By neglecting deprivation, cardiovascular risk scoring will exacerbate social gradients in disease

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Objective: To examine whether the efficiency and equity of cardiovascular risk scores that identify patients at high risk for preventive interventions are compromised by omitting social deprivation, which contributes to risk.
Design: Cohort study.
Setting: The SHHEC (Scottish heart health extended cohort) study of random sample risk factor surveys across 25 districts of Scotland in 1984–87 and North Glasgow in 1989, 1992, and 1995
Participants: 6419 men and 6618 women aged 30–74, free of cardiovascular disease at baseline, followed up with permission for mortality and morbidity to March 1997. Participants were allocated to population fifths of the Scottish index of multiple deprivation (SIMD) and their observed coronary risk was compared with that expected from the Framingham score for all coronary heart disease.
Results: The Framingham score overestimated risk overall and in each SIMD fifth. It seriously underestimated the variation in risk with deprivation. The relative risk of observed 10 year coronary risk (sexes combined) analysed across population fifths had a steep gradient, from least to most deprived, of 1.00, 1.81, 1.98, 2.22, and 2.57. Expected risk, calculated from baseline risk factor values and the Framingham score, had one quarter of that gradient, with relative risks of 1.00, 1.17, 1.19, 1.28, and 1.36.
Conclusion: Cardiovascular risk estimated by the Framingham and related scores is misleading in guiding treatment decisions among people at different levels of social deprivation. Such scores foster relative undertreatment of the socially deprived, exacerbating the social gradients in disease, which national policies seek to minimise. Debate and action are needed to correct this anomaly.

Is our failure to include deprivation in assessing cardiovascular risk resulting in unnecessary premature deaths through inefficient and unfair allocation of preventive treatment? Until recently risk was equated with cut points of single risk factors—blood pressure $\geqslant$ 160/95 mm Hg and total cholesterol $\geqslant$ 7.8 mmol/l, for example. It is now recognised that the continuous gradient of risk with rising values of individual factors, and their multiplicative effect when combined together, demand composite cardiovascular scores to aid decisions on treatment. These are based on what is called total, global, or absolute risk—30% risk over 10 years, for example. Included in such composite scores are the classic modifiable risk factors of cigarette smoking status, blood pressure, and total cholesterol or its components and non-modifiable determinants of risk, such as age and sex.[1]

Basing treatment decisions on predetermined levels of a risk score has obvious appeal. It replaces potentially arbitrary decisions with transparency, consistency, and potential for audit. It maximises efficient use of limited resources. It implies fairness in ensuring equitable distribution of limited resources. Determining by score whose condition warrants treatment and whose does not seems free of bias. Does further analysis confirm these claims?

Innumerable studies have followed and replicated a classic report from the Whitehall study of civil servants in the 1970s, which showed that the incidence of coronary heart disease varied with social status, in this case employment grade, in a manner inadequately explained by standard risk factors.[2] Even in apparently egalitarian countries, whose people would deny the existence of social class, large and sometimes widening social gradients for cardiovascular disease have been reported.[3]

Social status, or deprivation, is not incorporated into existing standard risk scores. Its definition varies from culture to culture, so that it is not readily standardised for international use. Hence its neglect, even though by default it may compromise the fairness and efficiency of using cardiovascular risk scores. Even in health services providing free access and hoping to target inequality the failure to consider deprivation may exacerbate the inverse care law, which states that "the availability of good medical care tends to vary inversely with the need for it in the population served".[4 5]

Following a request from a group reviewing and renewing previously published guidelines on cardiovascular risk assessment for the Scottish Intercollegiate Guidelines Network (SIGN),[6 7] we examined this problem in a cohort study of Scottish men and women followed up for cardiovascular disease morbidity and mortality over about 10 years, from the middle 1980s.

METHODS

The SHHEC (Scottish heart health extended cohort) study's recruitment and follow up have been described.[8 9] It included random sample population surveys from 1984 to 1987 across 25 districts of Scotland—the Scottish heart health and baseline MONICA (monitoring trends and determinants in cardiovascular disease) surveys in Glasgow and Edinburgh—and similar repeated MONICA surveys in North Glasgow in 1989, 1992, and 1995, all following the same basic protocol.

Abbreviations: MONICA, monitoring trends and determinants in cardiovascular disease; SHHEC, Scottish heart health extended cohort; SIMD, Scottish index of multiple deprivation

For this analysis we studied 6419 men and 6618 women aged 30–74 years who were free of cardiovascular disease at recruitment. Detailed methods, statistical procedures, and results for different social determinants and cardiovascular end points will be communicated separately (M Woodward *et al*, unpublished data).

We examined the newly constructed Scottish index of multiple deprivation (SIMD).[10] It is based on 31 indicators, produced by different government agencies for 6505 geographical data zones, based on the six domains: current income; employment; housing; health; education; and skills and training and geographic access to services and telecommunications. Calculated for small areas, it is available by individual postcodes of residence and therefore was linked directly to each SHHEC participant's home address at recruitment. The SIMD was divided into fifths of the Scottish population from 1, the least, to 5, the most deprived.

We used data from ongoing notification of deaths from the National Health Service Central Register and of hospital inpatient episodes from the Scottish record linkage scheme to March 1997. We calculated the 10 year incidence, by SIMD fifths, of coronary heart disease deaths, hospitalisation for myocardial infarction and other acute coronary disease (with case note review), and coronary artery procedures, by using Kaplan-Meier[11] survival estimates. We compared *observed* risk with the risk *expected* from the individual risk factor data from the baseline surveys, using the version of the Framingham risk score for all coronary heart disease[1] that was adopted into clinical practice for SIGN and other British guidelines.[7 12]

RESULTS

Table 1 illustrates the grounds for debate. The SIMD is shown to be a powerful determinant of coronary risk when examined across the population fifths.

Observed risk has a steep gradient by social status. It varied twofold in men between the top (least) and bottom (most deprived) fifth of the population (from 4.9% to 10.0%) and fivefold, although at lower levels, in women (from 1.1% to 5.5%).

Expected (estimated or predicted) risk was based on the Framingham score, which therefore calculated the estimated effect on risk in the SIMD fifths of their differences in conventional cardiovascular risk factors. This also has a social gradient, but it is quite modest and considerably smaller than that *observed* (from 10.3% to 12.7% in men and from 4.3% to 7.5% in women).

As in many other studies[13–16] but not all[17] we find lower observed risk than that expected from the Framingham score. However, the variation between fifths in the observed to expected ratio (which can be regarded as the Framingham score standardised ratio) is considerable—nearly two to one when the sexes are combined (from 0.47 to 0.79 in men and from 0.25 to 0.74 in women).

The implications of this increasing observed to expected ratio with increasing deprivation are considerable. If the basic Framingham score were to be applied as the universal criterion for deciding treatment, treatment levels would follow the expected and not the observed distribution. The most socially deprived fifth has twice as much observed risk as the least deprived fifth in proportion to the expected or treatment level risk. The most socially deprived would be receiving proportionately half the treatment in relation to their prospective disease burden of that given to the least deprived, a modern day example of Julian Tudor Hart's inverse care law.[4 5]

Tested against a social gradient such as the fifths of the SIMD, use of the Framingham score therefore fails to allocate preventive treatment in relation to actual need, resulting in relative overtreatment of the most affluent and relative undertreatment of the most deprived.

Other Framingham risk score end points such as all cardiovascular disease give the same overall results. Removal of the 1992 and 1995 MONICA surveys, which contributed to the excess numbers in the SIMD bottom 20% in the SHHEC studies and had shorter follow up, also made no appreciable difference to the results (M Woodward *et al*, unpublished data).

DISCUSSION

Our findings, based on a large, nationwide and nationally representative cohort study and using a modern index of deprivation, categorically and elegantly confirm what was

Table 1 Calculated 10 year risk percentage for all coronary heart disease by fifths of the Scottish index of multiple deprivation (SIMD) observed in the SHHEC (Scottish heart health extended cohort) population to March 1997 and expected from the Framingham risk score

		Observed		Expected		Observed:expected	
Fifth	**Number**	**Risk (%)**	**Relative risk**	**Risk (%)**	**Relative risk**	**Ratio**	**Relative ratio**
Men							
1	1175	4.86	1.00	10.32	1.00	0.47	1.00
2	998	8.48	1.74	11.65	1.13	0.73	1.55
3	1075	9.13	1.88	11.54	1.12	0.79	1.68
4	1203	8.91	1.83	12.46	1.21	0.72	1.52
5	1968	9.98	2.05	12.66	1.23	0.79	1.67
Women							
1	1157	1.05	1.00	4.26	1.00	0.25	1.00
2	984	2.34	2.23	5.34	1.25	0.44	1.78
3	1087	2.75	2.62	5.95	1.40	0.46	1.88
4	1285	4.49	4.28	6.41	1.50	0.70	2.84
5	2105	5.52	5.26	7.47	1.75	0.74	3.00
Both							
1	2332	2.99	1.00	7.31	1.00	0.41	1.00
2	1982	5.42	1.81	8.52	1.17	0.64	1.56
3	2162	5.92	1.98	8.73	1.19	0.68	1.66
4	2488	6.63	2.22	9.33	1.28	0.71	1.74
5	4073	7.67	2.57	9.98	1.36	0.77	1.88

Fifth 1 is the least deprived 20% of the Scottish population and fifth 5 the most deprived. Repeated surveys for the Scottish MONICA (monitoring trends and determinants in cardiovascular disease) project have led to comparative overrepresentation of the most deprived.[8, 9]

predictable from previous work on risk factors and deprivation.[2] They also corroborate results derived by analysis of data from the Renfrew-Paisley study mounted in the west of Scotland in the 1970s at the epicentre and peak of the Scottish coronary epidemic.[17] This showed, unusually, underestimation of coronary risk by the Framingham score but a similar failure by the score to predict the full social gradient in relative risk. Results of these two Scottish studies provide an evidence base for modification of current use of coronary risk scores.

Risk scores are used firstly to prioritise treatment and secondly to assess progress. Incorporation of age and sex means that levels of the modifiable risk factors are not the sole determinants of treatment. Older men are inherently at higher risk than others and it is accepted that patients with a diagnosis of vascular disease or diabetes are also at a higher level of risk. Because of this they warrant treatment at lower starting levels of risk factors than others, with the additional aim of achieving especially low target values through treatment. Our analyses suggest that the estimated effect of being in the highest 20% of deprivation rather than the lowest 20% is equivalent in risk scoring terms to a decade or more in age or to a diagnosis of diabetes. In a socially mixed population, deprived people therefore warrant preventive treatment at lower levels of risk factors than do others, to counterbalance their disadvantaged health status.

Adding social deprivation as a new risk factor to existing multifactorial scores would improve the overall efficiency of discriminating those at greatest risk[18] (M Woodward *et al*, unpublished data) but, equally important, would restore equity between social groups by redressing the existing bias towards inverse care. Making this correction to current procedures raises practical and medicopolitical questions in three major areas.

- Mortality rates for coronary heart disease are declining, so current risk is lower than that in historical cohorts. Even in them, many, like this one, show that the Framingham score overestimates incidence of coronary heart disease. At the same time the somewhat arbitrary treatment thresholds for risk factor interventions are coming down. If the score were applied as it is, which of the five groups shown in table 1, if any, would be receiving the appropriate level of treatment in relation to their observed risk? If it were not the least deprived fifth, would redirecting resources for coronary heart disease prevention towards the most deprived be possible without increasing resources overall? Would doctors apply a modified score comprehensively or retain the old one so they could use both to maximise the chances of treatment of each patient?
- What indicator of social status should be used to typecast patients, indeed the whole population, given that results for other measures are similar to those for SIMD? Occupation was long used by doctors to identify susceptibility to disease and by the Registrar Generals' offices to derive social class.[19] Place of residence, leading to analysis by small area statistics, and now postcodes have precedents dating back to Charles Booth in the 1880s,[20] and are widely used in commerce—for example, in allocating credit. Medical administrators may prefer to categorise patients by their local doctor's practice population, rather than individually, but they still need a social index with which to calculate any differentials.
- Can we get away with continuing to use existing scores such as Framingham, recognising patients' adverse or beneficial cardiovascular risk from deprivation by adjusting their age—that is, adding or subtracting years to the chronological age, as is done by life insurance actuaries? Given that the age gradient in risk in the Framingham score is unexpectedly flat, this adjustment may result in surprising if not impractical additions, particularly among women.[21] Alternatively, do we need a new cardiovascular risk score that incorporates coefficients for social deprivation? Such a score may be derived from the SHHEC and other similar British cohort studies if the social indicators they incorporated were compatible. A similar question arises in relation to differences in risk of cardiovascular disease in different ethnic groups, but that is outside the scope of this paper.

These findings and questions are relevant to populations in many industrialised countries. They warrant discussion and debate by those concerned with cardiovascular health and disease in society overall and in the socially deprived in particular.

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HTP planned the study in consultation with the SIGN risk estimation group, obtained the funding, coded the end points, and prepared the database with staff of the Dundee Unit, is guarantor of the data, and drafted the paper. MW conducted the statistical analyses and is authoring a more comprehensive technical report.

APPENDIX
Members of the SIGN (Scottish Intercollegiate Guidelines Network, 28 Thistle Street, Edinburgh EH2 1EN, UK) risk estimation group who helped to refine the study proposal and analyses were Dr James Grant (chair, principal in general practice, Auchterarder), Dr Moray Nairn (secretary, SIGN Edinburgh), Dr Adrian Brady (consultant cardiologist, Glasgow), Dr Peter Brindle (principal in general practice, Wellcome research fellow, Bristol), Dr Alex McConnachie (statistician, Robertson Institute, Glasgow), Mr Adam Redpath (Programme Principal, Information Services, NHS National Services Scotland, Edinburgh), Mr Roger Stableford (patient representative, Falkirk), Prof Hugh Tunstall-Pedoe (cardiovascular epidemiologist, Dundee), and Prof Graham Watt (general practice, Glasgow). Some members of the group have been involved in earlier studies of cardiovascular risk scores applied to other populations.

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