JOURNAL OF INSURANCE MEDICINE

J Insur Med 2001;33:277–289

ORIGINAL ARTICLE

Alcohol Abuse and Liver Enzymes (AALE): Results of an Intercompany Study of Mortality

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Evaluation of applicants for life insurance who have elevations of their liver function tests or an increased probability of alcohol abuse has always been difficult for underwriters. This paper reports the results of an intercompany study in which the pooled mortality experience of a group of insureds with evidence of alcohol abuse, an adverse driving record or elevations of the liver transaminases or gamma-glutamyl transferase is summarized.

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Key words: Liver enzymes, alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma glutamyl transferase (GGTP), alcohol abuse, excessive alcohol use, adverse driving, insured lives, mortality.

Received: May 15, 2001.

Accepted: May 30, 2001.

One of the most challenging areas of underwriting has long been the detection of alcohol abuse in those applying for insurance. This is not surprising since alcohol abuse often goes undetected by physicians treating patients. Alcohol abuse is known to be the cause of premature mortality through several mechanisms and some associated conditions.[1] Liver enzymes have been utilized in insurance underwriting in an attempt to identify those individuals who have been abusing alcohol as well as those who have other forms of occult liver disease such as hepatitis. This study was undertaken to review pooled companies' mortality experience on cases reported to the Medical Information Bureau (MIB) with findings suggesting an increased probability of ethanol-related complications or hepatic dysfunction. More specifically, the number of deaths associated with evidence of excessive alcohol use, an adverse driving record, or abnormalities of the liver enzymes alanine aminotransferase (ALT), aspartate aminotransferase (AST), or gamma

glutamyl transferase (GGTP) were compared with the expected number of deaths for standard insured lives.

BACKGROUND

Variations in the definition of alcohol abuse, differences in individual tolerance levels for alcohol, a variable time course, and the tendency for patients to downplay alcohol intake are some of the issues that make the study of alcohol-related disorders difficult. The fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV*) separates the disorder into two broad categories, alcohol dependence and alcohol abuse.[2] Dependence is characterized by the presence of 3 or more of the following criteria occurring in the same 12-month period: (1) tolerance (requiring more alcohol intake for the same effect); (2) withdrawal symptoms and the avoidance thereof; (3) ingesting more over a longer period than initially intended; (4) persistent desire to cut down on use without success; (5) spending substantial time obtaining, using, or recovering from the use of the substance; (6) substance use interfering with social, familial, occupational, or recreational activities; (7) continued use despite knowledge that a recurrent physical or psychological problem is being worsened by the substance use.

Abuse is characterized by one or more of the following occurring in a 12-month period: (1) recurrent alcohol use causing a failure to meet social, familial, or occupational obligations; (2) recurrent alcohol use in hazardous situations (drinking and driving); (3) recurrent legal problems related to alcohol abuse; (4) continued alcohol use despite persistent or recurrent social or interpersonal problems exacerbated by the use.

Despite these specific criteria, the determination of impairment due to alcohol is often difficult for several reasons. For one, the key factors are fairly subjective in nature. In addition, there is a strong element of denial associated with alcohol dependence, which may lead to underreporting. The disease is also characterized by a variable time course and many of those who are affected experience periods of sobriety between episodes of binge drinking. Tolerance is also a problem. Individuals may be able to tolerate increasing quantities of ethanol before showing evidence of adverse effects.

THE NATURAL HISTORY OF ALCOHOL ABUSE

For many Americans, intemperate use of alcohol seems to be part and parcel of the maturation process. Several highly publicized deaths have occurred on college campuses in the last few years. However, more typically, local newspapers regularly report premature deaths due to overdoses, accidents, or violence associated with alcohol intoxication. Fortunately, most individuals survive these early bouts of drinking and begin to moderate their alcohol use by the middle to late 20s. Yet true alcohol abusers will not moderate their use despite problems that may already have occurred. Typically, the first major life difficulties associated with alcohol will occur in the time frame between the middle 20s and early 40s, and often the abuser will be able to stop or sharply curtail ethanol use for a period of time. However, in individuals who have a serious problem, the use of alcohol will eventually escalate toward prior levels.

Suspicion of alcohol abuse should be entertained when there is a recurrent pattern of job problems, legal difficulties, dysfunctional relationships, accidents, etc. Medical impairments such as fluctuating hypertension, repeated episodes of pneumonia, unexplained cardiac arrhythmias, pancreatitis, cancers of the head and neck, cirrhosis, bilateral swelling of the parotid glands, and peripheral neuropathy may also be encountered. In addition, laboratory abnormalities such as an elevated mean corpuscular volume (MCV), elevated uric acid, elevated carbohydrate-deficient transferrin (CDT) or hemoglobin acetaldehyde (HAA), and elevated triglycerides are commonly seen in association with alcoholism.[3]

However, it should also be noted that there is a syndrome of late-onset alcoholism that occurs after age 40. Thus, with the aging of the baby boom generation, it will not be surprising to see some retirees turning to alcohol. This phenomenon is especially common when the relief from the responsibilities of child rearing and job performance is combined with the stresses of chronic illness, the deaths of acquaintances, and social isolation. Indeed, one study found alcoholism prevalence rates of 14% for men and 1.5% for women over the age of 65.[4]

MORTALITY

On average, the alcohol abuser's life span may be shortened by 10–15 years. The major causes of premature death associated with alcoholism are (in descending order of frequency) heart disease, cancer, accidents, and suicide.[3] Thus, the detection of alcohol abuse is potentially of great value to insurers. Two major tools in this exercise have traditionally been the measure of liver enzymes and assessment of the applicant's driving record.

LIVER ENZYMES

Due to the difficulties associated with diagnosing alcoholism, biochemical markers of alcohol abuse have been sought for years. This study focuses on the markers that were reported to the Medical Information Bureau (MIB) during the study period. Those fit into 2 categories: an elevation of the transaminases, aspartate aminotransferase (AST) and/or alanine aminotransferase (ALT); and/or an elevation of gamma glutamyl transferase (GGTP). Other alcohol markers, such as carbohydrate deficient transferrin (CDT) and hemoglobin-associated acetaldehyde were not reported separately during the time period being studied.

GGTP is a membrane-bound glycoprotein found in many tissues, including liver, kidney, brain, spleen, pancreas, and heart.[5] While it is well recognized that long-term use of excessive amounts of alcohol (>50–60 g of ethanol daily) can result in elevations of GGTP, short-term excessive use, or binge drinking, may not do so. It is theorized that alcohol causes excess amounts of GGTP to be released by a combination of enzyme induction via increased metabolism and release due to liver cell damage. The sensitivity for the detection of alcohol abuse is variable and has been reported to be from 39 to 87%. In addition, the test is very nonspecific. Other factors can also cause elevation of GGTP. Drugs that induce liver cells to increase activity (like Dilantin, phenobarbital, or nonsteroidal anti-inflammatory drugs) can cause elevations, as can nonalcoholic liver disease, heart disease, biliary disease, or kidney disease. Some of these causes would be significant mortality considerations. Hence, most clinical literature does not recommend using GGTP as a screening test for alcoholism. No attempt was made in this study to identify the underlying cause of GGTP elevation, just to correlate elevated GGTP with mortality.

AST and ALT are considered hepatocellular enzymes and are released into the serum when liver cells are damaged or destroyed. However, like GGTP, both are found in a variety of other tissues. In particular, AST may also be found in heart, brain, muscle, pancreas, kidney, lung, and blood cells. For that reason, elevation of the ALT is generally taken as a more specific marker for liver dysfunction. The most common cause for this dysfunction is steatosis or fatty infiltration of the liver. This may or may not be related to alcohol intake. The most common causes of transaminase elevation that carry a significant mortality implication are alcoholic liver disease and hepatitis B and C. The latter has become especially important from an underwriting perspective in recent years. There are a variety of other possible causes for elevated transaminases that are potentially serious but, fortunately, uncommon. These include hepatitis due to toxins, viral infections, ischemia, or autoimmune processes; tumors; thyroid disease, hemochromatosis, Wilson's disease, alpha-1-antitrypsin deficiency; muscle injury; drug effects; or inflammation from a

variety of causes.[6] In general, the degree of elevation of the transaminases associated with alcohol abuse is lower than that seen in other conditions that damage the liver. Levels of ALT and AST seldom exceed 250–350 U/L when due to alcohol abuse, whereas they may reach into the thousands in acute viral hepatitis. In addition, the ratio of AST/ALT is of diagnostic and prognostic importance. A ratio >1 suggests the presence of hepatic fibrosis or cirrhosis, regardless of cause, and a reading >2 is very suggestive of alcohol-related disease. It should be noted, however, that advanced cirrhosis might see a return of AST and ALT to normal ranges as more hepatocytes are replaced by scar tissue and fewer are available to release the enzymes into the circulation.

Some have attempted to calculate the sensitivities and specificities for the diagnosis of alcohol abuse for the various liver enzymes. However, one should keep in mind that the sensitivity and specificity vary based on the chosen cutoff value of the test, the definition of alcohol abuse or alcoholism, and the population being studied.

DRIVING CRITICISM

The final impairment studied is an adverse driving history. As reported to the MIB, this may or may not represent driving under the influence of alcohol. An adverse driving record may result in an increased probability of accidental or traumatic death. There is also evidence that drivers with multiple moving violations are 10-fold more likely than the general public to receive their first DWI (driving while intoxicated) conviction during the following 3 years.[7] This fact has mortality implications, as it has been reported that up to 55% of all driving fatalities are caused by intoxicated drivers. The value of the overall driving record is underscored when one considers a study of a group of 70 drivers admitted to the emergency room for trauma. Of those with a documented blood alcohol level of more than 100 mg%, only 33% were charged and 21% were actually convicted of driving under the influence of alcohol.[8] The risk of alcohol-related fatalities is highest in those under the age of 35.

METHODS

The Alcohol Abuse and Liver Enzyme (AALE) study involved a review of records on 131,394 policies issued during the years 1989–1995 and exposed to the 1997 anniversary. The MIB database was searched for codes representing cases with 1 or more of the following 4 conditions: alcohol use significant to health and longevity; adverse diving record, or multiple moving violations; liver enzymes abnormal; and GGTP abnormal. A questionnaire along with a list of the reports that had been submitted was then mailed to 600 MIB member companies along with a letter requesting their participation. Approximately 100 companies expressed some interest in taking part and 47 actually contributed data to the study. Company participation consisted of updating the status on cases coded for 1 or more of the above impairments. These updates included issue date and age, sex of the insured, reinsurance status, policy size, smoker status, a list of all impairments noted, current policy status, premium status, termination date if applicable, and deaths. Of the 398,940 code reports submitted to the participating companies for review, 131,394 information forms, or 32.9%, were returned. These forms were reviewed and cases were excluded from the study for the following reasons: the applicant was a non-U.S. resident, the case was not regularly underwritten (guaranteed or simplified issues), the case represented reinsured business, the applicant was insured under a spouse or child rider or a joint life contract, the policy was marketed on other than a regular basis, or there was any uncertainty regarding the accuracy of policy lapse or claim information. After exclusions, the final number of policies included in the review was 82,262. Maximum exposure was 8 years and the average was 2.5–3 years. Observed deaths were compared with the number of expected

Table 1. Alcohol Abuse and Liver Enzyme Study (AALE) Compared with 1990–95 Basic Table (Age Nearest Birthday), Total Experience

Sex	Rating	Issue Age	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	20–29	33,006	34	21	158	0.38
		30–39	42,432	50	30	167	0.47
		40–49	22,734	33	31	106	0.08
		50–59	5631	27	18	151	1.63
		60–69	1033	15	8	(196)	(7.13)
		Total	104,836	159	108	147	0.49
	Substandard	20–29	23,933	35	16	221	0.80
		30–39	46,094	60	32	187	0.61
		40–49	30,441	68	41	166	0.88
		50–59	8421	33	27	124	0.75
		60–69	1798	30	14	218	9.02
		Total	110,686	226	129	175	0.87

deaths derived from the sex distinct 1990–95 Select Basic Tables that are based on standard lives experience. Results were reported for males and females and for standard and substandard issues. Results were also reported on a smoker/nonsmoker basis. Expected deaths were not adjusted for substandard ratings or smoking status.

RESULTS

The exposure in females was quite low and represented only 9.5% of that for the total study group. Only 22 claims were recorded in toto for the standard issue group and 21 deaths for the substandard issue cohort (total claims = 43). Because of this limited number of deaths, the confidence intervals surrounding the calculated mortality ratios in females are too broad to permit valid conclusions about the results. Consequently, the remainder of this discussion will focus on the experience among males.

The final study group (ie, males) as a whole consisted of insureds with 1 or more of the above noted coded impairments. These individuals could also be coded for any other impairment (heart disease, cancer, occupation, etc) as well. The overall mortality ratio for the standard issue subset of this population was 147% and that for the substandard cohort was 175% (see Table 1). (Note: In Tables 1–14, where the number of actual deaths is less than 10, values are not expressed for the mortality ratio [MR] and excess death rate [ED/M]. Where the number of actual deaths is between 10 and 24, the values for the mortality ratio and excess death rate are reported in parentheses.) Further analysis of the overall study results revealed several distinct mortality patterns. Mortality ratios did not clearly vary with age in either the standard or substandard issues (see Table 1). In addition, mortality ratios were higher in the lower policy face amounts (see Table 2) and in smokers (see Table 3). When the anticipated mortality ratios as reflected by applied ratings were compared with actual death rates, the insured life experience was consistently either better than expected or at the lower end of the rating range (see Table 4).

In a subanalysis of the total study group, the mortality experience related to individuals with abnormal liver enzymes and/or an abnormal GGTP was reviewed. When other impairment codes (other than those specific to the study) were included and when there was no code for alcohol abuse or adverse driving experience, the calculated mortality ratios were lower than those found in the study group as a whole. The ratios for the standard and substandard issue groups were 87 and 139%, respectively, for all ages com-

Table 2. Alcohol Abuse and Liver Enzyme Study (AALE) compared with 1990–95 Basic Table (Age Nearest Birthday), Total Experience

Sex	Rating	Amount Band	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	Under $50,000	15,570	48	18	264	1.91
		$50,000–$99,999	23,792	42	24	175	0.76
		$100,000–$249,9999	46,019	47	45	104	0.04
		$250,000 and over	19,455	22	21	(107)	(0.07)
		Total	104,836	159	108	147	0.49
	Substandard	Under $50,000	16,431	64	23	276	2.49
		$50,000–$99,999	25,379	51	29	178	0.88
		$100,000–$249,9999	49,936	79	55	144	0.48
		$250,000 and over	18,941	32	123	141	0.49
		Total	110,686	226	129	175	0.87

Table 3. Alcohol Abuse and Liver Enzyme Study (AALE) Compared with 1990–995 Basic Table (Age Nearest Birthday), Total Experience

Sex	Rating	Smoker Status	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	Unknown	20,478	47	23	207	1.19
		Nonsmoker	67,237	60	68	88	−0.12
		Smoker	17,121	52	17	300	2.03
		Total	104,836	159	108	147	0.49
	Substandard	Unknown	17,994	43	21	204	1.22
		Nonsmoker	70,642	110	83	132	0.38
		Smoker	22,051	73	25	292	2.18
		Total	110,686	226	129	175	0.87

Table 4. Alcohol Abuse and Liver Enzyme Study (AALE) Compared with 1990–995 Basic Table (Age Nearest Birthday), Total Experience

Sex	Rating	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	104,836	159	108	147	0.49
	SS—degree unknown	6498	4	6	—	—
	SS—slight (under 175%)	52,284	85	63	134	0.41
	SS—moderately (175–250%)	24,048	55	30	181	1.02
	SS—highly (over 250%)	13,160	43	17	257	2.00
	SS—with flat extra premium	1509	2	2	—	—
	SS—flat extra premium only	13,188	37	11	334	1.97
	Total (substandard)	110,686	226	129	175	0.87

bined (see Table 5). A breakdown by substandard rating showed a similar pattern of diminished relative risk in those with increased liver enzymes alone (see Table 6). In addition, a mortality pattern that varied with policy amount (higher ratios with lower bands) and smoking status (increased claims in smokers) similar to that observed in the total popula-

Table 5. Alcohol Abuse and Liver Enzyme Study (AALE) Compared with 1990–995 Basic Table (Age Nearest Birthday), Abnormal Liver Function Tests and/or GGTP, No Adverse Driving or Alcohol Abuse, Other Impairments Included

Sex	Rating	Issue Age	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	20–29	8048	4	5	—	—
		30–39	24,024	14	17	(82)	(−0.13)
		40–49	15,874	20	22	(92)	(−0.11)
		50–59	3648	10	11	(88)	(−0.39)
		60–69	581	4	4	—	—
		Total	52,175	52	60	87	−0.14
	Substandard	20–29	8440	3	5	—	—
		30–39	32,106	35	22	57	0.40
		40–49	23,342	44	31	141	0.55
		50–59	6110	19	19	(100)	(0.00)
		60–69	1184	19	9	(211)	(8.46)
		Total	71,182	120	87	139	0.47

Table 6. Alcohol Abuse and Liver Enzyme Study (AALE) Compared with 1990–995 Basic Table (Age Nearest Birthday), Abnormal Liver Function Tests and/or GGTP, No Adverse Driving or Alcohol Abuse, Other Impairments Included

Sex	Rating	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	52,175	52	60	87	−0.14
	SS—degree unknown	1845	4	2	(189)	(1.02)
	SS—slight (under 175%)	44,298	65	52	124	0.28
	SS—moderately (175–250%)	17,099	28	22	129	0.37
	SS—highly (over 250%)	7302	20	10	(208)	(1.42)
	SS—with flat extra premium	330	2	0	—	—
	SS—flat extra premium only	308	1	0	—	—
	Total (substandard)	71,182	120	87	139	0.47

tion was noted in the liver test-alone group. However, the overall mortality ratios were lower than in the total study population (see Tables 7 and 8). When all other impairment codes were excluded (ie, the group consisted only of those with abnormal liver function tests and/or GGTP), mortality ratios for all ages combined remained in the same general range (61 and 151%). However, the number of recorded deaths in most of the age bands was too small to permit meaningful conclusions. The confidence intervals were simply too wide. Nevertheless, the basic pattern of limited mortality risk related to liver enzyme elevations remained. Additional analysis revealed that the relative mortality risk was, in general, higher with an elevation of the GGTP than that with an elevation of other hepatic enzymes. However, the great majority of the exposure in the group with abnormal GGTP code involved individuals with other nonstudy impairments.

When a similar subanalysis was performed using the adverse driving and alcohol abuse codes (ie, the liver test codes were excluded but other nonstudy codes could be present), the results differed significantly. The mortality ratios for all ages combined were 217% for the standard group and 246% for the substandard group (see Table 9). These values

Table 7. Alcohol Abuse and Liver Enzyme Study (AALE) Compared with 1990–995 Basic Table (Age Nearest Birthday), Abnormal Liver Function Tests and/or GGTP, No Adverse Driving or Alcohol Abuse, Other Impairments Included

Sex	Rating	Amount Band	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	Under $50,000	3225	9	5	—	—
		$50,000−$99,999	7702	15	10	(150)	(0.65)
		$100,000−$249,9999	27,378	17	29	(58)	(−0.45)
		$250,000 and over	13,870	11	15	(74)	(−0.28)
		Total	52,175	52	60	87	−0.14
	Substandard	Under $50,000	4646	23	9	(258)	(3.03)
		$50,000−$99,999	12,648	19	16	(117)	(0.22)
		$100,000−$249,9999	37,847	50	42	118	0.20
		$250,000 and over	16,041	28	19	147	0.56
		Total	71,182	120	87	139	0.47

Table 8. Alcohol Abuse and Liver Enzyme Study (AALE) Compared with 1990–995 Basic Table (Age Nearest Birthday), Abnormal Liver Function Tests and/or GGTP, No Adverse Driving or Alcohol Abuse, Other Impairments Included

Sex	Rating	Smoker Status	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	Unknown	11,991	19	14	(138)	(0.44)
		Nonsmoker	35,563	20	41	(49)	(−0.58)
		Smoker	4621	13	5	(249)	(1.68)
		Total	52,175	52	60	87	−0.14
	Substandard	Unknown	10,813	22	13	(166)	(0.81)
		Nonsmoker	51,083	76	62	122	0.27
		Smoker	9286	22	11	(198)	1.17
		Total	71,182	120	87	139	0.47

Table 9. Alcohol Abuse and Liver Enzyme Study (AALE) Compared with 1990–95 Basic Table (Age Nearest Birthday), Adverse Driving and/or Alcohol Abuse Codes, No Abnormal Liver Function Tests and/or GGTP, Other Impairments Included

Sex	Rating	Issue Age	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	20−29	24,810	30	16	183	0.55
		30−39	18,053	34	13	270	1.19
		40−49	6657	13	9	(140)	(0.56)
		50−59	1887	16	6	(262)	(5.24)
		60−69	430	10	3	(308)	(15.70)
		Total	51,837	103	48	217	1.07
	Substandard	20−29	15,185	32	10	305	1.42
		30−39	12,835	19	9	(213)	(0.79)
		40−49	6334	22	9	(251)	(2.09)
		50−59	2098	14	7	(199)	(3.32)
		60−69	582	11	5	(241)	(11.07)
		Total	37,034	98	40	246	1.57

Table 10. Alcohol Abuse and Liver Enzyme Study (AALE) Compared with 1990–95 Basic Table (Age Nearest Birthday), Adverse Driving and/or Alcohol Abuse Codes, No Abnormal Liver Function Tests and/or GGTP, Other Impairments Included

Sex	Rating	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	51,837	103	48	217	1.07
	SS—degree unknown	4563	0	4	—	—
	SS—slight (under 175%)	7197	16	10	(161)	(0.84)
	SS—moderately (175–250%)	6210	25	8	322	2.78
	SS—highly (over 250%)	5244	21	6	(328)	(2.78)
	SS—with flat extra premium	1019	0	1	—	—
	SS—flat extra premium only	12,801	36	11	340	1.99
	Total (substandard)	37,034	98	40	246	1.57

Table 11. Alcohol Abuse and Liver Enzyme Study (AALE) Compared with 1990–95 Basic Table (Age Nearest Birthday), Adverse Driving and/or Alcohol Abuse Codes, No Abnormal Liver Function Tests and/or GGTP, Other Impairments Included

Sex	Rating	Amount Band	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	Under $50,000	12,219	39	13	305	2.15
		$50,000−$99,999	15,938	26	14	188	0.76
		$100,000−$249,9999	18,211	27	15	175	0.63
		$250,000 and over	5469	11	6	(199)	(1.00)
		Total	51,837	103	48	217	1.07
	Substandard	Under $50,000	11,504	41	14	297	2.36
		$50,000−$99,999	12,038	29	11	254	1.46
		$100,000−$249,9999	10,974	25	11	222	1.25
		$250,000 and over	2518	3	3	—	—
		Total	37,034	98	40	246	1.57

were significantly higher that those recorded for the liver tests alone and the total study population. A review of the breakdown of substandard group revealed that the observed mortality experience was consistently worse than would have been expected by applied ratings (see Table 10). These results also differ from those seen with the liver tests-alone group. When policy amount and smoking status are considered, a mortality pattern consistent with that noted above is also evident. However, the adverse influence of smoking on survival may be even greater in the adverse driving/alcohol abuse group (see Tables 11 and 12). Excluding nonstudy impairments reduced the overall number of deaths somewhat but did not significantly change the pattern of mortality. In addition, further analysis indicated that the mortality pattern remained essentially the same when the adverse driving and alcohol abuse codes were analyzed individually.

It should be noted that there was a distinct difference between the liver tests and driving/alcohol groups in the degree of exposure by policy amount and smoking status. The percentage of insureds with policy face amounts under $100,000 was 20.9 and 24.3% for the standard and substandard cohorts, respectively, in those with elevated liver enzymes/GGT. The corresponding values in the adverse driving/alcohol abuse group were 54.0 and 33.1%. The percentage of smokers was also higher in the adverse driving/alco-

Table 12. Alcohol Abuse and Liver Enzyme Study (AALE) Compared with 1990–95 Basic Table (Age Nearest Birthday), Adverse Driving and/or Alcohol Abuse Codes, No Abnormal Liver Function Tests and/or GGTP, Other Impairments Included

Sex	Rating	Smoker Status	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male	Standard	Unknown	8181	27	8	321	2.27
		Nonsmoker	31,271	39	27	144	0.38
		Smoker	12,385	37	12	308	2.02
		Total	51,837	103	48	217	1.07
	Substandard	Unknown	6692	19	7	(263)	(1.76)
		Nonsmoker	18,321	33	20	169	0.74
		Smoker	12,020	46	13	353	2.74
		Total	37,034	98	40	246	1.57

Table 13. Summary Report With our Without Other Nonstudy Impairment or Test Codes

Impairment	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male standard data					
Adverse driving record	42,084	69	34	205	0.84
Alcohol abuse	9244	32	14	237	2.00
Adverse driving and/or alcohol abuse*	51,837	103	48	217	1.07
Abnormal liver enzyme	28,248	27	28	96	−0.04
Abnormal GTTP	13,670	17	20	(87)	(−0.19)
Abnormal liver enzyme and/or GTTP*	52,175	52	60	87	−0.14
Total	104,836	159	108	147	0.49
Male substandard data					
Adverse driving record	20,855	47	18	263	1.40
Alcohol abuse	14,885	45	21	217	1.63
Adverse driving and/or alcohol abuse*	37,034	98	40	246	1.57
Abnormal liver enzyme	25,057	19	28	(69)	(−0.34)
Abnormal GTTP	21,441	56	32	177	1.13
Abnormal liver enzyme and/or GTTP*	71,182	120	87	139	0.47
Total	110,686	226	129	175	0.87

* Indicates codes present alone or in combination.

hol abuse cohort for both standard and substandard issues (23.9 versus 8.9% and 32.5 versus 13.0%, respectively).

Unfortunately, it was not possible to study the experience in applicants who were coded for both a liver enzyme and/or GGTP code and an adverse driving and/or alcohol abuse code. The exposure and number of deaths for this subset were too small to permit any reasonable analysis.

There were also only a very limited number of cases that had elevated liver enzymes and/or GGTP and that also had a code for hepatitis or a liver disorder other than hepatitis. The number of deaths recorded with these impairments was too low to provide any meaningful information.

All of the data on the individual codes is summarized in Table 13 (including nonstudy impairments) and Table 14 (with nonstudy impairments excluded). The limited exposure in individuals with both a liver function test

Table 14. Summary Report Without Other Nonstudy Impairment or Test Codes

Impairment	Exposure	Actual Deaths	Expected Deaths	MR	ED/M
Male standard data					
Adverse driving record	36,291	59	28	213	0.86
Alcohol abuse	5400	13	7	(187)	(1.12)
Adverse driving and/or alcohol abuse*	42,076	72	35	206	0.88
Abnormal liver enzyme	17,231	8	15	—	—
Abnormal GTTP	7532	7	9	—	—
Abnormal liver enzyme and/or GTTP*	31,160	19	31	(61)	(0.38)
Total	73,236	91	66	138	0.34
Male substandard data					
Adverse driving record	17,118	38	14	276	1.42
Alcohol abuse	5988	15	7	(207)	(1.29)
Adverse driving and/or alcohol abuse*	24,079	56	22	256	1.42
Abnormal liver enzyme	8204	4	7	—	—
Abnormal GTTP	7655	13	9	(148)	(0.55)
Abnormal liver enzyme and/or GTTP*	28,922	43	28	151	0.50
Total	53,001	99	50	197	0.92

* Indicates codes present alone or in combination.

and/or GGTP code and an adverse driving and/or alcohol abuse code can be seen in Table 13 in the small discrepancy between the sum of the exposures in rows 3 and 6 and the overall total expressed in row 7 of that table. This is not seen in Table 14 because there was no overlap in the 2 groups when there were no other nonstudy impairments present.

DISCUSSION

There are several limitations that should be kept in mind in reviewing this data. First, this is an intercompany study and as such represents pooled information that blends differing target marketplaces and underwriting procedures. Thus, varying standards may be used in separating the standard and substandard cohorts and for estimating the gradation of risk within the substandard issue group. Another limitation is the lack of knowledge regarding the degree of elevation of the liver enzymes. There was no degree modifier specified for these codes during the time frame of the study. In all likelihood, since this experience was accrued on policies that were actually issued, the vast majority of the exposure has occurred in individuals with mild elevations (less than 3 times normal) of the hepatic enzymes. Higher values would more likely result in highly rated (and not taken) or declined policies. Thus, there may be an inherent bias toward more mild disease. It should also be kept in mind that the data on individuals whose underwriting impairment is limited exclusively to a liver enzyme/GGTP abnormality is small. Many of the insureds had codes reported for impairments other than the target ones specified in the description of the study design. Hence, there may be other illnesses contributing to the measured mortality outcomes. However, the likelihood is that these other impairments were not of a severe nature; otherwise, the application would have been declined or approved at highly substandard rates and likely not taken. The length of the study also raises a serious question. The maximum and average follow-up periods were relatively short, only 8 and 2.5–3 years, respectively. It is possible that this time frame is insufficient to assess the true long-term mortality risk of elevated liver enzyme tests and chronic alcohol abuse.

Deaths due to alcoholic liver disease and hepatitis frequently occur only after many years of disease activity. A final limitation is the paucity of data on females. The level of exposure and number of claims were simply too low to make any meaningful conclusions regarding the mortality risk in this important group of insureds.

Despite these limitations, some conclusions regarding this study seem reasonable. First, the overall mortality ratios associated with isolated elevations of liver enzymes, GGTP, or both (ie, without evidence of adverse driving or alcohol abuse) were good in the standard issue group (87%) and only modestly increased in the substandard cohort (139%). The mortality ratio exceeded 200% in only 1 age band despite the presence of other impairments that might contribute to the measured death rates. This finding is supported by the review of data in selected clinical articles in which individuals with chronic liver enzyme elevations were evaluated with liver biopsy. Analysis of these studies indicated risk levels similar to those detected here. Indeed, a review of 3 separate clinical articles revealed estimated relative mortality ratios for individuals with chronic liver enzyme abnormalities of 184, 198, and 208%, respectively. It is not surprising that the mortality was somewhat higher in the clinical populations because the study groups in those articles consisted of individuals with suspected liver disease that were being treated at tertiary medical centers. A major reason for the relatively low mortality was the frequency of benign diagnoses, with the most common biopsy finding being steatosis. The most frequently encountered serious illnesses were alcohol-related disease and hepatitis.[9–11]

Second, the mortality ratios were consistently higher for the codes related to adverse driving experience or alcohol abuse when compared with those for the abnormal liver tests. This pattern persisted whether the driving and alcohol abuse codes were analyzed separately or taken together. The mortality ratios for the standard issue group were especially notable, as they consistently exceeded 200%. Thus, the mortality ratio of 147% noted for the standard issue group of the total study population is attributable primarily to the adverse experience associated with the driving and alcohol abuse codes and not those related to the liver tests. Part of the reason for the higher mortality ratios in this group may be the fact that it contained a larger number of insureds whose policies were of lower face amount and/or who were smokers, factors that are associated with a greater than expected number of claims (see below).

Third, at least using the criteria employed by the companies contributing to this study, the estimate of the relative risk of mortality assigned to applicants with elevated liver enzymes and/or GGTP alone (ie, without evidence of adverse driving experience or alcohol abuse) consistently exceeded the actual observed results. In general, those with isolated liver test codes did better than expected. Part of the reason for this could be the influence of previous studies relating liver enzymes to alcohol abuse. These results may have led underwriters to a more conservative approach.

Fourth, the converse was true for the adverse driving and alcohol abuse codes. The actual experience for this group consistently exceeded the mortality estimate of the participating companies. This was true for both the standard and substandard groups. These results would indicate that the information and criteria used in evaluating risk for individuals with evidence of adverse driving or alcohol abuse were inadequate in terms of predicting actual claims experience.

Fifth, there was no clear-cut mortality pattern associated with the age of the insureds. This held true for the total population, the liver enzyme/GGTP, the adverse driving record, or alcohol abuse codes. This is somewhat unexpected when one considers the epidemiology of the impairments (ie, hepatitis and alcohol abuse) representing the most likely causes of death in individuals with one of the study codes. All of these conditions are, in general, more common and more serious in the younger, risk-taking years. In addition, a

mortality pattern reflecting a higher death rate in the lower age bands has been previously observed in both insured lives experience (the 1983 Medical Impairment Study) and numerous clinical articles.[12,13] Why a definite relationship of age to mortality is not more evident here is not clear.

Sixth, mortality ratios are highest in lower policy amounts. While the reason for this is not completely obvious, it most likely is a reflection of the socioeconomic factors, such as smoking, that are associated with the primary causes of death in the study group. In addition, applicants for larger policy face amounts were more likely to go through a more rigorous risk selection process (examination, blood testing, etc).

Seventh, smokers had the highest mortality ratios of any of the subgroups analyzed. This adverse experience most likely represents the combined effects of the inherent life risk of smoking itself and the fact that this habit is associated with overall risk-taking behavior (ie, indiscreet driving) in general and alcohol abuse in particular.

What is clear from the above observations is that the study group as originally conceived really consisted of 2 distinct cohorts (ie, 1 with abnormal liver tests and 1 with evidence of an adverse driving record and/or alcohol abuse). In effect, AALE represented 2 different studies under the umbrella of a single analysis. These 2 groups had distinctly different epidemiologic and mortality patterns. These patterns are of significance in the risk selection process and bear consideration by all of those involved in pricing and underwriting of life insurance products.

A most interesting question is whether the association of elevated liver tests with adverse driving experience or alcohol abuse would produce mortality results greater than that associated with either the test or the impairment codes alone. In theory, it should. Unfortunately, the exposure in the group with an abnormal liver enzyme/GGTP code and an abnormal driving and/or alcohol abuse code was too limited to answer this important question.

Special thanks to CMAS and MIB and, in particular, to Stacy Gill, Keith Hoffman, and Bill McDonald, whose efforts helped make this study possible. Data and analysis were supplied by the Center for Medicoactuarial Studies (CMAS) of the Medical Information Bureau (MIB).

REFERENCES

1. Brackenridge RDC, Elder WJ. *Medical Selection of Life Risks.* London, UK: MacMillan Reference Ltd; 1998.
2. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV*). Washington, DC: American Psychiatric Association; 1994.
3. Shuckit MA. ''Alcoholism and Drug dependency'', *Harrison's Principles of Internal Medicine.* 14th ed, Fauci AS, Braunwald E, Isselbacher KJ, et al., eds., New York. McGraw-Hill. 1998:2503–2508.
4. Kaplan. *Comprehensive Textbook of Psychiatry.* 6th ed. Baltimore, MD: Williams & Wilkins; 1995.
5. Mihas AA, et al. Laboratory markers of ethanol intake and abuse: a critical appraisal. *Am J Med Sci.* 1992;303:415–428.
6. Johnston DE. Special considerations in interpreting liver function tests. *Am Fam Physician.* 1999;59;2223–2230.
7. Buntain-Ricklefs JJ, Rivara FP, Donovan DM, et al. Differentiating 'bad drivers' with and without DWI. *J Stud Alcohol.* 1995;56:356–360.
8. Cydulka RK, Harmody MR, Barnoski A, et al. Injured intoxicated drivers: citation, conviction, referral, and recidivism rates. *Ann Emerg Med.* 1998;32: 349–352.
9. Hultcrantz R, Glaumann H, Lindberg G, et al. Liver investigation in 149 asymptomatic patients with moderately elevated activities of serum transaminases. *Scand J Gastroenterol.* 1986;21:109–113.
10. Mathiesen UL, Franzen LE, Fryden A, et al. The clinical significance of slightly to moderately increased liver transaminase values in asymptomatic patients. *Scand J Gastroenterol.* 1999;34:85–91.
11. van Ness M, Diehl AM. Is liver biopsy useful in the evaluation of patients with chronically elevated liver enzymes? *Ann Intern Med.* 1989;111:473–478.
12. Klasky AL, Armstrong MA, Griedman GD. Alcohol and mortality. *Ann Intern Med.* 1992;117:646–654.
13. Neumark YD, Van Etten ML, Anthony JC. 'Alcohol dependence' and death: survival analysis of the Baltimore ECA sample from 1981 to 1995. *Subst Use Misuse.* 2000;35:533–549.