

Name: _____

Public Health 253B—Epidemiology and Control of Infectious Diseases
Homework #1 (Version 2, 2009-01-28)
Due Monday, February 9, 2009

Short-answer questions

1. Name five infectious diseases of humans where humans are both the reservoir of the pathogenic microbial agent and the source of infection.
2. Name five infectious diseases of humans where the reservoir is non-human and the source is non-human but different from the reservoir.
3. You are a member of a field team investigating an outbreak of a pustular rash consistent with smallpox. You have been assigned to collect specimens from a male patient who is at home. Although you have been vaccinated against smallpox, you are concerned that his infection may be caused by an engineered strain or possibly another infectious disease (viral hemorrhagic fever). Describe what practical precautions you will take to protect yourself when you go to the home to interview this patient and collect specimens.
4. Select two human infectious diseases for which you have primary responsibility (for example, in your job) or have a strong knowledge base. Create a table where each column heading is the name of each infectious disease. For the row headings, list the major components of the Chain Model and Natural History models of infectious diseases. Fill in the tables with concise descriptions. Use the World Wide Web, your library, or any authoritative resources available to you.
5. Repeat the above exercise for two human infectious diseases for which you have an interest but a weak knowledge base.
6. Describe how the terms infectivity, transmissibility, and transmission probability differ?
7. Using the damage-response framework of Pirofski et al. (PMID: 12383613), define infection and its possible outcomes. For each outcome give an example. What is the difference between colonization and carriage?
8. According to Musher (PMID: 12660390), describe the similarities and differences of *Mycobacterium tuberculosis* compared to *Neisseria meningitidis* (or *Streptococcus pneumoniae*) in terms of modes of transmission and pathways to disease.
9. Meningococcal disease is deadly (see Musher, PMID: 12660390). When a child develops meningococcal disease and exposes a sibling, what is the transmission probability for colonization $P(I|E)$ (Musher calls this infection $[I]$)? For the exposed sibling, what is the probability of disease given colonization $P(D|I)$? What qualitative term has been used for this probability?
10. In epidemiology, the per-capita or average infection rate among susceptibles is calculated as the number of new infections divided by the person-time at risk. The components of the infection rate are summarized by $I = cpP$, where I is the infection rate among susceptibles, c is the contact rate of a susceptible with a potentially infectious source, p is the transmission probability given contact with an infectious source, and P is the probability that the source is infectious. For person-to-person transmissible infections, a first estimate of P is the prevalence¹ of infectious persons (number of infectious persons divided by the target population at a point in time). In a closed population, as an infection spreads person-to-person, P increases and I increases; yet, the number of new cases eventually peaks and starts declining. In other words, explain what is happening.
11. Selected California counties have experienced outbreaks of West Nile virus encephalitis. Are mosquitos the reservoir, the source, both, or neither? Justify your answer.

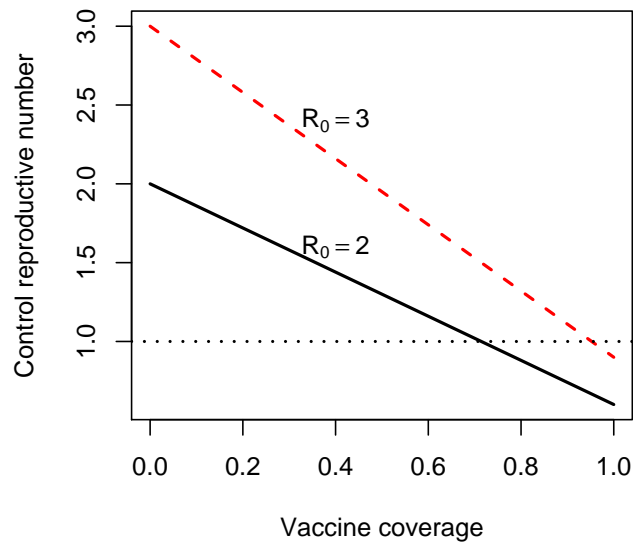


Figure 1: Control reproductive number and vaccine coverage

12. The formula for the effective reproductive number is $R = R_0x$, where x is the fraction of the population that is susceptible to infection. When we are using a vaccine to impact x the formula changes to $R_C = R_0(1 - hf)$, where R_C is the control reproductive number, f is the fraction vaccinated (vaccine coverage), and h is the fraction (of those vaccinated) that have full protection (vaccine coverage). Based on this information, interpret Figure 1.
13. Using basic algebra, show the derivation of this relation:

$$f > \frac{1 - (1/R_0)}{h} \quad (1)$$

14. Explain the difference between the latent period and incubation period. How are they related and why is this relationship important? Illustrate your points using two human infectious diseases.
15. For respiratory microbial pathogens, what is the difference between obligate, preferential, and opportunistic airborne transmission? Give an example of each.
16. “In terms of sheer drama, the emergence of the severe acute respiratory syndrome (SARS) rivaled the most exotic Michael Crichton thriller. A novel viral strain spread in “wet markets” from an obscure animal to food handlers; through a rural province in southern China; to Hong Kong, by way of an ill Chinese physician who had traveled to attend a wedding; and in one night at a Hong Kong hotel, from that man to at least 12 other people. These 12 returned to their five home countries and created multiple chains of transmission that, over the course of the next four months, led to more than 8000 cases of SARS, resulting in almost 800 deaths in 27 countries, representing every continent.” (PMID: 15175434)

Despite the lack of a rapid diagnostic test, a vaccine, and an effective therapy, basic public health measures led to the global control of a snowballing epidemic within four months. Using epidemiologic concepts, summarize these public health measures and why they succeeded.

¹Prevalence is the proportion of the target population with a given condition at a point in time.

Computational questions

Use a calculator or spreadsheet to complete the following exercises.

Table 1: Estimated per-act risk (transmission probability) for acquisition of HIV, by exposure route to an infected source. Source: CDC (PMID: 15660015)

Exposure route	Risk per 10,000 exposures
Blood transfusion (BT)	9,000
Needle-sharing injection-drug use (IDU)	67
Receptive anal intercourse (RAI)	50
Percutaneous needle stick (PNS)	30
Receptive penile-vaginal intercourse (RPVI)	10
Insertive anal intercourse (IAI)	6.5
Insertive penile-vaginal intercourse (IPVI)	5
Receptive oral intercourse on penis (ROI)	1
Insertive oral intercourse with penis (IOI)	0.5

1. Use the formula for the basic reproductive number ($R_0 = cpd$). R_0 is from the perspective of an infectious case. The median incubation period, from the time of HIV infection until the development of AIDS, was 10 years before the availability of anti-viral therapies. For each non-blood transfusion per-act risk (transmission probability) in Table 1, calculate what the average annual contact rates must have been for R_0 to be greater than 1. (Hint: For $R_0 > 1$, $cpd > 1$, or $c > 1/(pd)$). For example, if an HIV-infected male were introduced into a susceptible population and practiced insertive oral intercourse with his penis, the per-act risk, p , is 0.5/10,000. To make $R_0 > 1$, he would need to have more than $[(0.5/10,000) \times 10]^{-1} = 2000$ contacts per year.)

Do these contact rates make intuitive sense? Why or why not?

2. Assume one is HIV-negative. If the probability of infection per act is p , then the probability of not getting infected per act is $(1 - p)$. The probability of not getting infected after 2 consecutive acts is $(1 - p)^2$, and after 3 consecutive acts is $(1 - p)^3$. Therefore, the probability of not getting infected after n consecutive acts is $(1 - p)^n$, and the probability of getting infected after n consecutive acts is $1 - (1 - p)^n$. For each non-blood transfusion transmission probability (per act risk) in Table 1, calculate the risk of being infected after one year (365 days) if one carries out the same act once daily for one year with an HIV-infected partner. Do these cumulative risks make intuitive sense? Why or why not?
3. Using previous results, graphically plot per act risk (per 10,000 acts) vs. cumulative one-year risk for each act. Describe and interpret your findings.
4. The formula for the effective reproductive number is $R = R_0x$, where x is the fraction of the population that is susceptible to infection. When we are using a vaccine to impact x the formula changes to $R = R_0(1 - hf)$, where f is the fraction vaccinated (vaccine coverage) and h is the fraction (of those vaccinated) that have full protection (vaccine efficacy). This is one form of vaccine efficacy. Given R_0 and h , we might want to know what minimum fraction of the population must be vaccinated to get $R < 1$. By rearrangement, the fraction to vaccinate is given by this formula:

$$f > \frac{1 - (1/R_0)}{h} \quad (2)$$

Consider a smallpox outbreak: if the R_0 for smallpox ranges from 3 to 7, and h ranges from 0.94 to 0.98, using Equation 2, create a table that displays the fractions to vaccinate for all possible combinations of R_0 and h . Describe your findings and summarize your interpretation.

5. (Optional) According to Real and Biek (PMID: 15102996), there are two common methods for estimating the transmission probability. What are these methods? Briefly summarize the two human examples from this article.