Self-Evaluation Problems
Class 4

The following questions refer to the results of a study investigating the role of cumulative lead burden (long-term exposure to lead as measured by tibia bone lead levels) and low dietary calcium in relationship to the odds of hypertension in 471 men participating in the Normative Aging Study (Epidemiology 2006;17:531-537).

In the models, the outcome variable is the presence of hypertension (1 – yes, 0 – no).

Table 2 presents the results of logistic regression models stratified by dietary calcium intake.

TABLE 2. Logistic Regression Models of Hypertension Status in Relation to Lead Biomarkers in the Normative Aging Study, Stratified by Calcium Intake

	Model A		Model B		Model C		Model D	
Variable	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Low calcium intake (≤800 mg/day)	(n = 259)		(n = 259)		(n = 258)		(n = 259)	
Age ≥70 yr	1.29	(0.66–2.48)	1.33	(0.68–2.59)	1.08	(0.54–2.14)	1.17	(0.60–2.30)
Family history of hypertension	2.34	(1.26–4.34)	2.43	(1.30–4.54)	2.50	(1.34–4.67)	2.46	(1.32–4.58)
Ever smoker	2.42	(1.20–4.87)	2.48	(1.23–5.04)	2.21	(1.09–4.48)	2.29	(1.13–4.65)
Body mass index (kg/m²)	1.13	(1.05–1.23)	1.14	(1.06–1.23)	1.13	(1.05–1.23)	1.14	(1.05–1.23)
Blood lead (µg/dL)	—	—	1.07	(1.00–1.15)	—	—	—	—
Tibia bone lead levels (µg/g)	—	—	—	—	1.02	(1.00–1.04)	—	—
Patella bone lead levels (µg/g)	—	—	—	—	—	—	1.01	(1.00–1.03)
High calcium intake (>800 mg/day)	(n = 212)		(n = 212)		(n = 209)		(n = 211)	
Age ≥70 yr	2.10	(1.03–4.28)	2.05	(1.00–4.19)	1.97	(0.92–4.22)	1.85	(0.87–3.93)
Family history of hypertension	2.36	(1.22–4.59)	2.24	(1.15–4.39)	2.32	(1.19–4.53)	2.34	(1.20–4.55)
Ever smoker	1.02	(0.50–2.07)	1.04	(0.51–2.12)	1.07	(0.52–2.20)	0.98	(0.48–2.02)
Body mass index (kg/m²)	1.17	(1.07–1.28)	1.17	(1.07–1.29)	1.20	(1.09–1.32)	1.17	(1.07–1.28)
Blood lead (µg/dL)	—	—	1.03	(0.97–1.11)	—	—	—	—
Tibia bone lead levels (µg/g)	—	—	—	—	1.01	(0.97–1.04)	—	—
Patella bone lead levels (µg/g)	—	—	—	—	—	—	1.01	(0.99–1.03)

OR indicates odds ratio.

1. The results of the logistic regression models stratified by dietary calcium intake displayed in **Model B in Table 2** suggest that:

   a) BMI modifies the association between ever smoking and hypertension.
   b) Calcium modifies the association between ever smoking and hypertension.
   c) Family history of hypertension is the weakest predictor of hypertension for both the low and high calcium intake groups, after controlling for the other variables.
   d) Age ≥ 70 years is the strongest predictor of hypertension for both the low and high calcium intake groups, after controlling for the other variables.
   e) Differences in the sample sizes of the low and high calcium intake groups result in different associations.

2. From the results of the low calcium intake group in **Model A in Table 2**, the odds ratio of hypertension in males aged ≥ 70 years with a family history of hypertension versus males < 70 years without a family history of hypertension, adjusted for the other variables indicates that the:

   a) Odds of hypertension are 10% higher in males aged ≥ 70 years with a family history of hypertension.
   b) Odds of hypertension are 3 times higher in males aged ≥ 70 years with a family history of hypertension. (This is because OR = $e^{(\log 2.34 + \log 1.29)} = 3.02$).
   c) Odds of hypertension are 33% lower in males < 70 years without a family history of hypertension
   d) Odds of hypertension are 3 times lower in males< 70 years without a family history of hypertension
   e) Cannot determine from these data

Table 3 presents the results of a final logistic regression model after assessing possible interactions of age, BMI and tibia bone lead with dietary calcium.

TABLE 3. Logistic Regression Model of Hypertension Status in Relation to Tibia Lead in the Normative Aging Study With Interaction Terms (n = 467)

Variable	Odds Ratio	(95% CI)
Age ≥ 70 yr	1.44	(0.87–2.40)
Family history of hypertension	2.27	(1.44–3.57)
Ever smoker	1.55	(0.94–2.54)
Body mass index (kg/m^2)	1.06	(0.92–1.21)
Calcium (mg/d)	0.997	(0.99–1.00)
Tibia bone lead levels (μg/g)	1.02	(1.00–1.04)
Body mass index × calcium	1.0001	(1.00–1.00)

3. Suppose we had the data set for **Table 3** and we repeated the analysis using the covariates in the order listed in the table. The standard error (SE) for the log OR of hypertension in ever smoker males with a family history of hypertension versus never smoker males without a family history of hypertension, adjusted for the other variables, could be obtained from `Stata` by fitting the regression model and then:

   a) Using the `test` command to test Ho: $\beta_2=\beta_3$.
   b) Using the `lrtest` command to compared nested models.
   c) Using the `lfit` command to perform the Hosmer-Lemeshow goodness of fit command.
   d) Using the `lincom` command to test Ho: $\beta_2+\beta_3$.
   e) Using `estimate` command to compute AIC.

4. In **Table 3** suppose that the interaction between calcium intake and BMI on the odds of hypertension after adjusting for other variables is statistically significant. We can then conclude that:

    a) The difference in the adjusted log odds of hypertension per mg/day increase in calcium intake does not vary by level of BMI.
    b) The difference in the adjusted log odds of hypertension per mg/day increase in calcium intake increases with increasing level of BMI.

    Since the exponentiated interaction coefficient is 1.0001, we know that the coefficient is log(1.0001) which indicates that the difference increases, rather than decreases. Note: If the interaction term was not statistically significant, then we would conclude that the hypertension-calcium intake relationship does not vary by level of BMI).

    c) The difference in the adjusted log odds of hypertension per mg/day increase in calcium intake decreases with increasing level of BMI.
    d) The adjusted odds of hypertension decrease by .3% with each mg/day increase in calcium intake.
    e) The adjusted odds of hypertension increase by 6% with each kg/m^2 increase in BMI.

5. Suppose propensity scores were used as a method to control for confounding in the analysis of the association between the outcome of hypertension and a binary indicator variable of high/low tibia bone lead level. A reasonable approach is to calculate the propensity scores as the predicted values from:

    a) A multiple logistic regression of the log odds of high tibia bone lead level on age, family history of hypertension, ever smoker, BMI, calcium and BMI-calcium interaction.
    The predicted values from this regression represent an individual's propensity to have high tibia bone lead levels based on the values of the confounding variables. The propensity score is then used as a covariate in the linear regression model with the outcome of hypertension.

    b) A multiple logistic regression of the log odds of hypertension on age, family history of hypertension, ever smoker, BMI, calcium and BMI-calcium interaction.
    c) A multiple logistic regression of the tibia bone lead level on hypertension, age, family history of hypertension, ever smoker, BMI, calcium and BMI-calcium interaction.
    d) The quintiles of tibia bone lead level.
    e) A stratified analysis of hypertension and calcium intake level, adjusted for tibia bone lead level.

