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ORIGINAL ARTICLE

Body Mass Index and Mortality in an Insured Population

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Objective.—This study was conducted to explore the relationship between body mass index (BMI) and mortality in an insured population issued policies at standard rates or rated only for build using contemporary analytic techniques.

Background.—Many factors influence the relationship between build and mortality. Recent clinical literature on this subject often employs multivariate statistical techniques to better define this relationship and reduce the influence of confounders. BMI, a common surrogate variable for build in clinical literature, is our variable of choice in studying the relationship between build and mortality.

Methods.—We studied internal data on direct and reinsurance business issued between 1975 and 1998 at standard rates or rated only for build. The policies were followed till termination (death or lapse) or to the end of 1999. The average policy duration was 4.7 years. Cox proportional hazards model runs were used to study the multivariate relationship between mortality and BMI in moderately over- and underweight insured individuals.

Results:—During follow-up, 4105 deaths were observed. Mortality was noted to vary with BMI, most significantly in middle-aged male nonsmokers. Consistent with reports from the clinical literature, significant factors influencing the BMI-mortality relationship in this insured population included issue age and smoking status.

Conclusions.—BMI is a predictor of statistically significant mortality differentials in insured populations. The strength of the BMI-mortality relationship was found to vary by age, gender, and smoking status. In our study population, the male nonsmoker subgroups tended to exhibit the strongest graded relationship between hazard of death and increasing or decreasing BMI.

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The prevalence of overweight or obese individuals in the United States and in other parts of the world is rising.[1,2] Changes in physical activity levels and dietary patterns have contributed to the increase in global prevalence. Consequently, underwriters commonly face applicants whose health may be adversely affected by excess weight. An individual is normally considered obese if they are 20% over average weight or have a body mass index (BMI) greater than 30. BMI is expressed as the weight in kilograms divided by the square of the height in meters.[3,4]

Obesity is associated with an increased risk of several serious diseases, including hypertension, atherosclerosis, stroke, non–insulin-dependent diabetes, and sleep apnea.[4–6] Evidence of recent weight loss may be due to undiagnosed disease or recent changes in diet and activity level. In the latter case, if changes are recent, the permanency of weight loss may be difficult to assess since weight cycling is common.[7]

Clinical studies[7] have identified age, gender, and smoking status as among the most common factors influencing mortality. Comorbid conditions such as hypertension, hyperlipidemia, diabetes, or other disease can also influence the relationship between BMI and mortality. As a result, many clinical studies have attempted to screen out at least some individuals with these conditions. In the remaining clinical studies, the presence of individuals with these conditions may have biased estimates of relative mortality risk.

The purpose of this current investigation was to define the relationship between build and mortality in an insured population. We used analytical methods similar to those in contemporary clinical literature. This allowed us to compare the mortality effects of build in the general and insured populations. BMI was used as the build variable. Individuals issued standard policies or those rated only for build made up the study cohort. Excluding individuals rated for conditions other than build was considered an effective surrogate for removing individuals from the study population with comorbid conditions. This provision also had the effect of creating a study population composed primarily of individuals with average weight or those mildly to moderately underweight or overweight.

METHODS

The study population comprised 356,926 individual life insurance applicants from the insurance and reinsurance companies of Lincoln Financial Group. These individuals were issued policies beginning in 1975 through 1998 and were followed till termination (death or lapse) or to the end of 1999. Policies were in force for a mean duration of 4.7 years.

We defined entry criteria similar to those used in contemporary clinical studies[7] to reduce the influence of confounding factors on the BMI-mortality relationship. Two groups of adult insureds (age 18+) were included. Group A included individuals issued standard or preferred insurance policies without impairment codes. Group B included individuals who were rated only for build and who did not have other impairment codes recorded in our electronic data files. These 2 groups were combined to produce our final study population. We further restricted our sample to include only policies having height and weight data, as these were required for the calculation of BMI. To reduce the influence of possible coding errors, individuals who were shorter than 54 inches or taller than 96 inches or who weighed less than 70 pounds or more than 400 pounds were excluded.

Individuals were classified by smoking status as nonsmokers, smokers, and unknown based on policy application information. Unknown smoking status individuals comprised two thirds of the study population (Table 1). More than 90% of the policies were issued by 1982, when an underwriting distinction between nonsmokers and smokers was not made. Three issue age groups were chosen for analytic purposes, that is, 18–39 years, 40–59 years, and ≥60 years.

Table 1 includes separate breakdowns for several variables, including BMI, gender, duration, issue year, proportion rated for build, smoking status, and issue age groups by the number of policies and the number of exposure years. Table 2 lists the number of deaths for each combination of BMI groupings, issue age, and gender. We attempted to form BMI categories that would contain a reasonable number of deaths for statistical analysis, but this was not always possible, as is evident from the BMI < 19 and BMI ≥ 34 subgroups.

We used Cox proportional hazards model runs[8] to compute risk ratios (also referred to as hazard ratios in statistical literature). The ratios are displayed in Table 3 and are adjusted for duration and other factors including issue age group, gender, and smoking status, where appropriate. The risk ratio for different combinations of issue age groups, gender, and smoking status is defined as the

Table 1. Descriptive Statistics for the Variables Included in the Study Population

	Policies		Exposure Years	
Overall	356,926	100%	1,676,838	100%
Rated for build	64,823	18.2%	310,699	18.5%
Not rated for build	292,103	81.8%	1,365,689	81.5%
Male	256,031	71.7%	1,172,845	69.9%
Female	100,895	28.3%	503,993	30.1%
Nonsmokers	87,747	24.6%	396,166	23.6%
Smokers	33,675	9.4%	143,193	8.5%
Unknown	235,404	66.0%	1,137,479	67.8%
18–39	270,396	75.8%	1,202,764	71.7%
40–59	79,485	22.3%	424,565	25.3%
≥60	7045	2.0%	49,509	3.0%
BMI	Mean = 24.5	SD = 3.5	Mean = 24.5	SD = 3.5
Duration	Mean = 4.7 years	SD = 4.5 years	Mean = 5.1 years	SD = 4.5 years
Issue year	Mean = 1979	SD = 3.3 years	Mean = 1978.7	SD = 3.2 years

ratio of the mortality risk for a particular BMI range to the mortality risk at a baseline (or reference) BMI range for the same combination of factors. PROC PHREG, a standard statistical procedure offered by SAS version 6.12 (SAS Institute, Cary, NC) was used in each of these Cox model runs. Each model run utilized two ranges of BMI—the reference range and the range being compared with the reference range.

We performed an exploratory analysis of the data stratified by smoking status based on the hypothesis that a portion of lean smokers issued standard policies might be more likely to harbor occult malignancies compared with nonsmokers. The BMI reference range associated with the lowest mortality was noted to vary from study to study based on a review of the clinical literature. In this study, a higher BMI category was chosen as a reference range for smokers compared with nonsmokers. This study displays results for the combined gender study population and the male-only group since less than 25% of the deaths in the study occurred in females.

RESULTS

Males accounted for about 70% of the study population. The 18–39 issue age group comprised about 72% of the study population. Four thousand one hundred five deaths occurred over 1,676,838 years of policy exposure. Ninety-two percent of the policies were issued by 1983. The average policy was in force for a duration of 4.7 years. The average BMI for our study population was 24.5. The deaths in each subcategory are summarized in Table 2.

Risk ratios for the combined gender study population and the male-only subgroups are summarized separately in Table 3. As an example, male nonsmokers in the 40–59 issue age group had a risk ratio of 1.69 for the <22 BMI range. This means that the mortality risk for the <22 BMI range is 69% higher than the mortality risk for the 22–24 BMI reference range. Table 3 details risk ratios by different BMI categories for the various groups of the total study population. Caution should be used in interpreting results of the Cox model for subgroups having few deaths. A pattern of increasing risk ratios with movement away from the reference category is noted in many of the subgroups presented in Table 3.

Other factors also appear to modify the magnitude of the risk ratios. Obesity was more strongly associated with an increased mortality risk for nonsmokers. For most age groups in both the combined gender and male-only populations, the risk ratios were generally higher for the nonsmoking groups compared with the smoking groups. Age was

Table 2. Deaths by Different Subcategories of the Study Population

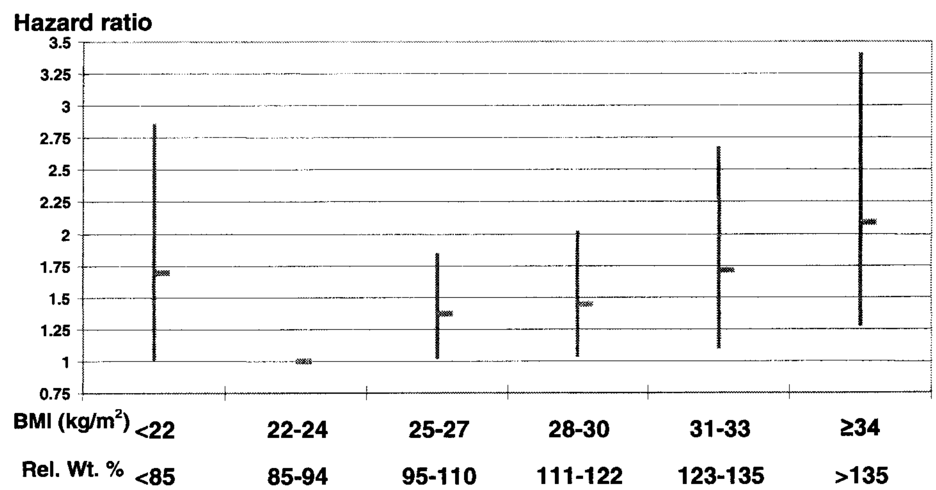
	BMI Range (kg/m²)	Both Genders				BMI range (kg/m²)	Males			
		All Ages	18–39	40–59	≥60		All Ages	18–39	40–59	≥60
Overall (smokers + nonsmokers + unknown)	<19	5	2	2	1	<19	4	2	1	1
	19–21	558	242	213	103	19–21	301	142	107	52
	22–24	1407	499	619	289	22–24	1024	403	449	172
	25–27	1096	282	554	260	25–27	894	249	453	192
	28–30	713	170	376	167	28–30	612	154	328	130
	31–33 (≥31)	230	(78)	(172)	(76)	31–33 (≥31)	184	(68)	(135)	(53)
	≥34	96				≥34	72			
Smokers	<19	0	0	0	0	<19	0	0	0	0
	19–21	109	23	59	27	19–21	64	19	29	16
	22–24	255	47	141	67	22–24	184	39	100	45
	25–27	200	28	129	43	25–27	171	27	111	33
	28–30	116	16	75	25	28–30	93	15	62	16
	≥31	54	13	38	3	≥31	43	13	29	1
Nonsmokers	<19	3	1	2	0	<19	2	1	1	0
	19–21	91	30	35	26	19–21	41	14	17	10
	22–24	241	68	96	77	22–24	163	56	67	40
	25–27	302	56	155	91	25–27	255	50	128	77
	28–30	162	29	82	51	28–30	147	28	75	44
	31–33 (≥31)	67	(22)	(59)	(32)	31–33 (≥31)	56	(20)	(50)	(23)
	≥34	46				≥34	37			

Table 3. Risk Ratios For Different Subcategories of the Study Population

	BMI Range (kg/m2)	Both Genders				BMI Range (kg/m^2)	Males			
		All Ages	18–39	40–59	≥60		All Ages	18–39	40–59	≥60
Overall (smokers +	<19	1.21					1.18*	1.08	1.16	1.56*
nonsmokers + unknown	19–21 (<22)	1.09***	(1.03)	(1.02)	(1.45)*	<22	1.07**	1.05	1.02	1.27*
	22–24	1.1*	1.05	1.00	1.42*	22–24	Ref	Ref	Ref	Ref
	25–27	Ref	Ref	Ref	Ref	25–27				
	28–30	1.13*	1.25*	1.08	1.15***	28–30	1.17*	1.23*	1.1	1.28*
	31–33 (≥31)	1.22*	(1.42*)	(1.11)	(1.20)	31–33 (≥31)	1.25*	(1.49*)	(1.21**)	(1.15)
	≥34	1.19				≥34	1.29*			
Smokers	19–21	1.16	1.78*	0.94	1.59**	19–21	1.20	1.82*	0.90	1.83**
	22–24	1.22*	1.35	1.12	1.20	22–24	1.15	1.23	1.08	1.07
	25–27	Ref	Ref	Ref	Ref	25–27	Ref	Ref	Ref	Ref
	28–30	1.11	1.25	1.07	1.08	28–30	1.06	1.20	0.97	1.58
	≥31	1.32**	2.22*	1.24	0.64	≥31	1.49*	2.32*	1.45**	0.35
Nonsmokers	<22	1.16	1.01	1.35	1.04	<22	1.37**	1.06	1.69*	0.94
	22–24	Ref	Ref	Ref	Ref	22–24	Ref	Ref	Ref	Ref
	25–27	1.08	0.94	1.41*	0.77**	25–27	1.18***	0.91	1.37*	1.08
	28–30	1.01	1.10	1.32**	0.65*	28–30	1.23**	1.17	1.45*	1.02
	31–33 (≥31)	1.45*	(1.56**)	(1.60*)	(1.14)	31–33 (≥31)	1.68*	(1.67*)	(1.84*)	(2.23*)
	≥34	1.48*				≥34	1.84*			

* Significant at $p < .05$.
** Significant at $.05 < p < .1$.
*** Significant at $.1 < p < .15$.

Fig. 1 Hazard ratios and 95% confidence intervals for male nonsmokers age 40-59



Hazard ratios and 95% confidence intervals for male nonsmokers age 40–59 years.

also noted to influence the magnitude of the risk ratio. For the overall male population, risk ratios tended to decline as age increased.

For the ≥31 BMI category in the overall male-only group, the risk ratio declined from 1.49 to 1.15 as the issue age group increased from 18–39 years to ≥60 years. For those BMI ranges less than the reference category, there was some evidence that lower weight individuals were at an increased risk of death. In the male-only group for the <22 BMI range, the risk ratio increased from 1.08 to 1.56 as the age group increased from 18–39 years to ≥60 years.

A review of all of the subgroups revealed that male nonsmoker subgroups tended to exhibit the strongest graded relationship between hazard of death and increasing or decreasing BMI. The Figure displays each risk ratio with its corresponding 95% confidence interval for male nonsmokers, issue age 40–59 years.

As BMI increased above the reference category, mortality also increased. Similarly, as the BMI decreased below the reference category, a statistically significant increase in the hazard of death also occurred. This pattern appears to be J-shaped. Therefore, both individuals having a <22 and >24 BMI were found to be at an increased mortality risk. For individuals with a ≥34 BMI, the mortality risk was increased twofold.

DISCUSSION

Characteristics of the study population displayed in Table 1 were very similar when analyzed by number of policies or exposure years. This implied that using either criteria, that is, the number of policies or the number of exposure years, would not unduly influence the interpretation of our results.

We found that mortality risk increased in the higher BMI categories for many subsets of our study population, especially male nonsmokers. A statistically significant J-shaped relationship between BMI and the hazard of death appeared to be most consistent for the male nonsmokers group for the combined age group and in the 40–59 issue age group. Our data suggests that a 25–27 BMI range may be modestly protective in insured male smokers rather than for male nonsmokers. The patterning of risk ratios around the BMI reference ranges appears to support a higher optimal 25–27 BMI range for smokers compared with a 22–24 BMI range for nonsmokers.

Our findings for this insured lives cohort agree with other studies that have shown an association between BMI and mortality risk in the general population and in insured populations. A J-shaped or progressive increase in mortality with increasing BMI was found among males in recent studies of build conducted by Bender et al[9] in a German population, Seidell et al[10] in a Dutch population, and Calle et al[7] in a US population. All three authors employed the Cox proportional hazards model to estimate the hazard of death associated with varying levels of BMI and to adjust for potential confounders in the BMI-mortality relationship. These investigators noted statistically significant increases in total or all-cause mortality with increasing levels of BMI. Calle's group further stratified the study population by smoking status and by history of preexisting disease. Calle's study also noted a strong relationship between BMI and total mortality in male nonsmokers having no history of disease. Mortality risk was noted to increase both at the lower and at the higher BMI ranges and followed a J-shaped pattern. The risk estimates in Calle's male nonsmoker/no-disease group exhibited a similar J-shaped pattern to the risk estimates we found in our all-age male nonsmoker group. Additionally, risk estimates in Calle's population tended to decline with age.[7]

Our results for males are also generally consistent with the much larger Society of Actuaries and Association of Life Insurance Medical Directors of America's 1979 Build Study.[11] In our study, we found that the mortality risk associated with a BMI of 34 (roughly equivalent to a relative weight >135% based on our internal average weights for males) was not as high as what was noted in the 1979 Build Study (a risk ratio of 1.29 in our study versus mortality ratios of 140% and higher in the 1979 Build Study). This difference may have been due to varying entry criteria between the 2 studies or due to temporal differences in treatment of the complications of obesity (especially cardiovascular disease).

A number of factors affected the interpretation of our results and are important to note. The large size of our cohort, −356,926 individual life insurance policyholders free of preexisting comorbidities followed for 24 years, allowed us to examine the relationship between BMI and mortality across different combinations of issue age groups, gender, and smoking status. Using life insurance policyholders as the study population enabled us to better screen for preexisting conditions that may have been potential confounders in our model.

The average duration of our policies (until death, cancellation/lapse, or the end of the study) of 4.7 years was shorter than the average policy duration reported in the 1979 Build Study (6.6 years) and is also shorter than the follow-up times reported by some clinical investigators. The accrual period of this study represents a period of intensive pricing competition in the insurance industry. This is likely to have increased lapsation rates and therefore decreased mean policy duration. The mortality risk of being over- or underweight is most likely indirect, increasing cardiovascular and cancer morbidity over a period of years, resulting in increased relative mortality.

Our strict exclusionary criteria reduced the probability of preexisting disease in the study population, resulting in a reduced likelihood of individuals with significantly high or low BMIs being included in our study population. This fact, combined with the relatively short average follow-up, may have resulted in an underestimation of the strength of the relationship between build and mortality in some of the subgroups we examined. Based on findings from clinical studies (Lee et al[12], Singh et al[13]) and the 1979 Build Study, the risk estimates might actually be higher with longer periods of average follow-up.

While our study was large by internal measures, it is smaller than the 1979 Build Study (1,676,838 person-years in our study versus over 27,000,000 person-years, estimated at 6.6 years of average exposure for 4,200,000 policies, in the 1979 Build Study). In particular, conclusions from the oldest issue age subgroups were limited by a small exposure.

Another important characteristic of the study was the large proportion of individuals with unknown smoking status. Smoking history was not available for two thirds of the study cohort. This reduced the size of the nonsmoker and smoker groups available for analysis.

CONCLUSION

There continue to be questions in the clinical literature about the significance of obesity in a healthy cohort that is free of apparent disease. Our study and clinical studies that have well-defined subgroups have identified a statistically significant increased mortality risk associated with overweight or underweight subgroups of individuals free of apparent preexisting disease. Because of an underlying lower expected death rate, healthy male nonsmokers appear to be at greatest relative mortality risk. At modest deviations from optimal BMI, the magnitude of that risk appears to be small. However, in a highly competitive preferred product marketplace, even small deviations in expected mortality can have a significant impact on the profitability of a group of policies. In this marketplace, each company should carefully consider the mortality implications of abnormal build.

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