

**Midterm exam, Health economics, Spring 2007**  
**Answer key**

**Instructions:** All points on true/false and multiple choice questions will be given for the explanation. Note that you can choose which questions to answer in the short answer and long answer sections. You must answer all 6 of the true-false questions. You may choose which 2 of the 3 short answer questions (7, 8, and 9), and 2 of the 3 long answer questions (10, 11, and 12) to complete. Be concise. Note that the last page of the exam contains extra credit questions about the health insurance game we played in class (worth up to 10 points).

**True or false (explain)—answer all 6 questions. Each question is worth 4 points.**

1. T/F (4 points) One of the reasons that health care is different from other sectors of the economy is that the public sector is not very involved with health care.

*False. The public sector pays for a large share of health care expenditures in the US. The public sector is also an extensive provider of health insurance.*

2. T/F (4 points) We evaluate new technologies in health by comparing the sum of consumer and producer surplus when using the technology and when not using it. If the difference is positive, we adopt the new technology.

*False. We evaluate new technologies in two main ways. We consider the costs and benefits to society of the new technology, and adopt it if the benefits are greater than the costs. Alternatively, we compare the cost for using the new technology to generate a given health outcome and compare it to either what is done currently or to a cutoff value. If the new way is cheaper or below the cutoff cost, we adopt it.*

3. T/F (4 points) The Grossman model of health is a model predicting that people consume more medical care if they have a taste for health care.

*False. The Grossman model predicts that health care is a good we consume because we value health. We invest in our health by using health care (and with other inputs.)*

4. T/F (4 points) The RAND Health Insurance Experiment showed us that the generosity of health insurance coverage does not affect use of medical care.

*False. The RAND HIE found that more generous health insurance coverage led to using more care.*

5. T/F (4 points) The RAND Health Insurance Experiment showed us that the generosity of health insurance coverage does not affect overall health on average.

*True. While overall health was unaffected by the generosity of health insurance, health for some subgroups of people in poor health suffered.*

6. T/F (4 points) We think that demand for treatment of lung cancer will be more price elastic than demand for treatment of acne.

*False. We think demand for treatment for lung cancer will be relatively price inelastic.*

**Short answer/multiple choice—pick 2 of questions 7, 8, and 9 to answer. Each question is worth 15 points.**

7. (15 points) Which of the following factors if any affect health? Write two or three sentences for each contributor about how it affects health/how we know it affects health.

a. Health insurance

*The RAND HIE suggested that for the non-elderly, health insurance generosity did not affect overall health, but it may have affected health for some groups.*

b. Use of health care

*The amount of health care one uses matters for health, but not as clear that the marginal effect is very large. Doctors' services do matter for heart disease and for treating pain and mental health.*

c. Education

*Much evidence suggests that more educated people are healthier. One model (Grossman model) suggests this is because more educated people are better at producing health. Another model (Fuchs) suggests that people with low discount rates (who value the future) find it easier to stay healthy and to get education.*

**d. Age**

*Older people are indeed unhealthier. One way we know that most deaths are due to causes for older people.*

**8.** (15 points) In which of the following ways is cost-benefit analysis different from cost-utility (cost-effectiveness) analysis for evaluating health interventions or public programs? If one of these is not a way in which they differ, explain what is wrong with the statement.

**a.** Cost-benefit analysis compares societal costs and benefits whereas cost-utility analysis looks only at gains to specific people.

*This is correct. Cost-benefit analysis weighs societal costs and benefits, while cost-utility analysis looks at the cost of improving someone's health a given amount.*

**b.** Cost-benefit analysis is worse than cost-utility analysis in settings where there are externalities (for example, price signals do not work).

*This is incorrect. Since CBA looks at societal costs and benefits, it is better for settings where there are externalities. CUA may miss some of the costs or benefits to others in settings with externalities.*

**c.** Cost-benefit analysis uses present discounted values to account for long run impacts of interventions while cost-utility analysis does not.

*This is incorrect. Both methods can look at longer run impacts (by using PDV).*

**d.** Cost-benefit analysis weights the utility of being sick and of being well differently while cost-utility analysis does not.

*This is incorrect. CUA assigns different weights to a year when healthy and when sick. CBA usually looks at the value of statistical lives.*

**9.** (15 points) Which of the following are information problems that arise in the health care sector? Give an example of where they occur in health care.

**a.** Adverse selection.

*This is indeed an information problem in health care. Inability of the insurance company to detect how big a risk people are leads to some healthy people being unable to get insurance at a price they are willing to pay.*

**b.** Agency problems.

*This is indeed an information problem in health care. You must trust your doctor to make decisions on your behalf but they may be optimizing something different from what you are optimizing.*

**c.** Imperfect information.

*This is indeed an information problem in health care. One example is detecting the quality of different hospitals or other facilities.*

**d.** Moral hazard.

*This is indeed an information problem in health care. One example is when you have coinsurance (you only pay for a share of your total health care use). In this case you will consume more health care than you would if you had to pay the full cost of the care you consumed.*

**Long answer questions. Choose 2 of questions 10, 11, and 12 to answer. Each question is worth 23 points.**

**10.** (23 points) The following question is another screening/testing question, which will require you to use Bayes' rule. Remember, Bayes' rule says:

$$Pr(A_i|B) = \frac{Pr(A_i) * Pr(B|A_i)}{\sum_1^k Pr(A_j) * Pr(B|A_j)}.$$

Suppose we have a test for breast cancer that is better at detecting who is not sick for people who are not sick than for telling who is sick. For someone with breast cancer, it will correctly identify them as having cancer 90% of the time (10% of the time they will be misdiagnosed as not having cancer). Someone without breast cancer will be identified as having cancer 5% of the time (95% of the time they will be correctly diagnosed as not having cancer, and 5% of the time they will be incorrectly diagnosed as having cancer). Using our previous notation,  $Pr(+|C) = 0.90$ ,  $Pr(+|NC) = 0.05$ ,  $Pr(-|C) = 0.10$ ,  $Pr(-|NC) = .95$ .

**a.** Suppose there is a population of 1,000 women, and 20% (200) have breast cancer, and 80% do not (800 do not). Calculate the probability of getting a false positive ( $P(NC|+)$ ), a true positive ( $P(C|+)$ ), a false negative ( $P(C|-)$ ), and a true negative ( $P(NC|-)$ ).

*Use Bayes' law.*

*For false positive,  $A_1$  is NC,  $A_2$  is C, and B is +.*

$$\begin{aligned} P(NC|+) &= \frac{(P(NC) * P(+|NC))}{(P(NC) * P(+|NC) + P(C) * P(+|C))} \\ &= \frac{0.80 * 0.05}{(0.80 * 0.05 + 0.20 * 0.90)} \\ &= \frac{80/100 * 5/100}{(80/100 * 5/100 + 20/100 * 90/100)} \\ &= \frac{400/10,000}{(400/10,000 + 1800/10,000)} \\ &= \frac{400/10,000}{2200/10,000} = \frac{2}{11}. \end{aligned}$$

*For true positive,*

$$P(C|+) = 1 - P(NC|+) = 1 - \frac{2}{11} = \frac{9}{11}.$$

*For false negative,  $A_1$  is C,  $A_2$  is NC, and B is -.*

$$P(C|-) = \frac{(P(C) * P(-|C))}{(P(C) * P(-|C) + P(NC) * P(-|NC))}$$

$$\begin{aligned}
&= \frac{0.20 * 0.10}{(0.20 * 0.10 + 0.80 * 0.95)} \\
&= \frac{20/100 * 10/100}{(20/100 * 10/100 + 80/100 * 95/100)} \\
&= \frac{200/10,000}{(200/10,000 + 7600/10,000)} \\
&= \frac{200/10,000}{7800/10,000} = \frac{2}{78} = \frac{1}{39}.
\end{aligned}$$

For true negative,

$$P(NC|-) = 1 - P(C|-) = 1 - \frac{1}{39} = \frac{38}{39}.$$

**b.** Now suppose we consider a population of 1,000 women whose mothers all have breast cancer. Suppose that 40% of them have the disease and 60% do not. So 400 have cancer, and 600 do not. Calculate the probability of getting a false positive ( $P(NC|+)$ ), a true positive ( $P(C|+)$ ), a false negative ( $P(C|-)$ ), and a true negative ( $P(NC|-)$ ).

Use Bayes' law.

For false positive,  $A_1$  is  $NC$ ,  $A_2$  is  $C$ , and  $B$  is  $+$ .

$$\begin{aligned}
P(NC|+) &= \frac{(P(NC) * P(+|NC))}{(P(NC) * P(+|NC) + P(C) * P(+|C))} \\
&= \frac{0.60 * 0.05}{(0.60 * 0.05 + 0.40 * 0.90)} \\
&= \frac{60/100 * 5/100}{(60/100 * 5/100 + 40/100 * 90/100)} \\
&= \frac{300/10,000}{(300/10,000 + 3600/10,000)} \\
&= \frac{300/10,000}{3900/10,000} = \frac{1}{13}.
\end{aligned}$$

For true positive,

$$P(C|+) = 1 - P(NC|+) = 1 - \frac{1}{13} = \frac{12}{13}.$$

For false negative,  $A_1$  is  $C$ ,  $A_2$  is  $NC$ , and  $B$  is  $-$ .

$$\begin{aligned}
 P(C|-) &= \frac{(P(C) * P(-|C))}{(P(C) * P(-|C) + P(NC) * P(-|NC))} \\
 &= \frac{0.40 * 0.10}{(0.40 * 0.10 + 0.60 * 0.95)} \\
 &= \frac{40/100 * 10/100}{(40/100 * 10/100 + 60/100 * 95/100)} \\
 &= \frac{400/10,000}{(400/10,000 + 5700/10,000)} \\
 &= \frac{400/10,000}{6100/10,000} = \frac{4}{61}.
 \end{aligned}$$

For true negative,

$$P(NC|-) = 1 - P(C|-) = 1 - \frac{4}{61} = \frac{57}{61}.$$

Note that the probability of a false positive is lower in the second group, and the probability of a false negative is higher.

c. Imagine we have the following costs and benefits of screening.

Table 1: Benefits and costs of screening (per person per year)

Dollar values (1000s)	
Screening costs	0.1
Treatment costs (if diagnosed positive)	5
Benefit of thinking you are negative	0.1
Benefit from early treatment (if sick only)	10
Cost of bad reaction to screen	0.02
Extra cost of false positive	5.5

What are the net benefits of this screen in the population described in part a.? What about in the population from part b.? Which population benefits more (on a per-person basis)?

In a., total number of people with cancer who get diagnosed with it is  $200 * 0.90 = 180$ . Total number of people without cancer who get diagnosed with it is  $800 * 0.05 = 40$ . Total number of false negatives (people with cancer who get diagnosed as not having cancer) is  $200 * 0.10 = 20$ .

Total screening costs are  $1000 * 0.1 = 100$ .

Total treatment costs are  $220 * 5 = 1100$ .

Total benefits of thinking you are negative are  $0.1 * 780 = 78$ .

Total benefits from early treatment are  $180 * 10 = 1800$ .

Total costs from bad reaction to screen are  $1000 * 0.02 = 20$ .

Total costs from false positives are  $40 * 5.5 = 220$ .

Net total benefits are  $78 + 1800 - 100 - 1100 - 20 - 220 = 438$ .

In **b.**, total number of people with cancer who get diagnosed with it is  $400 * 0.90 = 360$ . Total number of people without cancer who get diagnosed with it is  $600 * 0.05 = 30$ . Total number of false negatives (people with cancer who get diagnosed as not having cancer) is  $400 * 0.10 = 40$ .

Total screening costs are  $1000 * 0.1 = 100$ .

Total treatment costs are  $390 * 5 = 1950$ .

Total benefits of thinking you are negative are  $0.1 * 610 = 61$ .

Total benefits from early treatment are  $360 * 10 = 3600$ .

Total costs from bad reaction to screen are  $1000 * 0.02 = 20$ .

Total costs from false positives are  $30 * 5.5 = 165$ .

Net total benefits are  $61 + 3600 - 100 - 1950 - 20 - 165 = 1426$ .

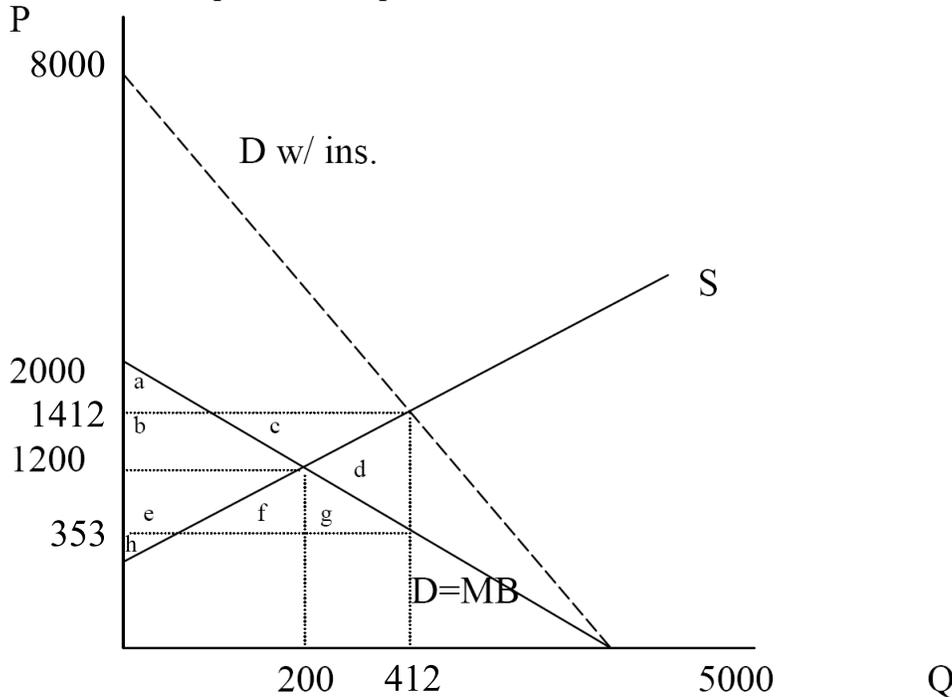
People in group **b.** benefit more.

**d.** Does it matter if the test is done once per decade or once per year?

Yes, it matters but we can't tell how from this information. Benefits from early treatment will be higher if it is caught earlier. Costs of bad reactions/false positives will be lower if the test is done less often.

11. (23 points) Consider a market for elbow surgery where no one in the market has insurance. Let the demand curve for elbow surgery be  $P = 2000 - 4Q$ . Let the supply curve for elbow surgery be  $P = 1000 + Q$ .

a. Graph the supply and demand curves and find the equilibrium price and quantity. Note on the graph the consumer and producer surplus created in the market.



Equilibrium is shown in the graph at  $P = 1200$  and  $Q = 200$ . Consumer surplus is the area given by  $a + b$  and producer surplus is the area given by  $e + h$ .

b. Now assume everyone in the market buys an insurance policy that pays for 75% of any elbow surgery (so the coinsurance rate is 0.25). Redraw the graph from part a. above and add the effective demand curve now that everyone has insurance. What is the new equilibrium price and quantity? On the graph, illustrate consumer and producer surplus as well as any dead-weight loss that may result from moral hazard.

When the insurance is introduced, it will lead to a shift (or pivot) in the demand curve. In particular, the slope will increase by the inverse of the coinsurance rate. Since the coinsurance rate is .25, the slope will be 4 times what it was before. This leads to a new demand curve of  $P = 8000 - 16Q$ . Equilibrium is shown in the graph at  $P = 1412$  and  $Q = 412$ . Consumer surplus is the area given by  $a + b + e + f + g$  and producer surplus is the area given by  $b + c + e + h$ . The deadweight loss is given by  $d$ .

c. True or false. If the increase in consumer and producer surplus from having insurance is greater than the dead-weight loss that results from the market after insurance is bought, then insurance increased economic wellbeing despite the dead-weight loss. Explain your reasoning.

Once you consider the premium cost to consumers, total surplus is actually smaller with insurance.

12. (23 points) This question is about the choice of insurance for a risk-averse consumer. Suppose my utility function is  $U(w) = \sqrt{w}$ , where  $w$  is my wealth in \$1000. Suppose I face a risk  $p$  of getting sick, where  $p = 19/36$ . Suppose my initial wealth \$100,000, but if I get sick, it falls to \$64,000. This question will ask you to do some calculations (leaving numbers in fractions is fine). For partial credit, draw the graph and discuss what you find.

a. What is my marginal utility of wealth when sick? When well? Am I risk averse? Risk loving? Risk neutral?

*My marginal utility is  $U'(w) = \frac{1}{2\sqrt{w}}$ , which is decreasing as  $w$  increases. My marginal utility when well is  $\frac{1}{2\sqrt{100}} = \frac{1}{20}$ . My marginal utility when sick is  $\frac{1}{2\sqrt{64}} = \frac{1}{16} > \frac{1}{20}$ . Because my marginal utility is higher at lower values of  $w$ , I am risk averse.*

b. What is my expected wealth with no insurance? What is my expected utility with no insurance?

$$E(w) = 100 * 17/36 + 64 * 19/36 = (1700 + 1216)/36 = 2916/36 = 81.$$

$$E(U) = 10 * 17/36 + 8 * 19/36 = (170 + 152)/36 = 322/36 = 161/18 = 817/18.$$

c. What is the actuarially fair premium (expected value of my loss)?

*My expected loss if sick is  $100 - 81 = 19$ .*

d. What is the most I would be willing to pay to shed the risk?

*I would be willing to pay the expected loss when sick of 19, plus a risk premium. The amount of the risk premium I am willing to pay is the difference between 81 and the wealth  $w'$  for which utility is the same as my expected utility, or  $w'$  where  $U(w') = 161/18 = \sqrt{w'}$ .  $w' = 25921/324 = 801/324$ . The total amount I am willing to pay is  $81 - (25921/324) + 19 = 19323/324$ .*

#### Extra credit

EC1. (2 points) How many rounds of the health insurance game did we play in class?

2

EC2. (2 points) How many types of people were there trying to buy insurance?

3

EC3. (6 points) Did the market clear? Was there an externality?

*No, the market didn't clear. The externality is that the presence of the low quality types drives up the price of insurance to a point where high quality types drop out. So, even though the insurer would be willing to sell the high quality types insurance at a rate that was fair for them if she knew what their risk was, she must charge a price that allows her to recoup the costs of the sick people, and some healthy people stay uninsured.*