Gender and Smoker Distinct Mortality Table Development

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Introduction

The significantly lower mortality rates and longer life expectancies experienced by females compared to males have been well known for some time. Various mortality studies by medical professionals and actuaries show that life expectancy of a female child is about six years longer than a male child. Similarly, excess mortality risks associated with use of cigars, cigarettes, snuff and other tobacco products are well documented (Cowell & Hirst, 1980[1]). A 30-35 year old male two-pack-a-day smoker has an expectation of life eight to nine years shorter than a male nonsmoker. The medical literature makes ample references to association between smoking and cardiovascular diseases. In both urban and rural India, projections are that by 2015 circulatory diseases will account for 34% and 32% of the deaths for males and females, similar to those experienced in Western populations (Nayak et al, 1997[3]; Gupta et al 1997[2]; Reddy et al 1998[5]). Epidemiologists predict that tobacco-attributable deaths in India will rise from 1.4% in 1990 to 13.3% in 2020. This information could be obviously of great interest to insurers who would like to sell coverage in the Indian market with smoker/nonsmoker and male/female distinct pricing to be able to balance competitive requirements of the market with effective risk management. This paper proposes a methodology to develop a gender and smoker distinct mortality table from the IRDA standard unigender and unismoker LIC 1994-96 Table.

Background

Until recently, it has been the general approach for the insurance companies in many countries to offer, often unintentionally, unismoker and unigender premium rates. Insurance markets evolved this way for some of the following reasons:

- Historically wage earners have been mostly males who purchased life insurance to protect their families in old age or death.
- Lack of adequate awareness of the effects of smoking on health and life expectancy was a major factor for a mostly smoker population.
- Insurers felt very little justification to allocate resources to develop nonsmoker rates in order to cater to a very small section of the potential insurable prospects.

However, starting about 1950s, health professionals in many countries began to assert a definite correlation between smoking and health and started a conscious public awareness education about the dangers of smoking. Almost simultaneously in many industrialized countries, before and during the post World War II era, a large number of women began to enter the workforce to fill the shortage of workers in a growing economy. A number of insurance companies noticed the social change and started investigating the mortality differentiation by gender. In the annuity and pension market, in most countries, the mortality difference by gender was beginning to receive recognition. A practice evolved to offer separate female rates as "age setback rates" of three to six years to male rates. The first gender specific table was not developed until 1940's. It was an annuity table and yet wasn't used for valuation of pension and annuities. Practitioners continue even today to use setback to male rates for pension valuations. However, in insurance many gender distinct tables are in use since the 1960s. Almost all of the developed and many of the developing countries are currently offering gender distinct pension, annuity and life insurance rates. Therefore there are number of gender distinct valuation and experience mortality tables in use.

Reflection of smoking in life insurance rates is a relatively more recent phenomenon. In 1964, a few months after the publication of the U.S. Surgeon General's report "Smoking & Health", State Mutual Life Assurance Co, Worcester, Massachusetts became the first

company in US to reflect smoking habits in life insurance underwriting and pricing. Many companies followed State Mutual in l960s and early 1970s to offer smoker and nonsmoker distinct life insurance rates. Currently some of the developed countries also offer life insurance rates based other life style factors. In USA companies have been offering for a few years preferred, super preferred and many other versions of nonsmoker life insurance premium rates. In Canada companies are offering lifestyle1, lifestyle2 and similar insurance rates by taking into consideration healthy habits and factors in addition to smoking. Initially the nonsmoker rates offered in 1970s were age set back discounts to standard rates. One company offered nonsmoker premium rate discounts to standard rates at a rate of 0.1% times the age of the insured. One Asian country currently follows an approach to sell riders at a price to obtain nonsmoker discount to standard rates. The age set back type discounts, percent discounts and the rider approach as described above are empirical estimates, although they reflect the general principle to some degree. However, sufficient statistical information is now available in developed countries to assist in the development of mortality rates distinguished by gender and smoking status. Intercompany Mortality Studies under the auspices of the Society of Actuaries actively promote recording and tracking mortality experience by gender and smoking habits. The reports are available to public and all insurance companies. Regulatory valuation tables are constructed based on these studies and are updated routinely approximately every ten years. Today practically all insurance companies in US, Canada and Western Europe offer rates that take into account mortality distinctions by gender and smoking habits.

It is important to mention here that the primary purpose of offering smoker distinct life insurance rates is not to promote a certain social awareness of the effects of smoking on health. It is a by-product of such social awareness whereby insurers offer nonsmoker rates for competitive reasons. Clearly, it is very ineffective use of insurance company resources to develop and offer nonsmoker rates in a certain country or ethnic group that exhibits very high percentage of smokers in the population. The following table shows percent smokers in the populations by country.

Estimated Smokers in

Certain Asian countries for ages 15 and over

Country	Males	Females
Bangladesh	60%	15%
China	75%	5%
India	40%	3%
Indonesia	53%	4%
Malaysia	41%	5%
South Korea	68%	7%

Method to develop a gender and smoker distinct table from the LIC 1994-96 Table

It is estimated that at certain ages smoker mortality could be as high as 300% of nonsmoker mortality (Dr. Pokorski, 2003[4]). Similarly, female mortality is estimated to be of the order of about 60%-70% of male mortality. However, this paper assumes that these relative measures actually vary by age. The method to develop smoker distinct mortality employs, at each age, the proportion of assumed smokers and nonsmokers in the underlying table and the relative mortality differentials (ratios of smoker mortality to nonsmoker mortality) at that age to develop age specific mortality rates. The method then proceeds to develop female mortality rates by assuming ratio of female to male mortality rates at each age from standard tables.

Assumptions.

P_x^S : Proportion of smokers in LIC 1994-96 Table

P_x^N : Proportion of non-smokers in LIC 1994-96 Table

Clearly, $P_x^S + P_x^N = 1.00$

R_x : Relative Risk (RR) of smoker mortality rate to nonsmoker mortality rate at age x

Q_x^{LIC} : Mortality Rate at age x of the LIC 1994-96 Table

Q_x^N : Nonsmoker mortality rate at age x of the LIC 1994-96 Table

Q_x^S : Smoker mortality rate at age x of the LIC 1994-96 Table

Two simultaneous equations must be solved for each age x as follows:
For age x of LIC 1994-96 Table,

$$P_x^{S.}\, Q_x^{S} + P_x^{N.}\, Q_x^{N} = Q_x^{LIC} \quad \ldots\ldots\ldots\ldots \quad (1)$$

and,
$$Q_x^{S} = R_x.\, Q_x^{N} \quad \ldots\ldots\ldots\ldots \quad (2)$$

The relative risk of mortality rate (RR) used above is a measure often used by epidemiologists to compare mortality rates among diverse groups of risks. As mentioned above Relative Risk of smokers to nonsmokers could be as high 300% (Dr. Pokorski, 2003[4]) indicating that at some ages smokers may be three times as likely to die than a nonsmoker. The following table suggests certain ratio of Relative Risks (RR) of mortality of smokers to nonsmokers from several countries around the world:

Country	Relative Risk (RR) Smoker to Nonsmoker
US - male	234% to 273%
US - female	182% to 246%
UK	210%
China-male	172% to 342%
Korea	150% to 180%
Singapore-male	160%

Actual Relative Risks of mortality rates vary by age and ranges between 100% at very young ages to 280% at the middle ages. It progressively diminishes to about 100% by age 90 indicating that at the terminal ages smoking has a relatively less effect, as other old age diseases and natural causes become more important factors leading to eventual death. The following two tables suggest age specific RRs for two standard tables in US.

Paquin's Mortality Scaling Factors Table.

Claude Y Paquin developed mortality scaling factors to apply to standard unismoker "experience mortality table" known as the 1975-80 Select & Ultimate Mortality Table which is widely used for pricing life insurance products in the US. Paquin's table RR rates are as follows:

Paquin's Mortality Relative Risk rates by age		
Age	Relative Risk (RR) Smoker to Nonsmoker Males	Relative Risk (RR) Smoker to Nonsmoker Females
35	225%	174%
45	250	190
55	230	176
65	188	153
75	149	130
85	119	111
95	100	100

US 1980 CSO Valuation Mortality Scaling Factors Table.

The 1980 CSO Valuation table uses more conservative mortality differentials (Cowell & Hirst[1]) by smoking habits and also incorporates margins commonly used for valuing the life insurance liabilities. The RR factors embedded in this table are as follows:

US 1980 CSO Valuation Mortality Table Relative Risk rates by age		
Age	Relative Risk (RR) Smoker to Nonsmoker Males	Relative Risk (RR) Smoker to Nonsmoker Females
35	156%	132%
45	189	154
55	193	153
65	172	141
75	142	125
85	117	100
95	100	100

We adopted a more conservative approach to mortality differentials implicit in the 1980 CSO table for the development of the smoker and gender distinct mortality table. The complete table is renamed "2003 RR-A Table" and is reproduced in Appendix A.

A further assumption was made regarding smoker to nonsmoker proportions in the LIC 1994-96 table as follows:

Proportion of Smokers by age in the LIC 94-96 table		
Age	Males	Females
0-10	0%	0%
11-19	Linearly graded between 0% and 80%	0%
20-80	80%	0%
81-98	Linearly graded between 80% and 50%	0%
99	50%	0%

The proportion of males to females in LIC 94-96 was assumed to be as follows:

Proportion of Males to Females in the LIC 94-96 table		
Age	Males	Females
All	100%	0%

Then it was possible to develop equations (1) and (2) for each age. The equations were solved for Q_x^S, Q_x^N for each x. The procedure was applied for ages 15 and above, as younger age mortality distinction by smoking was unavailable and negligible.

It has already been mentioned that the mortality rates of females to males is estimated to be between 60%-80%. Females rates start out to be about 50% of male rates at age 25, then gradually builds up to about 80% during the middle range of ages from 35 to 45 and then drops back to 60% at about 55 to 65. At extreme ages the ratio increases back to about 100% at age 95 indicating, as expected, practically no difference in mortality between men and women at terminal ages. The following table from the US 75-80 Experience Table mentioned earlier is indicative of this pattern.

Female to Males Relative Risk (RR) rates by age 1975-80 Experience Table	
Age	Female to Male mortality
25	40%
35	66
45	83
55	66
65	56

Female to Males Relative Risk (RR) rates by age 1980 CSO Valuation Table	
Age	Female to Male mortality
25	66%
35	78
45	78
55	68
65	57

75	55
85	70
95	77

75	60
85	76
95	96

The pattern illustrated above is markedly different from a similar table that can be constructed by using an age setback approach as shown below:

Female to Males Relative Risk (RR) rates by age 1980 CSO Valuation Table	
Age	Female to Male mortality
25	107%
35	87%
45	78%
55	76%
65	75%
75	74%
85	77%
95	77%

The difference in the two tables highlights the drawback of using an "age setback to male rates' scheme for female rates, as it implicitly shifts the timing of the risk in an inappropriate manner. Therefore female to male RR tables based on known actual experience table or derived valuation table is a better approximation. In our analysis, we adopted the more conservative approach of the 1980 CSO Table mortality differentials between males and females. The complete table renamed "2003 RR-B Table" is reproduced in Appendix B. The procedure to develop female rates then is as follows:

Assumptions:

Q_x^N : Male Nonsmoker mortality rate at age x

Q_x^S : Male Smoker mortality rate at age x

${}^f_mRR_x^S$: Relative female smoker mortality to male smoker mortality for age x

${}^f_mRR_x^N$: Relative female nonsmoker mortality to male nonsmoker mortality for age x

Then, $${}^fQ_x^N = Q_x^N \cdot {}^f_mRR_x^N$$

and, $${}^fQ_x^S = Q_x^S \cdot {}^f_mRR_x^S$$

Numerical Example:

From LIC 1994-96

At age 45, $Q_{45}^{LIC} = 0.003110$

$P_{45}^{S} = 0.8$ or 80%

$P_{45}^{N} = 0.2$ or 20%

Therefore, $0.80 \cdot Q_{45}^{S} + 0.20 \cdot Q_{45}^{N} = 0.003110$

And from the 2003 RR-A Table for age 45: $R_{45} = 1.88855$

Therefore, $(0.80)x(1.88858.Q_{45}^{N)} + 0.20.Q_{45}^{N} = 0.003110$

Or, $Q_{45}^{N} = 0.003110 / (0.20 + 0.80x1.88858) = 0.001818$

and, $Q_{45}^{S} = 1.88858 \times 0.001818 = 0.003433$

${}^{f}Q_{45}^{N} = 0.001818x0.90060^{*} = 0.001637$

${}^{f}Q_{45}^{S} = 0.003433x0.73525^{*} = 0.002524$

* shown as 90% and 74% in 2003 RR-B Table

The complete table developed in this method was named "1994-96 NSSM Table". The table is reproduced in Appendix C. The following table illustrates the relationship between the mortality at sample ages and risk classes between the 1994-96 NSSM Table and the Standard LIC 1994-96 Table.

1994-96 NSSM Table Mortality rates as percentage of Standard LIC 1994-96 Table				
Age	Male Nonsmoker	Male Smoker	Female Nonsmoker	Female Smoker
35	69%	108%	60%	79%
45	58	110	53	81
55	57	111	45	69
65	64	109	41	57
75	75	106	47	59

The methodology used in this paper is one of many possible approaches used in similar situations where the experience is not recorded or available by risk classes. As the Indian insurance market further develops, it is probable that Intercompany Mortality Studies will

develop that may lead to the formulation of a gender and smoker distinct mortality table. Then it may be possible to further validate and refine the assumptions and methods presented in this paper.

References

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Exhibit A

2003 RR-A Table

Mortality Scaling Factors

Attained Age	male smoker to male nonsmoker	Attained Age	male smoker to male nonsmoker
15	128%	60	183%
16	131%	61	181%
17	133%	62	179%
18	135%	63	177%
19	136%	64	174%
20	138%	65	172%
21	140%	66	169%
22	140%	67	166%
23	140%	68	163%
24	141%	69	160%
25	141%	70	157%
26	141%	71	152%
27	141%	72	151%
28	142%	73	148%
29	143%	74	145%
30	146%	75	142%
31	148%	76	140%
32	149%	77	138%
33	152%	78	135%
34	154%	79	132%
35	156%	80	130%
36	159%	81	127%
37	162%	82	125%
38	165%	83	122%
39	168%	84	119%
40	172%	85	117%
41	176%	86	114%
42	179%	87	111%
43	183%	88	110%
44	186%	89	108%
45	189%	90	106%
46	190%	91	104%
47	192%	92	103%
48	193%	93	102%
49	194%	94	101%
50	195%	95	100%
51	195%	96	100%
52	195%	97	100%
53	195%	98	100%
54	195%	99	100%
55	194%	100	100%
56	192%		
57	191%		
58	189%		
59	186%		

Exhibit B

2003 RR-B Table

Mortality Scaling Factors

Attained Age	female smoker to male smoker	female nonsmoker to male nonsmoker	Attained Age	female smoker to male smoker	female nonsmoker to male nonsmoker
15	57%	65%	60	54%	67%
16	53%	62%	61	53%	66%
17	51%	60%	62	52%	65%
18	50%	59%	63	52%	64%
19	50%	59%	64	52%	64%
20	50%	60%	65	53%	64%
21	51%	61%	66	53%	64%
22	53%	63%	67	52%	63%
23	54%	65%	68	52%	63%
24	57%	69%	69	52%	62%
25	60%	72%	70	51%	61%
26	64%	76%	71	52%	60%
27	67%	78%	72	52%	61%
28	70%	81%	73	53%	62%
29	72%	83%	74	54%	62%
30	74%	86%	75	56%	63%
31	74%	86%	76	57%	65%
32	75%	87%	77	58%	66%
33	74%	87%	78	60%	67%
34	75%	88%	79	61%	68%
35	74%	87%	80	63%	70%
36	74%	88%	81	64%	71%
37	75%	89%	82	66%	73%
38	75%	90%	83	68%	74%
39	76%	90%	84	71%	76%
40	76%	91%	85	73%	77%
41	77%	91%	86	75%	79%
42	77%	92%	87	77%	81%
43	76%	92%	88	80%	83%
44	75%	91%	89	82%	85%
45	74%	90%	90	84%	86%
46	72%	89%	91	87%	88%
47	71%	88%	92	90%	90%
48	70%	87%	93	92%	93%
49	69%	86%	94	94%	94%
50	68%	85%	95	96%	96%
51	67%	84%	96	98%	98%
52	66%	83%	97	99%	99%
53	65%	82%	98	100%	100%
54	63%	80%	99	100%	100%
55	62%	78%	100	100%	100%
56	61%	76%			
57	59%	74%			
58	57%	72%			
59	56%	69%			

Exhibit C

1994-96 NSSM Table

attained age	MNS	MSM	FNS	FSM
15	0.000693	0.000886	0.000451	0.000505
16	0.000717	0.000938	0.000441	0.000496
17	0.000736	0.000980	0.000440	0.000497
18	0.000750	0.001013	0.000446	0.000511
19	0.000762	0.001038	0.000450	0.000519
20	0.000768	0.001056	0.000462	0.000530
21	0.000785	0.001095	0.000479	0.000555
22	0.000804	0.001128	0.000510	0.000594
23	0.000824	0.001157	0.000537	0.000629
24	0.000839	0.001181	0.000577	0.000679
25	0.000853	0.001202	0.000612	0.000724
26	0.000866	0.001218	0.000656	0.000784
27	0.000872	0.001230	0.000681	0.000824
28	0.000875	0.001239	0.000711	0.000863
29	0.000870	0.001245	0.000725	0.000895
30	0.000856	0.001249	0.000737	0.000922
31	0.000848	0.001252	0.000733	0.000929
32	0.000861	0.001286	0.000752	0.000964
33	0.000882	0.001337	0.000768	0.000996
34	0.000914	0.001407	0.000806	0.001055
35	0.000960	0.001494	0.000835	0.001102
36	0.001008	0.001600	0.000889	0.001190
37	0.001067	0.001725	0.000948	0.001294
38	0.001132	0.001868	0.001013	0.001410
39	0.001207	0.002030	0.001088	0.001539
40	0.001302	0.002241	0.001183	0.001706
41	0.001399	0.002459	0.001280	0.001887
42	0.001480	0.002653	0.001363	0.002033
43	0.001567	0.002861	0.001436	0.002170
44	0.001678	0.003120	0.001530	0.002339
45	0.001818	0.003433	0.001637	0.002524
46	0.001997	0.003799	0.001774	0.002753
47	0.002201	0.004220	0.001934	0.003012
48	0.002434	0.004695	0.002121	0.003300
49	0.002695	0.005224	0.002315	0.003610
50	0.002984	0.005809	0.002546	0.003974

Exhibit C (continued)

1994-96 NSSM Table

attained age	MNS	MSM	FNS	FSM
51	0.003304	0.006447	0.002779	0.004323
52	0.003663	0.007138	0.003031	0.004700
53	0.004043	0.007885	0.003307	0.005112
54	0.004461	0.008684	0.003574	0.005506
55	0.004924	0.009533	0.003860	0.005919
56	0.005428	0.010434	0.004145	0.006321
57	0.005967	0.011375	0.004433	0.006709
58	0.006441	0.012171	0.004630	0.006954
59	0.007076	0.013170	0.004910	0.007310
60	0.007839	0.014382	0.005278	0.007758
61	0.008724	0.015807	0.005732	0.008361
62	0.009748	0.017442	0.006309	0.009097
63	0.010916	0.019286	0.007024	0.010067
64	0.012244	0.021333	0.007873	0.011156
65	0.013733	0.023585	0.008806	0.012394
66	0.014634	0.024746	0.009362	0.013002
67	0.016737	0.027837	0.010621	0.014614
68	0.019130	0.031246	0.011988	0.016244
69	0.021831	0.035007	0.013503	0.018102
70	0.024883	0.039147	0.015233	0.020083
71	0.028711	0.043601	0.017222	0.022468
72	0.032211	0.048687	0.019670	0.025392
73	0.036580	0.054154	0.022531	0.028785
74	0.041508	0.060128	0.025899	0.032739
75	0.046821	0.066705	0.029717	0.037139
76	0.052761	0.073878	0.034093	0.042105
77	0.059401	0.081689	0.039062	0.047643
78	0.066811	0.090175	0.044725	0.053836
79	0.075065	0.099383	0.051184	0.060782
80	0.084243	0.109353	0.058566	0.068585
81	0.094773	0.120556	0.067262	0.077653
82	0.106434	0.132616	0.077177	0.087818
83	0.119308	0.145561	0.088437	0.099145
84	0.132198	0.157820	0.100069	0.111355
85	0.144803	0.169066	0.111980	0.122694
86	0.158382	0.180738	0.125091	0.135996
87	0.172965	0.192796	0.139622	0.149367
88	0.187544	0.205700	0.154847	0.164298
89	0.203001	0.219050	0.171576	0.179051
90	0.219359	0.232808	0.189672	0.196267
91	0.236612	0.246926	0.209263	0.214701
92	0.254733	0.261365	0.230394	0.234365
93	0.272324	0.277006	0.252043	0.254198
94	0.290608	0.293066	0.274547	0.274547
95	0.309522	0.309522	0.297665	0.297665
96	0.327549	0.327549	0.320045	0.320045
97	0.346073	0.346073	0.342304	0.342304
98	0.365052	0.365052	0.363870	0.363870
99	0.384436	0.384436	0.384436	0.384436

Exhibit D

LIC 1994-96 Table

attained age	rate	attained age	rate
15	0.000770	60	0.013073
16	0.000823	61	0.014391
17	0.000873	62	0.015904
18	0.000919	63	0.017612
19	0.000961	64	0.019516
20	0.000999	65	0.021615
21	0.001033	66	0.022724
22	0.001063	67	0.025617
23	0.001090	68	0.028823
24	0.001113	69	0.032372
25	0.001132	70	0.036294
26	0.001147	71	0.040623
27	0.001159	72	0.045392
28	0.001166	73	0.050639
29	0.001170	74	0.056404
30	0.001170	75	0.062728
31	0.001171	76	0.069655
32	0.001201	77	0.077231
33	0.001246	78	0.085502
34	0.001309	79	0.094519
35	0.001387	80	0.104331
36	0.001482	81	0.114992
37	0.001593	82	0.126553
38	0.001721	83	0.139067
39	0.001865	84	0.151077
40	0.002053	85	0.162298
41	0.002247	86	0.174149
42	0.002418	87	0.186638
43	0.002602	88	0.199775
44	0.002832	89	0.213560
45	0.003110	90	0.227995
46	0.003438	91	0.243072
47	0.003816	92	0.258782
48	0.004243	93	0.275109
49	0.004719	94	0.292031
50	0.005244	95	0.309522
51	0.005819	96	0.327549
52	0.006443	97	0.346073
53	0.007116	98	0.365052
54	0.007839	99	0.384436
55	0.008611		
56	0.009433		
57	0.010294		
58	0.011025		
59	0.011951		