

# TRANSACTIONS

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## A PILOT STUDY OF HYPERTENSION

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**T**HIS investigation was undertaken to determine what the electrocardiogram and X-ray, if used routinely, would contribute to the selection of risks with an elevated blood pressure, and to test the accuracy of our impression that women tolerate hypertension better than men do.

The study is based on 1,227 employees of The Prudential Insurance Company of America, 745 males and 482 females. While this group has the disadvantage of being small, it has the advantage of having been followed with periodic examinations. It was, therefore, possible to study the progress of the group and to reappraise the risk on those still living at the end of the observation period—a procedure which cannot be carried out in the usual mortality investigation.

### MATERIAL AND METHOD

All of our examinations are on a voluntary basis. In some cases the hypertension was discovered on a routine check-up examination. In others the individual sought medical advice because of symptoms or came for an electrocardiogram at the request of the attending physician. It is noteworthy, in view of the marked difference in mortality that was found between males and females, that the proportion of females in this study (39.3%) was approximately the same as on the Prudential staff at ages 40 and over (41%), and in the group requesting routine periodic examinations (43.5%).

The individuals were treated in this study in all respects as if they were applicants for insurance. The observation period began, in each case, with the date on which a ratable blood pressure and an electrocardiogram and X-ray were first obtained on the same examination. If there were previous electrocardiograms and X-rays at the time of this examination, they were considered to be available for comparison with the current ones. If there were earlier records of elevated blood pressure, they were treated as history in determining the underwriting action. Ages at entry ranged from 17 to 66.

Observations were closed June 30, 1953, but no new entrants were added to the group after December 31, 1952. The observation period ranged from six months to twenty years, with an average duration of 6.5 years. Twelve individuals left the Company's employ after entering the experience, and these were treated as lapses. All others were followed through the Company's employment and retirement files to the end of the period or until death.

In selecting individuals for this study, certain related impairments were permitted. Soft systolic murmurs in the mitral and aortic areas were included where they were of the type designated "functional," as such murmurs are frequently associated with hypertension and may reasonably be considered part of the arteriosclerotic process. No murmur was included which was thought to be the result of an old endocarditis. Overweight, also a common associated condition, was included. Premature beats were allowed if their frequency did not exceed five a minute. In every such case, an additional rating for the associated impairment was added to the rating required by the blood pressure and, if necessary, an extra rating for the combination of impairments (for example, hypertension and overweight or double murmurs). No one was included who had a ratable amount of albumin or casts. No one was included who had a noncardiac impairment—such as diabetes, tuberculosis, or peptic ulcer—even if it were only a history that no longer required a rating.

Chest pain is a frequent complaint in the Company's health service and is also a recurrent problem in insurance selection, and some method of dealing with it had to be devised. Most of the chest pain reported did not even remotely suggest a coronary origin, but it is well known that coronary pain is often atypical and sometimes completely misleading, so that caution is required. There were, however, a few cases of typical angina pectoris and a somewhat larger number in which the symptoms, although not typical, strongly suggested a coronary origin. Where the symptoms had not caused any absence from work that would be known to associates, they might readily have been concealed on an insurance examination had the applicant desired to conceal them. It was decided to include all such cases and to classify the symptoms, as best one could from the description given and without reference to the electrocardiogram, into two groups to be studied separately: those presumed to be coronary in origin (which included the typical cases of angina pectoris) and those presumed not to be coronary. No one who had had a definite coronary occlusion was admitted.

In any attempt to distinguish between coronary and noncoronary pain, it must be recognized that some mistakes will be made in both direc-

tions, since each often simulates the other. The classical symptoms of angina pectoris are (1) substernal pain or oppression, (2) lasting a few minutes, (3) brought on by exertion, emotion, or a heavy meal, (4) rather promptly relieved by rest or nitroglycerin, and (5) radiating to the left shoulder or arm or, less frequently, to the neck, jaw, to both arms, or to the right arm alone. Chest pain of neurogenic origin, the most common cause of confusion, is: (1) occasionally substernal but usually in the left precordium or across the entire anterior chest; (2) either sharp and momentary or a dull ache that lasts for hours or days; (3) brought on, perhaps, by emotion but not by exertion; (4) not relieved by rest or nitroglycerin; and (5) sometimes radiating to the left shoulder or down the left arm. After careful study it was concluded that the most consistent and dependable feature was the relation of the symptoms to exertion, and chief reliance was placed on this, but with some weight given to other characteristics.

There were, all told, 53 cases with chest pain presumed to be coronary in origin, 160 with chest pain presumed not to be coronary, and 1,014 without chest pain. The group with chest pain presumed not to be coronary and the group without chest pain were found to show no significant difference in mortality and were combined. (It should be remarked in passing that it is doubtful whether the distinction between coronary and noncoronary pain could be made so successfully on a group of applicants for insurance, since the histories would be less dependable.) The experience is presented here in two ways: first, the 1,174 cases with no chest pain or with chest pain presumed not to be coronary; and second, the entire 1,227 cases, including those presumed to have coronary disease. The former assumes that the Company has full details on the chest pain and the latter that it knows nothing about it. In practice the truth would lie somewhere between these two extremes—just where, it is impossible to say.

THE HYPERTENSIVE CLASSIFICATION

The hypertension was classified in four broad groups corresponding to the Company's substandard rating classes, defined as follows:

Hypertensive Classification	Substandard Rating Classes	Equivalent Extra Mortality
Slight.....	Special A and B	+ 30% to + 80%
Moderate.....	Special C and D	+ 81% to +200%
Marked.....	Special E and F	+201% to +400%
Very Marked.....	Decline	Over +400%

TABLE 1

Ages			Diastolic Pressure (5th Point)													
15-29	70-86	-90	-93	-95	-97	-99	100	101	102	103	104	105	106	107	108	109
30-39	70-87	-91	-94	-96	-98	-100	101	102	103	104	105	106	107	108	109	110
40-49	70-88	-92	-95	-97	-99	-101	102	103	104	105	106	107	108	109	110	111
50 and over	70-90	-94	-97	-99	-101	102	103	104	105	106	107	108	109	110	111	112

  

SYSTOLIC PRESSURE			DEBITS															
Ages 60 and over	Ages 50-59	Ages under 50																
134	131	128	0	0	15	20	35											
137	134	131	0	0	20	25	40	55	70									
140	137	134	0	0	20	30	45	60	75	90	105							
143	140	137	0	15	25	35	50	65	80	95	110	130	155					
146	143	140	0	20	30	40	55	70	85	100	115	135	160	190	225			
149	146	143	20	30	40	50	65	80	95	110	125	145	170	200	235	275	320	
152	149	146	30	40	50	60	75	90	105	120	135	155	180	210	245	285	330	380
155	152	149	40	50	60	70	85	100	115	130	145	165	190	220	255	295	340	390
158	155	152	50	60	70	85	100	115	130	145	160	180	205	235	270	310	355	
161	158	155	60	70	85	100	115	130	145	160	175	195	220	250	285	325	370	
164	161	158	75	85	100	115	130	145	160	175	190	210	235	265	300	340	385	
167	164	161	90	100	115	130	145	160	175	190	205	225	250	280	315	355	400	
170	167	164	110	120	135	150	165	180	195	210	225	245	270	300	335	375		
173	170	167	135	145	160	175	190	205	220	235	250	270	295	325	360	400		
176	173	170	165	175	190	205	220	235	250	265	280	300	325	355	390			
179	176	173	195	205	220	235	250	265	280	295	310	330	355	385				
182	179	176	225	235	250	265	280	295	310	325	340	360	385					
185	182	179	255	265	280	295	310	325	340	355	370	390						
188	185	182	285	295	310	325	340	355	370	385	400							
191	188	185	320	330	345	360	375	390										
194	191	188	355	365	380	400												
197	194	191	395															

NOTE.—Hypertensive classification: Debits 0 to 29, Normal (Standard); 30 to 80, Slight (Special A-B); 81 to 200, Moderate (Special C-D); 201 to 400, Marked (Special E-F); over 400, Very Marked (Reject).

The classification of each case was determined by the rating obtained from the schedule currently in use for underwriting purposes at the Prudential, shown in Table 1. The blood pressure used in entering the table was calculated as follows: (1) If two or more blood pressure readings were obtained on the same day, the average was used. (2) If blood pressure readings were obtained on two or more days, the average of the averages for the several days was used. (3) If previous blood pressure readings were higher than the current average, the average of the two highest systolics and the two highest diastolics was averaged with the current average.

The rating required by the blood pressure alone determined the hypertensive classification. To this was added the rating, if any, required for associated impairments and combinations of impairments, and for electrocardiographic and X-ray abnormalities, to get the total rating. The total ratings for all cases in any given group studied were averaged to obtain the figures shown in the tables under "Mortality Provided for by Ratings." The ratings used in this study for X-ray and electrocardiographic abnormalities are given in the Appendix.

#### MORTALITY EXPERIENCE

The expected mortality was calculated by lives on the 1946-1949 Basic Table, Select and Ultimate. The Select Table was used because the group studied is select except for the impairment under investigation and associated impairments that are an integral part of the syndrome.

Throughout the investigation, males and females were studied both separately and combined. The ratios of actual to expected mortality were compared with the average of the ratings imposed on the group under the rules set out in the foregoing sections. The group was studied in its entirety, including all types of chest pain (Tables 2 and 3), and then excluding the 53 cases, 36 men and 17 women, having chest pain of known or suspected coronary origin (Tables 4 and 5).

The study was based on the degree of hypertension, assuming that selection of risks was made: (1) on the clinical background alone, without electrocardiogram or X-ray; (2) with electrocardiogram; (3) with X-ray; and (4) with both electrocardiogram and X-ray.

When subdivided by age groups, fluctuations were so great that the results were not informative and, therefore, are not shown. It appeared, however, that moderate to marked hypertension is tolerated better at the middle and older ages than at the younger ages.

The causes of death are shown in Table 6.

**TABLE 2**  
**MORTALITY EXPERIENCE**  
**HYPERTENSION WITH AND WITHOUT CHEST PAIN**  
**SELECTION WITHOUT EKG OR X-RAY**

Initial Hypertensive Class'n	Number of Lives	Expected Mortality	Actual Mortality	Mortality Ratios	Mortality Provided for by Ratings
<b>MALES</b>					
Slight.....	390	16.3	25	153% $\left\{ \begin{array}{l} +26^* \\ -21 \end{array} \right.$	153%
Moderate.....	193	8.6	27	313 $\left\{ \begin{array}{l} +51 \\ -43 \end{array} \right.$	230
Marked.....	80	5.6	24	430 $\left\{ \begin{array}{l} +75 \\ -61 \end{array} \right.$	390
Totals.....	663	30.5	76	249% $\left\{ \begin{array}{l} +19 \\ -19 \end{array} \right.$	204%
Very Marked.....	82	5.0	35	698 $\left\{ \begin{array}{l} +98 \\ -83 \end{array} \right.$	Decline
<b>FEMALES</b>					
Slight.....	217	14.3	4	28% $\left\{ \begin{array}{l} +15 \\ -10 \end{array} \right.$	152%
Moderate.....	128	8.9	7	78 $\left\{ \begin{array}{l} +30 \\ -21 \end{array} \right.$	235
Marked.....	60	5.7	9	158 $\left\{ \begin{array}{l} +51 \\ -39 \end{array} \right.$	388
Totals.....	405	28.9	20	69% $\left\{ \begin{array}{l} +14 \\ -11 \end{array} \right.$	213%
Very Marked.....	77	6.6	18	274 $\left\{ \begin{array}{l} +56 \\ -46 \end{array} \right.$	Decline
<b>MALES AND FEMALES</b>					
Slight.....	607	30.6	29	95% $\left\{ \begin{array}{l} +15 \\ -12 \end{array} \right.$	153%
Moderate.....	321	17.5	34	194 $\left\{ \begin{array}{l} +27 \\ -23 \end{array} \right.$	232
Marked.....	140	11.3	33	293 $\left\{ \begin{array}{l} +42 \\ -36 \end{array} \right.$	389
Totals.....	1068	59.4	96	162% $\left\{ \begin{array}{l} +11 \\ -11 \end{array} \right.$	207%
Very Marked.....	159	11.6	53	458 $\left\{ \begin{array}{l} +42 \\ -42 \end{array} \right.$	Decline

\* Confidence intervals for a confidence level of 50%, assuming a Poisson distribution, where the number of deaths does not exceed 35. Probable deviation where the number of deaths is over 35.

TABLE 3  
MORTALITY EXPERIENCE  
HYPERTENSION WITH AND WITHOUT CHEST PAIN  
SELECTION WITH EKG

Initial Hypertensive Class'n	Number of Lives	Expected Mortality	Actual Mortality	Mortality Ratios	Mortality Provided for by Ratings
MALES					
Slight.....	330	13.4	17	127% $\left\{ \begin{array}{l} +27 \\ -22 \end{array} \right.$	158%
Moderate.....	145	6.5	16	245 $\left\{ \begin{array}{l} +55 \\ -44 \end{array} \right.$	232
Marked.....	56	3.3	12	366 $\left\{ \begin{array}{l} +97 \\ -76 \end{array} \right.$	389
Totals.....	531	23.2	45	194% $\left\{ \begin{array}{l} +19 \\ -19 \end{array} \right.$	203%
FEMALES					
Slight.....	194	12.8	3	23% $\left\{ \begin{array}{l} +14 \\ -7 \end{array} \right.$	158%
Moderate.....	107	6.9	6	87 $\left\{ \begin{array}{l} +38 \\ -26 \end{array} \right.$	236
Marked.....	48	4.5	6	134 $\left\{ \begin{array}{l} +58 \\ -40 \end{array} \right.$	379
Totals.....	349	24.2	15	62% $\left\{ \begin{array}{l} +14 \\ -12 \end{array} \right.$	212%
MALES AND FEMALES					
Slight.....	524	26.2	20	76% $\left\{ \begin{array}{l} +15 \\ -12 \end{array} \right.$	158%
Moderate.....	252	13.4	22	164 $\left\{ \begin{array}{l} +30 \\ -24 \end{array} \right.$	234
Marked.....	104	7.8	18	232 $\left\{ \begin{array}{l} +47 \\ -39 \end{array} \right.$	384
Totals.....	880	47.4	60	127% $\left\{ \begin{array}{l} +11 \\ -11 \end{array} \right.$	206%

NOTE.—The "Very Marked" hypertensive groups were omitted in Tables 3 and 5, since they would have been rejected on the blood pressure readings alone and no electrocardiogram would have been obtained in practice.

**TABLE 4**  
**MORTALITY EXPERIENCE**  
**HYPERTENSION, EXCLUDING CHEST PAIN PRESUMED TO BE CORONARY**  
**SELECTION WITHOUT EKG OR X-RAY**

Initial Hypertensive Class'n	Number of Lives	Expected Mortality	Actual Mortality	Mortality Ratios	Mortality Provided for by Ratings
<b>MALES</b>					
Slight.....	376	15.7	21	134% $\left\{ \begin{array}{l} +26 \\ -21 \end{array} \right.$	153%
Moderate.....	188	8.6	25	292 $\left\{ \begin{array}{l} +51 \\ -41 \end{array} \right.$	230
Marked.....	70	4.1	17	414 $\left\{ \begin{array}{l} +88 \\ -73 \end{array} \right.$	386
Totals.....	634	28.4	63	222% $\left\{ \begin{array}{l} +19 \\ -19 \end{array} \right.$	202%
Very Marked.....	75	4.6	31	673 $\left\{ \begin{array}{l} +100 \\ -86 \end{array} \right.$	Decline
<b>FEMALES</b>					
Slight.....	212	13.2	3	23% $\left\{ \begin{array}{l} +14 \\ -7 \end{array} \right.$	152%
Moderate.....	123	8.1	7	86 $\left\{ \begin{array}{l} +34 \\ -23 \end{array} \right.$	235
Marked.....	57	5.1	9	175 $\left\{ \begin{array}{l} +56 \\ -43 \end{array} \right.$	384
Totals.....	392	26.4	19	72% $\left\{ \begin{array}{l} +14 \\ -12 \end{array} \right.$	212%
Very Marked.....	73	6.4	15	236 $\left\{ \begin{array}{l} +55 \\ -44 \end{array} \right.$	Decline
<b>MALES AND FEMALES</b>					
Slight.....	588	28.9	24	83% $\left\{ \begin{array}{l} +15 \\ -12 \end{array} \right.$	153%
Moderate.....	311	16.7	32	192 $\left\{ \begin{array}{l} +28 \\ -24 \end{array} \right.$	232
Marked.....	127	9.2	26	281 $\left\{ \begin{array}{l} +47 \\ -39 \end{array} \right.$	385
Totals.....	1026	54.8	82	150% $\left\{ \begin{array}{l} +11 \\ -11 \end{array} \right.$	206%
Very Marked.....	148	11.0	46	419 $\left\{ \begin{array}{l} +41 \\ -41 \end{array} \right.$	Decline



**TABLE 5**  
**MORTALITY EXPERIENCE**  
**HYPERTENSION, EXCLUDING CHEST PAIN PRESUMED TO BE CORONARY**  
**SELECTION WITH EKG**

Initial Hypertensive Class'n	Number of Lives	Expected Mortality	Actual Mortality	Mortality Ratios	Mortality Provided for by Ratings
<b>MALES</b>					
Slight .....	322	13.0	16	123% $\begin{cases} +28 \\ -22 \end{cases}$	158%
Moderate .....	143	6.5	15	231 $\begin{cases} +54 \\ -43 \end{cases}$	232
Marked .....	54	3.1	11	354 $\begin{cases} +100 \\ -77 \end{cases}$	386
Totals .....	519	22.6	42	186% $\begin{cases} +19 \\ -19 \end{cases}$	202%
<b>FEMALES</b>					
Slight .....	189	11.7	2	17% $\begin{cases} +11 \\ -7 \end{cases}$	158%
Moderate .....	104	6.4	6	93 $\begin{cases} +40 \\ -28 \end{cases}$	237
Marked .....	46	3.9	6	153 $\begin{cases} +66 \\ -46 \end{cases}$	377
Totals .....	339	22.0	14	63% $\begin{cases} +15 \\ -12 \end{cases}$	212%
<b>MALES AND FEMALES</b>					
Slight .....	511	24.7	18	73% $\begin{cases} +15 \\ -12 \end{cases}$	158%
Moderate .....	247	12.9	21	162 $\begin{cases} +31 \\ -26 \end{cases}$	234
Marked .....	100	7.0	17	242 $\begin{cases} +51 \\ -43 \end{cases}$	382
Totals .....	858	44.6	56	125% $\begin{cases} +11 \\ -11 \end{cases}$	206%

## DISCUSSION

Use of the X-ray contributed little or nothing to the selection of this group of hypertensive risks and the results are not shown in detail. Selection with X-ray gave a mortality of 243% for males, 65% for females, and 158% for the two sexes combined as compared with 249%, 69%, and 162%, respectively, without X-ray (from Table 2).

Use of the electrocardiogram resulted in a much lower mortality than did selection without electrocardiogram. It was more effective in the selection of males than of females, as might be expected in view of the fact that coronary occlusion is, in our experience, much more frequent in

TABLE 6  
CAUSES OF DEATH

CAUSES	MALES		FEMALES	
	Number of Deaths	Percentage of Total	Number of Deaths	Percentage of Total
Coronary occlusion . . . . .	48	43.3%	6	15.8%
Cerebral hemorrhage . . . . .	25	22.5	16	42.1
Other cardiovascular* . . . . .	21	18.9	11	28.9
Unrelated . . . . .	17	15.3	5	13.2
	111	100.0%	38	100.0%

\* Causes given as: hypertensive heart disease; arteriosclerotic heart disease; acute myocarditis; chronic myocarditis; acute dilatation of heart; myocardial decompensation; congestive failure; left ventricular failure; coronary sclerosis; chronic coronary insufficiency; hypertensive cardiovascular-renal disease; chronic nephritis; nephrosclerosis; uremia.

males. It was more effective, as one would also expect, in cases with chest pain presumed to be coronary than in those without it. The percentage of electrocardiograms resulting in a higher rating or outright rejection is shown in the last two columns of Table 7.

The 36 males and 17 females with chest pain believed to be of coronary origin (not shown in the table as a separate group) had a mortality ratio of 397% for all degrees of hypertension combined, 651% (17 deaths) for males and 148% (4 deaths) for females. Use of the electrocardiogram made very little difference in the mortality ratios in this group. Selecting these risks on the basis of history would appear to be more effective than using the electrocardiogram, although dependable histories in such cases are difficult to obtain on insurance examinations. However, further study of the data suggests that a longer period of observation might show results more favorable to the electrocardiogram, as some of the survivors are in poor condition.

The most striking feature of the investigation is the marked difference in mortality between males and females. It has long been known that the mortality rate is substantially lower for normal females than for normal males. In a recent Prudential study on insured lives, at ages over 40, the rates on females were 55% to 60% of those on males. The table used for expected mortality in this study, *i.e.*, the 1946-1949 Basic Table, is based on 90% male data. When the female mortality ratios in Tables 2 to 5

TABLE 7  
CHARACTERISTICS OF THE GROUP AS A WHOLE

HYPERTENSIVE CLASSIFICATION	AVERAGE AGE YEARS	AVERAGE DURATION YEARS	DISTRIBUTION BY DEGREE OF HYPERTENSION	PERCENTAGE OF EKGS SHOWING SOME ABNORMALITY	
				Without Chest Pain Presumed Coronary	With Chest Pain Presumed Coronary
MALES					
Slight.....	45.8	5.8	52%	22%	50%
Moderate.....	45.2	6.1	26	25	40
Marked.....	47.4	7.1	11	29	80
Very Marked.....	52.8	5.8	11	48	86
FEMALES					
Slight.....	48.3	6.7	45%	16%	0%
Moderate.....	48.1	7.2	27	16	40
Marked.....	48.8	9.1	12	19	33
Very Marked.....	50.8	7.2	16	30	100

are adjusted to a female table for expected deaths (roughly an increase of 60% in the ratios shown) there is still very little extra mortality.

Another interesting observation is that the expected mortality was greater for females than for males. In Table 2, for example, 80 males with marked hypertension had an expected mortality of 5.6 deaths, while 60 females had a slightly higher expected mortality, 5.7 deaths. This led to further analysis of the data and it was found that women entered the experience at an older age than men in most categories and had a longer duration (Table 7), which accounts for the greater expected mortality. The women who died cardiovascular deaths died older, on the average, than did the men—age 60.8 for females, 59.0 for males. Furthermore,

Table 7, giving the distribution of hypertension by degree, shows that the women had more hypertension of moderate and marked degrees on entering the experience than did the men. One is forced to the conclusion that women withstand the stresses of hypertension better than men do.

While some of these results were unexpected, a search of the literature indicates that they are not at variance with the impressions of clinicians who have followed groups of hypertensive patients over a period of years. Blood and Perera, O'Hare and Holden, and Palmer and Meunch have, among them, commented on all of the following points:

That the disease increases in severity at a slower rate in women than in men, and results in a lower mortality.

That a young person with high blood pressure is more likely to die of the condition than an older person with high blood pressure.

That the principal causes of death are congestive failure (40% to 50%), myocardial infarction and cerebral hemorrhage (10% to 20% each), with not more than 5% dying of renal insufficiency.

That a considerable number of patients carry on far better than might be anticipated on the basis of initial observations. They make a distinction here between essential hypertension, which pursues a mild and relatively static course, and malignant hypertension, which is rapidly progressive and is associated with necrosis of the arteriolar walls, advanced hyalinization, and hemorrhages involving particularly the kidneys and retinae. Malignant hypertension is, on occasion, apparent at onset, but is more likely to develop without warning in the course of essential hypertension and go on to a rapidly fatal conclusion.

That the initial blood pressure level, the presence or absence of symptoms, X-ray evidence of cardiac enlargement, and retinal arterio-venous compression bore no relation to the rate of progression or the subsequent development of major cardiovascular complications. That, on the other hand, a steadily rising blood pressure over a period of time, cardiac pain or insufficiency, electrocardiographic signs of myocardial damage, progressive renal damage, cerebral vascular accidents, retinal hemorrhages, exudate or papilledema were, in general, indicative of a relatively short life expectancy.

#### PROGRESS OF SURVIVORS

It is of interest to follow, through the observation period, the progress of those who did not die.

Everyone realizes that blood pressure levels fluctuate considerably from time to time and even within a few minutes, but it was surprising, to this writer at least, to see individuals whose blood pressures were rather consistently in the 180 to 200 systolic and 100 to 120 diastolic ranges

(there being numerous blood pressure readings taken over a long period of time) showing many readings in the "Slight" hypertensive range and occasional normal readings. Clinicians, also, have commented on this point. The practice among insurance companies of averaging blood pressure readings and requiring readings on two or more different days is designed to minimize fluctuations, but with fluctuations so marked it is evident that the rating might vary considerably depending on what the blood pressure happened to be when the readings were taken.

At the other extreme are cases with what appears to be a single high reading, followed by a series of normal readings. This occurred fairly frequently in our series in the "Slight" hypertensive classification, a number of times in the "Moderate" classification, and a few times even in the "Marked" and "Very Marked" groups. In the natural course of insurance events, most such cases would apply for and receive reduction or removal of rating. It goes without saying that removal of these cases from their respective standard groups would make the mortality ratios even higher than those shown in the tables.

There are also cases that show a single high reading followed by several normal readings over a period of time, and then go on to a definite hypertensive status. Many of these cases, too, might readily qualify for removal or reduction of rating during the interval of normal readings.

Table 8 shows the changes in hypertensive status between the beginning and end of the observation period among the 1,078 who survived. The "Initial" hypertensive classification was based, as already described, on the then current averages, averaged with higher previous readings, if any. The "Ultimate" classification was arrived at by reviewing all of the blood pressure readings available, taking into consideration the average for the entire period and the trend. An individual whose blood pressure fluctuated between "Slight" and "Marked" was classified as having a "Moderate" hypertension, while one whose readings were, in general, "Slight," then "Moderate," and in the latter part of the observation period "Marked," was classified as "Marked."

Table 9 shows the changes in electrocardiographic status among the survivors. In the beginning 23% of the group had abnormalities in the electrocardiogram that required rating or rejection, and at the end 40% had such findings. In addition, many (not tabulated) had slight electrocardiographic abnormalities at the beginning which became more marked as time went on. It is noted that both the percentage of abnormal electrocardiograms at the beginning and the proportion becoming abnormal during the observation period increases with the severity of the hypertension.

TABLE 8

CHANGES IN HYPERTENSIVE STATUS DURING OBSERVATION PERIOD  
 AMONG PERSONS STILL LIVING AT END OF OBSERVATION  
 HYPERTENSION WITH AND WITHOUT CHEST PAIN

HYPERTENSIVE CLASS'N	INITIAL CLASS'N		CHANGES IN HYPERTENSIVE STATUS TO:					ULTIMATE CLASS'N	
	Number of Lives	Percentage of Total	Nor.	Sl.	Mod.	Mk'd	Very Mk'd	Number of Lives	Percentage of Total
MALES									
Normal.....								77	12%
Slight.....	365	58%	64	19	44	16	18	246*	39
Moderate.....	166	26	11	3	17	17	17	163	26
Marked.....	56	9	2	1	17	9	9	66	10
Very Marked..	47	7	0	1	0	8	8	82	13
Totals....	634	100%						634	100%
FEMALES									
Normal.....								38	9%
Slight.....	213	48%	26	9	36	10	16	148	33
Moderate.....	121	27	9	17	13	17	17	117	26
Marked.....	51	12	1	4	12	13	13	53	12
Very Marked..	59	13	2	2	4	9	9	88	20
Totals....	444	100%						444	100%
MALES AND FEMALES									
Normal.....								115	11%
Slight.....	578	53%	90	36	80	26	34	394	36
Moderate.....	287	27	20	3	30	34	34	280	26
Marked.....	107	10	3	7	29	22	22	119	11
Very Marked..	106	10	2	3	4	17	17	170	16
Totals....	1078†	100%						1078	100%

\* 246 = 365 - (64 + 44 + 16 + 18) + (19 + 3 + 1), etc.

† Original 1,227 less 149 deaths.

In Table 10, broad changes in underwriting action are shown in the group acceptable with electrocardiogram at the beginning of the observation period who were still living at the end. Of the 820 who would have been accepted, 14% had qualified for a reduction or removal of rating, 11% would have required a higher rating, and 23% had become uninsurable. Those who qualified for a lower rating had demonstrated that their blood pressure level was lower than that indicated by their initial reading.

TABLE 9

CHANGES IN ELECTROCARDIOGRAPHIC STATUS DURING OBSERVATION PERIOD AMONG PERSONS STILL LIVING AT END OF OBSERVATION HYPERTENSION WITH AND WITHOUT CHEST PAIN

INITIAL HYPERTENSIVE CLASS'N	NUMBER OF LIVES	ELECTROCARDIOGRAMS REQUIRING RATING OR REJECTION AT BEGINNING		ELECTROCARDIOGRAMS REQUIRING RATING OR REJECTION AT END	
		Number	Percent	Number	Percent
MALES					
Slight.....	365	83	23%	135	37%
Moderate.....	166	41	25	69	42
Marked.....	56	16	29	32	57
Very Marked.....	47	22	47	35	74
Totals.....	634	162	26%	271	43%
FEMALES					
Slight.....	213	34	16%	62	29%
Moderate.....	121	20	17	38	31
Marked.....	51	9	18	24	47
Very Marked.....	59	18	31	38	64
Totals.....	444	81	18%	162	36%
MALES AND FEMALES					
Slight.....	578	117	20%	197	34%
Moderate.....	287	61	21	107	37
Marked.....	107	25	23	56	52
Very Marked.....	106	40	38	73	69
Totals.....	1078*	243	23%	433	40%

\* Original 1,227 less 149 deaths.

Those who required a higher rating had shown progressively higher blood pressure levels with the passage of time or developed ratable murmurs, for the most part. Those who had become uninsurable were no longer acceptable because of a rise in blood pressure to the "Very Marked" level, because of electrocardiographic changes, because of some acute clinical episode (such as coronary occlusion or cerebral hemorrhage), or because some chronic condition (diabetes, or albumin and casts) developed which,

TABLE 10  
CHANGES IN UNDERWRITING STATUS DURING OBSERVATION PERIOD  
AMONG PERSONS ACCEPTED AT BEGINNING AND LIVING AT END  
HYPERTENSION WITH AND WITHOUT CHEST PAIN  
SELECTION WITH EKG

INITIAL HYPERTENSIVE CLASS'N	ACCEPTED AT BEGIN- NING	UNDERWRITING STATUS AT END					
		Decline		Higher Rating		Lower Rating	
	Number of Lives	Number	Percent	Number	Percent	Number	Percent
MALES							
Slight.....	313	64	20%	32	10%	44	14%
Moderate.....	129	26	20	18	14	19	15
Marked.....	44	17	39	0	0	8	18
Totals.....	486*	107	22%	50	10%	71	15%
FEMALES							
Slight.....	191	42	22%	31	16%	13	7%
Moderate.....	101	23	23	11	11	20	20
Marked.....	42	20	48	0	0	11	26
Totals.....	334*	85	25%	42	13%	44	13%
MALES AND FEMALES							
Slight.....	504	106	21%	63	13%	57	11%
Moderate.....	230	49	21	29	13	39	17
Marked.....	86	37	43	0	0	19	22
Totals.....	820	192	23%	92	11%	115	14%

\* From Table 3: Males, 531 accepted with EKG less 45 deaths. Females, 349 accepted with EKG less 15 deaths.



with the impairments already present, increased the rating to more than +400%. To be consistent with the initial selection, it was again assumed that we knew nothing of angina pectoris if it had not resulted in a conspicuous absence from work. It should be pointed out that the decreases in rating did not offset the increases in rating in magnitude and that, in actual practice, the company would have been forced to grant reductions or removals of rating to most of the 14% who qualified or permit the policies to lapse.

#### CONCLUSION

The group available for this study is much too small for the mortality ratios to be relied on for rating purposes and the female mortality is incredibly low for reasons that are not apparent. The difference between the sexes is so great, however, as to indicate that in future investigations males and females should be studied separately. If a substantial difference is confirmed by an experience sufficiently large to be dependable, more lenient treatment of females with hypertension would be in order.

The electrocardiogram appears to be of value in selecting hypertensive risks, particularly in uncovering evidence of myocardial damage when symptoms are withheld.

The X-ray, apparently, does not contribute enough to justify its use.

Caution should be exercised in reducing or removing ratings imposed for elevated blood pressure.

It is probable that the practice of averaging blood pressure readings to get the ratable blood pressure gives too little weight to the higher readings in most cases.

#### APPENDIX

##### RATINGS FOR X-RAY AND ELECTROCARDIOGRAPHIC ABNORMALITIES

The ratings for X-ray and electrocardiographic abnormalities given in this section are those currently in use at the Prudential. They simply represent our best judgment, since there is not yet sufficient material for a statistical approach to the rating problem.

It will be noted that our ratings take the form of adding one or more rating classes to the rating required by the hypertension and any associated impairments. Since the Company's substandard rating classes broaden as the ratings increase, this automatically results in a larger addition to the rating the more severe the hypertension is. For example, adding one rating class for a given X-ray or electrocardiographic abnormality would add +30% if the hypertension called for a Special A rating,

or +100% if the hypertension called for a Special D rating. Adding one rating class to a Special F rating would, of course, result in declination, as would adding two rating classes to a Special E rating.

An X-ray showing cardiac hypertrophy was considered to warrant rejection in itself. A slightly rounded left ventricular curve without increase in heart size was not considered definite evidence of hypertrophy and was ignored for the purpose of this study.

An X-ray showing a marked degree of dilatation, elongation, or tortuosity of the aorta was deemed cause for rejection; in very few cases was the aorta abnormal to this degree. Dilatation, elongation, or tortuosity of the aorta less marked than this but considered excessive for the age and/or any amount of aortic intimal calcification were rated as follows:

Ages 40-49	Add three rating classes
Ages 50-59	Add two rating classes
Ages 60-66	Add one rating class

Evaluation of X-ray findings, as X-rays are read at the Prudential, is a matter of the interpreter's judgment, without measurements, so that no more definite idea of what was considered a ratable or uninsurable degree of abnormality can be given.

The electrocardiographic abnormalities in this group of cases consisted chiefly of abnormal T waves, as they probably would in any group of hypertensives. T waves were considered abnormal if they were low (less than one millimeter), diphasic, inverted, or notched in any of the standard or precordial leads except Lead 3 and  $V_1$ , with some leniency allowed in  $V_2$ . In the unipolar extremity leads, considerable judgment had to be exercised because T waves may normally be lower than one millimeter and may even be inverted, much depending on the position of the heart. As in the case of X-ray findings, this depends to some extent on our own conception of what constitutes normal and abnormal T waves in the unipolar extremity leads. We believe that—

In a  $V_3$ , T waves must be inverted to be normal. Diphasic or upright T waves in this lead are abnormal.

In a  $V_1$ , normal T waves are usually upright but may be inverted if QRS complexes in this lead are mainly inverted, a combination frequently seen in normal, vertical hearts. Inverted or diphasic T waves with QRS complexes mainly upright were considered to be abnormal and to have the same significance as T wave inversion in the standard and precordial leads.

In a  $V_2$ , criteria are the same as in a  $V_1$ , the inverted QRS-T pattern being considered normal in a transversely placed heart, but with somewhat less assurance.

In either  $aV_L$  or  $aV_F$ , very shallow inversion of the T wave with the R wave small (about five millimeters or less) was considered a questionable rather than a definitely abnormal finding. We feel that it may sometimes be due to a semivertical or semihorizontal position of the heart, but we have also seen it as the only remaining evidence of definite abnormalities in previous electrocardiograms.

In any unipolar extremity lead, T waves were considered low when they appeared low in proportion to the R waves. Thus, an almost isoelectric T wave in  $aV_L$  or  $aV_F$  would be considered abnormal with an R wave of ten or twelve millimeters but normal with an R wave of three or four millimeters. In  $aV_R$ , T wave voltage is, of course, compared with the amplitude of the chief downward deflection of QRS.

Ignoring the low, diphasic, and inverted T waves that we consider normal, action on the others was as follows:

With moderate or marked hypertension:

T waves low, diphasic, inverted, or notched—decline

With slight hypertension:

T waves diphasic, inverted, or notched—decline

Except: shallow inversion with low R waves in  $aV_L$  or  $aV_F$ —add two rating classes.

T waves low in  $aV_L$  alone—add one rating class

T waves low in  $aV_F$  alone—add two rating classes

T waves low in Lead I,  $aV_L$ ,  $V_5$ , and  $V_6$ —add two rating classes

T waves low with more generalized distribution—decline

T waves normal currently but low, diphasic, or inverted in previous electrocardiograms—decline

T waves significantly lower than in previous electrocardiograms but still normal—decline

The distinctions based on the leads in which the abnormalities occurred were made for these reasons: Disproportionately low T waves in  $aV_L$  alone or low T waves in Lead I,  $aV_L$ ,  $V_5$ , and  $V_6$  may be the earliest change in left ventricular hypertrophy, before there is enlargement sufficient to show on X-ray. Low T waves that are more widespread than the foregoing or differently distributed may be a manifestation of coronary disease. Significant changes in T wave voltage from record to record, whether progressive or regressive, constitute serial changes that strongly suggest the possibility of underlying coronary involvement.

Each of the electrocardiographic findings listed below occurred in a small number of cases. They do not exhaust the possibilities that might be found in association with hypertension, but they were all that chanced

to occur in the group studied here. It will be noted that no abnormal Q waves were present, since individuals who had had an acute coronary occlusion were excluded from this study.

S-T segment depression, definite, even though slight—decline

Left axis deviation with QRS<sub>2</sub> mainly inverted or with high voltage of QRS, if  
 out of proportion to body build—add one rating class.

Low voltage of QRS—no debit

Prolonged P-R interval:

Under age 40

.22 to .24 sec.—no debit

.25 sec. or more—add one rating class

Age 40 and over

.22 to .24 sec.—add one rating class

.25 sec. or more—add two rating classes

Wandering pacemaker or sino-auricular block:

Under age 40—no debit

Age 40 and over—add one rating class

Incomplete right bundle branch block:

Under age 40—no debit

Age 40 and over—add one rating class

Premature beats, not more than five a minute:

If electrocardiogram is normal except for premature beats and total rating (including the usual rating for premature beats without electrocardiogram) is:

not over +80—credit -30

+81 to +200—no credit

+201 to +400—add one rating class<sup>1</sup>

It should be emphasized that the ratings given for these electrocardiographic findings are considered to apply to hypertensive risks, and would not necessarily be the same with some other clinical background.

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<sup>1</sup> A previous study ("The Evaluation of Certain Fundamental Electrocardiographic Patterns in the Selection of Insurance Risks" by H. B. Kirkland, M.D., C. E. Kiessling, M.D., and A. M. Lyle, *Tr. Assoc. Life Insur. Med. Dir. Amer.* 35:86, 1951) showed that when premature beats develop in the course of long-standing organic heart disease (hypertensive, arteriosclerotic, or rheumatic), the mortality thereafter is very high.