	Mortality Improvement
Gamifying Health - Financial Incentives	52.5 Č	3.5%
Smoking Cessation Programs*	32.08 Č	25%
Safety Campaigns	22.5 Č	4%
Cancer Prevention Initiatives	52.5 Č	7.5%
Educational Workshops	52.5 Č	3%
Annual Health Check-ups**	0 Č	7.5%

* See Appendix A.2

** See Appendix B.3

- <u>Mortality improvement</u> rates for each program (as shown above) were also dependent on the 'Interventions Data' provided by SuperLife's product team.
  - ▫ We have also assumed that mortality improvements uniformly impact all ages, except policyholders over 80, who experience no mortality improvement, as mortality improvements are unlikely to occur at older ages.
  - ▫ As there are numerous incentives in place, there is likely to be an interaction effect, which reduces the improvement in mortality as certain interventions may overlap. This is done by applying a penalty to mortality improvement based on the number of interventions, which is six for smokers and five for nonsmokers (Appendix B.4).
  - ▫ Mortality improvements were also assumed to be gradual across the first 10 years after the program is implemented. Mortality improvements are only fully realised in the 11th year (Appendix B.5).
- <u>Mortality rates</u> were analysed separately for different ages, sex, smoking and underwriting risk as each had a noticeable impact. To model the impact, a logistic regression was fitted (Appendix B.6) and used to create 12 subsets of policyholders. There are 12 subsets, as there are no smokers that have very low, or low underwriting risk. A manual adjustment was made to the mortality table, whereby the maximum age was set to be 90, reflecting the data from existing policyholders where there are very few survivors past age 80. Mortality for ages 81 to 89 were thus linearly interpolated from 80 to 90 to reflect high probability of death for the elderly.
- It was assumed that with no program put into place, the annual increase in new policy count would increase in a linear trend in line with historical data subject to a 10% penalty to be conservative. With implementation of the program, due to the attractiveness of the program and improved marketing efforts, it is assumed that the annual increase in new policy count would be 30% more than if no program was to be implemented.
- Profit Margin was assumed to 10% for each policy (for both T20 and SPWL)

5. Data and Data limitations:

1) **Mortality Improvements:** Due to limited availability of data, the impact of each program on mortality rates is heavily reliant on SuperLife's product development team's data.
2) **Program Costs:** Due to the limited data available on program incentive costs, we also rely heavily on the Interventions data provided by SuperLife's product development team.
3) **Smoking Cessation Costs:** We have used external research to estimate smoking cessation costs, however, it should be noted that this was based on the US demographic as of 2008. Existing US smoking cessation programs have contributed to a fatter right tail in their age distribution relative to Lumaria. Costs were inflated to 2023 US dollars and then converted to Crowns using the given exchange rate (Lumarian Č 1.743 = US \$1) to produce an estimate.

4) **Mortality Table:** The logistic regression that was used to model mortality used the in-force dataset provided by SuperLife, which does not have a very long history of selling life insurance (started in 2001). As term life insurance has a maximum issue age of 55 and whole life insurance has a maximum age of 65, the oldest cohort of survivors is only currently 87, which severely impacts the ability to model mortality of older policyholders.

5) **Mortality Improvement Per Age:** The given interventions were utilised and were assumed to have the same impact on mortality for policyholders younger than 80. This is a very strong assumption and is thus a key limitation to the results as it is unknown if certain interventions may improve mortality in males more than females or improve mortality in those aged 50 and younger more than improving mortality in those aged 50-80.

6) **Other Causes of Improvement:** Our mortality tables do not account for the fact that mortality tends to improve yearly (Crimmins, 2015), and even without the program. Therefore, our mortality tables are conservative in this regard.

6. Pricing/Costs

Mortality Savings

The mortality savings were calculated to assess the impact of mortality improvements on pay-outs. To obtain this, we found the total sum of claims per segment per year for the last 20 years. The improved mortality rate if the program was in effect for each segment was then divided by the base mortality with no program to identify the ratio of improved to base mortality. Finally, the improved mortality ratio was multiplied by the total pay-out without the program to obtain the new total pay-out and the percentage saving because of the program. From the below graph, by implementing the program, we can expect mortality savings ranging from 10% to 24%.

| Segment (Sex/Smoker Status/Underwriting Class)	Total Pay-out without Program ($m)	Improved Mortality Ratio	Total Pay-out with Program ($m)	% Saving
Male/Smoker/High	1,822.05	76.64%	1,396.37	23.36%
Male/Smoker/Moderate	5,045.60	76.86%	3,877.80	23.14%
Male/Non-Smoker/High	1,522.05	89.60%	1,363.70	10.40%
Male/Non-Smoker/Moderate	2,617.50	89.50%	2,342.54	10.50%
Male/Non-Smoker/Low	3,496.45	89.50%	3,129.16	10.50%
Male/Non-Smoker/Very Low	3,873.30	89.59%	3,470.22	10.41%
Female/Smoker/High	605.75	76.48%	463.29	23.52%
Female/Smoker/Moderate	1,690.65	76.43%	1,292.14	23.57%
Female/Non-Smoker/High	676.30	89.56%	605.71	10.44%
Female/Non-Smoker/Moderate	1,297.65	89.60%	1,162.64	10.40%
Female/Non-Smoker/Low	1,620.55	89.56%	1,451.34	10.44%
Female/Non-Smoker/Very Low	1,961.10	89.47%	1,754.63	10.53%

Economic Value

To assess the economic value of the program, the profit was used. It was calculated by first finding profit per policy per year and then multiplying it by the best estimate of policy count.

A step-by-step methodology on how annual premium and profit was calculated for T20 and SPWL policies can be found in Appendix C.2.

20-Year Term Life

Due to the improved mortality, the premiums charged per individual have improved across all segments (Appendix C.3), even with the increase of expenses charged to the policyholder with the program. The improvement is very minimal for the first 10 years, whilst the decrease is more noticeable when mortality improvements are realised. Due to decrease in premium collected, the profit per policyholder expectingly will decrease. However, this is offset by an increase in policyholder count.

As shown in the figure to the right, the first 10 years showcases an increase in profit. This is due to an increase in expenses with very minimal mortality benefit. However, after the full benefit for mortality is realised, and the number of policyholders expected to join SuperLife increases, the overall PV of profit earned per year exceeds that of the status quo.

T20: Present Value (as at 2024) of Profits Sold Each year
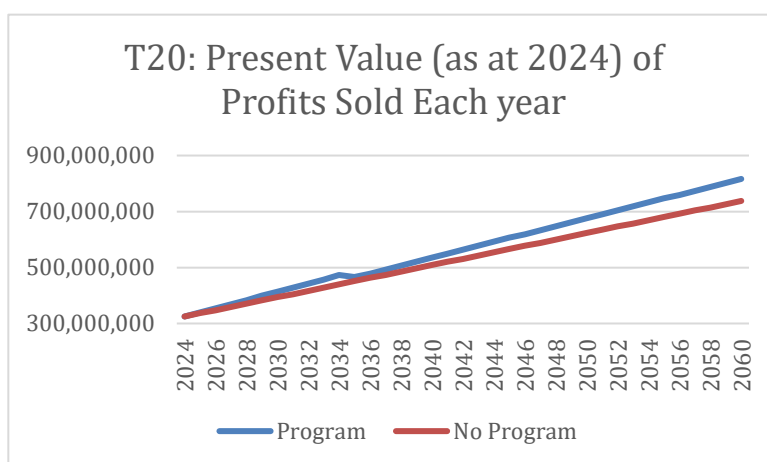
Single Premium Whole Life Insurance

A similar trend was found for SPWL, as shown on the right. The premiums were lower across all consumer segments since mortality savings were greater than the expenses paid (Appendix C.3). However, due to SPWL insurance being, on average, more profitable compared to term life insurance, the magnitude of the profit earned is far greater.

SPWL: Present Value (as at 2024) of Profits Sold Each year
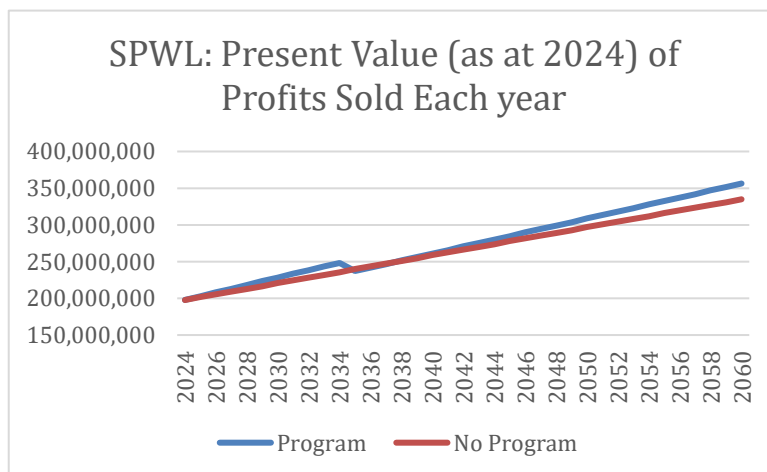
Premium Changes

The premiums above assume a 10% profit margin. Due to limited data, we were not able to carry out extensive research into competitor pricing. If competitor pricing is cheaper, SuperLife should consider reducing their profit margins to become more competitive. Cost-reduction efforts can involve negotiation with vendors (i.e., partnered medical care providers can provide lower-cost service) and creating more targeted incentives (i.e., health incentives will prioritise more at-risk

groups with poorer lifestyle, as opposed to already healthy groups with adequate lifestyle, to ensure the highest mortality reductions).

Due to profit margins being embedded in the premium price, the trend of economic value should not change, but rather the magnitude. As we will pass on the mortality savings to our customers in the form of reduced premiums (keeping the profit margin fixed at 10%), the average profit per customer will decline. However, the decrease in profit per customer should be more than offset by a significant increase in the total number of policyholders due to more competitive pricing.

At the same time, SuperLife should also ensure that premiums are not significantly below competitors. This could lead to adverse selection, whereby we are writing risky business for less premium, and could lead to a decline in profitability. Moreover, continuously lowering premiums without a commensurate reduction in mortality will be unsustainable in the long-term, so SuperLife needs to ensure its finances are strong enough to fulfil financial obligations and maintain the quality of its health benefits. That way, the company can ensure it will be financially stable even when mortality improvements deviate from the program assumptions.

7. Ethical Considerations

There are some ethical considerations with the recommendations we provided. The "cross-subsidisation" for the smoking program may create inequity, as non-smokers might resent subsidising for smoking cessation treatment. This can be seen as coercive and discriminatory towards people who choose to not participate. However, the program's high cost might be an obstacle for smokers who genuinely want to quit. Therefore, we decided during the design stage that the whole cohort will help subsidise the cost, making it more affordable when shared amongst many.

The program might disadvantage people from lower SES (Socioeconomic Status) backgrounds, as they might struggle to afford fresh produce or gym memberships. Moreover, as people in lower SES backgrounds tend to work long hours, they might not have enough spare time to fully participate.

This can also especially impact vulnerable policyholders who are unable to participate in some programs, such as the disabled who may not have the accessibility to attend educational workshops and have trouble achieving 10,000 steps per day. This may be mitigated by adjusting the financial incentives for disabled individuals (e.g. more points for being outdoors) as well as promoting online workshops for policyholders that have difficulty attending in-person programs.

To ensure SuperLife is acting in the best interest of its policyholders, we recommend continuous surveys to be collected to identify any other ethical concerns and to check whether the program is accessible for as many people as economically possible. This ensures SuperLife is not only profitable but provides a service that embodies ethics and fairness, bolstering its reputation.

8. Sensitivity Analysis

Through carrying out various sensitivity analysis, we found the greatest impact on profit is the number of policyholders that the new program will attract.
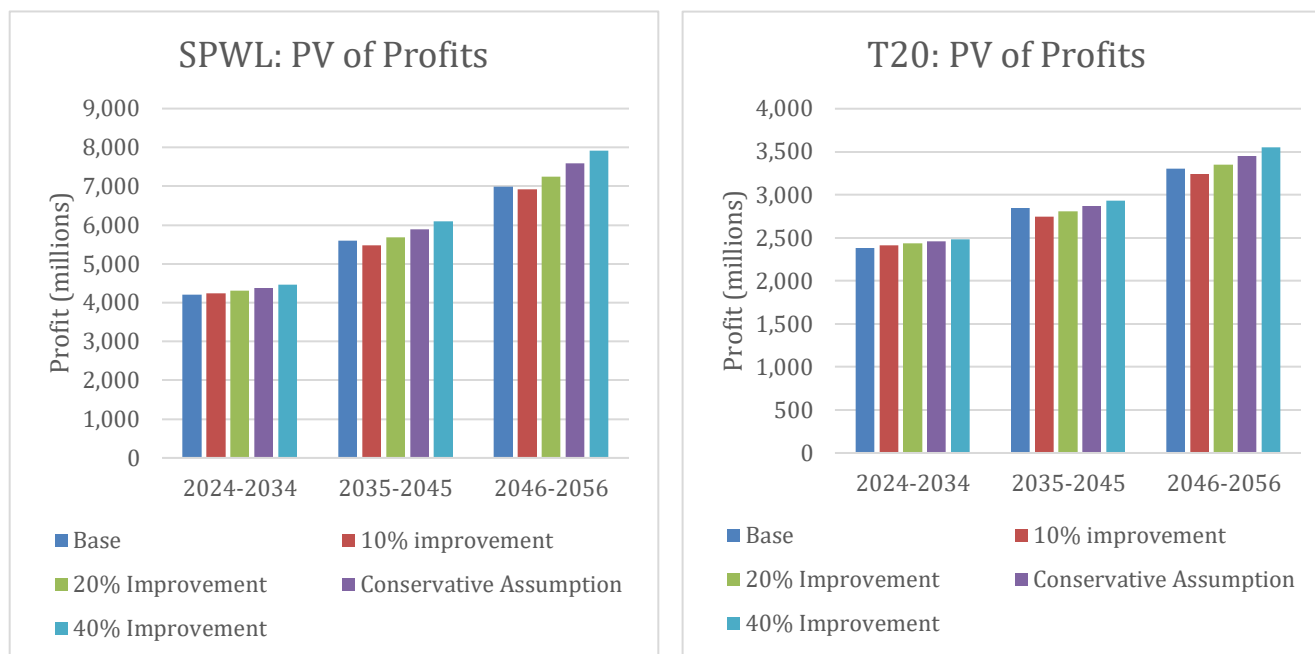
Similar trends are found for T20 and SPWL products, where the increase in policyholders has the greatest impact on profit after 10 years. Whilst majority of the stresses overtake the base case (which assumes no program), a 10% improvement in policyholder rates does not ever generate more profit than the base case. If SuperLife finds itself in a situation whereby profits are not exceeding the base case due to policyholder participation, investigation into why this is the case should be undertaken. SuperLife should reassess its premiums, marketing, or attractiveness of each program. However, we are confident that the attractiveness and marketability of the program will fall between a 20-30% improvement in participation. This, as shown above, will reap favourable economic benefits.

9. Risk and Risk Mitigation Considerations

I.   **Cost Overruns (Financial):** Actual costs may be higher than anticipated due to increased admin costs, reward pay-outs or unexpected changes in participant behaviour. SuperLife should monitor expenses closely and adjust as required to align with budget restraints. This involves having robust budgeting and financial forecasting processes.

II. **Investment Risk (Financial):** Unexpected market downturns or return fluctuations could impact SuperLife's ability to fund the health program. SuperLife should implement stress testing to understand how market fluctuations could impact investment returns and

program funding. To minimise the impact of market volatility, investments should be diversified.

III. **Strategic Risk:** There is a lot of volatility surrounding the health incentive program's performance. This includes impact on mortality improvements and yearly increase in policyholder count. As shown in our sensitivity analysis, these can greatly impact performance. SuperLife should monitor its key performance metrics to ensure assumptions are updated to respond to any shortfall from expectation.

IV. **Market saturation:** Other insurance companies also offer similar or more competitive health incentive programs. As a result, the health incentive program does not attract the desired level of new policyholders. SuperLife should undertake competitive analysis to differentiate its program and tailor marketing strategies to target a specific market segment to attract and retain policyholders.

V. **Underwriting Risk:** There is a risk of mispricing the product due to inaccurately assessing a policyholder's health status. If SuperLife does not ask the correct questions, and the premium prices are not reflective of the risks, it could lead to adverse selection. When investigating SuperLife's experience, the distribution of deaths from High and Moderate risks were quite similar. This may indicate an underwriting issue. SuperLife should regularly review its underwriting modelling techniques to accurately reflect real world data. Continuously monitoring and reacting to feedback from the program is essential.

VI. **Operational Risk:** The program might struggle to handle large numbers of participants. SuperLife should design the programs with scalability in mind by having separate but easily integrable modular components. (i.e., first component handling user registration, second for handling goal tracking, third for reward management)

10. Conclusion

Rare5 Consulting advises SuperLife to adopt a three-pillar approach (Gamifying Health, Smoking Cessation Program and Holistic Prevention & Educational Programs) to incentivise healthy behaviours. This will reduce mortality rates, boost life insurance sales, and thus create economic value. Through the constant monitoring of performance metrics, we believe that the program will on average yield significant mortality savings. Despite several data limitations necessitating the development of assumptions, we remain confident that SuperLife will still benefit from mortality improvements and make strong progress towards its five objectives which collectively will improve the health & wellbeing of the Lumarian population.

11. Appendices

Appendix A – Program Design Details

A.1 Gamifying Health Incentives

We propose financial incentives for healthy behaviour in the form of a rewards scheme with three daily goals. Every day, we will encourage our policyholders to walk at least 10,000 steps, spend at least three hours in sunlight and sleep at least seven hours. The table below indicates the proposed breakdown of points for each activity, with bonuses issued to policyholders who consistently meet at least 90% of all goals over a prolonged duration.

Activity	Points
Walk 10,000 steps in a day	1
Spend three hours outdoors in sunlight in a day	2
Sleep seven hours in a day	3
One month completing 90% of goals	5 (bonus)
Three months completing 90% of goals	20 (bonus)
One year completing 90% of goals	100 (bonus)
Five years completing 90% of goals	1,000 (bonus)
Ten years completing 90% of goals	2,500 (bonus)
Fifteen years completing 90% of goals	5,000 (bonus)
Twenty years completing 90% of goals	10,000 (bonus)
Thirty years completing 90% of goals	25,000 (bonus)
Forty years completing 90% of goals	50,000 (bonus)
Fifty years completing 90% of goals	100,000 (bonus)

Conversion rate: 100 points = 1Č

Conditions:
- Customers required to own a smartwatch (or activity tracker) capable of accurately measuring number of steps, time spent outdoors in sunlight per day as well as number of hours of sleep per day.
- Policyholders must submit themselves to an annual health check-up with their GP.
- Any newly diagnosed medical conditions must be reported to the insurer.
- The scheme will be reviewed annually at the discretion of SuperLife.

A.2 Smoking Cessation Program Details

The smoking cessation program is based on a 2008 study in the US (Joyce, et al,. 2008) and will include 3 components:

1) **Nicotine replacement therapy (NRT):** Products like nicotine patches, gum, inhalers. This will provide immediate and short-term relief to physical withdrawal symptoms that smokers experience when they go through "cravings".
2) **Anti-depressants:** Most typically Bupropion, which can attenuate the effects of nicotine withdrawal. Smoking triggers a release of dopamine in the brain – which is why it is addictive. When trying to abstain from smoking, the brain craves dopamine, which can cause significant cravings and mood swings. Bupropion allows dopamine to remain in the brain for longer, thus helping the patient deal with cravings and feel better overall. (Wilkes, 2008)
3) **Counselling:** Tobacco dependency is a chronic medical illness, implying underlying psychological issues caused by external stressors. Appropriate counselling can help patients overcome tobacco dependence by resolving external stressors. Three minutes of counselling can double cessation rates as compared to no intervention. (Bhattacharyya, et al, 2008)

Treatments	Coverage	Cost in USD (2008 study in US)	Cost in Crowns (2023, indexed by inflation)
NRT	1 prescription + 1 refill	$30 for 14-day supply (21mg)	77.28
Bupropion	1 prescription + 1 refill	$295 for 84-day supply	759.92
Counselling (10min/session)	4 sessions / year. (2 sessions maximum every 3 months)	$36.98 for consultations	95.26

Total Cost Per Participant: 932.46 Č

For cessation programs, the average cost per participant was calculated as 932.46Č. According to the U.S. Centers for Disease Control and Prevention (CDC), 68% of smokers are interested in quitting. We therefore expect a 68% participation rate. The cost for smokers will be split across all policyholders, therefore, the price was calculated as 68% x (% of policyholders who are smokers) x 932.46Č. Based on the in-force policy data we assumed the expected percentage of policyholders to be 5.05%.

Limitations

1. **Demographic differences:** The study in which the cessation program was based on was conducted in 2008 in the US, and *only* targeted senior citizens aged 65 and above. However, in Lumaria, the smoking population is a mix of people of younger ages, ranging from 25 – 65. The differences in demographics might impact the overall effectiveness of the program.

2. **Cost:** The economic values given in the study are from US in 2008. Although it has been converted to Crowns and indexed by inflation, we still assumed that the cost of pharmaceutical products + medical service in Lumaria is the same as in the US for 2008, which might not be the case.

Appendix B – Assumptions Methodologies
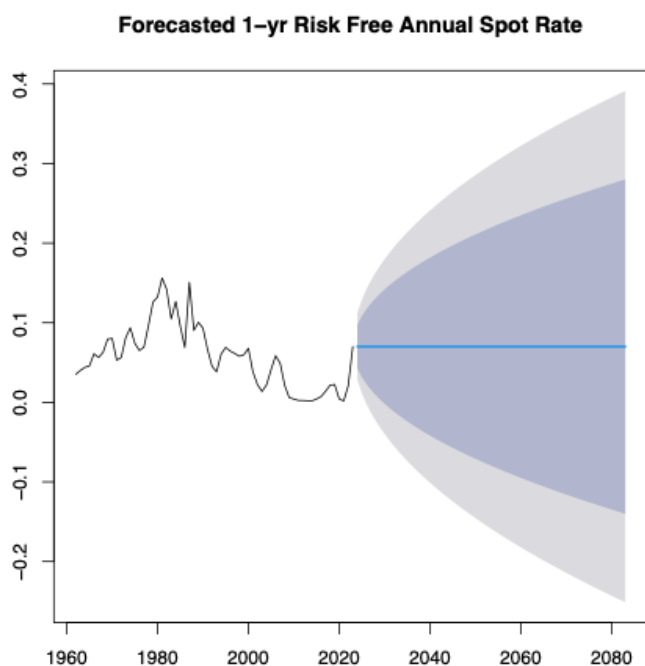
B.1 Lapse Rates – T20 Policies

To estimate lapse rates for the pricing model, the time taken for a policyholder to lapse was calculated first (by subtracting the 'Issue Year' by 'Lapse Year') for each 'Issue Year'. This value was the divided by the total number of policies in each 'Issue Year'. The following table was formed.

Issue Year	Year of Lapse 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2001	1.04%	0.99%	0.98%	0.93%	0.99%	0.86%	0.96%	0.82%	0.81%	0.84%	0.93%	0.92%	0.85%	0.96%	0.79%	0.87%	0.66%	0.72%	0.83%
2002	1.24%	1.16%	1.27%	1.43%	1.13%	1.08%	1.17%	1.37%	1.22%	1.20%	1.24%	1.16%	0.98%	0.97%	1.09%	1.20%	0.98%	0.99%	0.91%
2003	1.14%	1.42%	1.38%	1.38%	1.33%	1.14%	1.40%	1.40%	1.32%	1.29%	1.21%	1.43%	1.23%	1.18%	1.19%	1.03%	1.20%	1.15%	1.07%
2004	1.35%	1.49%	1.49%	1.34%	1.23%	1.30%	1.29%	1.21%	1.34%	1.38%	1.24%	1.12%	1.27%	1.25%	1.05%	1.13%	1.10%	1.18%	1.07%
2005	1.46%	1.39%	1.49%	1.31%	1.38%	1.45%	1.32%	1.38%	1.32%	1.28%	1.24%	1.29%	1.14%	1.34%	1.10%	1.26%	1.36%	1.00%	1.13%
2006	1.65%	1.66%	1.58%	1.70%	1.54%	1.55%	1.68%	1.62%	1.26%	1.63%	1.30%	1.30%	1.47%	1.26%	1.51%	1.34%	1.27%	1.36%	
2007	1.70%	1.93%	1.86%	1.82%	1.72%	1.74%	1.68%	1.65%	1.69%	1.69%	1.51%	1.51%	1.53%	1.43%	1.49%	1.44%	1.46%		
2008	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%			
2009	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%				
2010	1.76%	1.76%	1.82%	1.94%	1.91%	1.84%	1.97%	1.74%	1.87%	1.94%	1.74%	1.63%	1.73%	1.82%					
2011	1.98%	1.93%	1.79%	1.66%	1.79%	1.86%	1.93%	1.66%	1.79%	1.54%	1.89%	1.82%	1.48%						
2012	2.17%	2.06%	2.10%	2.07%	1.99%	1.74%	1.83%	2.04%	1.93%	1.70%	2.04%	1.87%							
2013	2.25%	1.98%	2.05%	1.86%	2.02%	1.95%	2.18%	2.00%	2.02%	1.96%	1.85%								
2014	2.02%	1.91%	1.96%	2.02%	2.04%	1.89%	2.02%	1.87%	1.98%	2.09%									
2015	1.98%	1.84%	2.04%	1.88%	1.87%	1.85%	1.88%	1.88%	1.68%										
2016	2.38%	2.25%	2.04%	2.29%	2.15%	2.23%	2.20%	2.04%											
2017	2.07%	2.04%	2.07%	2.13%	1.91%	2.02%	1.91%												
2018	2.18%	2.19%	2.26%	2.27%	2.21%	2.23%													
2019	2.41%	2.44%	2.29%	2.44%	2.15%														
2020	2.50%	2.45%	2.52%	2.46%															
2021	2.46%	2.63%	2.41%																
2022	2.49%	2.49%																	
2023	2.45%																		

Based on the above information, we found that a constant lapse rate of 2% was a reasonable assumption for the pricing model. Note that in 2008 and 2009 there were no lapses observed and we have assumed that this was a data issue.

B.2 Investment Return and Discounting Rates

We have calculated the investment return of 8% by assuming that 80% of the portfolio was invested in government bonds with a 7% risk-free annual rate and 20% in risky assets with a 12% annual rate of return. The annual risk-free rate of 7% was derived by forecasting the next 60 years (2024-2083) with an ARIMA model whose parameters were optimised using the provided historical (1962-2023) Lumaria 1-year risk-free spot rates. A conservative 5% loading was added to the risk-free rate to arrive at the 12% desired return on capital for investments which bear risk. The graph to the left plots the predictions, lower and upper confidence intervals obtained from the ARIMA modelling of the 1-year risk-free rate. A similar approach was used to project the future 10-yr risk free annual spot rate as well as the future annual inflation rate. The predictions were 3.07% and 6.65%, respectively. A discount rate of 10% was established by combining the two rates together with a risk premium of 0.28%.

Forecasted 1-yr Risk Free Annual Spot Rate

Below are plots of the ARIMA model results which were used in deriving the discount rate.

Forecasted 10-Year Risk Free Annual Spot Rate

Forecasted Inflation
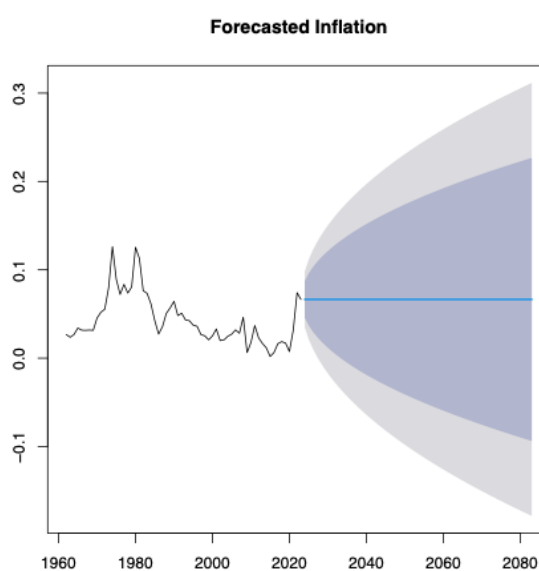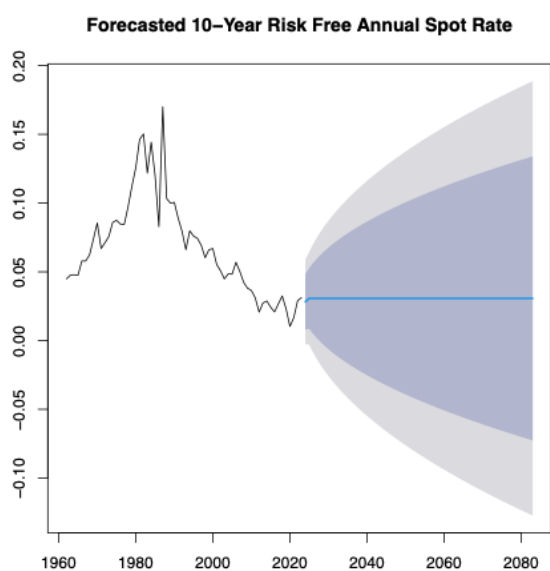
B.3 Annual Health Check-up Cost & Lumaria Universal Healthcare System

The assumption that the cost of annual health check-ups to SuperLife would be 0Č is based on the presumption that the check-ups will be conducted by general practitioners and that Lumaria has a universal healthcare system, as mentioned in the encyclopaedia entry for the country. Universal healthcare ensures that all residents of Lumaria have access to necessary health services without encountering financial obstacles. In such a system, the goal is to enhance overall health outcomes by guaranteeing access to healthcare services when and where needed. This model of healthcare does not necessarily imply that all healthcare expenses are covered, but rather that individuals have access to essential services without facing financial hardship. Given Lumaria's commitment to universal healthcare, it is reasonable to anticipate that the cost of annual health check-ups for SuperLife would be absorbed by the broader healthcare system, ensuring that policyholders can access preventive care without incurring additional expenses.

B.4 Mortality Improvement

A penalty was applied to the mortality improvement as many interventions may overlap thus reducing cumulative mortality improvement. As smokers have six interventions and nonsmokers have five interventions, the mortality improvement penalty was 60% for smokers and 50% for nonsmokers. For example, in our best estimate case, after all mortality improvements have been factored in, we would expect a mortality improvement of 42.33% for smokers. This is calculated by $1-(1-3.5\%)(1-25\%)(1-4\%)(1-7.5\%)(1-3\%)(1-7.5\%)$. A penalty of 60% is applied leaving a mortality improvement of 25.4% after considering interaction effects.

B.5 Mortality Improvement

Benefit	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
Financial Incentives	0%	0%	0%	1%	1%	1%	2%	2%	2%	3%	3%	4%
Smoker Cessation Programs	0%	0%	3%	5%	8%	10%	13%	15%	18%	20%	23%	25%
Safety Campaigns	0%	0%	0%	1%	1%	2%	2%	2%	3%	3%	4%	4%
Cancer Prevention Initiatives	0%	0%	1%	2%	2%	3%	4%	5%	5%	6%	7%	8%
Educational Workshops	0%	0%	0%	1%	1%	1%	2%	2%	2%	2%	3%	3%
Annual Health Checkup	0%	0%	1%	2%	2%	3%	4%	5%	5%	6%	7%	8%
Mortality Improvement	0%	0%	5%	10%	14%	19%	23%	27%	31%	35%	39%	42%
Mortality Improvement Post Penalty	0%	0%	3%	6%	9%	11%	14%	16%	19%	21%	23%	25%

B.6 Mortality Tables

The coefficients of the logistic regression are as follows:

- Intercept: -7.385021
- Smoker: 2.559791
- Age: 0.065499
- Sex = Male: 0.283438
- Underwriting Risk = Low: 0.146981
- Underwriting Risk = Moderate: 0.276671
- Underwriting Risk = High: 0.266938

Thus, the default policyholder is a female nonsmoker with very low underwriting risk.

Appendix C – Pricing/Costs

C.1 Pricing Methodology

To assess the economic value of the program, the present value (PV) of premium was first calculated by using the following formula:

$$PV(Premium\ at\ Policy\ Inception) = [PV(Claims) + PV(Expenses)] \times (1 + Profit\ Margin)$$

The present value of claims was dependent on mortality tables. The expenses were calculated using the assumptions previously mentioned. Profit margin was set at 10%.

Interest was calculated by:

$$Interest = Premium \times Investment\ Rate$$

Finally, profit was calculated by:

$$Profit\ Per\ Policy$$
$$= PV(Premium\ at\ Policy\ Inception) + PV(Interest) - PV(Claims) - PV(Expenses)$$

C.2 Premium Pricing Model

20-year Term life policy

To calculate expected present value of premiums for a 20-year term life policy after the incentive program is implemented, expected death payments were first calculated per year for the next 20 years for a policyholder aged "x" through multiplying the face value by mortality rate and survival probability per year.

Yearly expenses from the program were also considered and multiplied by the survival probability each year.

The expected death payment and expenses was calculated for each age per year for the next 20 years, then discounted to present value and multiplied by a 10% profit margin.

For simplicity of the calculation, reserves were not incorporated into the pricing model.

The below is an extract from RStudio noting the exact code used.

```
#The below function should be used for policies that are written before year 11

program_premium_TERM_before_year_11 <- function(age, mortality_table, face_amount, yearly_expense, smoker_expense){
  #set amounts
  discount_rate <- 0.1
  investment_return <- 0.08
  lapse_rate <- 0.02

  # Initialize vectors
  expected_death_payment <- numeric(20)
  expenses <- numeric(20)
  interest <- numeric(20)
  survival_probability <- numeric(20)
  premium <- numeric(20)
  profit <- numeric(20)
  probability_of_death <- numeric(20)
  death_probability_per_year <- numeric(20)

  #calculate the probability of death
  for (i in 1:20){
    if (i ==1){
      survival_probability[1] <- 1
      index <- mortality_table[mortality_table$Age == age + i,i+1]
      probability_of_death[i] <- as.numeric(index)
    } else {
      index <- mortality_table[mortality_table$Age == age + i,i+1]
      probability_of_death[i] <- as.numeric(index)
      survival_probability[i] <- survival_probability[i-1] - (probability_of_death[i]+ lapse_rate)*survival_probability[i-1]
    }
  }

  for (i in 1:20){
    index <- mortality_table[mortality_table$Age == age + i,i+1]
    death_probability_per_year[i] <- as.numeric(index)
    expected_death_payment[i] <- face_amount*survival_probability[i]*death_probability_per_year[i]*(1/(1+discount_rate)^i)
    expenses[i] <- yearly_expense*survival_probability[i]*(1/(1+discount_rate)^i)
    premium[i] <- (expenses[i] + expected_death_payment[i])*1.10
    interest[i] <- (premium[i])*investment_return*(1/(1+discount_rate)^i)
    profit[i] <- premium[i] + interest[i] - (expenses[i] + expected_death_payment[i])
  }

  total_premium <- sum(premium) + smoker_expense #smoker expense is a one off payment


  return(total_premium)
}
```

Single Premium Whole Life policy

For a single premium whole life policy, a similar methodology was used, however expected death payment and expenses were calculated per year for a whole life of a policyholder aged x to a maximum age of 90. These were then discounted to present value and multiplied by the 10% profit margin to find the value of the single premium a policyholder would pay for their whole life policy.

Unlike the 20-year term life policy's pricing methodology, a lapse rate was not considered as surrender values were not assumed in the valuation. Reserves were also not incorporated into the pricing model.

The below is an extract from RStudio noting the exact code used.

```r
#The below function should be used for policies that are written before year 11

program_premium_SPWL_before_year_11 <- function(age, mortality_table, face_amount, yearly_expense, smoker_expense){
  #set amounts
  discount_rate <- 0.1
  investment_return <- 0.08

  # Initialize vectors
  expected_death_payment <- numeric((90-age))  # Initialize vectors
  expenses <- numeric((90-age))
  interest <- numeric((90-age))
  survival_probability <- numeric((90-age))
  premium <- numeric((90-age))
  profit <- numeric((90-age))
  probability_of_death <- numeric((90-age))
  death_probability_per_year <- numeric((90-age))

  #calculate the probability of death
  for (i in 1:(90-age)){
    if (i ==1){
      survival_probability[1] <- 1
      index <- mortality_table[mortality_table$Age == age + i,i+1]
      probability_of_death[i] <- as.numeric(index)
    } else {
      index <- mortality_table[mortality_table$Age == age + i,i+1]
      probability_of_death[i] <- as.numeric(index)
      survival_probability[i] <- survival_probability[i-1] - (probability_of_death[i])*survival_probability[i-1]
    }
  }

  for (i in 1:(90-age)){
    index <- mortality_table[mortality_table$Age == age + i,i+1]
    death_probability_per_year[i] <- as.numeric(index)
    expected_death_payment[i] <- face_amount*survival_probability[i]*death_probability_per_year[i]*(1/(1+discount_rate)^i)
    expenses[i] <- yearly_expense*survival_probability[i]*(1/(1+discount_rate)^i)
    premium[i] <- (expenses[i] + expected_death_payment[i])*1.10
    interest[i] <- (premium[i])*investment_return*(1/(1+discount_rate)^i)
    profit[i] <- premium[i] + interest[i] - (expenses[i] + expected_death_payment[i])
  }

  total_premium <- sum(premium) + smoker_expense #smoker expense is a one off payment

  return(total_premium)
}
```
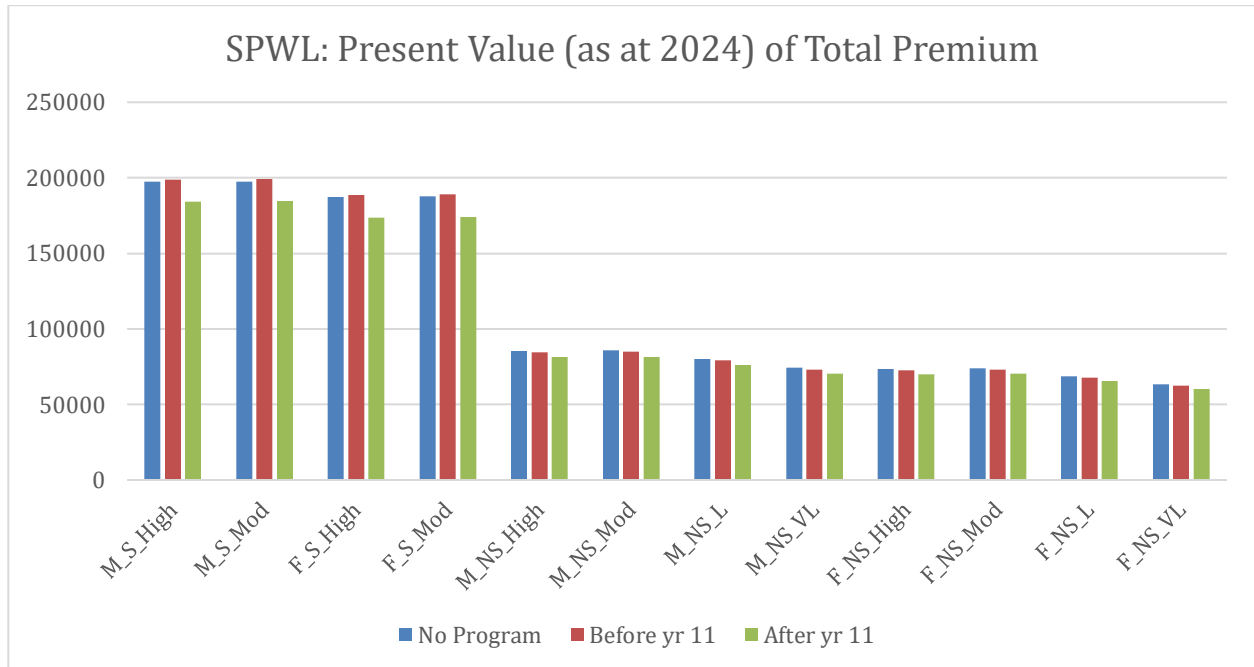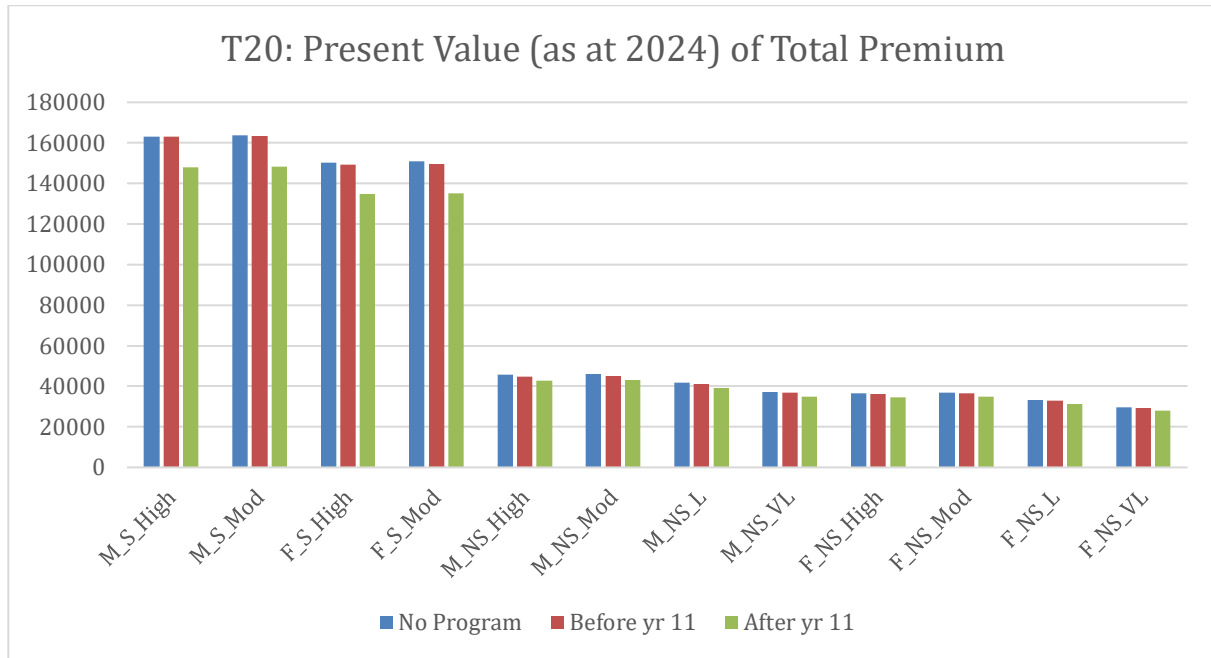
C.3 Average Premium Charged Per Segment

T20: Present Value (as at 2024) of Total Premium

SPWL: Present Value (as at 2024) of Total Premium

Appendix D – Other Areas of Interest

After analysing the data, we have found that most of the risks written by SuperLife are from regions 1 and 2. The risk types of regions 3 to 6 are not significantly different from regions 1 and 2. Due to limited data, it is unclear if Regions 3 – 6 have less risks written due to reduced population density. However, we recommend SuperLife investigates this as if population density is not the main reason, marketing efforts should be concentrated in these areas as they could present an opportunity for strong growth in sales to future new customers from regions 3 to 6.

In addition, we recommend SuperLife to pursue additional lines of insurance, that being single premium term insurance, annual premium whole life insurance, as well as term insurance with 10 or 30 contract years. Thus, SuperLife can offer more flexibility to customers, diversify its risk, and attract a larger customer base.

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