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MORTALITY

Mortality and Morbidity Liaison Committee – ISCS Body Mass Index Study

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Objective.——This study used the Impairment Study Capture System (ISCS) to examine the relationship between mortality and body mass index (BMI) in an insured population, particularly BMI in isolation from other risk factors.

Background.——Large-scale studies of build in an insured population have traditionally been done on policies issued at standard premium rates. Insured mortality experience on elevated BMI is scarce or outdated. Increasingly competitive underwriting of build throughout the years has influenced what has been issued standard, and therefore, the relative experience of substandard to standard business.

Methods.——We studied 241,966 policies submitted through the ISCS between 1989 and 2003 with actual height and weight and a code signifying abnormal build. Actual BMI were derived for these insureds. The average BMI was 35.0. Standardized mortality ratios (SMR) were computed using the 2001 Valuation Basic Table (VBT) as the expected basis. The average duration of exposure was 2.5 years. Results were stratified by underwriting factors of interest.

Results.——Standardized mortality ratios rose quite modestly as BMI increased up until reaching severe obesity. Ratios for nonsmoker policies where elevated build was the only impairment saw SMR of 265% at BMI $<$18.5, 130% at BMI 30.0–34.9, 160% at BMI 35.0–39.9 and 239% at BMI $\geq$40.0. Ratios where other impairments were present tended to be higher in moderately obese ranges and lower at extremely obese ranges. No underwriting factor of significance impacted the pattern of ratios as BMI increased.

Conclusions.——While an average of 3 years may not be long enough to see the true manifestations of obesity, excess mortality is exhibited at low and high BMI ranges, especially when seen in isolation. The study is not a direct comparison of obese to non-obese subjects, but it is a point of reference for how obese insureds have fared vs standard issued policies. The relatively favorable experience may have more to do with the construction of the (standard) VBT table than any mitigating effect of modest obesity.

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INTRODUCTION

An acknowledged obesity epidemic is reported almost daily in the scientific,[1] business,[2] trade,[3] and clinical press.[4,5] More importantly, the association of obesity with potentially decreasing life expectancies has become publicized.[6] Demonstrated comorbidity with hypertension,[7] diabetes,[8] coronary heart disease,[9] sleep apnea,[10] and several cancers[11] clearly make obesity a concern in underwriting. The effect of obesity in isolation should not be overlooked however. The insured population may be thought of as screened already for the severest of preexisting conditions and thus may provide the most credible estimates of obesity-related mortality in otherwise healthy people.

Conceptually, obesity is defined as an excessive accumulation of body fat. In the absence of actual anthropometric measurements, body mass index (BMI) is widely accepted to be the best proxy for obesity and is the parameter recommended in the National Institutes of Health Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults.[12] A person's BMI is found by dividing weight in kilograms by height in meters squared. Classification of BMI is shown in Table 1.

BMI, or its less specific historical namesake ''build,'' has been used in life insurance underwriting for over 100 years.[13] Masked by a high correlation with tuberculosis, underweight insureds were originally thought to present the worst mortality risk. With the containment of TB in the middle of the 20th century, the adverse effect of being overweight or obese was more readily recognized.

This study fills a long-standing gap in examination of build or BMI in insured lives. The large-scale Society of Actuaries 1959 Build and Blood Pressure Study[14] and 1979 Build Study[15] are considered the hallmark studies of insured lives but focused predominantly on standard issues and weights within 25% of average. Those studies, collectively, covered experience of 1935–1972, a period when a mere 10% of American men could be classified as obese. In 1999–2002 that percent for all adults was estimated to be 30%.[16]

Table 1. Classification of BMI

Classification	BMI	Obesity Class
Underweight	<18.5	
Normal	18.5–24.9	
Overweight	25.0–29.9	
Obesity	30.0–34.9	I
	35.0–39.9	II
Extreme obesity	≥40.0	III

METHODS

Analysis was performed on the total mortality experience of 241,966 insured lives submitted by 17 participating Impairment Study Capture System (ISCS) insurance companies. The policies were issued at standard or substandard premium rates between 1989 and 2003 policy anniversaries and followed for up to the first 10 annual policy durations. BMI was calculated for each participant. MIB practice calls for report of height and weight only if abnormal build affects the mortality risk assessment. Therefore, the majority of the study population is either underweight or obese. Few policies had normal BMI (18.5–24.9) or overweight BMI (25.0–29.9), which are predominantly accepted as standard. BMI >55 was excluded because such extreme values are rare and possibly result from coding errors. Table 2 shows distributions of BMI ranges by key study variables.

Expected deaths were based on the 2001 Valuation Basic Tables (2001 VBT) created by the Society of Actuaries (SOA) Individual Life Insurance Valuation Mortality Research Task Force (Task Force) and published in its November 2001 report.[17] The experience studies underlying the 2001 VBT are based on fully underwritten policies and specifically exclude substandard policies. Issue age, duration and smoker specific VBT mortality rates were used to calculate expected deaths. If the smoking status of the insured was

Table 2. Distribution of Exposures and Deaths by BMI Ranges for Key Variables Included in Study

	Overall			Male		Single Impairment		Standard	
	Exposure Years	% All BMI Exposure Yrs	Deaths	% All BMI Exposure Yrs	Deaths	% All BMI Exposure Yrs	Deaths	% All BMI Exposure Yrs	Deaths
BMI 15.0–18.5	38,804	6%	60	2%	16	8%	43	9%	51
BMI 18.5–24.9	18,968	3%	23	1%	9	4%	15	5%	19
BMI 25.0–29.9	12,272	2%	19	2%	10	2%	7	3%	12
BMI 30.0–34.9	213,689	35%	360	48%	236	34%	182	46%	252
BMI 35.0–39.9	238,760	40%	391	38%	186	39%	214	34%	171
BMI 40.0–55.0	79,781	13%	134	9%	41	13%	77	4%	27
Total	602,274		987		498		538		532
% of Overall		100%	100%	46%	50%	70%	55%	65%	54%

unknown, the composite version of the 2001 VBT is used.

SMR and approximations to exact 95% confidence intervals were computed using accepted methods.[18] Comparisons between 2 BMI range SMR should strictly be made only when there is evidence of homogeneity of gender-age SMR within the 2 BMI ranges. Appendix A is a comprehensive summary of analytic results. Appendix B addresses the use of a chi-square test of homogeneity first suggested for this purpose in studies of occupational mortality.[19] The test is not appropriate for groups where the number of expected deaths is 5 or less, and so this paper does not address the comparability of normal BMI range SMR as numbers of deaths in any gender-age grouping are consistently below this threshold. There was no need to address non-homogeneity although methods exist for standardizing inter-SMR comparisons.[20]

RESULTS

The overall SMR in the study was 151% of the 2001 VBT with a 95% confidence interval (95% CI) 141%–160%. (Table 3)

By BMI Range

A ''U'' shaped pattern of mortality emerged across the specified BMI ranges. Underweights (SMR 211%, 95% CI 161%–271%) and the extremely obese (SMR 186%,

Table 3. Standardized Mortality Ratio with 95% Confidence Interval and Excess Death Rate per 1000

	Exposure Years	Actual Deaths	Expected Deaths	SMR (%)	95% CI	EDR
Overall	602,274	987	655	151	141–160	0.55

Table 4. Standardized Mortality Ratios with 95% Confidence Intervals, and Excess Death Rates per 1000 by BMI Range

	Exposure Years	Actual Deaths	Expected Deaths	SMR (%)	95% CI	EDR
BMI 15.0–18.4	38,804	60	28.5	211	161–271	0.81
BMI 18.5–24.9	18,968	23	15.0	153	97–230	0.42
BMI 25.0–29.9	12,272	19	15.5	123	74–191	0.28
BMI 30.0–24.9	213,689	360	258.2	139	125–155	0.48
BMI 35.0–39.9	238,760	391	265.7	147	133–162	0.52
BMI 40.0–55.0	79,781	134	71.9	186	156–221	0.78

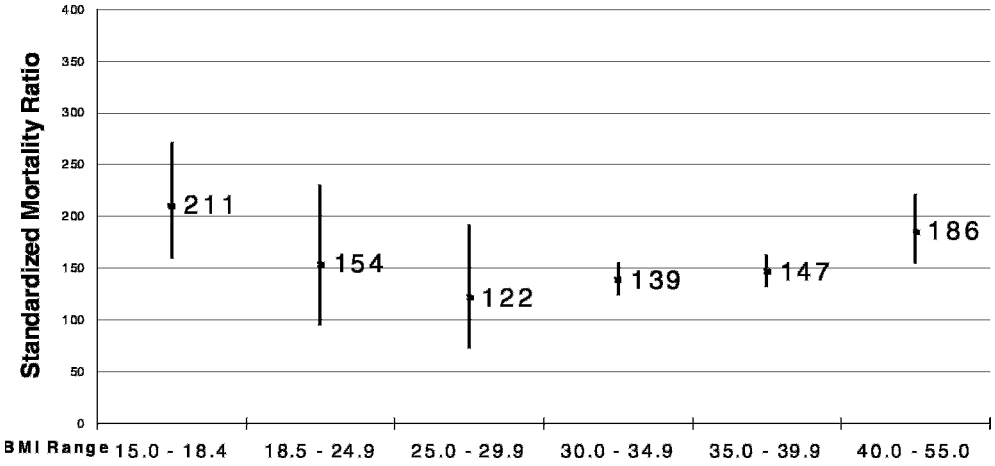

Figure 1. *SMRs and 95% Confidence Intervals, Overall.*

95% CI 156%–221%) had similar mortality ratios. Overall, the lowest mortality ratio was observed in the overweight BMI range (SMR 123%, 95% CI 74%–191%) although based on only 19 deaths. (Table 4)

SMR and their confidence intervals are shown here for all BMI ranges. Wide confidence intervals at normal and overweight BMI and narrower confidence intervals at obese BMI are a natural consequence of this being a study of builds of underwriting significance, where the vast majority of deaths were observed. (Figure 1)

By Impairment Classification

The difference between mortality ratios for policies with BMI as the only impairment (SMR 146%, 95% CI 134%–158%) and those that had one or more other impairments (SMR 157%, 95% CI 143%–173%) was fairly modest. The differences between single and multiple impairment SMR became smaller as BMI increased. (Table 5)

By Smoking Status

The difference between mortality ratios for nonsmoker policies (SMR 162%, 95% CI 149%–175%) and smoker policies (SMR 128%, 95% CI 112%–146%) was appreciable, keeping in mind the effect of smoking is already adjusted for in the 2001 VBT. (Table 6) Nonsmoker mortality ratios across all BMI ranges were higher than those for smokers. SMR for smokers were remarkably flat across all BMI.

By Impairment Classification and Smoking Status

A more pronounced U-shaped pattern by BMI is seen when experience is isolated to nonsmokers where BMI is the only impairment. (Figure 2)

Table 5. Abnormal BMI by Impairment Status, Standardized Mortality Ratios with 95% Confidence Intervals and Excess Death Rates per 1000

	All		Underweight BMI 15.0–18.5		Obese Class I BMI 30.0–34.9		Obese Class II BMI 35.0–39.9		Extreme Obesity BMI 40.0–55.0	
	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR
Single Impairment	146 (139–158)	0.40	199 (144–268)	0.61	130 (127–166)	0.29	143 (124–163)	0.39	192 (151–240)	0.68
Multiple Impairment	157 (131–173)	0.91	249 (145–398)	2.59	150 (129–174)	0.87	153 (131–177)	0.83	180 (136–233)	0.97

Table 6. Abnormal BMI by Smoking Status, Standardized Mortality Ratios with 95% Confidence Intervals and Excess Death Rates per 1000

	All		Underweight BMI 15.0–18.5		Obese Class I BMI 30.0–34.9		Obese Class II BMI 35.0–39.9		Extreme Obesity BMI 40.0–55.0	
	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR
Nonsmoker	162 (149–175)	0.61	277 (195–382)	1.09	145 (127–166)	0.49	159 (140–180)	0.59	215 (173–264)	0.90
Smoker	128 (112–146)	0.45	154 (66–304)	0.67	141 (107–182)	0.44	148 (113–190)	0.33	144 (82–234)	0.62
Unknown	211 (161–271)	0.45	211 (161–271)	0.30	211 (161–271)	0.44	211 (161–271)	0.48	211 (161–271)	0.41

This view of results is arguably the best proxy for the true effect of obesity and so is treated in detail here. For each pair wise comparison of BMI ranges 15.0–18.4, 30.0–34.9, 35.0–39.9, and 40.0–55.0, a test of homogeneity was done to ensure an inter-SMR comparison was appropriate (see Appendix B). For each pair of ranges, homogeneity was supported.

Based on a comparison then of confidence intervals for Nonsmoker with Single Impairment, the SMR for BMI 40.0–55.0 is not equal to the SMR of BMI 30.0–34.9. Also, the SMR for BMI 40.0–55.0 is not equal to the SMR for BMI 35.0–39.9. The SMR for BMI 15.0–18.4 is also not equal to the SMR for BMI 30.0–34.9. Any other pairwise comparison of abnormal BMI suggests no statistical difference in SMR.

In the presence of other impairments the pattern is much flatter by increasing BMI. (Figure 3)

By Rating

Substandard rated policies exhibited appropriately higher mortality ratios (SMR 180%, 95% CI 164%–197%) over policies accepted at standard rates (SMR 132%, 95% CI 121%–144%). (Table 7) The difference became smaller as BMI increased. The best explanation for this convergence is that more substandard experience is comprised of multiple impairment contributions, and as seen above, multiple and single impairment SMR converge at higher BMI. Underwriting appeared to be able to select the better risks in the midranges but was less effective at the extremes in policies taken at standard rates.

By Gender

Overall, mortality ratios for males (SMR 156%, 95% CI 142%–170%) and females (SMR 146%, 95% CI 133%–160%) were virtually

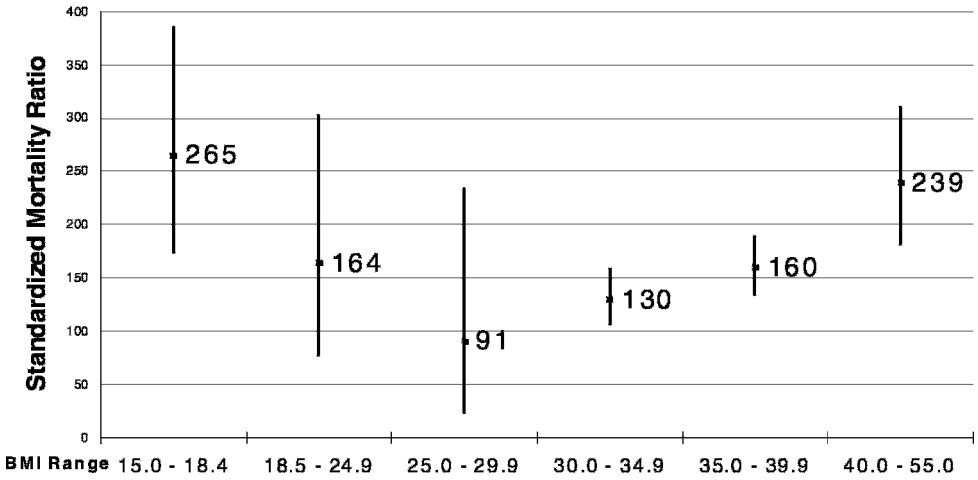

Figure 2. *SMRs and 95% Confidence Intervals, Nonsmoker with Single Impairment.*

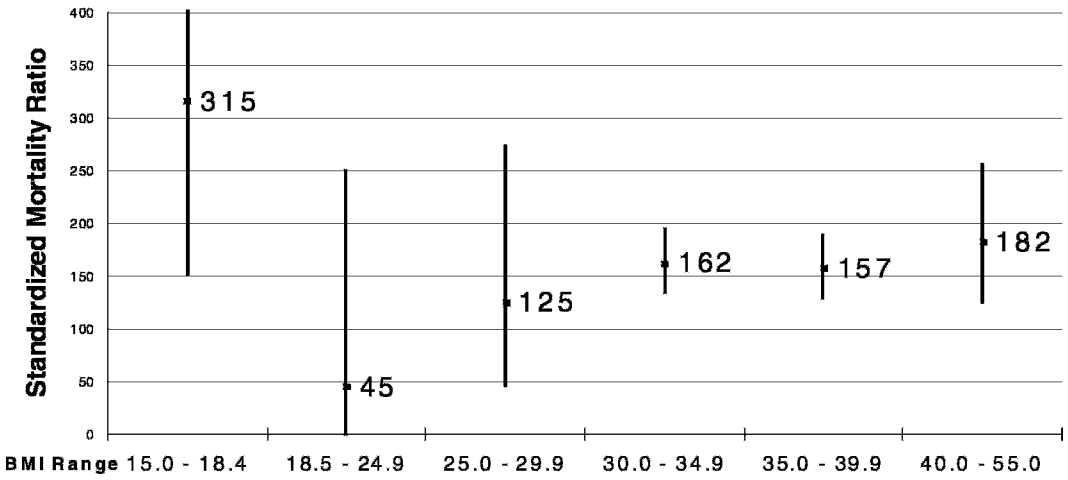

Figure 3. *SMRs and 95% Confidence Intervals, Nonsmoker with Multiple Impairments.*

identical. Male SMR were higher except at BMI ≥40.0. (Table 8)

By Issue Age

Mortality ratios by issue age were remarkably consistent with the overall pattern. (Table 9)

By Policy Duration

Mortality ratios were highest overall in policy durations 1–2 and especially so for underweights (SMR 278%, 95% CI 192%–388%) and extremely obese (SMR 227%, 95% CI 177%–286%). (Table 10)

DISCUSSION

The notion of a ''J'' or ''U'' shaped mortality curve when plotted against BMI corresponds to extra mortality associated with the very lean, as well as very obese. The pattern is widely reported to exist

Table 7. Abnormal BMI by Rating, Standardized Mortality Ratios with 95% Confidence Intervals and Excess Death Rates per 1000

	All		Underweight BMI 15.0–18.5		Obese Class I BMI 30.0–34.9		Obese Class II BMI 35.0–39.9		Extreme Obesity BMI 40.0–55.0	
	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR
Standard Rating	132 (121–144)	0.33	200 (149–263)	0.69	126 (111–143)	0.29	125 (107–145)	0.26	188 (124–274)	0.81
Substandard Rating	180 (164–197)	0.96	302 (138–573)	3.44	184 (151–223)	1.38	171 (149–195)	0.85	186 (152–225)	0.77

Table 8. Abnormal BMI by Gender, Standardized Mortality Ratios with 95% Confidence Intervals and Excess Death Rates per 1000

	All		Underweight BMI 15.0–18.5		Obese Class I BMI 30.0–34.9		Obese Class II BMI 35.0–39.9		Extreme Obesity BMI 40.0–55.0	
	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR
Male	156 (142–170)	0.65	227 (129–368)	1.57	149 (131–169)	0.59	157 (136–182)	0.65	173 (124–235)	0.71
Female	146 (133–160)	0.47	205 (149–398)	0.68	124 (103–174)	0.30	139 (121–177)	0.43	193 (156–233)	0.81

Table 9. Abnormal BMI by Issue Age, Standardized Mortality Ratios with 95% Confidence Intervals and Excess Death Rates per 1000

	All		Underweight BMI 15.0–18.5		Obese Class I BMI 30.0–34.9		Obese Class II BMI 35.0–39.9		Extreme Obesity BMI 40.0–55.0	
Issue Age	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR
20–39	151 (132–172)	0.22	183 (112–183)	0.28	139 (109–173)	0.19	137 (108–170)	0.16	209 (149–286)	0.43
40–59	153 (140–168)	0.76	224 (131–359)	1.85	147 (127–169)	0.69	153 (133–176)	0.74	175 (134–223)	0.94
≥60	146 (130–165)	2.52	230 (146–356)	9.00	128 (104–156)	1.57	145 (120–174)	2.37	187 (127–265)	4.09

among many risk factors such as blood pressure[21] and cholesterol.[22]

Nonsmokers with no adjunct impairments perhaps afford the cleanest look at mortality from isolated elevated BMI. The effect of increasing BMI here appears to be positively correlated with increasing SMRs. The more pronounced effect on nonsmokers is consistent with results in both population[23] and insured studies.[24]

When other impairments and smoking are introduced, SMRs are higher for moderate obesity and lower for the extremely obese than in the nonsmoker, single impairment experience. This may suggest BMI acts more as a threshold function in these cases, where other impairments and smoking trump the effects of mild obesity but at some point around a BMI of 35, the effects of obesity take over. While lower SMRs in smokers may have more to do with the intricacies of the 2001 VBT, it may also suggest a counterintuitive notion – that smoking confers a constant, additive hazard as opposed to the widely accepted belief that it exhibits itself as a proportional hazard. This may be even more plausible in early durations.

With average policy duration of 2.5, it is unlikely that all the harmful effects of obesity would have time to play out, although the effects of extreme underweight might be expected to be more acute in the presence of say, occult cancer. Indeed, higher SMRs were seen in early durations for underweights.

Underweights consistently exhibited SMRs greater than those of the extremely obese. The only subset where this relationship did not hold was issue ages under 30. Female underweights fared slightly better than male underweights. The underwriting process appears to identify the riskiest of the underweight population as those that were substandard had an SMR of 302% vs 200% for those accepted standard. However, the 200% SMR in the standard issue group suggests a need for additional underwriter education and vigilance in evaluating applicants who are significantly underweight.

This study supports the assertion that life insurance risk classification has historically been lenient on elevated BMI. For policies where abnormal build was the only noted impairment, 66% of all exposures still came from policies rated standard. Even at BMI

Table 10. Abnormal BMI by Duration, Standardized Mortality Ratios with 95% Confidence Intervals and Excess Death Rates per 1000

	All		Underweight BMI 15.0–18.5		Obese Class I BMI 30.0–34.9		Obese Class II BMI 35.0–39.9		Extreme Obesity BMI 40.0–55.0	
Durations	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR	SMR (CI)	EDR
1–2	167 (152–184)	0.52	278 (192–388)	1.03	143 (120–168)	0.36	159 (136–184)	0.46	227 (177–286)	0.83
3–5	136 (122–151)	0.47	128 (108–151)	0.44	136 (115–160)	0.41	172 (133–176)	0.50	175 (134–223)	0.80
6–10	147 (127–172)	1.10	194 (146–356)	0.97	163 (104–156)	1.51	153 (120–174)	1.09	136 (127–265)	0.32

≥35.0, 41% of experience was rated standard. An unknown portion of these could be due to credits from other underwriting factors.

The modest, although essentially non-overlapping, mortality difference between standard and substandard rated business speaks both to the modest additional mortality for higher BMI and to the fact that marginal BMI accepted at standard rates experience worse than the *average* standard mortality. Colloquially known as the ''Will Rogers effect,'' this explains how raising the threshold for classifying disease can have the effect of making the newly ''diseased'' population compare favorably with a new ''non-diseased'' population that is in fact not as healthy as before the change in classification.[25] During the period from which the VBT was constructed (1995–2000), BMI of 37.5 were commonly accepted as standard, unless complicated by other impairments.

Three percent of the study's contribution is from clinically normal BMI. While 27% of these records have an associated code for recent weight loss, and thus of underwriting significance, it is not clear the source of the remainder. Other significant underwriting factors may have been coded on these policies, prompting underwriters to code the BMI in addition. The inclusion of these records is more for completeness than an attempt to study normal insured BMI.

As is true of any insured lives study, results are not generalizable for clinical, medical, or public health purposes. As implied, the construction of the 2001 VBT itself could have as big an impact on the pattern of SMR as the actual experience itself, to the extent that it included an ever ''expanding'' standard insured population.

COMPARISON WITH 1979 BUILD STUDY

The landmark 1979 Build Study examined the mortality experience between 1935 and 1972 of nearly 4.2 million policies issued to individuals in ''ostensibly good health who did not have any significant health impairments other than (build).'' Substandard issues comprised only 5% of experience. Remarkably, the study included some 106,000 deaths.

Direct comparison of the 1979 study to the current study is difficult for a number of reasons:

- The 1979 study excluded all but minor adjunct impairments, essentially leaving the equivalent of Single Impairment experience, using this study's terminology.
- The 1979 study enjoyed a lengthy follow-up period and is not reported in enough detail to adjust for durational effect on results between the two studies. In general, duration 1–5 experience in the 1979 study had lower mortality ratios than later durations.
- The 1979 study combined standard and substandard issues by a predetermined 4 to 1 ratio to match the prevailing mix of business in the industry at the time. Standard experience was not reported separately.
- The two study populations span experience that is potentially 50 years apart, and, accordingly, the two studies used different tables as their standard bases making comparison of mortality ratios wildly speculative. A reconciliation of the 1954–1972 Basic Table and the 2001 VBT is beyond the scope of this paper.

Comparison is also made difficult in that actual height and weight measurements of applicants are used in the current study - allowing for the calculation of BMI. Whereas, in the 1979 study, only codes signifying ranges of height and weight were tabulated. A code signifying heights of 5′7″ to 5′10″ with a code signifying weights of 235–244 lbs could result in a BMI of anywhere from 33.8 to 38.3. Taking the midpoints of each of these ranges would result in a BMI of 36.0.

In a guarded attempt to compare results of this study to the 1979 Build Study, we grouped the 1979 study into BMI ranges based on the midpoints of the height/weight code combination reported in that study. By

Table 11. Comparison of 2005 MMLC BMI Study to 1979 SOA Build Study Standardized Mortality Ratios*, Males 20–69, BMI >30

	Single Impairment / Standard**		Single Impairment / Substandard		All	
BMI	1979 SOA Build Study	2005 MMLC BMI Study	1979 SOA Build Study	2005 MMLC BMI Study	1979 SOA Build Study	2005 MMLC BMI Study
30.0–34.9	115	129	145	169	120	150
35.0–39.9	151	152	155	171	163	157
40.0–55.0	100	184	385	180	217	175

* 1979 SOA Build Study vs 1952–1974 Basic Table, 2005 MMLC BMI Study vs 2001 VBT

** 1979 SOA Standard experience estimated by solving for SMR that when combined in 4:1 ratio with substandard SMR produces overall SMR

that method, there were over 30,000 policies terminated by death issued at a BMI >30.

Results for obese males, issued at ages 20–69, are compared in Table 11. It is interesting to note that SMR are not all that dissimilar to their contemporaneous insurance standard basis in each study, except for the extremely obese.

CONCLUSION

Insurance selection and classification undoubtedly have a mitigating effect on mortality due to excess obesity. In this study, the effect of obesity is most pronounced when in isolation, which might be expected of a cohort essentially screened of other disease. Compared to the 2001 VBT, extra mortality exhibited ranges amounting to roughly 25%–75% extra in the obese and 75%–150% extra in underweights and the extremely obese.

Even in the shortest of follow-up durations, there was excess mortality, particularly for underweights and the extremely obese. The pattern of mortality ratios by BMI was not materially different by any significant underwriting factor.

Without detailed knowledge of how much the experience underlying the 2001 VBT was tainted by insured obesity during the 1990s, it is difficult to say how the patterns of mortality are affected in this study when compared to that standard basis.

While this study bridges the long-standing gap in studies of build for insured lives, it highlights the ongoing need for more extensive research. The dearth of large scale mortality investigations has forced reliance on studies, like this one, that have a mere fraction of the number of exposures and deaths compared to historical, sweeping investigations.

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APPENDIX A:

SUMMARY TABLE
Mortality Experience in Males and Females
1989 to 2003 Policy Anniversaries

MALE						Risk Categories & Groups	FEMALE					
Exposure Policy-yrs	Observed Deaths	Expected Deaths*	Mortality Ratio (%)	95% CI (%)	Excess Deaths/M	By Rating & Smoker Status All Ages and Durations Combined	Exposure Policy-yrs	Observed Deaths	Expected Deaths*	Mortality Ratio (%)	95% CI (%)	Excess Deaths/M
275,900	498	319.9	156	[142–170]	0.7	Total: All Ratings; All S, NS, U Combined	326,375	489	334.9	146	[133–160]	0.5
5706	16	7.1	225	[129–368]	1.6	BMI 15.0–18.5	33,099	44	21.4	206	[149–276]	0.7
131,898	236	158.4	149	[131–169]	0.6	BMI 30.0–34.9	81,791	124	99.8	124	[103–148]	0.3
104,652	186	118.2	157	[136–182]	0.6	BMI 35.0–39.9	134,108	205	147.5	139	[121–159]	0.4
24,367	41	23.7	173	[124–235]	0.7	BMI 40.0–55.0	55,414	93	48.2	193	[156–236]	0.8
112,012	170	112.7	151	[129–175]	0.5	Standard; Non-Smoker	123,297	152	106.4	143	[121–167]	0.4
2807	6	2.8	214	[79–469]	1.2	BMI 15.0–18.5	17,822	25	9.1	275	[177–404]	0.9
69,061	102	7.2	1417	[118–176]	0.5	BMI 30.0–34.9	44,726	53	45.2	117	[88–153]	0.2
32,378	52	31.7	164	[122–215]	0.6	BMI 35.0–39.9	42,291	50	38.4	130	[97–172]	0.3
2450	5	2.2	227	[73–528]	1.1	BMI 40.0–55.0	5554	12	4.5	267	[136–462]	1.3
31,151	60	55.7	108	[82–139]	0.1	Standard; Smoker	38,675	54	53.0	102	[76–133]	0.02
1160	6	2.3	261	[94–559]	3.2	BMI 15.0–18.5	5952	7	9.1	77	[177–404]	0.9
17,270	41	30.9	133	[95–180]	0.6	BMI 30.0–34.9	13,265	17	45.2	38	[88–153]	0.2
10,499	9	18.1	50	[23–94]	−0.9	BMI 35.0–39.9	14,009	20	38.4	52	[97–172]	0.3
888	1	1.6	63	[1–355]	−0.6	BMI 40.0–55.0	2230	5	4.5	111	[136–462]	1.3
44,134	62	42.9	145	[111–185]	0.4	Standard; Unknown	41,418	34	31.1	109	[76–153]	0.1
1370	0	1.3	0	—	−0.9	BMI 15.0–18.5	7946	7	3.6	194	[77–398]	0.4
23,732	28	23.9	117	[78–169]	0.2	BMI 30.0–34.9	9756	11	9.3	118	[59–212]	0.2
15,876	29	14.3	203	[136–292]	0.9	BMI 35.0–39.9	16,552	11	13.6	81	[40–144]	−0.2
1757	2	1.6	125	[110–285]	0.2	BMI 40.0–55.0	2790	2	1.8	111	[13–405]	0.1
187,296	292	211.3	138	[123–155]	0.4	Total Standard; All S, NS, U Combined	203,390	240	190.5	126	[110–143]	0.2
5337	12	6.4	188	[96–327]	1.0	BMI 15.0–18.5	31,720	39	19.1	204	[145–279]	0.6
110,063	171	125.1	137	[117–159]	0.4	BMI 30.0–34.9	67,747	81	74.5	109	[86–135]	0.1
58,753	90	64.1	140	[113–173]	0.4	BMI 35.0–39.9	72,852	81	72.6	112	[89–139]	0.1
5095	8	5.4	148	[64–295]	0.5	BMI 40.0–55.0	10,574	19	9.0	211	[127–330]	0.9
63,864	123	67.0	184	[153–219]	0.9	Substandard; Non-Smoker	91,912	174	96.1	181	[155–210]	0.9
211	3	0.3	1000	[232–3373]	13.0	BMI 15.0–18.5	813	3	1.2	250	[50–732]	2.2
15,602	37	20.3	182	[128–251]	1.1	BMI 30.0–34.9	10,421	30	17.1	175	[118–250]	1.2
33,848	62	34.9	178	[136–227]	0.8	BMI 35.0–39.9	47,015	84	51.2	164	[131–203]	0.7
13,398	19	10.4	183	[110–285]	0.6	BMI 40.0–55.0	32,750	55	25.2	218	[165–284]	0.9

APPENDIX A: Continued

SUMMARY TABLE
Mortality Experience in Males and Females
1989 to 2003 Policy Anniversaries

MALE						Risk Categories & Groups	FEMALE					
Exposure Policy-yrs	Observed Deaths	Expected Deaths*	Mortality Ratio (%)	95% CI (%)	Excess Deaths/M	By Rating & Smoker Status All Ages and Durations Combined	Exposure Policy-yrs	Observed Deaths	Expected Deaths*	Mortality Ratio (%)	95% CI (%)	Excess Deaths/M
15,890	48	29.1	165	[121–219]	1.2	Substandard; Smoker	19,440	55	31.6	174	[131–226]	1.2
117	0	0.3	0	—	−2.9	BMI 15.0–18.5	385	2	0.9	222	[24–784]	2.8
3787	14	8.9	157	[86–264]	1.3	BMI 30.0–34.9	2224	9	5.0	180	[83–344]	1.8
8209	22	13.6	162	[101–245]	1.0	BMI 35.0–39.9	9361	31	16.0	194	[132–275]	1.6
3498	8	5.4	148	[64–294]	0.8	BMI 40.0–55.0	7087	13	8.9	146	[78–251]	0.6
8850	35	12.5	280	[195–388]	2.5	Substandard; Unknown	11,635	20	16.4	122	[74–188]	0.3
42	1	0.04	2500	[30–12717]	22.8	BMI 15.0–18.5	181	0	0.2	0	—	−1.2
2448	14	4.1	341	[185–568]	4.0	BMI 30.0–34.9	1400	4	3.1	129	[34–327]	0.6
3843	12	5.5	218	[112–378]	1.7	BMI 35.0–39.9	4881	9	7.7	117	[53–222]	0.3
2379	6	2.6	231	[85–506]	1.4	BMI 40.0–55.0	5005	6	5.2	115	[42–253]	0.2
88,604	206	108.6	190	[165–217]	1.1	Total Substandard; All S, NS, U Combined	122,987	249	144	173	[152–196]	0.9
370	4	0.6	625	[167–1588]	9.1	BMI 15.0–18.5	1379	5	2.3	217	[69–499]	1.9
21,837	65	33.3	195	[150–248]	1.4	BMI 30.0–34.9	14,045	43	25.2	171	[123–230]	1.3
45,900	96	54.0	178	[144–217]	0.9	BMI 35.0–39.9	61,257	124	74.9	166	[138–97]	0.8
19,275	33	18.4	179	[124–252]	0.8	BMI 40.0–55.0	44,842	74	39.3	188	[148–237]	0.8
						By Issue Age						
Exposure Policy-yrs	Observed Deaths	Expected Deaths*	Mortality Ratio (%)	95% CI (%)	Excess Deaths/M	Substandard, All Durations Combined Smoker, Non-Smoker, Unknown Combined	Exposure Policy-yrs	Observed Deaths	Expected Deaths*	Mortality Ratio (%)	95% CI (%)	Excess Deaths/M
49,171	37	27.5	135	[95–186]	0.2	20–39	60,590	42	18.7	225	[162–304]	0.4
248	0	0.2	0	—	−0.6	BMI 15.0–18.5	830	1	0.2	500	[5–2265]	0.9
9,544	7	5.3	132	[53–271]	0.2	BMI 30.0–34.9	4404	3	1.4	214	[43–626]	0.4
26,368	18	14.7	122	[73–194]	0.1	BMI 35.0–39.9	29,483	17	9.1	187	[108–298]	0.3
12,484	10	7.0	143	[68–263]	0.2	BMI 40.0–55.0	25,239	20	7.7	260	[159–403]	0.5
35,550	121	54.2	223	[185–266]	1.9	40–59	49,869	96	63.5	151	[122–185]	0.7
87	3	0.2	1500	[354–5152]	32.7	BMI 15.0–18.5	316	0	0.5	0	—	−1.5
10,801	40	17.4	230	[164–312]	2.1	BMI 30.0–34.9	6893	20	9.7	206	[126–319]	1.5
17,640	56	26.4	212	[160–275]	1.7	BMI 35.0–39.9	25,000	45	32.4	139	[101–186]	0.5
6423	19	9.1	209	[125–326]	1.5	BMI 40.0–55.0	17,070	30	20.0	150	[101–214]	0.6
3884	48	26.9	178	[132–237]	5.4	60 and up	12,528	111	62.0	179	[147–216]	3.9
36	1	0.3	333	[4–1697]	18.9	BMI 15.0–18.5	234	4	1.6	250	[67–633]	10.2
1492	18	10.6	170	[101–269]	5.0	BMI 30.0–34.9	2747	20	14.1	142	[87–219]	2.1

APPENDIX A: Continued

SUMMARY TABLE
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MALE						Risk Categories & Groups	FEMALE					
Exposure Policy-yrs	Observed Deaths	Expected Deaths*	Mortality Ratio (%)	95% CI (%)	Excess Deaths/M	By Rating & Smoker Status All Ages and Durations Combined	Exposure Policy-yrs	Observed Deaths	Expected Deaths*	Mortality Ratio (%)	95% CI (%)	Excess Deaths/M
1892	22	12.9	171	[106–257]	4.8	BMI 35.0–39.9	6775	62	33.3	186	[143–239]	4.2
368	4	2.2	182	[48–456]	4.8	BMI 40.0–55.0	2533	24	11.5	209	[133–310]	4.9
						By Policy-Year Durations						
Exposure Policy-yrs	Observed Deaths	Expected Deaths*	Mortality Ratio (%)	95% CI (%)	Excess Deaths/M	Substandard; All Issue Ages Combined Smoker, Non-Smoker, Unknown Combined	Exposure Policy-yrs	Observed Deaths	Expected Deaths*	Mortality Ratio (%)	95% CI (%)	Excess Deaths/M
51,762	89	43.4	205	[164–252]	0.9	1–2	124,911	206	101.4	203	[176–233]	0.8
231	2	0.4	500	[62–2009]		BMI 15.0–18.5	1080	6	1.5	400	[5–2265]	4.2
12,764	31	12.9	240	[163–340]	0.2	BMI 30.0–34.9	20,945	48	22.8	211	[43–626]	1.2
26,705	42	21.4	196	[141–265]	0.1	BMI 35.0–39.9	62,695	97	50.4	192	[108–298]	0.7
11,357	12	7.9	152	[79–267]	0.2	BMI 40.0–55.0	38,613	52	24.8	210	[159–403]	0.7
29,715	82	45.2	181	[144–225]	1.2	3–5	69,665	176	104.7	168	[144–195]	1.0
117	2	0.2	1000	[108–3486]	15.3	BMI 15.0–18.5	539	3	1.0	300	—	3.7
7229	26	13.9	187	[122–274]	1.7	BMI 30.0–34.9	11,878	44	24.3	181	[126–319]	1.7
15,571	36	22.7	159	[111–220]	0.9	BMI 35.0–39.9	36,010	82	54.3	151	[101–186]	0.8
6392	14	7.5	187	[102–312]	1.0	BMI 40.0–55.0	20,671	43	23.2	185	[101–214]	1.0
7128	35	20.0	175	[122–244]	2.1	6–10	16,714	73	46.7	156	[123–197]	1.6
22	0	0.1	0	—	−3.6	BMI 15.0–18.5	130	0	0.5	0	[67–633]	−3.7
1844	8	6.5	123	[53–242]	0.8	BMI 30.0–34.9	3058	16	11.4	140	[87–219]	1.5
3624	18	10.0	180	[107–286]	2.2	BMI 35.0–39.9	8452	41	24.2	169	[143–239]	2.0
1525	7	3.0	233	[94–485]	2.6	BMI 40.0–55.0	4831	12	9.6	125	[133–310]	0.5

* Basis of expected deaths: 2001 VBT Expected Tables.

APPENDIX B.

For each pairwise comparison of BMI ranges 15.0–18.4, 30.0–34.9, 35.0–39.9, and 40.0–55.0, the test statistic

$$X^2 = \frac{\sum\sum (A_{1ij} - SMR * E_{1ij})^2 + (A_{2ij} - SMR * E_{2ij})^2}{\sum\sum (SMR * E_{1ij} + SMR * E_{2ij})}$$

was computed, where SMR is the pooled SMR of the two BMI ranges, A denotes actual deaths, E denotes expected deaths and N_{ij} is the index for the Nth BMI range, the ith gender and jth issue age group. This statistic can be compared to a chi-squared (X^2) distribution with five degrees of freedom, corresponding to $(r-1)*(c-1)$ where r is the two ranges, and c is the 6 gender-age cells. In general it appears comparison of any two abnormal BMI range SMRs is appropriate as a X^2 value greater than 6.63 is needed to reject homogeneity at even the 75% confidence level.

Values of X^2 in pairwise comparisons of BMI SMR homogeneity, Nonsmoker with Single Impairment

BMI range	30.0–34.9	35.0–39.9	40.0–55.0
15.0–18.4	1.11	1.64	0.94
30.0–34.9		1.33	1.76
35.0–39.9			1.84