

When measurements are misleading: modelling the effects of blood pressure misclassification in the English population

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Guidelines recommend that primary care teams measure their adult patients' blood pressures.¹ Is this always a useful activity? A measurement of blood pressure is an estimate of the true mean blood pressure. Clinical decisions are based on the average of several measurements. However, measurement is imperfect, and blood pressure shows random biological variation from beat to beat. Because of this unavoidable variation patients may be misclassified as above or below the treatment threshold. Thus, like any diagnostic or screening test, estimation of blood pressure is subject to false positives and false negatives. The proportion of test positives that are true positives is the positive predictive value of a test: an index of the test's precision. This paper calculates positive predictive values for blood pressure measurement in an English population.

Methods and results

A secondary analysis of a large dataset of individual patients' blood pressures yielded an estimate of intra-individual blood pressure variation between clinic visits. The dataset had been obtained by combining individual patient data from randomised controlled trials of blood pressure treatment. Intra-individual measurements of systolic blood pressure have a coefficient of variation of 9.9% and of diastolic blood pressure of 9.2%² (V. Musini, personal communication, 21 July 2003). These estimates can be applied across the study population because the coefficient of variation changes little with age or sex.³ A decision to treat raised blood pressure should be based on the mean of three estimations of blood pressure.¹ The coefficient of variation of an estimate of blood pressure based on the mean of three measurements is therefore 5.7% ($5.7\% = 9.9\%/\sqrt{3}$) for systolic and 5.3% ($5.3\% = 9.2\%/\sqrt{3}$) for diastolic blood pressure.

Combined data from the health survey for England of 1998, 1999, and 2000 provided a dataset of 13 284 people with complete information on cardiovascular risk factors.⁴ I used the Framingham risk equation to calculate individual 10 year coronary risks for each of these persons.⁵ On an MS Excel spreadsheet I generated an error term for each individual patient's systolic and diastolic blood pressures. Error terms were normally distributed, with a coefficient of variation equivalent to that obtained from the mean of three blood pressure measurements. In addition to their true blood pressure and true coronary risk I thus allocated to individual patients an estimated systolic and diastolic blood pressure and an estimated coronary risk, each incorporating an error term.

Patients are true positives (eligible for treatment) if their true blood pressure and true coronary risk exceed treatment thresholds based on current British guidelines. These are either blood pressure over 160/100 mm Hg (diastolic or systolic) or blood

pressure over 140/90 mm Hg with 10 year coronary risk exceeding 15%.¹ Patients are test positives if their estimated blood pressure and coronary risk exceed treatment thresholds. I calculated positive predictive values for each group by age and sex.

Positive predictive values for blood pressure estimation are highest in older age groups and lowest in younger age groups (table 1). Of 36 men aged 16-34 classified as needing treatment, only 11 are true positives—a positive predictive value of 31% (95% confidence interval 16% to 46%). Of 19 women 16-34 classified as needing treatment, five are true positives—a positive predictive value of 26% (95% confidence interval 7% to 46%). The positive predictive value of blood pressure estimation for men and women aged 16-35 combined is 29% (17% to 41%).

Comment

Routine measurement of blood pressure in persons under 35 is more likely to misdiagnose than to diagnose hypertension correctly. As 10 year coronary risk rarely exceeds 5% in adults under 35 clinicians should diagnose hypertension with caution—perhaps at a higher threshold. Blood pressure measurement is useful mainly in people with specific indications or coronary risk factors.

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- 2 Wright JM, Musini VJ. Blood pressure variability: lessons learned from a systematic review. Poster presentation D20, 8th International Cochrane Colloquium, Cape Town, October 2000.
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- 4 Department of Health. *Health survey for England 1998; 1999; 2000*. www.data-archive.ac.uk (accessed 25 Feb 2003).
- 5 Anderson KA, Wilson PWF, Odell PM, Kannel WB. An updated coronary risk profile. A statement for health professionals. *Circulation* 1991;83: 356-62.

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True prevalence of eligibility for antihypertensive treatment and positive predictive values based on the mean of three blood pressure measurements

Age in years	True prevalence of eligibility for antihypertensive treatment (%)		Positive predictive value of the mean of three blood pressure measurements (%)	
	Men	Women	Men	Women
16-34	0.9	0.3	31	26
35-44	4.4	1.4	62	60
45-54	17.0	8.3	86	79
55-64	38.6	22.4	93	83
65-74	45.2	35.6	94	83
75+	45.3	36.4	87	94

Source: Health survey for England 1998, 1999, 2000.⁴

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