JOURNAL OF INSURANCE MEDICINE

J Insur Med 2015;45:28–33

MORTALITY

Changing the "Normal Range" for Blood Pressure from 140/90 to 130/Any Improves Risk Assessment

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Objective.—Redefine the "normal" reference range for blood pressure from <140/90 to one that more effectively identifies individuals with increased mortality risk.

Method.—Data from the recently published 2014 CRL blood pressure study was used. It includes 2,472,706 life insurance applicants tested by Clinical Reference Laboratory from 1993 to 2007 with follow-up for vital status using the September 2011 Social Security Death Master File. Various upper limits of blood pressure (BP in mm Hg) were evaluated to determine if any was superior to the current, commonly used limit of 140/90 in identifying individuals with increased mortality risk.

Results.—An alternative reference range using a systolic BP (SBP) <130 with any diastolic BP (DBP) included 84% of life insurance applicants. It had a lower mortality rate and narrower range of relative risk than <140/90, including 89% as many applicants but only 68% as many deaths. This pattern of lives and deaths was consistent across age and sex.

Conclusion.—Switching to a "normal" reference range of SBP <130 offers superior risk assessment relative to using BP <140/90 while still including a sufficient percentage of the population.

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Key words: Blood pressure, hypertension, laboratory tests, life insurance, mortality.

Received: July 3, 2014

Accepted: October 5, 2014

INTRODUCTION

Current life insurance industry underwriting practice (and clinical practice) often lumps blood pressure (BP in mm Hg) <140/90 into a single "normal" reference range although, for lower premium "preferred classes," there will most often be further systolic BP (SBP) and/or diastolic BP (DBP) restrictions.

Other cardiovascular risk measures such as lipids are usually compared to narrower, more ideal reference bands and, therefore, may play a more prominent role in underwriting decision-making on the premise that such findings are more predictive as long as the BP is <140/90. This approach may be encouraged by two recent contrasting recommendations: the Eighth Joint National Committee in 2014 suggesting that BP treatment should be limited to those with blood pressures ≥140/90 at younger ages and ≥150/90 at older ages, as compared with recent ACC/AHA guidelines on cholesterol suggesting even more widespread use of statin therapy.[1,2] Recognizing that the value of treatment does not equate to the risk, such messages may still impact risk assessment practices.

In contrast, our recent BP study found SBP ≥130 to have substantially increased risk while higher DBP increased risk minimally.[3] In fact, low DBP with wide pulse pressure was a far more important risk determinant compared to high DBP. We therefore sought to determine if a more accurate ''normal'' reference range might be both practical and lead to better risk discrimination.

METHODS

Details on this pool of 2,472,706 life insurance applicants (31,033 deaths) tested between 1993 and 2007 with BP and laboratory results available are provided in our previous publication on BP.[3] All applicants with SBP between 90 and 199 and DBP between 50 and 120 were included. Follow-up for vital status was conducted by use of the September, 2011 Social Security Death Master File. The median duration of follow-up was 7 years (range 0 to 18).

Relative mortality risk was calculated by Cox regression analysis using IBM SPSS version 22. The analyses were split by sex and age 18 to 59 and 60 to 89 with age and smoking (defined as urine cotinine >200 ng/mL indicating use of tobacco or nicotine delivery device) included as covariates. Additional covariates included were age- and sex-adjusted mortality risk scores for body mass index (BMI) and for urine protein/creatinine ratio (urine p/c), and a simple positive/negative for history of heart disease. Those denying a heart disease history (66.5%) and not answering (32.6%) were combined as ''negative.'' Because BMI and urine p/c have a variable impact on relative mortality by age and sex, rather than use the values, the independent excess mortality risk (score) associated with those values (taken from previous research by the authors) was included as a covariate instead.[4-6] These additional covariates account for information which is often evaluated separately at the time of insurance underwriting or clinical assessment.

RESULTS

Table 1 shows the distribution of lives and deaths by age and sex using a BP reference

Table 1. Distribution of Study Population by BP Reference Range, Age and Sex

Blood pressure range	Age-sex group	Total	Deaths	Percent of all cases by age-sex	Percent of all deaths by age-sex
<130/any	F 20 to 59	916,217	4,250	91.8%	77.3%
	F 60 to 89	44,809	2,111	65.7%	51.8%
	M 20 to 59	1,054,266	8,843	81.1%	64.3%
	M 60 to 89	63,287	3,837	59.5%	49.7%
	Total	2,078,579	19,041	84.1%	61.4%
<140/90	F 20 to 59	972,633	5,005	97.4%	91.1%
	F 60 to 89	59,729	3,218	87.6%	79.0%
	M 20 to 59	1,223,313	11,787	94.1%	85.8%
	M 60 to 89	91,125	6,103	85.7%	79.0%
	Total	2,346,800	26,113	94.9%	84.1%
All BP values	F 20 to 59	998,113	5,495		
	F 60 to 89	68,187	4,073		
	M 20 to 59	1,300,053	13,744		
	M 60 to 89	106,353	7,721		
	Total	2,472,706	31,033		

Table 2. Relative Mortality by BP for Four Age-Sex Groups Using BP <140/90 as the Reference Range

Systolic BP	Female age 18-59			Male age 18-59			Female age 60-89			Male age 60-89		
90-139	*MR*	*95% CI*		*MR*	*95% CI*		*MR*	*95% CI*		*MR*	*95% CI*	
Diastolic	*(Cox)*	*Lower*	*Upper*	*(Cox)*	*Lower*	*Upper*	*(Cox)*	*Lower*	*Upper*	*(Cox)*	*Lower*	*Upper*
50 to 89 (ref)	*1.00*			*1.00*			*1.00*			*1.00*		
130-139	**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**	
Diastolic	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**
90 to 120	1.38	1.05	1.81	1.41	1.24	1.59	1.50	1.07	2.11	0.97	0.75	1.25
140-149	**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**	
Diastolic	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**
50 to 69	2.55	1.14	5.67	2.41	1.59	3.67	1.75	1.34	2.30	1.46	1.13	1.88
70 to 79	1.46	1.00	2.13	1.40	1.14	1.71	1.29	1.07	1.55	1.17	1.02	1.34
80 to 89	1.38	1.14	1.68	1.46	1.32	1.60	1.18	1.02	1.37	1.18	1.07	1.30
90 to 120	1.53	1.20	1.95	1.47	1.31	1.64	1.34	1.02	1.76	1.16	0.97	1.38
150-159	**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**	
Diastolic	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**
50 to 69	n/a	n/a	n/a	n/a	n/a	n/a	1.27	0.72	2.24	1.49	0.94	2.37
70 to 79	2.35	1.17	4.70	2.80	1.95	4.00	1.56	1.18	2.07	1.38	1.10	1.74
80 to 89	2.17	1.57	2.99	1.93	1.61	2.32	1.28	1.01	1.61	1.23	1.05	1.45
90 to 120	1.52	1.11	2.08	1.76	1.52	2.04	1.69	1.27	2.24	1.34	1.11	1.63
160-199	**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**	
Diastolic	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**
50 to 69	n/a	n/a	n/a	n/a	n/a	n/a	1.31	0.62	2.74	2.65	1.69	4.16
70 to 79	3.03	1.36	6.75	1.82	0.98	3.38	1.93	1.36	2.74	1.12	0.79	1.58
80 to 89	2.23	1.40	3.56	2.05	1.55	2.71	1.44	1.11	1.86	1.25	1.01	1.54
90 to 120	2.41	1.86	3.12	2.17	1.88	2.50	1.52	1.17	1.97	1.33	1.11	1.59

n/a = Number of deaths <5

Table 3. Relative Mortality by BP for Four Age-Sex Groups Using BP <130/Any as the Reference Range

Systolic BP	Female age 18-59			Male age 18-59			Female age 60-89			Male age 60-89		
90-129	**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**	
Diastolic	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**
50 to 120 (ref)	*1.00*			*1.00*			*1.00*			*1.00*		
130-139	**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**	
Diastolic	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**
50 to 59	n/a	n/a	n/a	n/a	n/a	n/a	1.35	0.70	2.59	2.18	1.39	3.42
60 to 69	2.10	1.52	2.89	1.71	1.40	2.09	1.51	1.27	1.80	1.37	1.19	1.57
70 to 79	1.28	1.11	1.48	1.30	1.21	1.41	1.28	1.15	1.43	1.17	1.09	1.27
80 to 89	1.33	1.20	1.47	1.37	1.31	1.44	1.26	1.14	1.39	1.12	1.05	1.20
90 to 120	1.45	1.10	1.91	1.52	1.34	1.71	1.63	1.16	2.29	1.02	0.80	1.32
140-149	**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**	
Diastolic	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**
50 to 69	2.69	1.21	5.99	2.63	1.73	3.99	1.92	1.46	2.53	1.55	1.20	2.00
70 to 79	1.55	1.06	2.26	1.52	1.24	1.86	1.41	1.17	1.70	1.24	1.07	1.42
80 to 89	1.47	1.21	1.78	1.58	1.44	1.75	1.29	1.11	1.50	1.24	1.12	1.37
90 to 120	1.62	1.27	2.06	1.59	1.42	1.78	1.46	1.11	1.91	1.22	1.03	1.46
150-159	**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**	
Diastolic	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**
50 to 69	n/a	n/a	n/a	n/a	n/a	n/a	1.40	0.79	2.47	1.58	1.00	2.52
70 to 79	2.50	1.25	5.01	3.05	2.13	4.36	1.71	1.29	2.27	1.47	1.16	1.85
80 to 89	2.31	1.67	3.18	2.11	1.76	2.54	1.40	1.11	1.76	1.30	1.11	1.54
90 to 120	1.62	1.19	2.22	1.92	1.66	2.22	1.84	1.39	2.44	1.42	1.17	1.73
160-199	**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**		**MR**	**95% CI**	
Diastolic	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**	**(Cox)**	**Lower**	**Upper**
50 to 69	n/a	n/a	n/a	n/a	n/a	n/a	1.44	0.68	3.02	2.82	1.79	4.42
70 to 79	3.24	1.45	7.21	1.99	1.07	3.70	2.11	1.49	3.00	1.19	0.84	1.68
80 to 89	2.39	1.50	3.81	2.25	1.70	2.98	1.57	1.21	2.03	1.33	1.07	1.64
90 to 120	2.58	1.99	3.33	2.38	2.06	2.74	1.65	1.27	2.15	1.40	1.17	1.68

n/a = Number of deaths <5

range of <140/90 and the alternative of <130/any. We found that 84.1% of applicants had SBP <130 with no diastolic restrictions and 94.9% had BP <140/90. For males age 60+ (group with the highest average BP), those percentages were 59.5% and 85.7% respectively. In contrast, the percentage of deaths included in BP <130 for all age-sex was only 61.4% compared to 84.1% for BP <140/90. Table 1 also shows that this pattern of a lower percentage of deaths included using 130/any is consistent across the age-sex groups rather than simply a shift to younger lives. Overall, using an SBP of <130 as a cut-off relative to using BP <140/90 included 88.6% as many lives and 72.9% as many deaths.

Table 2 displays the relative mortality using a reference range of <140/90 and Table 3 shows the same information for a reference range of <130/any. These mortality ratios have been adjusted for age, cotinine status, BMI risk, urine p/c risk, and admitted history of heart disease. Using BP <130/any reveals the excess risk associated with the very common finding of SBP 130 to 139, where relative mortality is increased by approximately 30%, except for males age 60+ where the increase is less. A higher relative risk is also seen using <130/any rather than <140/90 for the less common SBP ≥140.

Both Tables 2 and 3 illustrate that within each SBP band, risk associated with progressively higher DBP changes little.

DISCUSSION

In contrast to many diseases, hypertension (by any definition) is common so that the healthy reference pool is relatively smaller. It is also associated with increased mortality risk beginning at SBP well below 140 while DBP adds little risk discrimination (to SBP) as it increases from average to high levels.[3] This led us on a hunt for a better ''normal'' reference band that offered superior identification of increased risk associated with elevated BP while remaining large enough to be practical for screening purposes.

In our prior paper, when comparing SBP 90-119 (lowest relative risk) to SBP 125-129, relative mortality increased by 13% to 32% depending on age and sex, a range of risk we felt was probably acceptable within a ''normal'' pool. However, SBP ≥130 expanded this risk range, substantially increasing risk by roughly 30% for each 10 mm Hg. Using BP <130/any still includes 84.1% of applicants. Reaching the 94.9% included in BP <140/90 using SBP only would require a cut-off of <138/any. Both <140/90 and <138/any include substantial BP-associated excess mortality relative to using <130/any. The percentage of applicants included in <130/any when split by age and sex (older males being the lowest) relative to risk discrimination achieved also appears both satisfactory and superior to using BP <140/90.

The risk associated with DBP within each SBP band is highest with the lowest DBP rather than increasing as DBP increases. This is discussed in our earlier paper with pulse pressure/SBP > ½ (1% of applicants) identifying the excess risk associated with low DBP.

Limitations for our study include dependence on 1 to 3 BP measurements (just one for 24% of applicants) done at a single exam. In addition, our heart disease history was obtained from a question on the laboratory authorization (answer encouraged but usually not required) rather than on the insurance application. Our population of individual life insurance applicants also has fewer serious medical conditions and higher socio-economic status as compared to a general population sample.

CONCLUSION

Rather than use the pool of those with BP <140/90 as a reference to identify insurance applicants or those at a wellness exam as having increased risk, limiting that pool to those with SBP <130 without a cut-off for high DBP offers better risk assessment.

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