Objectives

The main objective for the proposed health incentive program is to decrease the overall mortality of policyholders by providing assistance with smoking cessation and promoting cancer awareness, alongside the objective to improve sales through increased competitiveness and marketability that ultimately adds economic value to SuperLife. By improving the mortality rates through various health incentive programs, the total profit should increase as claims amount will decrease in frequency as a result of better policyholder health. Additionally, there is also a predicted increase in sales through the offering of various benefits in health incentive programs, making the life insurance product more competitive in the market which increases the economic value of SuperLife.

In monitoring the overall success in the health incentive program on the mortality rates and sales, analysis is conducted on the difference between the expected number of deaths and new customers, when compared to the realised values. This should be analysed and monitored over both short and long term periods of 5 and 20 years to fully analyse the differing effect of the program on varying time horizons. This program should be analysed over a short period of 5 years to briefly analyse the effects of smoking cessation and cancer screenings on the mortality of policyholders, while also focusing mainly on the maintenance of cash flows due to heavier early investment for the smoking cessation program.

To analyse the more long-term effects of the program, a 20 year monitoring period has been suggested to allow for an observational period which wholly encompasses the lifetime of the term insurance of 20 years. This allows for a more detailed monitoring of the predicted mortality model’s accuracy throughout the lifetime of the term insurance and the realised effect of the program on mortality rates for policyholders.

Program Design

Our proposed health incentive program comprises two main sections: smoking cessation, and cancer awareness. These two initiatives aim to reduce the overall mortality of policyholders through targeting policyholders more susceptible to death, to achieve lower claims frequency.

The smoking cessation program, which will only be offered to smoking policyholders, aims to assist with smoking cessation through the use of Bupropion and proactive telephone counselling (Shearer & Shanahan, 2007). The cost of this program will be fully covered by SuperLife for the first year and 50% covered for any recurring years afterwards, to encourage participation from smoking policyholders. Ideally, through participation in this smoking cessation program, current smokers will be able to cease smoking and greatly improve their survival rates through abstinence. This would allow for a decrease in expected mortality for smokers as well as the frequency of term insurance claims, resulting in higher net profit.

Smokers, in particular, were chosen as a main focus for the health incentive program due to their significant impact on mortality. This was identified during the exploratory data analysis phase using a Cox-proportional hazard model to model mortality. While fitting the Cox-proportional hazard model, it was discovered that the most statistically significant variables (alpha = 0.05) were policy type, issue age, sex, and smoker status. To avoid multicollinearity, the underwriting class was omitted since it was a profiling variable based on the other covariates. As depicted in Figure 1, the most notable variable was smoking status, with smokers having 782% relative risk compared to non-smokers. Hence, the notion of smoking was greatly considered during the designing of our health incentive program, with smoking policyholders especially targeted to improve their overall mortality rates.

```
  n= 978582, number of events= 40376

                                      coef  exp(coef)   se(coef)        z Pr(>|z|)    
Policy.typeT20                  -1.969e-01  8.212e-01  1.343e-02  -14.663  < 2e-16 ***
Issue.age                        7.815e-02  1.081e+00  6.286e-04  124.327  < 2e-16 ***
SexM                             2.224e-01  1.249e+00  1.112e-02   20.008  < 2e-16 ***
Face.amount                     -4.148e-09  1.000e+00  7.809e-09   -0.531    0.595    
Smoker.StatusS                   2.057e+00  7.825e+00  1.377e-02  149.372  < 2e-16 ***
Underwriting.Classlow risk      -1.278e-01  8.800e-01  1.805e-02   -7.081 1.44e-12 ***
Underwriting.Classmoderate risk -1.582e-03  9.984e-01  1.430e-02   -0.111    0.912    
Underwriting.Classvery low risk -2.721e-01  7.618e-01  1.766e-02  -15.405  < 2e-16 ***
Urban.vs.RuralUrban              5.582e-03  1.006e+00  1.037e-02    0.538    0.590    
Region                           1.327e-03  1.001e+00  2.986e-03    0.445    0.657    
Distribution.ChannelOnline       1.424e-01  1.153e+00  1.459e-02    9.758  < 2e-16 ***
Distribution.ChannelTelemarketer 1.221e-02  1.012e+00  1.294e-02    0.943    0.346    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Figure 1: Cox-Proportional Hazard Model Variable Outputs

To target another significant cause of death, a cancer awareness program was also implemented to help reduce the overall mortality of policyholders. With ignorance and late detection being the root causes of death from cancer, this program aims to inform policyholders through an online awareness program that provides insight into the different methods to prevent and identify key cancer causes. To encourage participation in the online program, a $200 voucher towards a cancer screening or CT scan would also be provided yearly to all policyholders who have successfully completed the cancer awareness course, to assist in facilitating early detection of cancer. This would lower the overall mortality as deaths due to cancer would decrease from early detection and treatment.

As a key variable in mortality which affects all policyholders, cancer was nominated as a dominant cause which required mitigation interventions. This was identified through exploring the causes of death of SuperLife policyholders, which illustrated the overwhelming number of deaths due to Neoplasms and Diseases of the

Circulatory System in Figure 2. Being the highest cause of death, there were two main types of neoplasms which needed to be addressed: benign (not cancer) or malignant (cancerous). As malignant neoplasms (cancer) is the most likely cause of death, there was a need for cancer prevention within the proposed health incentive program to reduce the overall mortality rate and encourage a healthier lifestyle.

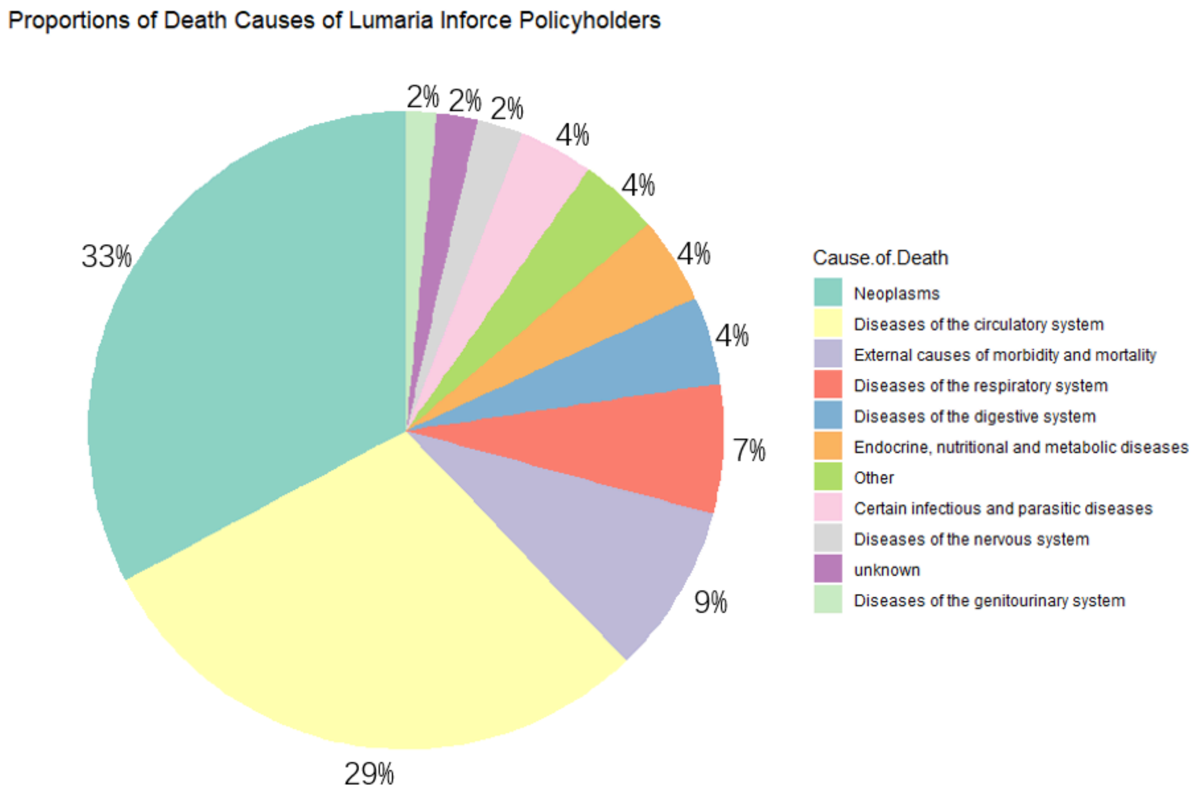


Figure 2: Pie Chart of Causes of Death for Policyholders

Both of these programs were monitored over a short and long-term period of 5 and 20 years. The short-term period of 5 years was chosen to prevent smokers from relapsing and ensuring the effectiveness of the smoking cessation program. According to Gilpin et al. (1997), the continuous abstinence rate only surpassed 90% after a 3 to 4 year duration of smoking abstinence, hence monitoring the program over a short term of 5 years would allow for at least 90% certainty of smoking discontinuation.

Furthermore, since cancer screening is a more long-term intervention, the choice of a 5 year time horizon for the short-term monitoring was unaffected by the cancer awareness program. Instead, the effects of this program were monitored during the long-term period of 20 years. This time frame was chosen to allow for an observational period which encompassed the entire lifetime of a term insurance policy. For both of these time periods, monitoring should be conducted and compared to the expected model to verify the accuracy and assist in the modification and improvement process of the model.

Pricing/Costs

To determine the economic value and overall profit of the proposed program, annual in-force policyholder data was projected over a 20 year period alongside corresponding interest rates (Appendix A) and mortality. The empirical mortality was selected as a benchmark for evaluating model performance, with various models tested before the Whittaker-Henderson smoothing model was selected to project mortality (see Appendix B). Focusing on the insurance benefit created by the proposed program, profits were evaluated as incremental quantities, meaning initial expenses and frictional costs were excluded from the calculation. Projection methods can be found in Appendix C with the detailed formula in Appendix D.

Following the modelling and projecting methods listed above, a prediction was able to be made about SuperLife's mortality savings if the health incentive program was implemented for the past 20 years. Historical inflation values were used to calculate the current value at the end of 2023 of death benefits paid from inforce dataset. Then using our life tables, we calculated the expected value of historical payments from our model before and after our proposed interventions.

Real Payments	Expected (Pre-intervention)	Expected (Post-intervention)	Expected Mortality Savings
31.31 billion Lumarian Crowns	30.39 billion Lumarian Crowns	26.35 billion Lumarian Crowns	4.04 billions Lumarian Crowns

Table 1: Comparison of Mortality Savings for the past 20 years

In addition to this, the economic value of the proposed program was also projected for future time periods of 5 and 20 years. Over the short-term timeframe (years 2024 to 2028) of five years, increases in profit were gradually accumulated as expenses lessened over the duration of a policy. The profitability is also heavily driven by large face amounts as seen by the skewed statistic of the mean being significantly larger than the median. A complete table of increase in profits per Č1,000 death benefits of all projected years is in Appendix E.

Year	Median	Mean
2024	83.96	425.18
2025	84.82	436.24
2026	85.35	447.44
2027	85.95	458.53
2028	86.76	468.30

Table 2: Increase in profits per Č1,000 death benefits with the program

Economic benefits were also analysed through profits for the long-term period of 20 years, which confirmed the health incentive program to be a profitable endeavour through the positive 25 percentile. Additionally, the average median is larger than the mean in the long term, which contrasts the presented values for the short-term profits and demonstrates a more left skewed distribution in profits.

Min	Q1	Median	Mean	Q3	Max
-29.39	12.93	534.51	507.08	980.87	1227.73

Table 3: Avg. statistics of increase in profits per Č1,000 death benefits with program

As a result of implementing the health incentive program, there has been an increase in overall premiums for all policyholders. Table 3 below displays the distribution of premium increases after introducing the proposed program, where the maximum increase could be lowered to optimise sales. This is further heightened through the analysis of projected total profits (see Appendix E). With projected profit of $889 billion in 2043, SuperLife could afford to sacrifice a portion of premium revenue for sale quantity through lower premiums. This would increase the overall competitiveness of SuperLife's life insurance policies through offering multiple health benefit programs. Also, policies with higher face amounts would be affected more by this increase as seen in the left skewed distribution.

Min	Q1	Median	Mean	Q3	Max
-355.72	5.07	12.74	24.16	30.60	105.36

Table 4: Avg. statistics of premium increase per Č1,000 death benefits with program

Assumptions

During the analysis of the health incentive program on our objectives, we have made a few assumptions which are briefly listed below and expanded upon in Appendix F.

- No selection behaviour bias upon entry into the program.
- Lapse rate remains unchanged after the introduction of the health incentive program.
- Future demographic changes are expected to follow patterns observed in the past.
- The effects on mortality of the smoking cessation and cancer awareness program are independent.
- Negligible mortality improvements over calendar year
- Existing premium rates do not change over time.
- Premium payments occur at the start of the period whilst death and lapses occur at the end.
- Policy term begins immediately after the policyholder's xth birthday.
- Stationary interest rates.

- Growth rate of reserves follows the inflation rate.
- Reduced mortality rates from cancer screening is constant over age.
- Gender ratio converges to 1:1 as seen on latest issue year data.
- Modelled covariates, except for smoker status, are independent.
- For smokers, the conditional distribution of other covariates reflects an average of the latest 3-year trend.
- Smoking cessation impacts mortality rates exactly 4 years after commencing.
- All policyholders will participate in the health incentive program.

The cost of the health incentive program is composed of both a fixed and variable component, with only the variable component susceptible to changes due to various assumptions. The main factor that impacts costs of the program is assuming 100% participation from policyholders for the entire program. However, this is most likely not the case since the program is optional, resulting in a potential overestimation of program costs.

Additionally, an assumption was also made on the effects of smoking cessation on mortality rates. It was deduced that mortality impacts would occur 4 years after program commencement, which was based on the 90% continuous abstinence rate in Gilpin's (1997) research. This assumption was used to surmise that smoking cessation program costs only last for a total of 4 years, resulting in potential undermining of program costs if smoking policyholders were to participate in the program longer than expected.

Furthermore, the assumption of the effect of cancer screening on mortality rates is surmised to be constant over age. Due to the limitations of data and available research, this assumption was created to facilitate ease of applying the effect of cancer screenings on general mortality. This is a significant assumption as profit modelling is extremely dependent on mortality rates to determine the general revenue and costs, impacting the overall profit.

Risk and Risk Mitigation Considerations

There are a multitude of risks that can potentially impact the proposed health incentive program. Some of these are listed and categorised below.

Quantitative	Qualitative
Inflation Risk: Long-term policies are susceptible to rising costs.	**Participation Risk:** Policyholders may not actively participate, leading to a suboptimal outcome
Adverse Selection Risk: When more individuals with higher	**Communication / Education Risk:** Policyholders may not understand or

health risks participate, leading to an imbalanced risk pool.	have a lack of awareness of the benefits that the program provides.
Underwriting Risk: Inappropriate assessment of policyholder's key risk features.	**Motivation Risk:** Over time, participants may lose interest in the program
Demographic Risk: Programs may lead to demographic shifts which affect risk profiles and pricing assumptions.	**Inaccurate Information Risk:** Giving incorrect or misleading information about cancer prevention or early detection.
Market Competition Risk: Emerging insurers may disrupt the market and affect demand.	**Accessibility Risk:** Policyholders with disabilities may face issues during the program.
Surrender Risk: Policyholders lapsing more than expected	**Unexpected Behavioural Risk:** Quitting smoking may lead to new unhealthy behaviours.
Catastrophic Events Risk: Unexpected large-scale health events can impact claims.	**New Regulations Risk:** New regulations for smoking may affect the program.

While these risks aren't an extensive list, the most significant risks and potential risk mitigation strategies have been summarised below:

Risk	Mitigation Strategy
Inflation Risk: Long-term policies are susceptible to rising costs.	- Build inflation protection into pricing models - Set aside reserves for future costs
Adverse Selection Risk: When more individuals with higher health risks participate, leading to an imbalanced risk pool.	- Transfer excess risk to reinsurers - Account for this risk in the model
Underwriting Risk: Inappropriate assessment of policyholder's key risk features.	- Conduct comprehensive evaluation of policyholder attributes at entry
Participation Risk: Policyholders may not actively participate, leading to a suboptimal outcome	- Regular communication about benefits - Reach out to inactive participants - Include additional incentives
Communication / Education Risk: Policyholders may not understand or	- Consistent and proper marketing - Content is well presented

have a lack of awareness of the benefits that the program provides.	
Motivation Risk: Over time, participants may lose interest in the program	- Give annual rewards like subsidy on screening if program has been completed

To test the limits of these risks, a sensitivity analysis was conducted to portray the effects of key financial impacts on the profit as depicted in Figure 3. The key financial impacts assessed were interest rate, cost of incentive programs and policy lapse rate. A size of 20% change has been tested in both favourable and unfavourable sensitivities: base case, best case (high interest, low cost, low lapse), worst case (low interest, high cost, high lapse). Under all cases, there is a steep increase in profits due to the lagged contribution of the incentive programs via mortality savings. This cautions the company to hold sufficient liquid capital for investment in earlier years to cover program expenses prior to the increase in profit.

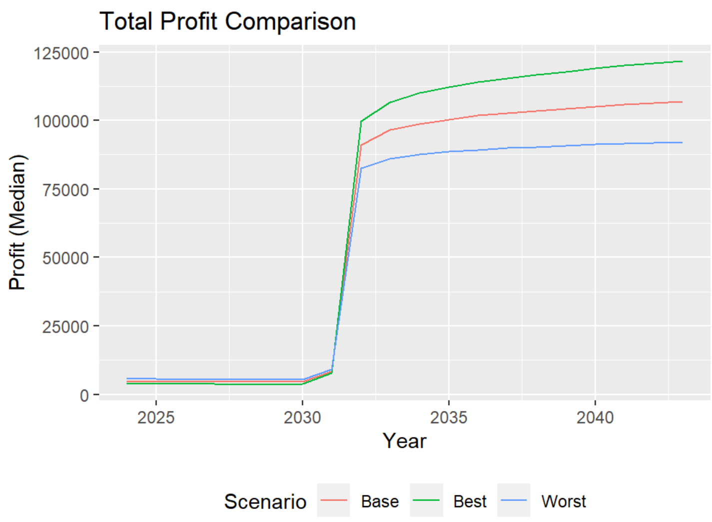


Figure 3: Sensitivity Analysis for Profit

In addition to this, risks relating to degrees of certainty of projected values have also been analysed. With regards to the predicted lower mortality for the past 20 years, there is an average degree of certainty for its accuracy. This is due to the outdated data sources and research papers that have been referenced for the projected mortality decreases, however it is certain that the proposed health incentive program will decrease mortality as a whole since it has been scientifically proven multiple times to have an effect on mortality. For the value of the policies, there is a relatively high degree of certainty that the value of policies with the program will exceed the policies without. This is due to the innate features of the proposed program, which inherently increases the benefits for both the company and policyholders. While the increased value could potentially be minimal for non participating policyholders, the program still produces value since it becomes more competitive in the market.

Data and Data Limitations

Data Source	Limitation	Impact on Analysis
JAMA Network	- The study grouped participants into four broad racial / ethnic related categories. Doesn't capture the full diversity. There is a risk of heterogeneity. - Information on smoking habits were collected at a single point. Meaning that they didn't follow up with participants to see if they've relapsed or completely quit. - Study did not separate based on disease status	- For the smoking cessation impact on mortality rates - RR values used to adjust mortality rates of smokers (at different ages) - Impacts profit
Science Direct	- Homogeneity assumptions: Not accounting individual differences - Only one intervention model per quit attempt. Doesn't consider multiple interventions that a smoker might take - Only follows a six month measure for abstinence - The findings of the combined interventions (hybrid ones) were based on a single trial.	- Cost of smoking program - Impacts profit
International Agency for Research on Cancer - World Health Organization	- Quality and completeness of cancer registry data vary between countries (but the data source itself is from the best available data at the time)	- Cancer death rates - Data relevancy
National Library of Medicine	- Sample size needs to be larger to determine a significant reduction in all-cause mortality - Fixed attendance rate assumption: varying rates could significantly have an significant effect - Excluding cervical and prostate cancer due to lower mortality rates and high mean age at death affecting the whole	- Mortality rate changes for cancer program (didn't use lung) - Impacts profit

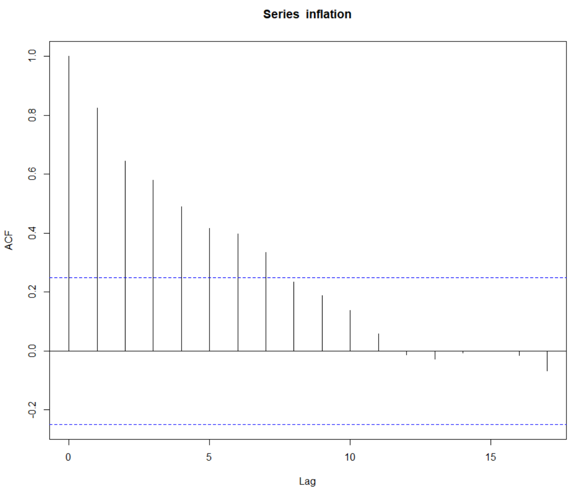
	purpose of an all-cause mortality study - Breast and lung cancer did not include deaths due to cancer treatment which could underestimate mortality in early years of screening	
Oxford Academic - Journal of the National Cancer Institute	- Cohort studied is from California, may not represent whole population - Data on smoking status is self reported introducing bias - Abstinence definition assumption does not guarantee absolute success in quitting smoking. (self reported cessation for more than 3 months is success) - Data relevancy (I'm putting this here in case we change our mind that the relevancy of the data is related to limitations of the data source)	- Quitting time period - Data may not be relevant (it is a report published at 1997)[
Society of Actuaries	- AI generated data - Only has static variables (i.e. smoker status could change over time) - Not a representative sample of Lumaria - Only over the lifetime of 1 term insurance	- Everything - Many assumptions were made based on the limited data that was provided

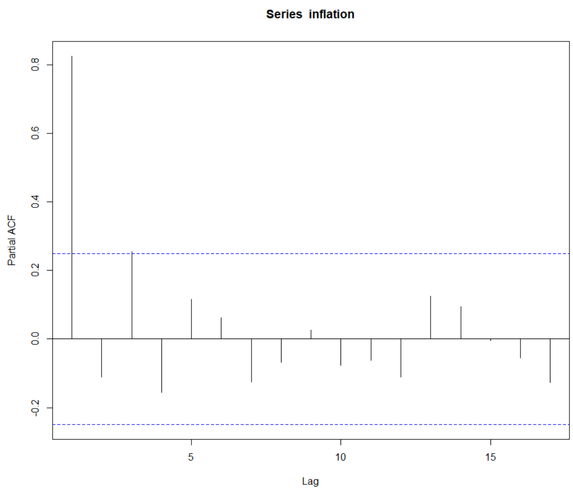
<u>**Appendix**</u>

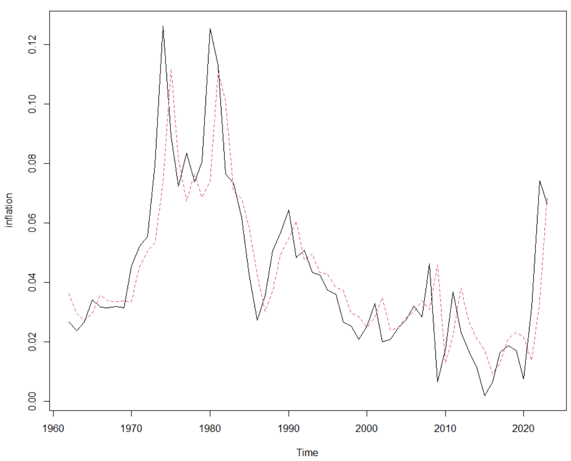
Appendix A - Interest Rate Modelling

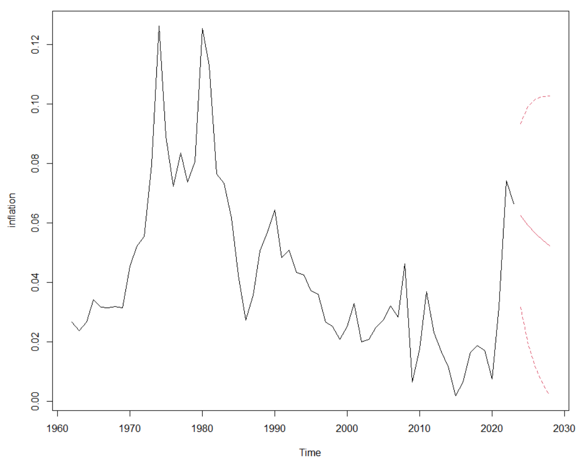
ARMA models were used to model each interest rate. After consulting ACF and PACF graphs, AR models appeared to be the best fit for each of the 4 rates. Models were then fitted and used to forecast interest rates over the next 5 years (2024-2028) with 95% CI.

Inflation: AR(1)

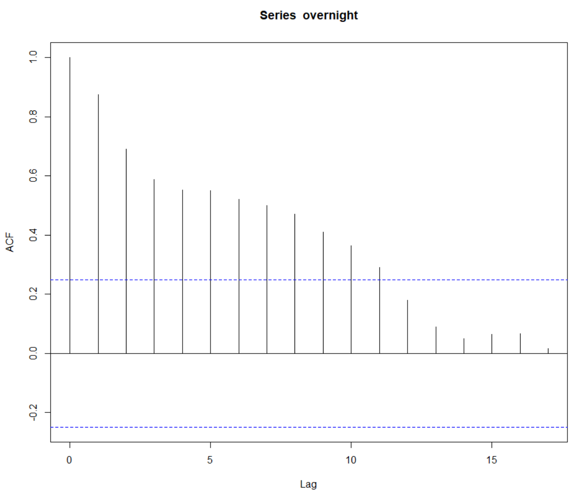


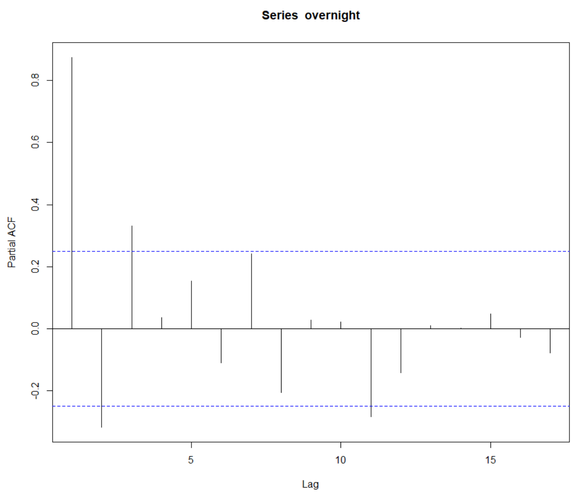


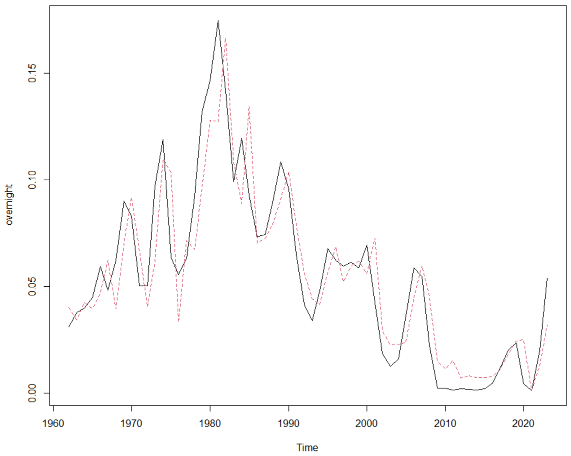


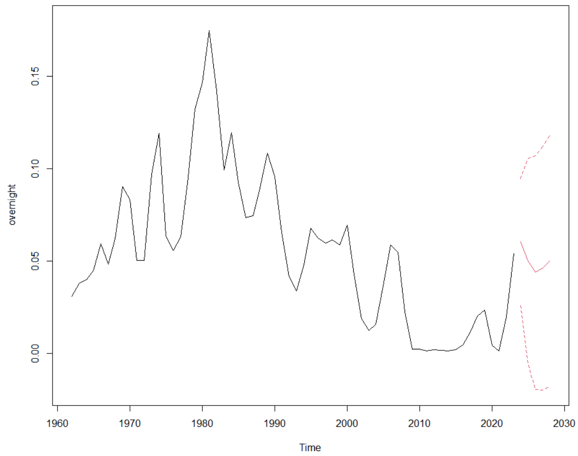


Government Overnight Rate: AR(3)

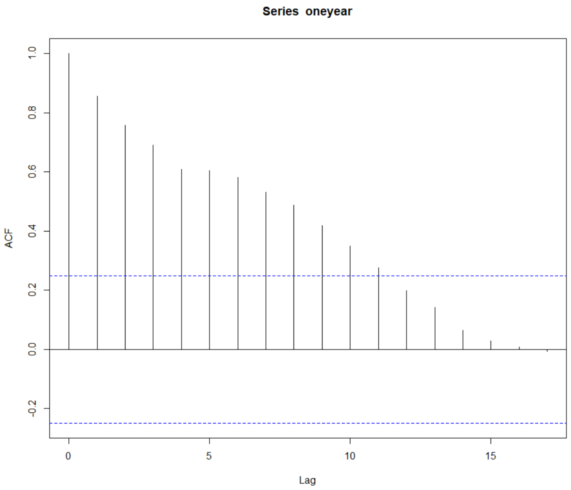


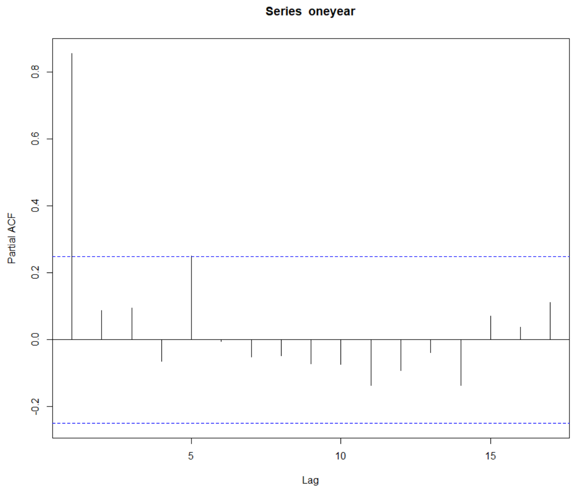


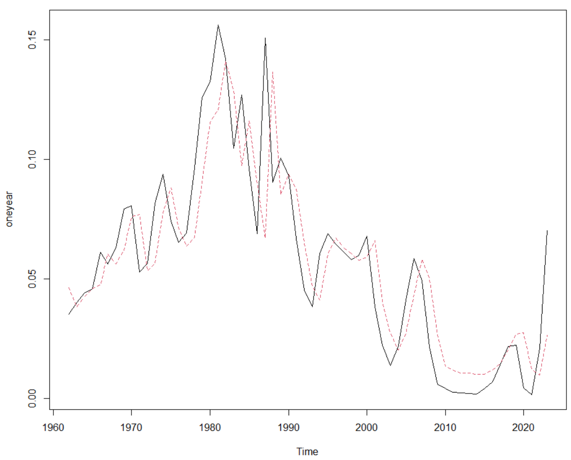


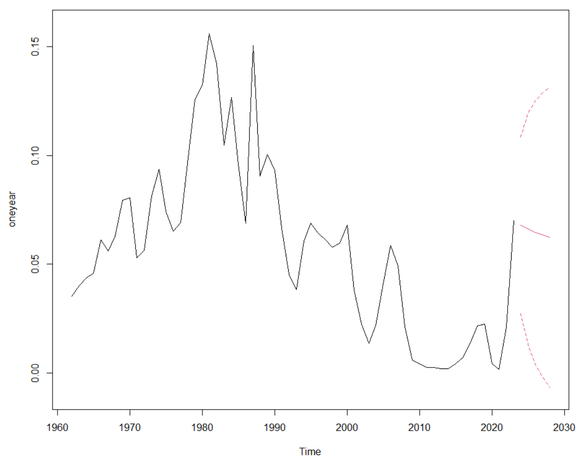


1-year spot rate: AR(1)

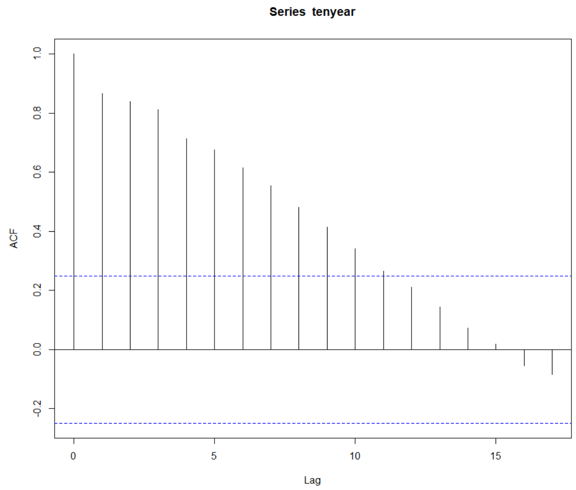


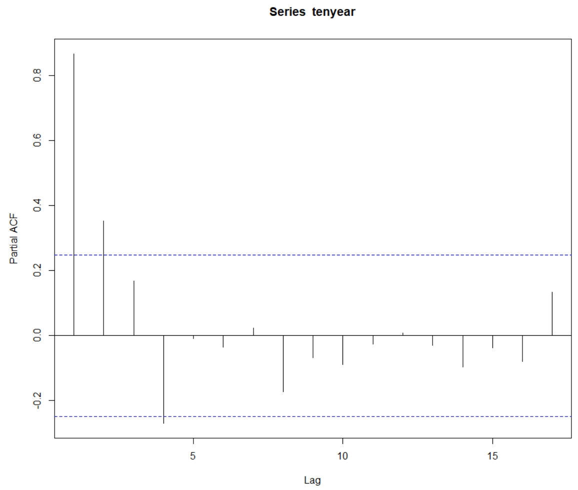


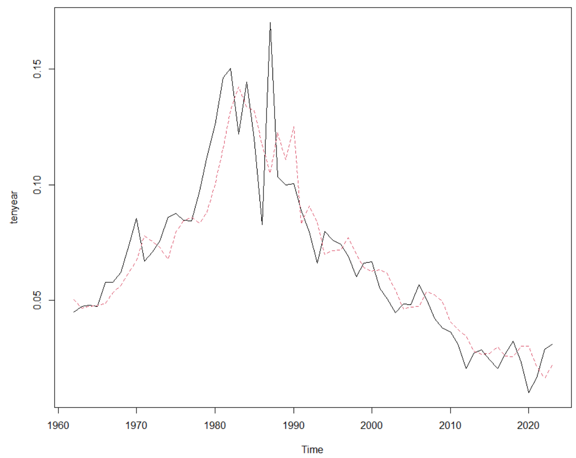


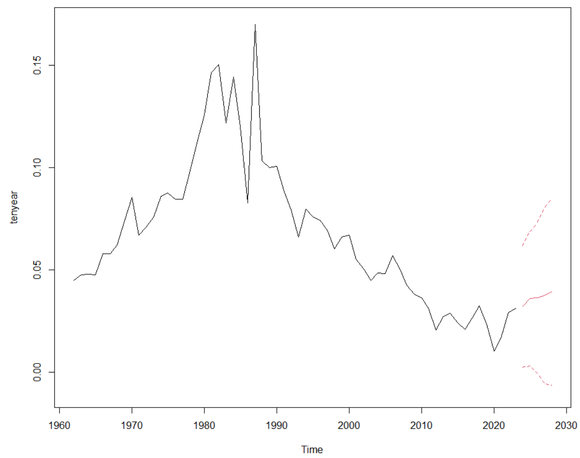


10-year spot rate: AR(4)

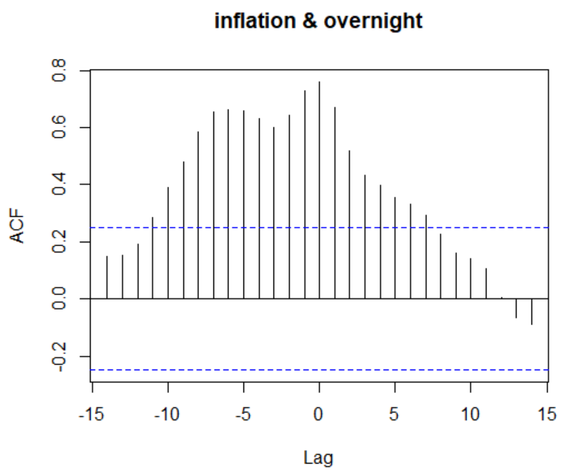


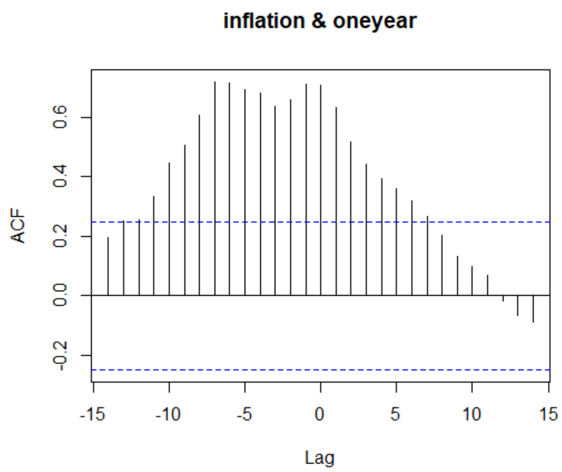


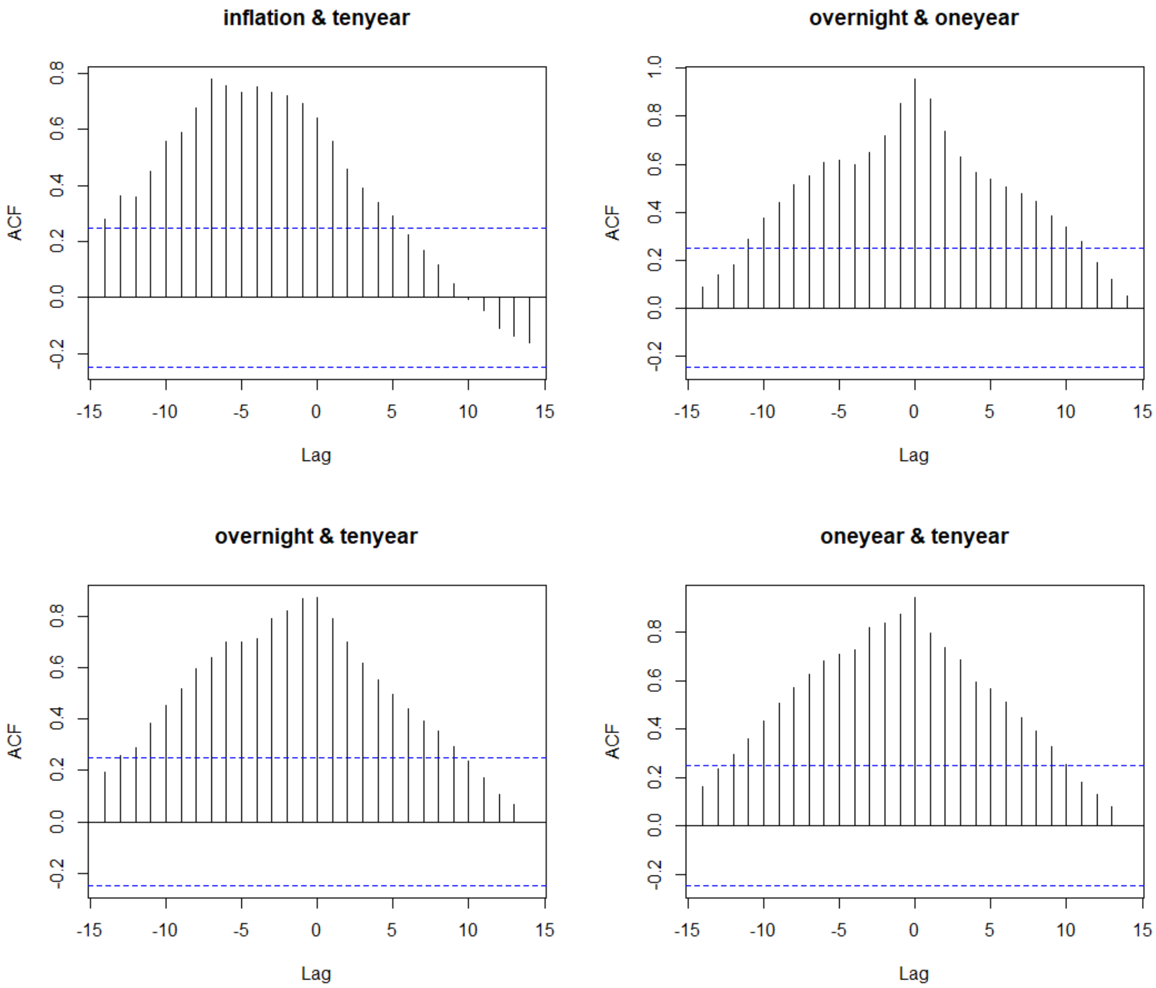




Cross-correlation graphing showed very high correlation at lag 0 between all interest rates, therefore interest rates can be assumed to decrease and increase together when evaluating interest rate risk.






inflation & tenyear
overnight & oneyear
overnight & tenyear
oneyear & tenyear
ACF
Lag

Appendix B - Mortality Modelling

Mortality Modelling - EDA with parametric models:
Within our mortality modelling, we explore various methodologies ranging from cox-proportional hazard models to Accelerated-Failure-Time (AFT) models.

Cox-proportional hazard model:
Cox-proportional hazard model is a popular framework in survival analysis for handling censored time-to-event data, such as in the insurance framework of simulating death of a policyholder. However, the model has a major reliance on a rarely-satisfied assumption in real-world data, which involves that the hazard risks of the underlying covariates are proportional and independent of time.

By conjuring a new variable within the inforce-dataset for tenure length (i.e. length of policyholder's tenure before lapse or death), we can fit a cox-proportional hazard model using all other covariates. To avoid interaction effects between covariates, we also fitted a cox-proportional hazard model against each individual covariate. In either case, we yield that the most statistically significant variables (alpha = 0.05) are Policy_type, Issue_age, Sex, and Smoker status. To avoid multicollinearity, we omit the use of an underwriting class which is a profiling variable based on the other covariates.

Figure B.1 Cox-Proportional Model Significance Test

```
Concordance= 0.749  (se = 0.002 )
Likelihood ratio test= 54949  on 12 df,   p=<2e-16
[illegible]
n= 978582, number of events= 40376

                                      coef  exp(coef)   se(coef)       z Pr(>|z|)    
Policy.typeT20                  -1.969e-01  8.212e-01  1.343e-02 -14.663  < 2e-16 ***
Issue.age                        7.815e-02  1.081e+00  6.286e-04 124.327  < 2e-16 ***
SexM                             2.224e-01  1.249e+00  1.112e-02  20.008  < 2e-16 ***
Face.amount                     -4.148e-09  1.000e+00  7.809e-09  -0.531    0.595    
Smoker.StatusS                   2.057e+00  7.825e+00  1.377e-02 149.372  < 2e-16 ***
Underwriting.Classlow risk      -1.278e-01  8.800e-01  1.805e-02  -7.081 1.44e-12 ***
Underwriting.Classmoderate risk -1.582e-03  9.984e-01  1.430e-02  -0.111    0.912    
Underwriting.Classvery low risk -2.721e-01  7.618e-01  1.766e-02 -15.405  < 2e-16 ***
Urban.vs.RuralUrban              5.582e-03  1.006e+00  1.037e-02   0.538    0.590    
Region                           1.327e-03  1.001e+00  2.986e-03   0.445    0.657    
Distribution.ChannelOnline       1.424e-01  1.153e+00  1.459e-02   9.758  < 2e-16 ***
Distribution.ChannelTelemarketer 1.221e-02  1.012e+00  1.294e-02   0.943    0.346    
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Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```
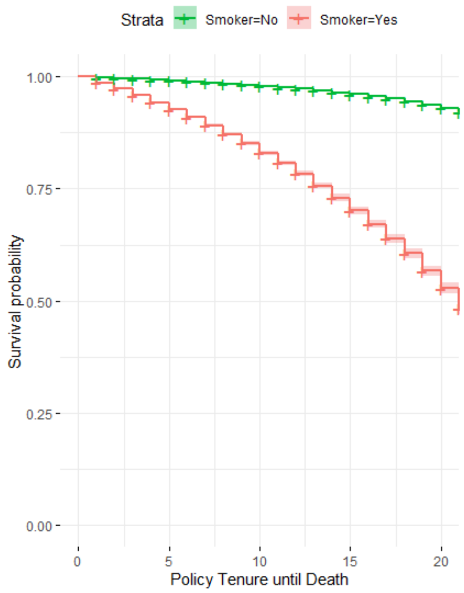

Most notably from the covariate values, we notice that smokers have the most significant effect on mortality with roughly a 7.8x relative risk compared to non-smokers. This motivated our incentive program to specifically target this segment.

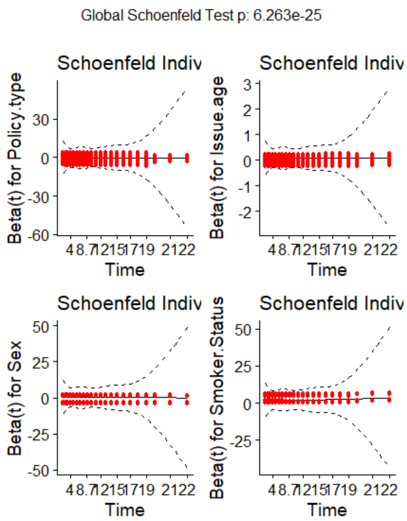
Figure B.2 Smoker vs Non-Smoker K-M Fit



Unfortunately, using a scaled Schoenfeld residuals test, we can see that the cox proportional assumption is violated on a model built using the significant covariates aforementioned. This motivates us to explore alternative models, such as the AFT which does not rely on the assumption.

Figure B.3 Scaled Schoenfeld Residuals Test

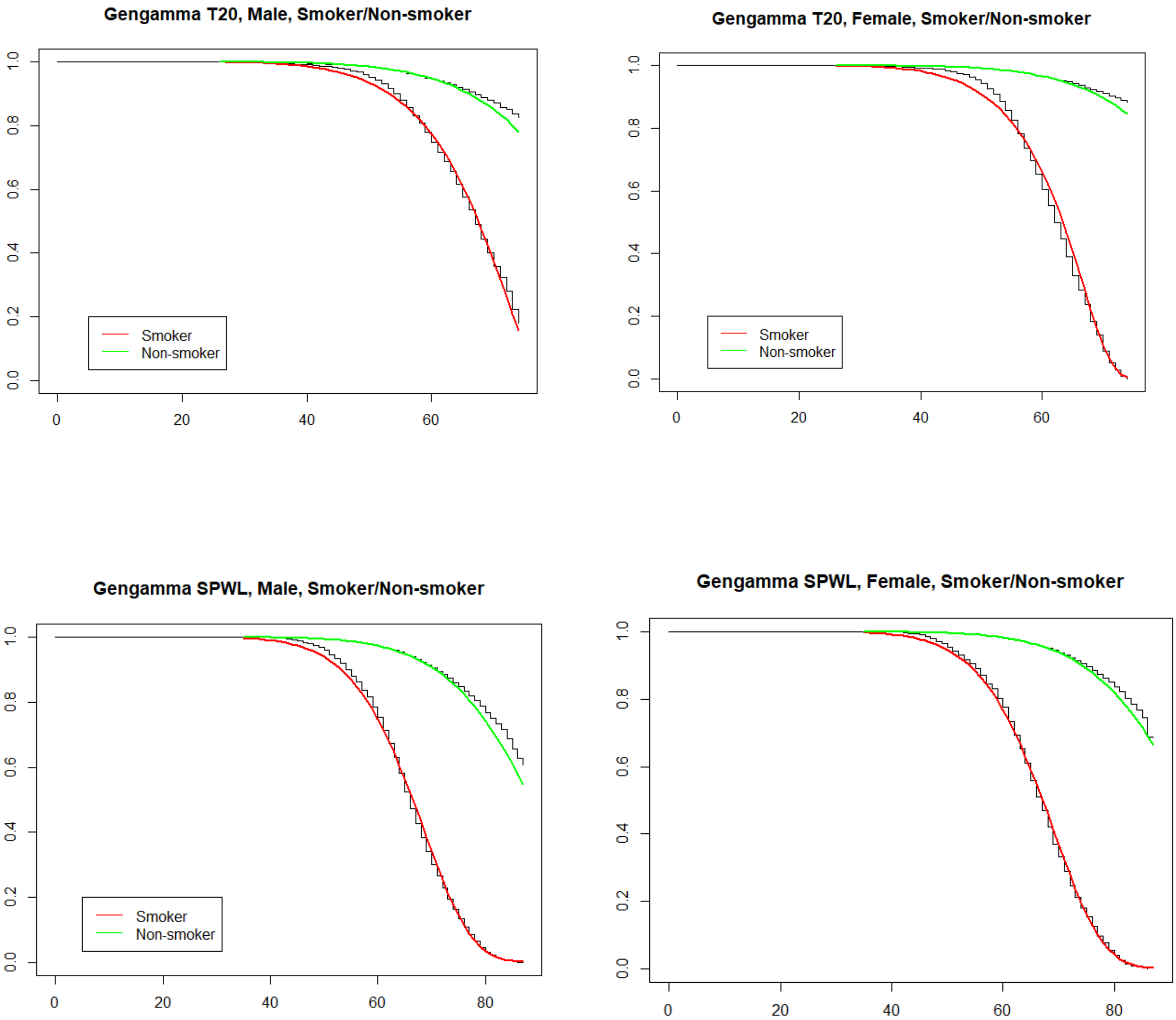
	chisq	df	p
Policy.type	6.10	1	0.014
Issue.age	35.64	1	2.4e-09
Sex	2.01	1	0.157
Smoker.Status	62.98	1	2.1e-15
GLOBAL	119.68	4	< 2e-16



Accelerated Failure-Time Model:

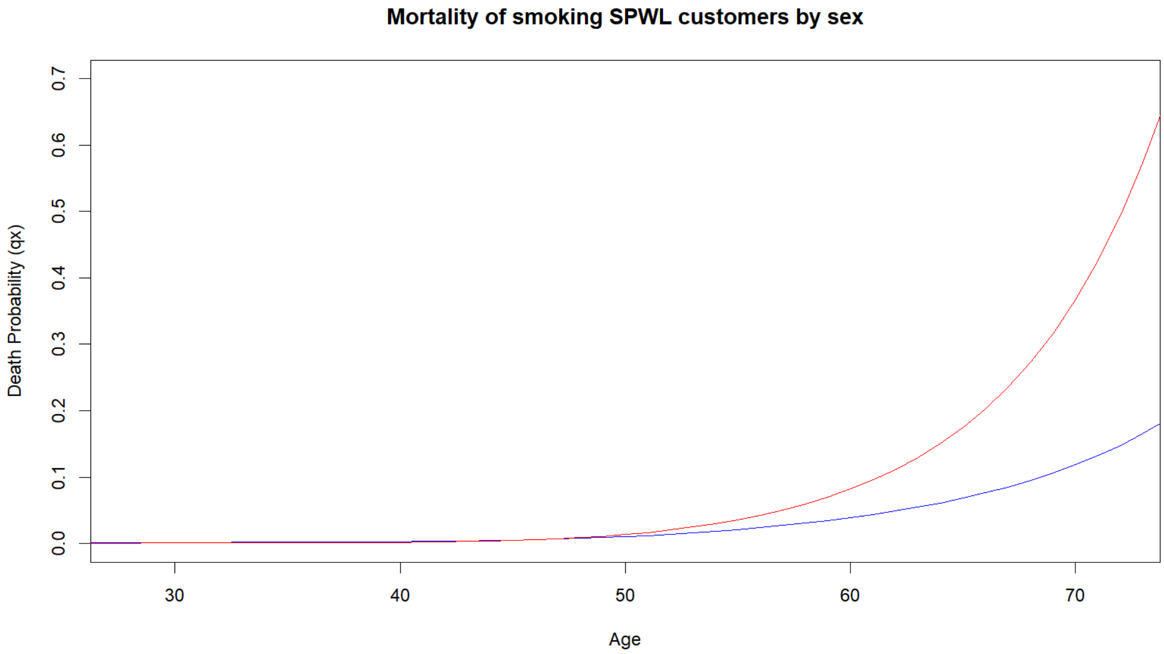
Accelerated failure-time model gives us a fully parametric approach to modelling mortality, conditional on the user making an assumption of the underlying distribution of life-time. In this approach, we are forced with the assumption of uninformative entry as we create a new covariate for life-time based on policy tenure added to the issue age. As we had the leverage of a large dataset, a segmentation between policy_type and sex was done to isolate smoker_status as the only variable in the AFT model to improve interpretability. AFT models using different underlying distributions across weibull, gamma, lognormal, and gengamma were tested on each segment and ultimately gengamma yielded the best fit across all. (See above graphs). However, while the model fitted KM well, it failed to fit with the empirical mortality rate generated. Ultimately, we conclude to use alternative non-parametric approaches for this dataset.

Figures B.4-7
Plots of Gengamma Model VS Kaplan-Meier on Different Policyholder Segments

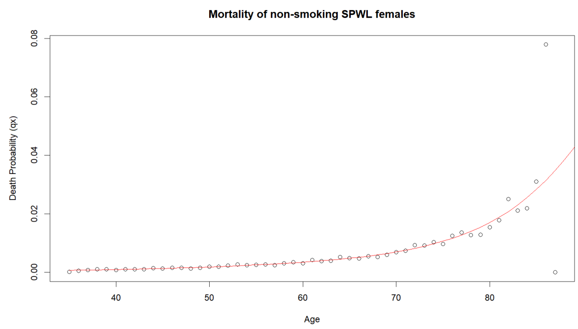


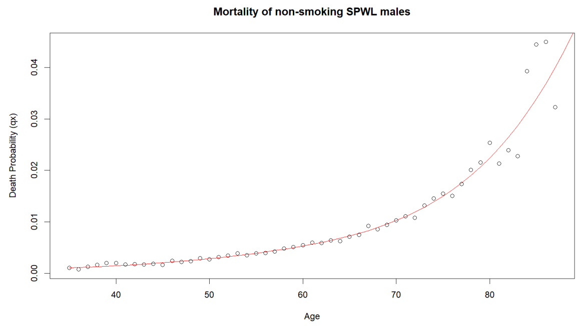
Final Mortality Model:

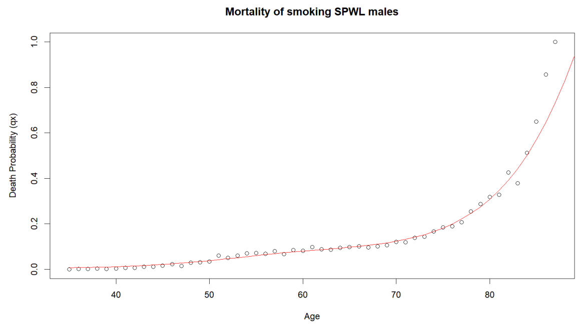
Mortality modelled using Whittaker-Henderson smoothing applied on the inforce dataset. "Whittaker-Henderson smoothing is a gradation method aimed at correcting the effect of sampling fluctuations on an observation vector. (Revisiting Whittaker-Henderson Smoothing). We chose to use this method after testing other parametric/semiparametric models that included the use of covariates. However, when viewing the dataset, some patterns could not be explained by a parametric model while maintaining simplicity (e.g. within the SuperLife customer base, female smokers have higher mortality than male smokers but male nonsmokers have higher mortality than female nonsmokers).

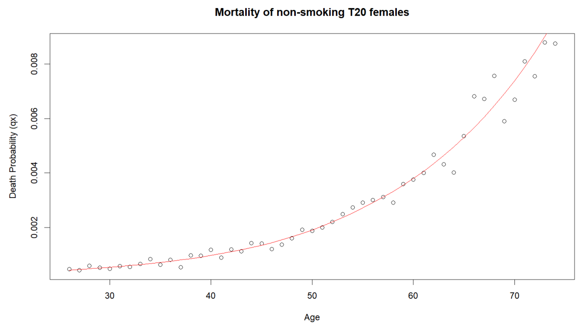


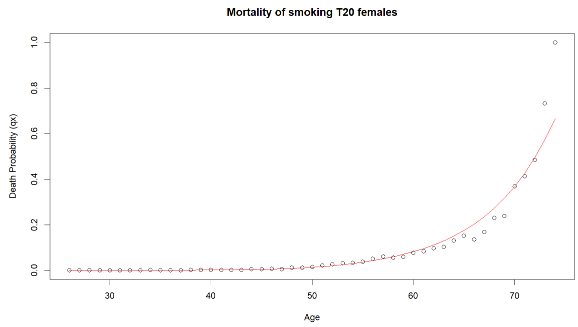
From our initial data analysis, policy type, sex and smoker status were found to be critical factors, so we modelled each of these subsets using Whittaker-Henderson smoothing to form a set of life tables. (ref. images) As this was taken directly from inforce dataset, the model fitted the data extremely well except for some outliers for the youngest and oldest ages where low sample size caused a high variance in observed mortality. Whittaker-Henderson smoothing is limited as it does not project mortality outside the age range of provided data. For the 20 year term insurance product, this did not matter as all recorded customers were between age 26-55, so the oldest customer still inforce would be in their age 74 year, which the data set still has data for. For the single premium whole life, an exponential distribution was used to extrapolate missing data from 87 up to age 120. Limited in accuracy at very high ages, may not be representative of real mortality as it increases sharply at 90-100+.

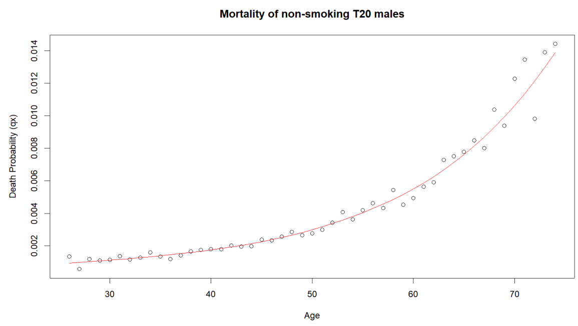


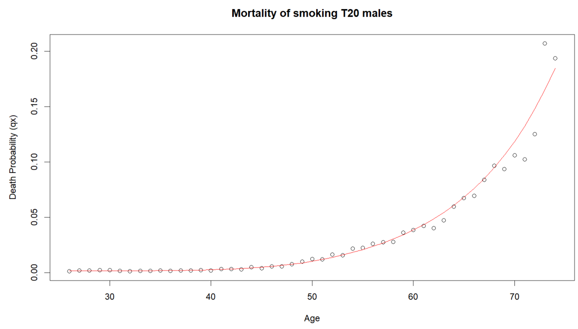






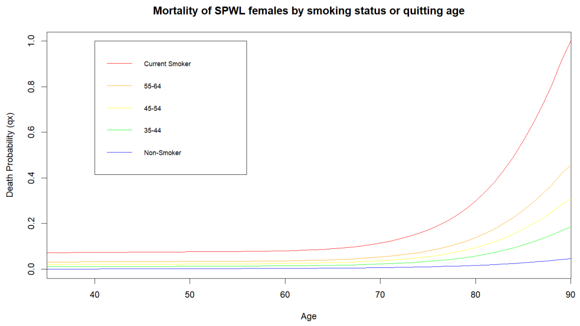


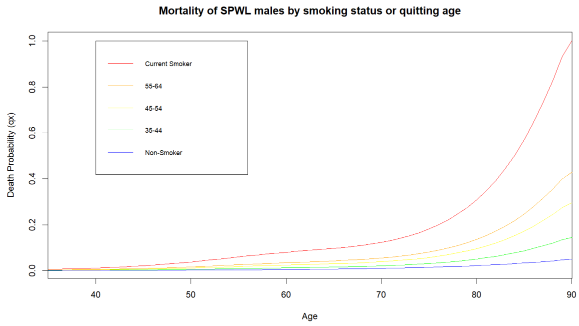


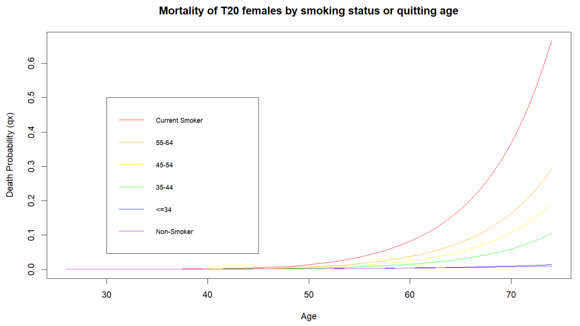


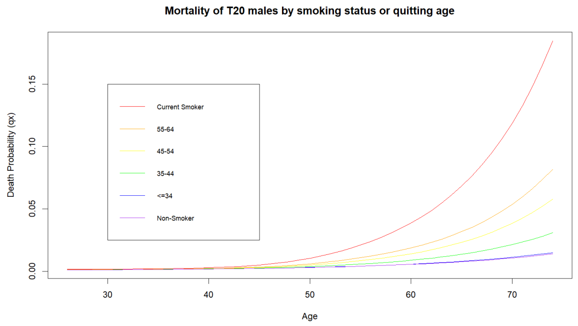
The effects of our health programs were added into our life tables by modifying the 1-year mortality rate. For smoking we used all-purpose mortality data and applied the age and sex based hazard rate to create new life tables for each age category where someone could quit smoking, applying linear interpolation using our existing mortality for nonsmokers and smokers (assumes all non smokers are never smokers and not ex smokers).

For cancers, we used the study from the [National Library of Medicine] which showed that their model had a 7/1000 reduction in all purpose mortality from breast cancer and 5/1000 for colorectal cancer from applying screening, so mortality in each year was multiplied by this reduction.









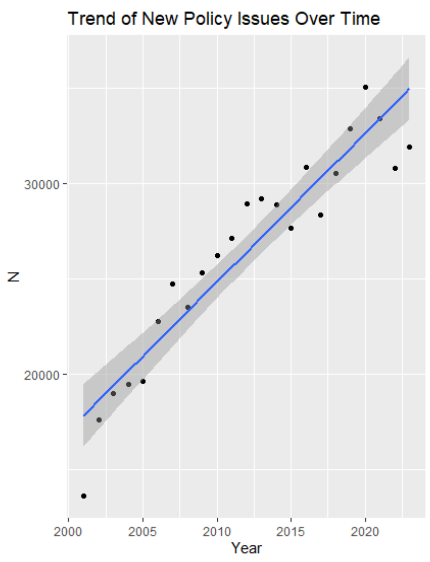
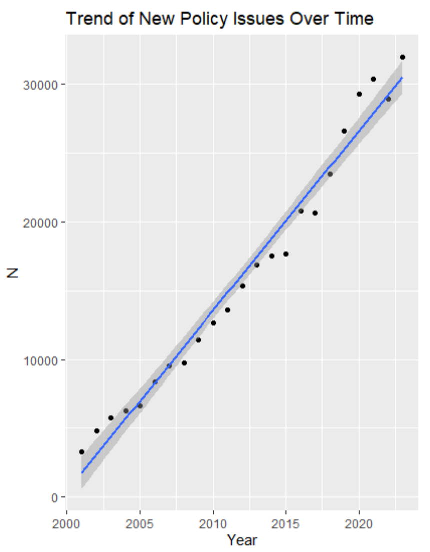
Appendix C - Future Projections:

Methodology Briefing:
To simulate the new active customer-base (i.e. new policy issues) into 20 years into the future, we look at T20 and SPWL policies separately. For the purpose of our methodology, only 5 different covariates are needed to be simulated, i.e. Issue_year, Face Amount, issue age, Gender, Smoker_indicator.

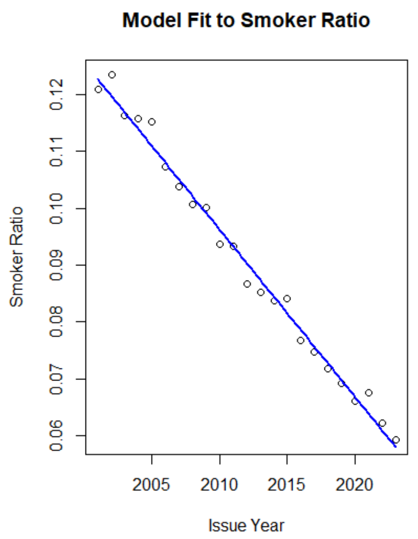
A comprehensive EDA was conducted to explore the trends of the aforementioned covariates, and both linear and polynomial models were fitted in accordance with exhibited trends for new policy issues at each age, as well as gender ratio and smoker ratio over time. Perhaps to be expected, we see that the gender ratio converges to roughly 1:1 over the years, so an equal distribution of gender assumption was utilised for the future projections. We observe some differences in the trends of smoker ratios between the two offered policies, but both tend to converge to zero into the future as the number of smokers within Lumaria reduces.

Before simulating, a correlation-analysis was conducted on factorised covariates in R, with covariates displaying little correlation apart from smoker status. As such, we can utilise a methodology where we assume that the covariate values are independent apart from smoker status. Within this methodology, for each future issue year, we first simulate the number of smokers and non-smokers, then we simulate the conditional distribution of other covariates conditional on whether the simulated policyholder is a smoker. This results in a very efficient methodology that can be extended to larger scale projections as desired by stakeholders.

Table C.1. Results Table for Exploratory Data Analysis on Covariate Trends by Issue Year

	Policy Types	
Covariate	T20	SPWL
New policy issues over time Largely linear trend across both policy types.		

<table>
<tr>
<td>Smoker ratio over time

Smoker ratio converges at a different trend between the policy types - linear vs. polynomial.</td>
<td>
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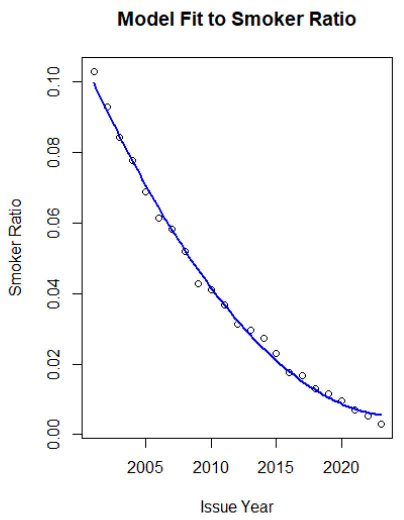
<td>
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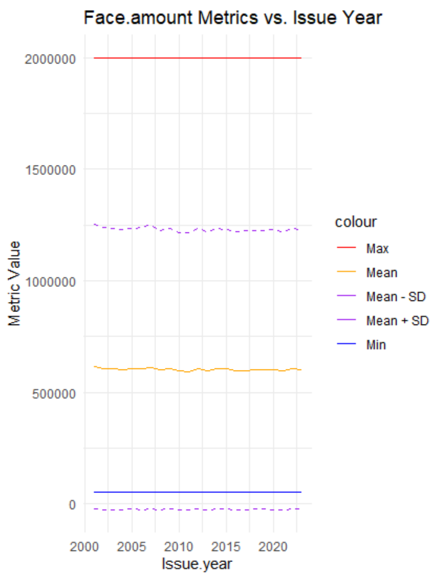
<tr>
<td>Face Amount

Face amount key distribution metrics appear roughly constant across time. Further analysis indicates they are discrete valued figures.</td>
<td>
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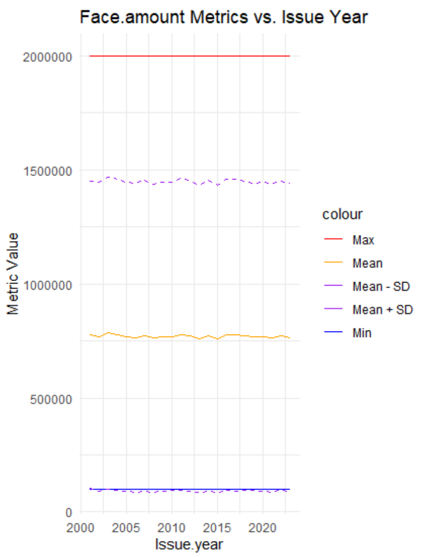
<td>
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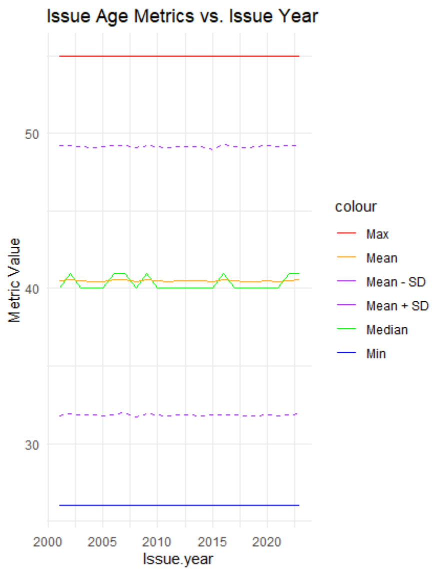
<tr>
<td>Issue Age

Distribution of issue ages appear largely constant across calendar years.</td>
<td>
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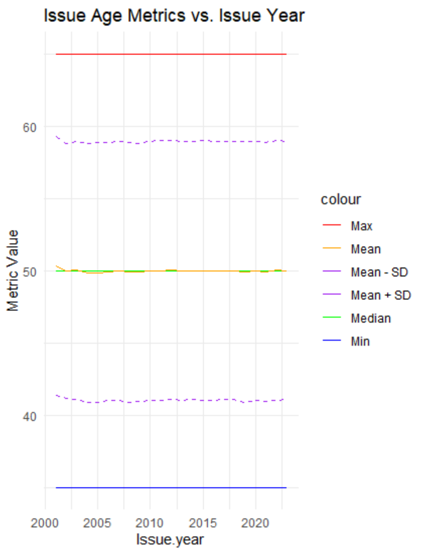
<td>
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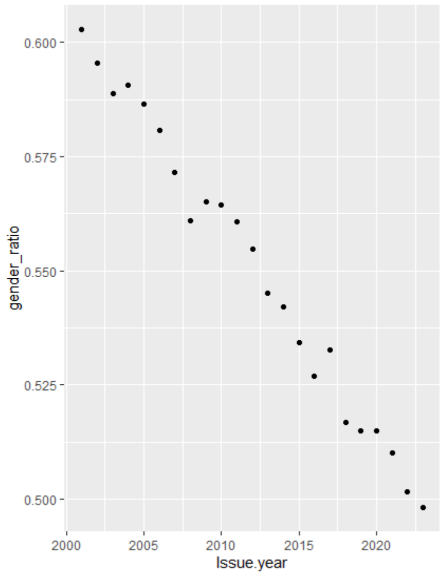
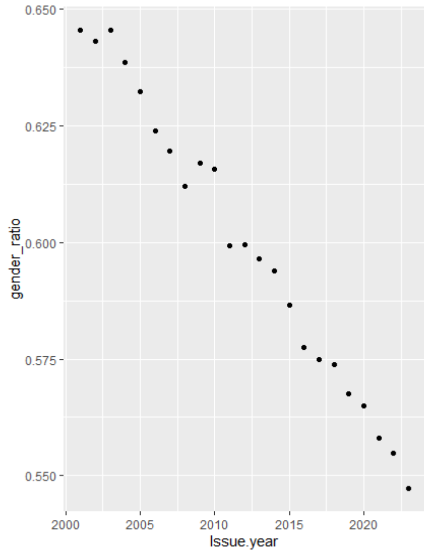
Gender Ratio over time

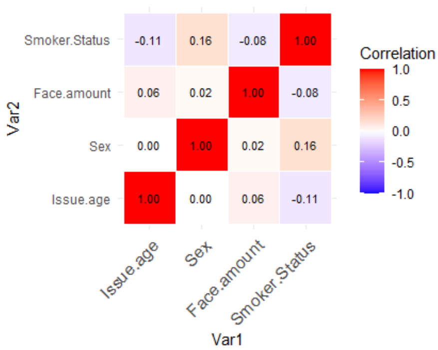
Gender ratio appears to converge to 1:1 by the end of 2023.

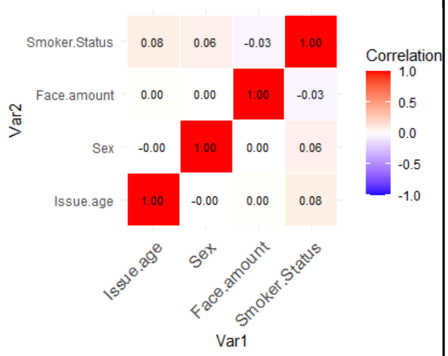




<u>Correlation Analysis</u>

Covariates displayed negligible correlation apart from Smoker.Status.





Appendix D - Profit Formula

Table D.1. Profit Formula Table

Accounts with Decrements						
Premium (sop)	Expenses (eop)	Death Benefits (eop)	Cash Flow	Reserve Increase	Interest	Profit
A	B	C	D = A - B - C	E	F = i * (A + reserve)	G = D - E + F

Appendix E - Summary Statistics

Increase in profits per Č1,000 death benefits with the program

year	min	q1	median	mean	q3	max
2024	-31.30	9.34	83.96	425.18	955.65	1248.81
2025	-31.37	9.23	84.82	436.24	961.72	1250.97
2026	-31.42	9.15	85.35	447.44	967.07	1250.67
2027	-31.44	9.12	85.95	458.53	971.57	1249.56
2028	-29.80	9.11	86.76	468.30	975.47	1252.25
2029	-29.48	9.07	87.21	419.82	851.44	1169.78
2030	-31.10	9.18	89.12	493.85	996.49	1261.64
2031	-31.10	11.02	91.78	501.63	996.51	1259.11
2032	-31.10	14.49	734.80	509.28	996.54	1254.59
2033	-31.10	14.66	791.01	516.44	996.49	1248.07
2034	-28.79	14.69	816.80	523.05	996.28	1239.80
2035	-26.28	14.68	830.76	528.75	996.07	1234.91
2036	-29.48	14.75	840.73	534.76	995.81	1228.88
2037	-27.86	14.81	846.93	539.74	995.65	1221.95
2038	-26.49	15.03	851.83	544.84	995.36	1213.38
2039	-25.05	15.51	854.67	549.98	994.88	1207.06
2040	-24.30	15.90	856.78	555.22	994.45	1199.71
2041	-29.48	16.15	858.35	559.70	994.10	1193.63
2042	-27.86	16.30	857.01	562.91	993.36	1188.09
2043	-32.96	16.47	855.63	565.98	992.58	1181.72

Increase in premium per Č1,000 death benefits with the program

year	min	q1	median	mean	q3	max
2024	-338.9978	5.567022	13.30629	26.66854	34.62067	114.80645
2025	-345.4392	5.538920	13.18601	26.32135	34.18018	114.80645
2026	-349.0471	5.508766	13.09311	25.97065	33.62604	114.80645
2027	-352.3783	5.474310	13.00645	25.70711	33.21509	114.80645
2028	-352.9012	5.424928	12.95042	25.42025	32.76245	114.80645
2029	-355.9070	5.376828	12.90532	25.18613	32.23727	112.30814
2030	-358.5468	5.302630	12.85096	24.96302	31.80998	111.42650
2031	-358.5468	5.222097	12.81959	24.74753	31.24767	111.42650
2032	-358.5468	5.123333	12.79685	24.47591	30.69779	110.46530
2033	-358.5468	5.028928	12.73458	24.22666	30.18135	108.72167
2034	-358.5468	4.933663	12.69793	24.00951	29.68942	106.34723
2035	-358.5468	4.847810	12.66065	23.80109	29.17468	102.83410
2036	-358.5468	4.783081	12.63737	23.52683	28.95159	99.63094
2037	-358.5468	4.756798	12.56582	23.35074	28.78313	97.24618
2038	-358.5468	4.747849	12.56032	23.15920	28.76093	95.45331
2039	-358.5468	4.747849	12.52063	22.87114	28.60684	95.45331
2040	-358.5468	4.744649	12.44963	22.56698	28.45039	95.45331
2041	-358.5468	4.744649	12.43046	22.35416	28.42590	95.45331
2042	-358.5468	4.742927	12.37671	22.06833	28.35675	95.45331
2043	-358.5468	4.741197	12.33142	21.71386	28.25574	95.45331

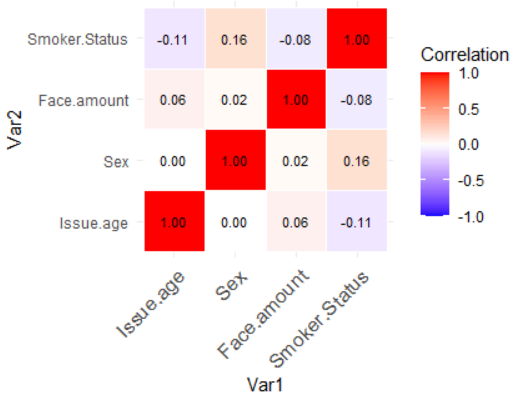
Projected total profits

year	summation	min	q1	median	mean	q3	max
2024	280970175497	-48976.25	4429.904	4801.652	313971.0	455129.1	1984377
2025	306428844750	-53049.91	4378.119	4738.385	322674.2	463485.7	2000496
2026	332862037656	-56805.25	4333.396	4682.070	331608.2	470441.7	2015027
2027	360171301213	-53420.84	4291.077	4630.283	340390.5	475995.0	2027514
2028	388052504557	-48441.89	4255.950	4612.494	347980.2	480176.6	2038171
2029	364430333558	-42735.54	4187.208	4603.693	310819.0	423777.0	1743639
2030	452994071975	-52581.13	4159.377	4656.968	368011.7	494682.9	2093405
2031	482682173882	-50111.60	4134.519	8438.371	374114.5	496870.3	2093405
2032	513084618364	-56258.78	4116.745	91175.659	380150.5	498793.7	2093405
2033	544009973505	-53103.22	4100.999	96490.554	385619.5	500602.5	2093405
2034	576058037886	-48597.37	4098.285	98829.504	390891.8	502238.0	2093405
2035	608577178856	-46732.12	4113.677	100430.777	395301.4	503423.3	2093405
2036	641577359534	-43307.21	4149.158	101775.219	399901.9	504803.7	2093405
2037	675456627512	-39450.57	4171.720	102618.282	403710.3	505888.7	2093405
2038	710293445920	-35781.35	4185.022	103470.855	407833.3	507219.5	2093405
2039	745007526102	-33518.35	4193.586	104348.784	411706.9	508337.5	2093405
2040	780064994270	-48597.37	4202.965	105172.458	415555.3	509424.9	2093405
2041	816575243913	-46732.12	4210.594	105837.153	419170.1	510526.9	2093405
2042	852772030392	-43307.21	4215.855	106386.059	421492.9	511363.6	2093405
2043	889551836941	-65913.50	4223.419	106950.772	423820.1	512082.8	2093405

Appendix F - Elaborated Assumptions

During the analysis of the health incentive program on our objectives, we have made a few assumptions which are as listed:

- Policyholders have a static mortality rate
    - Due to not having cohort data, this assumption was made. As a result, this leads to inaccurate projection of mortality rate.
- Life table extrapolated using exponential distribution for Whole Life products as data only goes up to 87 years - mortality may be inaccurate at very high ages.
- Existing premium rates do not change over time.
    - They remain constant regardless of any external factors that could potentially affect premium rates.
- No selection behaviour bias upon entry into the program.
    - In other words, we assume a homogeneous behaviour for all entering policyholders.
- Premium payments and program costs occur at the start of the period whilst death and lapses occur at the end.
- Policy term begins immediately after the policyholder's xth birthday.
- Stationary interest rates.
    - Interest rates were modelled by the ARMA (AutoRegressing Moving Average) model which assumes stationary interest rates over time.
- Lapse rate remains unchanged after the introduction of the health incentive program.
- Growth rate of reserves follows the inflation rate.
- Future demographic changes are expected to follow patterns observed in the past.
    - SuperLife products are offered to the same groups as before (ages 26-55 for T20 and ages 35-65 for SPWL). Even after the implementation of the health incentive program, these patterns will remain identical.
- The effects on mortality of the smoking cessation and cancer awareness program are independent.
    - Both programs target different aspects of mortality reduction and therefore their effects stack.
- Proportion of deaths caused by selected cancers is constant over age
- Gender ratio converges to 1:1 as seen on latest issue year data.
    - In the analysis of gender ratio over issue ages for the current inforce population, there was a trend towards 50% presence of male policyholders.
- Modelled covariants, except for smoker status, are independent.



- For smokers, the conditional distribution of other covariates reflects an average of the latest 3-year trend.
    - When modelling for the probability mass functions of covariates of face amount and issue age, the latest three year trend was taken. On the other hand, the proportion of gender spread conditional on smoker status was an average across all issue years.
- Smoking cessation impacts mortality rates exactly 4 years after commencing.
    - SuperLife incurs 1 year of full smoking cessation expenses and 3 years of 50%.
    - There is a time period of 4 years before a smoking policyholder is transferred into the non-smoker mortality tables.

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