ANNALS OF FAMILY MEDICINE

Online Supplementary Material

Franks P, Tancredi DJ, Winters P, Fiscella K. Including socioeconomic status in coronary heart disease risk estimation. *Ann Fam Med*. 2010;8(5):447-453.

http://www.annfammed.org/cgi/content/full/8/5/447/DC1

Supplemental Appendix. Analyses

Use of Martingale Residuals to Assess Model Calibration

The martingale residual is the individual's observed event indicator O (1 = "Event observed" 0 = "Censored") minus the Cox-Snell residual. The predicted event probability (*P*) can be derived from the Cox-Snell (CS) residual as *P* = 1–exponential(–CS), which, for the low-probability events observed in this study, closely approximates the observed event indicator minus the martingale residual.[1] The expected value of the martingale residuals in a given model is 0. If a model is similarly calibrated for each of 2 groups defined by a variable not in the model, then the mean martingale residuals for the 2 groups should not differ significantly. Hence, for each SES indicator not included in a given model, mean martingale residuals were computed for each of the 2 groups (low vs high SES) and Student's *t* tests were applied to the mean residuals to examine whether calibration was similar in both groups.

Derivation of Cholesterol Treatment Thresholds

We derived a simple method of incorporating SES risk into treatment decisions. The 2 key Adult Treatment Panel III treatment thresholds are 10% and 20% Framingham risk score–predicted risk of coronary heart disease; Framingham risk scoring is indicated for those with $\geq$2 risk factors. Given the Cox model is multiplicative on the hazard scale, additional model terms have an exponential impact on prediction. Applying the adjusted hazard ratio (H) for SES to the Framingham risk score–predicted risk ($R_{\text{Framingham Risk Score}}$) and using the relationship between a risk and the corresponding integrated hazard under the proportional hazards assumption yields $(1–R_{\text{Framingham Risk Score+SES}}) = (1–R_{\text{Framingham Risk Score}})^{H}$. Thus, low-SES persons whose Framingham risk score–predicted risk was below 10% but above $1–(0.90)^{1/H}$ would have an SES-adjusted predicted risk above the 10% risk threshold; similarly low-SES persons whose Framingham risk score was between $1–(0.80)^{1/H}$ and 20% would have an SES-adjusted predicted risk above the 20% threshold. We also examined the prevalence of various levels of Framingham risk score–predicted coronary heart disease risk by SES for those with 0, 1, and 2 risk factors.

Results

Supplemental Table 1 summarizes the results of the survival analyses, by sex, with the 3 methods of SES adjustment. It can be seen that the hazard ratios for the Framingham risk scores and SES are similar for men and women.

Supplemental Table 2 summarizes the calibration analyses with the survival model using Framingham risk score alone. Miscalibration by all SES measures was significant (P <.001). Coronary heart disease prediction was overestimated by 17.5% (mean martingale residual/observed 10-year event risk = –0.58/3.30) in those with higher individually based SES and underestimated by 24% in those with lower individually based SES; block group–based hybrid SES miscalibration was similar.

Supplemental Table 3 summarizes the calibration analyses with the 3 survival models using Framingham risk score and SES adjustments. In each model miscalibration by the SES measures not in the model was reduced. The miscalibration for both individually based and block group–based hybrid SES prediction models was nonsignificant. For example, in the survival model using individually based SES, coronary heart disease prediction was overestimated by 1.6% in those with

higher block group–based hybrid SES and underestimated by 3.9% in those with lower block group–based hybrid SES. The SES miscalibration from the zip code–based hybrid SES model was reduced, but remained statistically significant when tested against the other SES measures.

Reference

1. Hippisley-Cox J, Coupland C, Vinogradova Y, Robson J, May M, Brindle P. Derivation and validation of QRISK, a new cardiovascular disease risk score for the United Kingdom: prospective open cohort study. *BMJ*. 2007;335(7611):136.

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Supplemental Table 1. Cox Survival Analyses of Sex-Specific Coronary Heart Disease Risk Prediction Using Framingham Risk Scoring With Individually Based and Hybrid Socioeconomic Status (SES) Adjustment

Model	Hazard Ratio (95% CI)	*P* Value
Individual SES		
Women (N = 6,930, events = 156)		
Framingham risk score	2.57 (2.19-3.02)	<.01
Lower SES	1.54 (1.12-2.13)	.01
Men (N = 5,463, events = 340)		
Framingham risk score	2.61 (2.17-3.15)	<.01
Lower SES	1.52 (1.21-1.89)	<.01
Block group hybrid SES		
Women (N = 6,774, events = 155)		
Framingham risk score	2.52 (2.15-2.97)	<.01
Lower SES	1.55 (1.12-2.15)	<.01
Men (N = 5,258, events = 328)		
Framingham risk score	2.56 (2.12-3.10)	<.01
Lower SES	1.50 (1.21-1.87)	<.01
Zip hybrid SES		
Women (N = 7,268, event = 163)		
Framingham risk score	2.62 (2.24-3.07)	<.01
Lower SES	1.34 (0.97-1.84)	.08
Men (N = 5,653, event = 351)		
Framingham risk score	2.61 (2.18-3.14)	<.01
Lower SES	1.37 (1.10-1.71)	.01

CI = confidence interval.
Notes: Notes Framingham risk score is complementary log log transformed: log[–log(1–Framingham risk score)]. Lower SES refers to individually based, block group hybrid–based, or zip code hybrid–based SES adjustment.

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Supplemental Table 2. Calibration Analyses of Coronary Heart Disease Risk Prediction Using Framingham Risk Scoring Alone

	Individually Based SES (N = 12,393)		Block Group Hybrid SES (N = 12,032)		Zip Code Hybrid SES (N = 12,921)	
SES Category	Parameter Estimate (95% CI)	*P* Value	Parameter Estimate (95% CI)	*P* Value	Parameter Estimate (95% CI)	*P* Value
Observed cardiac event (10-year %)						
Overall	3.93 (3.59 to 4.28)		4.03 (3.67 to 4.38)		3.98 (3.64 to 4.62)	
Higher SES	3.30 (2.93 to 3.67)	< .01	3.28 (2.89 to 3.66)	< .01	3.43 (3.06 to 3.79)	< .01
Lower SES	5.70 (4.90 to 6.50)		5.83 (5.05 to 6.62)		5.54 (4.76 to 6.31)	
Predicted cardiac event rate (per 100 persons & 10 years of follow-up) based on Framingham risk score alone						
Overall	3.99 (3.92 to 4.06)		3.98 (3.91 to 4.05)		3.98 (3.91 to 4.04)	
Higher SES	3.88 (3.80 to 3.95)	< .01	3.80 (3.72 to 3.88)	< .01	3.84 (3.76 to 3.91)	
Lower SES	4.31 (4.18 to 4.45)		4.39 (4.25 to 4.53)		4.38 (4.24 to 4.51)	
Mean martingale residuals from prediction model using Framingham risk score alone						
Higher SES	–0.58 (–0.96 to –0.20)	< .01	–0.53 (–0.92 to –0.13)	< .01	–0.41 (–0.78 to –0.04)	< .01
Lower SES	1.39 (0.57 to 2.21)		1.44 (0.65 to 2.24)		1.16 (0.37 to 1.94)	

CI = confidence interval; SES = socioeconomic status.

Notes: Higher and lower SES refers to calibration testing using the individually based, block group hybrid–based, or zip code hybrid–based SES adjustment. *P* = statistical significance of comparison between higher and lower SES mean values (*t* test).

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Supplemental Table 3. Calibration Analyses of Coronary Heart Disease Risk Prediction Using Both Framingham Risk Scoring and SES Adjustment

	Individually Based SES (N = 12,393)		Block Group Hybrid SES (N = 12,032)		Zip Code Hybrid SES (N = 12,921)	
SES Category	**Parameter Estimate (95% CI)**	***P* Value**	**Parameter Estimate (95% CI)**	***P* Value**	**Parameter Estimate (95% CI)**	***P* Value**
Predicted cardiac event rate (per 100 persons & 10 years of follow-up), prediction based on Framingham risk score & SES						
Overall	3.93 (3.86 to 4.01)		4.03 (3.95 to 4.10)		3.98 (3.92 to 4.05)	
Higher SES	3.30 (3.23 to 3.37)	< .01	3.28 (3.21 to 3.34)	< .01	3.43 (3.36 to 3.49)	< .01
Lower SES	5.70 (5.52 to 5.88)		5.83 (5.66 to 6.01)		5.54 (5.37 to 5.70)	
Mean martingale residuals using individually based SES prediction model						
Higher SES	–		–0.05 (–0.45 to 0.35)	.50	0.03 (–0.35 to 0.42)	.77
Lower SES	–		0.23 (–0.60 to 1.06)		–0.09 (–0.90 to 0.72)	
Mean martingale residuals using block group–based hybrid SES prediction model						
Higher SES	–0.20 (–0.60 to 0.19)	.24	–		0.00 (–0.39 to 0.39)	.98
Lower SES	0.30 (–0.58 to 1.19)		–		0.01 (–0.80 to 0.82)	
Mean martingale residuals using zip code–based hybrid SES prediction model						
Higher SES	–0.24 (–0.61 to 0.14)	.04	–0.28 (–0.68 to 0.11)	.03	–	
Lower SES	0.60 (–0.21 to 1.41)		0.54 (–0.17 to 1.25)		–	

CI = confidence interval; SES = socioeconomic status.

Notes: Higher and lower SES refers to calibration testing using the individually based, block group hybrid–based or zip code hybrid–based SES adjustment. *P* = statistical significance of comparison between higher and lower SES mean values (*t* test).