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Healthcare Costs in the Long-Term

Using Data Science Techniques in Actuarial Work

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The Question

How much will healthcare cost you in the future?

Example:
Mak Cik Kiah is 40 years old today.
She spends RM 1,000 per year on healthcare.
She wants to improve the quality of her living standards, including enjoying healthcare services twice as good as those she is currently receiving.

How much would Mak Cik Kiah spend per year on healthcare when she is 60 years old?

The Approach

Future healthcare cost = **Current healthcare cost** × **Inflation Factor** × **Age Factor** × **Quality Factor**

Parameters	Details
Current Healthcare Cost	Based on current age, current quality of healthcare services required and current health status. At this juncture, our work is only applicable to healthy people.
Inflation Factor	We expect inflation to be 8% to 12% per year in the private medical sector. However this is not part of our current study.
Age Factor	Healthcare cost changes with age due to physiological as well as behavioural factors.
Quality Factor	Healthcare cost changes with the quality of healthcare services required. Over time, our preference for quality of healthcare services may increase.

It is noted that this multiplicative approach has a weakness as it cannot effectively deal with correlation between the variables, but it is fit for purpose as an initial finding.

What, Why, When, Where, How?

What did we do?

We computed the **Age Factor** & **Quality Factor**.

Together with the input of the **Current Healthcare Cost** and assumption of the **Inflation Factor** we are able to predict **Future Healthcare Cost** for each individual.

Why did we do it?

Main Objective:
Assist individuals & corporates in financial planning related to long term healthcare cost

Additional Benefit:
Assist insurance companies in pricing & benchmarking exercises.

When & where did we do it?

We did this project in early 2020 using Malaysian data.

Assumptions:
Our work assumes that the healthcare infrastructure in the future will not change significantly.

How did we do it?

Data Scrubbing
Collect data from desktop analysis.

Data Wrangling
Transform raw data into format suitable for analysis.

Curve Fitting
Express results in a best fit mathematical function.

How – Step 1: Data Scrubbing

Perform Desktop Analysis

Collect medical insurance brochures from all insurance and takaful company websites to obtain the premium rates for every age and plan (room and board).

Compute Age and Plan Relativities

Set a base age and compute the age relativities for each set of premium rates, for every room and board.

Furthermore, compute the room and board ratios and its relativities for each set of premium rates of the base age.

Example of computing relativities:

Age	Price (RM)	Age Relativity
20	85	0.85
30	100	1
40	150	1.5

Room & Board	Price (RM)	Room & Board Ratio	Plan Relativity
100	100	1	1
150	110	1.5	1.1
250	150	2.5	1.5

How – Step 2: Data Wrangling

Summarise the whole dataset as follows:

Age	Overall Age Relativities
0	1.060979
1	1.054461
2	1.048736
…	…
30	1.000000
31	1.059389
32	1.060916
…	…
98	27.177144
99	27.337474
100	24.125507

Room and Board Ratio	Overall Plan Relativities
1.00	1.000000
1.33	1.182462
1.40	1.363980
…	…
2.36	1.600390
2.67	2.190386
3.00	1.709261
…	…
8.0	2.051929
9.0	2.179525
10.00	2.299703

How – Step 3: Curve Fitting - Age

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Cubic Function

Statistically Significant Parameters

Quasi Poisson to address dispersion

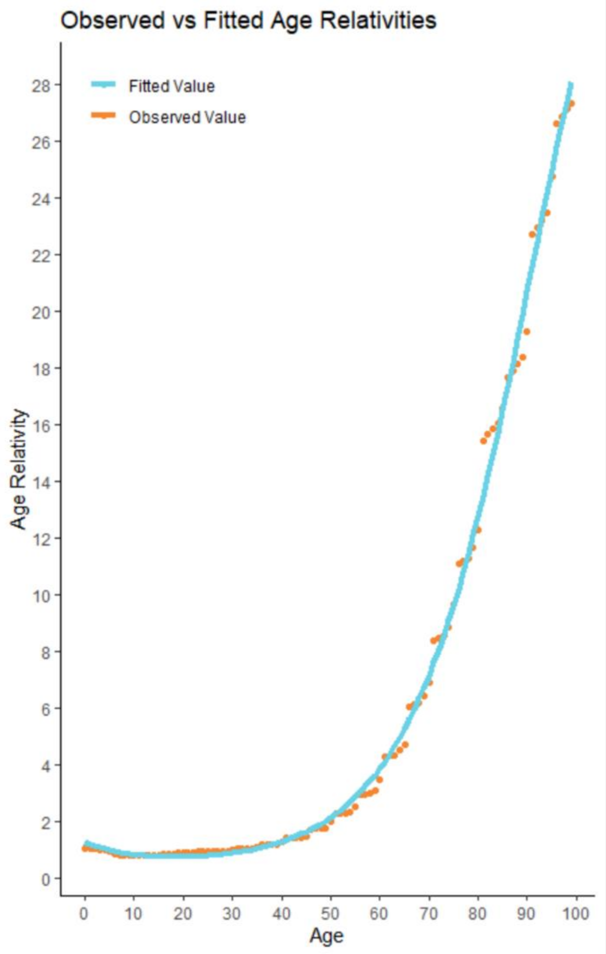
Deviation Goodness of Fit Test

RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

C:/Users/Microsoft User/OneDrive/Work/Medical Relativity/R Working/

```
> agemodel1 = glm(Overall.relativity..whole.dataset.~ Age +I(Age^2) +I(Age^3) , family = quasipoisson, data
 = agedatao)
> summary(agemodel1)

Call:
glm(formula = Overall.relativity..whole.dataset. ~ Age + I(Age^2) +
    I(Age^3), family = quasipoisson, data = agedatao)

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-0.33515  -0.10242  -0.00149   0.10149   0.52549

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  2.487e-01  5.197e-02   4.785  6.2e-06 ***
Age         -5.976e-02  3.665e-03 -16.306  < 2e-16 ***
I(Age^2)     1.896e-03  7.297e-05  25.979  < 2e-16 ***
I(Age^3)    -9.868e-06  4.225e-07 -23.357  < 2e-16 ***

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for quasipoisson family taken to be 0.02299041)

    Null deviance: 801.6162  on 99  degrees of freedom
Residual deviance:   2.1912  on 96  degrees of freedom
AIC: NA

Number of Fisher Scoring iterations: 4

> pchisq(agemodel1$deviance, df = agemodel1$df.residual, lower.tail = FALSE)
[1] 1
> ?ggplot2
> colours <- c("Observed Value" = "#F58732", "Fitted Value" = "#69D2E6")
> theme_set(theme_classic())
> ggplot(agedatao, aes(x = Age)) +
+   geom_point(aes(y = Overall.relativity..whole.dataset., colour = "Observed Value"), lwd = 1.5) +
+   geom_line(aes(y = agemodel1$fitted.values, colour = "Fitted Value"), lwd = 1.5) +
+   labs(title = "Observed vs Fitted Age Relativities", x = "Age", y = "Age Relativity", colour = "") +
+   scale_x_continuous(breaks=seq(0,100,10))+
+   scale_y_continuous(breaks=seq(0,30,2))+
+   scale_color_manual(values = colours) +
+   theme(legend.position = c(.2,.95)) +
+   theme(panel.background = element_rect(fill = "#FFFFFF"))
>
>
```



How – Step 3: Curve Fitting - Plan

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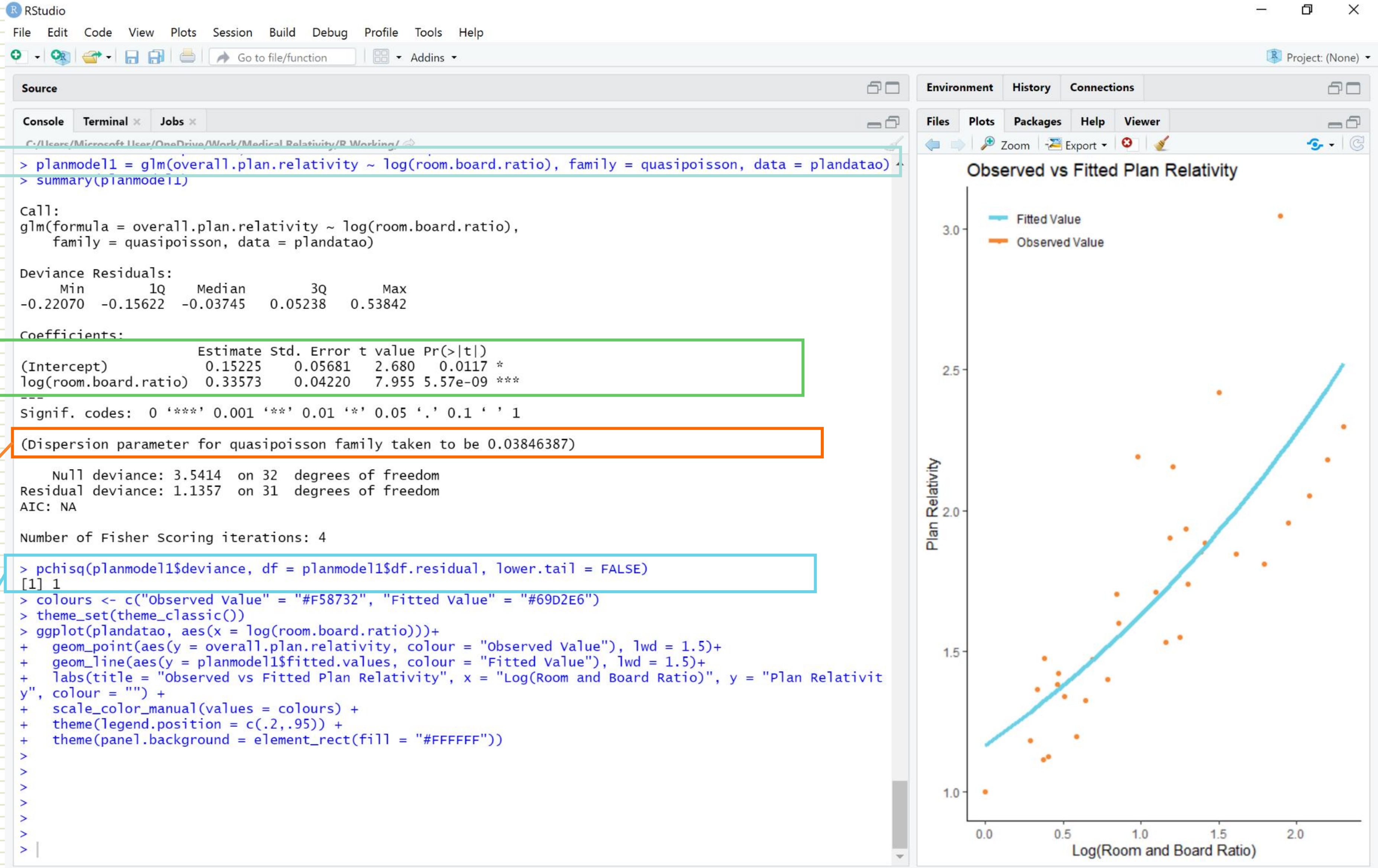
Log Function

Statistically Significant Parameters

Quasi Poisson to address dispersion

Deviation Goodness of Fit Test



The Answer

Mak Cik Kiah is 40 years old today.
She spends RM 1,000 per year on healthcare.
She wants to improve the quality of her living standards, including enjoying healthcare services twice as good as those she is currently receiving.

How much would Mak Cik Kiah spend per year on healthcare when she is 60 years old?

Age	Overall Fitted Age Relativity	Quality	Overall Fitted Plan Relativity
40	1.4393904	1.00	1.000000
60	4.3073958	2.00	1.262018

Future healthcare cost = Current Healthcare Cost * Inflation Factor * Age Factor * Quality Factor
= RM 1,000 * 1.08^20 * (4.3073958/1.4393904) * (1.262018/1.000000)
= RM 1,000 * 4.66 * 2.99 * 1.26
≈ RM 18,000 (assuming 8% per year medical inflation)

Mak Cik Kiah would spend RM 18,000 per year on healthcare cost when she is 60 years old.

The Next Question

Does the results differ between male and female?

Example:
Mak Cik Kiah's husband is also 40 years old today.
He also spends RM 1,000 per year on healthcare.

Will he spend the same amount as Mak Cik Kiah on healthcare when he is 60 years old?

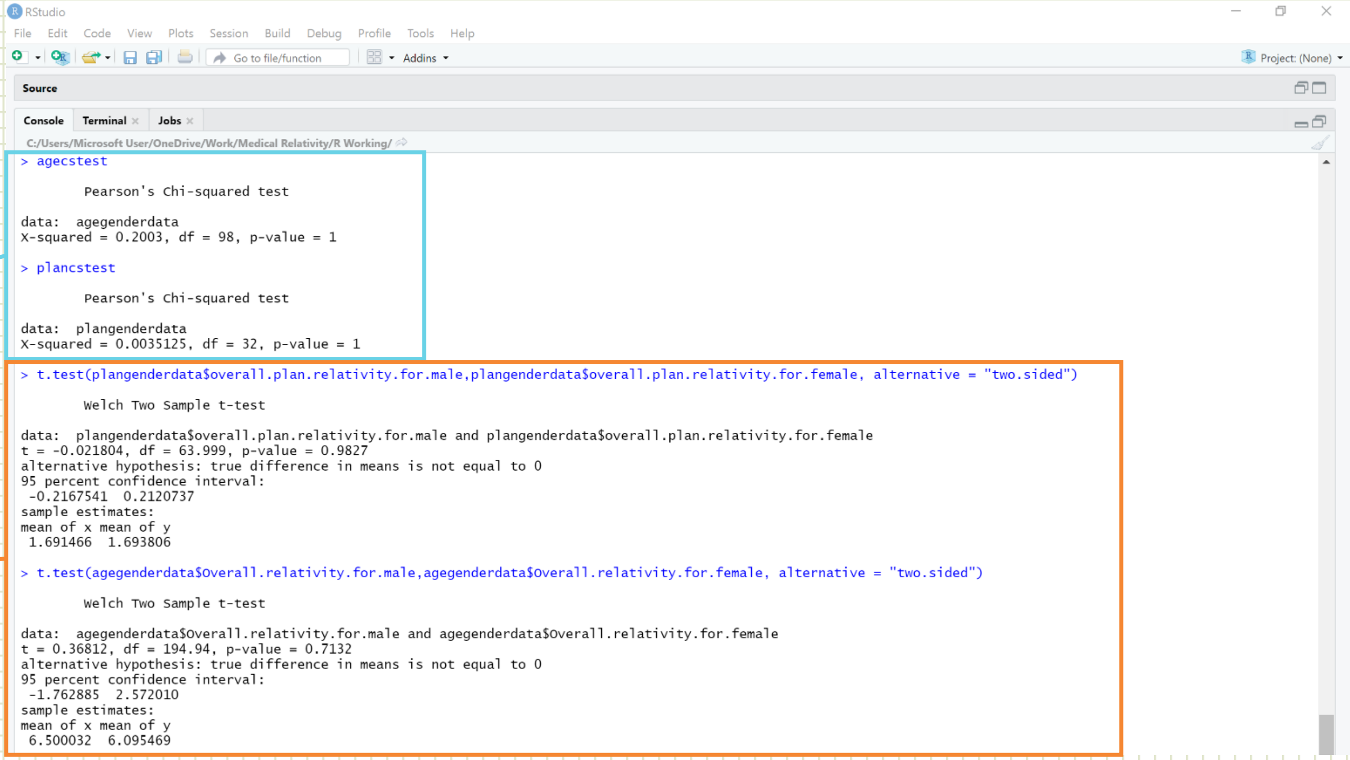
The Same Answer

Mak Cik Kiah's husband is also 40 years old today.
He also spends RM 1,000 per year on healthcare.

Will he spend the same amount as Mak Cik Kiah on healthcare when he is 60 years old?

Pearson's Chi Squared Test

Welch Two Sample t-test



Yes, based on our studies, the Age Factor and Quality Factor is not different for males and females.

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Appendix

Appendix A – Fitted Age Relativity

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Age	Fitted Age Relativity	Age	Fitted Age Relativity	Age	Fitted Age Relativity	Age	Fitted Age Relativity	Age	Fitted Age Relativity
0	1.4236176	20	0.8498327	40	1.4393904	60	4.3073958	80	14.1816815
1	1.3435633	21	0.8545336	41	1.5059815	61	4.5794714	81	14.9624304
2	1.2727519	22	0.8614528	42	1.5778035	62	4.8696069	82	15.7703108
3	1.2101091	23	0.8705919	43	1.6552087	63	5.1787473	83	16.6041381
4	1.1547146	24	0.8819682	44	1.7385750	64	5.5078497	84	17.4624303
5	1.1057794	25	0.8956133	45	1.8283074	65	5.8578774	85	18.3433893
6	1.0626258	26	0.9115740	46	1.9248390	66	6.2297927	86	19.2448848
7	1.0246710	27	0.9299107	47	2.0286321	67	6.6245491	87	20.1644403
8	0.9914139	28	0.9506986	48	2.1401793	68	7.0430819	88	21.0992215
9	0.9624242	29	0.9740270	49	2.2600044	69	7.4862984	89	22.0460295
10	0.9373313	30	1.0000000	50	2.3886634	70	7.9550661	90	23.0012965
11	0.9158178	31	1.0287364	51	2.5267453	71	8.4502002	91	23.9610867
12	0.8976122	32	1.0603704	52	2.6748726	72	8.9724499	92	24.9211027
13	0.8824832	33	1.0950523	53	2.8337017	73	9.5224830	93	25.8766967
14	0.8702346	34	1.1329481	54	3.0039236	74	10.1008698	94	26.8228880
15	0.8607020	35	1.1742415	55	3.1862627	75	10.7080659	95	27.7543872
16	0.8537488	36	1.2191340	56	3.3814779	76	11.3443933	96	28.6656269
17	0.8492637	37	1.2678453	57	3.5903606	77	12.0100213	97	29.5507985
18	0.8471579	38	1.3206150	58	3.8137342	78	12.7049463	98	30.4038978
19	0.8473638	39	1.3777028	59	4.0524521	79	13.4289705	99	31.2187748

Appendix B – Fitted Plan Relativity

Room and Board Ratio	Fitted Plan Relativity
1.00	1.000000
1.25	1.077794
1.50	1.145829
1.75	1.206690
2.00	1.262018

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