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Case 11 : The Case of the Long-Lived Orchestra Conductors

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CASE 11

The Case of the Long-Lived Orchestra Conductors

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PREFACE

What does it mean to 'think like an epidemiologist'? If you Google that phrase you will get over 100,000 hits. One top link is to a contest held as part of a Science Olympiad, where students devise and test an epidemiological hypothesis, which helps them "develop and use a variety of epidemiologic skills efficiently and effectively", using "judgment and innovation" (Teach Epidemiology, n.d.). A second link is to the University of California at Los Angeles' website to memorialize the famous English physician John Snow, whose large controlled 1854 study showed that cholera was eight and a half times more frequent among London homes whose drinking water came from a particularly polluted part of the River Thames (Page, 2000). (Not enough, incidentally, to nudge the medical establishment from their stubborn belief that crowd diseases were caused by 'foul and dank emanations' rather than passed from person to person by thousands of people drinking each other's diluted sewage.) A third site is an online course also aimed at infectious disease outbreak investigation. Students "master the scientific process, experimental design, data collection, logical reasoning, and statistical analysis … build a hypothesis, and balance the health, economic and media challenges of containing an outbreak", all part of doing science "thoughtfully, ethically, and efficiently" (Duke Talent Identification Program, n.d.).

To summarize the main themes: reason and logical thinking, creating hypotheses, and efficiently collecting and analyzing data to test them. These are all part of thinking like an epidemiologist. But (epidemio)logical thinking starts even before we create hypotheses to search for causes of health outcomes. It begins by applying critical thinking skills to ensure that the original observations are valid and the purported health issue is real. How do we know it's a problem? How is it defined? Are the data valid and reliable? Has the definition changed? Is it possible that an increasing trend is not real, but is merely an artifact of the way the data were collected?

The fourth link from the Google search has a perfect example of this, based on a typical sensational headline "ADHD diagnoses soar 43% in the United States" (Boyes, 2016). The author asks readers to list some "possible environmental or psychosocial explanations for why the rate of ADHD might have increased since the year 2000" (Boyes, 2016). He then invokes alternative explanations: what might cause the ***rate of diagnosed ADHD*** to increase even if the ***underlying prevalence stayed the same***? Finally, he asks readers to design studies to sort out the environmental/psychosocial hypotheses from the alternative explanations.

That, to me, is the first principle of 'thinking like an epidemiologist': an adaptable skillset in critical appraisal that always begins with the assumption that original observations about health issues are more often *apparently caused* by the application of methods than *actually caused* by something in our environment or our behaviours. The purpose of this case is to introduce this skill with an example that does not require extensive background knowledge: the Case of the Long-Lived Orchestra Conductors.

BACKGROUND

We are bombarded by causal claims about things that keep us healthy, make us sick, and help us get healthy again. Evaluating causal claims using epidemiological skills is an important part of public health practice. While fully evaluating causal claims involves subject matter expertise (biological, psychological, and sociological knowledge about the exposure and the outcome), critical appraisal of any causal claim begins with fundamental epidemiological questions – a skillset known as 'thinking like an epidemiologist'.

If you read newspapers or health blogs, you may have come across a variation of the following:

> "Did you know orchestra conductors live longer than nearly any other group of people? It's true. Many of the famous conductors of the past lived well into their 80s and 90s – Leopold Stokowski, 95, Pablo Casals, 96, Nadia Boulanger, 90, and Arturo Toscanini, 89, to name a few. And they were from a time when the average life expectancy was around 50 years old. There are two main reasons why:
>
> 1. Conductors flap their arms around for many hours a day. Upper body exercises are a great cardio-vascular workout because they expand the muscles of the chest and open the lungs. Plus, the movements cause your heart to pump strongly, so blood and nutrients flow to your muscles and organs.
>
> The result - conductors have low blood pressure. Their minds are sharpened because they get more blood circulation to their brains.
>
> 2. But there's one more vital ingredient that explains why conductors enjoy longer and healthier lives. Think about it. Why are they flapping their arms? What's being generated as a result? A cascade of gorgeous orchestral music. Beautifully arching melodies with superior rejuvenating powers. Intricate harmonies that create new brain cells and higher IQs. Alpha-state inducing rhythms that calm and sustain inner peace.
>
> Day after day conductors repeat this life-enhancing exercise." (French, n.d.)

QUESTION 1

Before reading ahead, recall your previous learning of the different aspects of the scientific method, and think of how you might (or might not) be able to apply them to this causal question.

Many elements of the scientific method are difficult to apply to this example:

- We use randomization (randomly assigning people to different exposure groups) because it lets chance alone determine the distribution in the exposure groups of all other factors that could cause the outcome. If a causal factor is unevenly distributed between groups, our estimate of the causal effect of our exposure of primary interest is confounded. Often it is unethical, impractical, or both, to apply randomization. In this case, at the very least, randomizing people to be conductors or not, and then following them until they die, is impractical.

- Blinding (or masking) is done to minimize measurement bias. For example, if coroners who complete death certificates consciously or subconsciously recorded older ages at death for deceased conductors, the observation of older age at death in conductors would be partly due to biased measurement of the outcome. It is *possible* that medico-legal officials have a bias in favour of the hypothesis that being a conductor causes one to live longer, but we have no evidence to support this. While just a hunch rather than hard evidence, most people would agree that of all the potential sources of bias in epidemiological research, we probably do not have to worry much about biased ascertainment of the age of conductors relative to non-conductors as an explanation of the finding that conductors live longer than other groups.
- Causal mechanism/biological plausibility: causal mechanisms are important to science because they are the link between theory and observation. There are two causal mechanisms proposed:

    - The first is a cardiovascular mechanism, because conductors move their arms, which pumps blood and nutrients to muscles and organs, and lowers blood pressure while also increasing blood circulation to the brain. There are hundreds of studies supporting the positive cardiovascular effects of physical activity, and this mechanistic claim is not by itself controversial. (Although it must be pointed out that conductors are not the only occupation who engage in vigorous upper body activity.)

    - The second, more 'vital' causal mechanism concerns the 'superior rejuvenating powers' of the 'beautifully arching melodies' and 'intricate harmonies' of 'gorgeous orchestral music' that create brain cells and increase intelligence. At the same time, musical rhythms induce an 'alpha-state' that calms and sustains inner peace. It would be much more difficult to find as many studies of high quality supporting these mechanisms as the cardiovascular one. In particular, the claim that music actually 'create[s] brain cells' is pretty far-reaching.

The potential application of some other parts of the scientific method, like controls, seems clearer.

QUESTION 2

What is the purpose of controls? Who would be an appropriate control group for this research question? (See "Section Summary" for answers.)

In addition to the basic elements of the Scientific Method like 'making observations' and 'formulating hypotheses', epidemiologists have developed expertise in sampling and measurement, and approach causal questions by thinking about:

1. Sampling:
    - Where did the sample of people being observed come from? Who collected the observations? Why?
    - Is the sample 'representative' of some larger population? Which larger population?
        - In what ways is it special or different?

2. Measurement:
    - What is the main outcome measure?
    - Is it appropriate to this causal question?

The choice of outcome measure is extremely important in epidemiology. Often there are many choices, and some expertise is required to select the most appropriate one:

1. Life expectancy at birth: "Average number of years a newborn baby can be expected to live if current mortality trends continue" (Porta, 2008).
   - Life expectancy is calculated from the ***mortality experiences of previous entire birth cohorts*** (people born in the same year), which are then extrapolated in today's newborns (hence the important qualifier, "if current mortality trends continue").

2. Average age at death: The arithmetic mean of the age at death of people who have died.

   - In contrast to average life expectancy, ***average age at death can be calculated on groups of any size***:
     - Dr. Albert Hoffman, the Swiss chemist who discovered LSD and took it several times, lived to 102. Thus, the average age at death of a habitual LSD user = 102/1 = 102.

MORE QUESTIONS ABOUT AVERAGE AGE AT DEATH

QUESTION 3
Seven people are observed for one year. What is the average age at death?

> **{Mary is 98. Fred is 62. Svetlana is 106. Ijeoma is 2. Manny is 8. Ahmed died, aged 21. Jerome died, aged 28.}**

QUESTION 4
Who was included in the calculation of average age at death? Who did it not capture? Describe how that might be a limitation when we use average age at death as a ***measure of average survival***.

QUESTION 5
Suppose you want to underwrite life insurance policies and you have the following data – ***knowing nothing else***, which group would you rather insure?

> **Group1: 1,000 people, average age at death, 4 years.**
> **Group2: 1,000 people, average age at death, 95 years.**

QUESTION 6
Thinking of your answer to Q5, what additional information would you like to have before you underwrite any insurance?

BRIEF SECTION SUMMARY
An ideal control group would be ***different on the main exposure variable of interest*** (i.e. they would not be orchestra conductors) but ***would be similar on all other factors related to the outcome***, which is mortality (e.g. they would be of the same age and sex, geographic location, time in history, etc.). However, the vast majority of people from any population are not orchestra conductors, so how exactly would we pick our controls from this huge group? ***Choosing appropriate controls is one of the most challenging aspects of epidemiology***. (We return to this below on 'Lack of Controls').

The average age at death of the 7 people in Q3 = (21 + 28) / 2 = 24.5. Average age at death is based ***only on those who die***. It ignores people who survive the period of observation. Thus, it can be a very misleading statistic and is particularly ill-suited for comparisons of average survival time or probability of survival between groups. In Q5, if Group 1 was 1,000 children in a daycare, one of whom died at age 4, and Group 2 was 1,000 people in a long-term care facility, 70% of whom died at 95 on average, you would make much more money insuring Group 1 than Group 2 (assuming identical premiums and payouts). So at a minimum, you would want to know the ages of the thousand people whose lives you are insuring.

THINKING MORE DEEPLY ABOUT AVERAGE LIFE EXPECTANCY STATISTICS

According to the CBC ("Life expectancy in Canada hits 80 for men, 84 for women", 2014):

Average life expectancy for Canadian babies born in 2012:	
Females	**84**
Males	**80**

But in a Globe and Mail article called "Why it's time to stop planning your 100th birthday party" (McFarland, 2014):

Canadian life expectancies at age 65 (2012):		
Females	**22**	**(added to 65 = 87 years)**
Males	**19.2**	**(added to 65 = 84.2 years)**

QUESTION 7

How would you explain that babies born today are expected to die at a ***younger age*** than people who are 65?

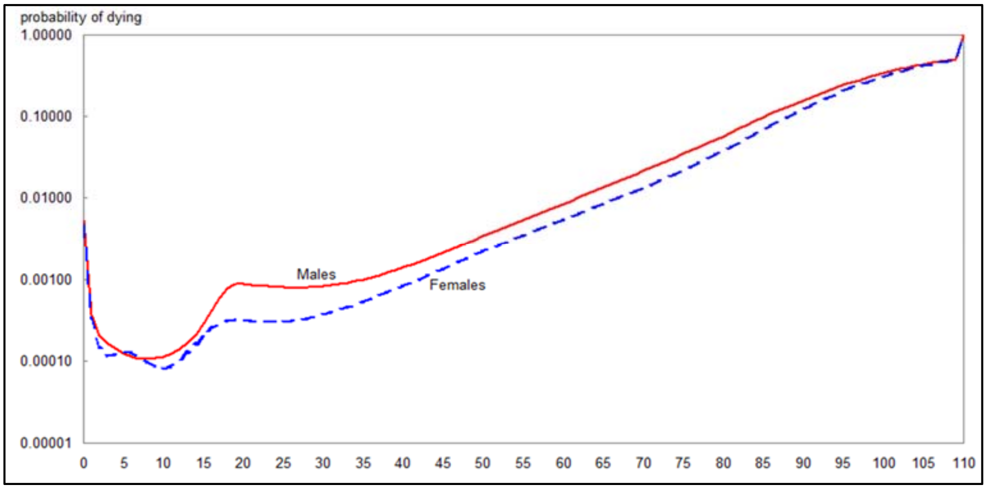
1. 'You can prove anything with statistics': These statistics are meaningless because epidemiology is a junk science (and while we're at it, let's besmirch demography too).
2. Another, even darker, interpretation is that because 65 year olds today will live longer than babies born today, we have reached the peak of civilization, and are witnessing the beginning of the apocalypse, a foul decay as surely as the fall of Rome, due to our hedonistic lifestyle, lack of discipline, deficit financing, and consumption of very unhealthy (if rather tasty) snacks.

QUESTION 8

Before we jump to either preposterous conclusion, there is something subtle at work. Can you put your finger on it?

- Hint 1: Since we're talking about life expectancy, what important thing have 65 year olds done that newborns haven't?
- Hint 2: Of all the years you have lived, at what age did you have the lowest probability of surviving until your next birthday? At what age did you have the highest probability of surviving to your next birthday?

EXHIBIT 1
Probability of Dying by Age and Sex, Canada, 2007



Source: Statistics Canada, 2015.

QUESTION 9

If you want to evaluate the longevity effect of being a conductor, can you think of a more appropriate statistic to use than life expectancy at birth? This section of the original source provides a clue: “Take for example, Leopold Stokowski (1882-1977) who made his official conducting debut in 1909…. Or, famed conductor Blanche Honnegger Moyse, born in 1909, who died in February of this year at the age of 102. After 40 years as a violinist, she was forced to retire due to a bow-arm ailment and so began conducting. Moyse made her Carnegie Hall debut 20 years later at age 78 and continued to conduct well into her 90's” (French, n.d.).

SECTION SUMMARY

One big difference between babies and 65 year olds is that the latter have survived six and a half decades of exposure to all causes of mortality. The riskiest day of life for a newborn is Day 1, followed by Day 2, and then Day 3. We don’t face the same risk of dying again until we are well into middle age. (The exact age when we regain our neonatal mortality risk differs by time and place. From Exhibit 1 you can see that in Canada it is somewhere around age 55. Many epidemiology students who are in their twenties are surprised to learn that the birthday at which they had the highest probability of surviving to their next birthday happened at least ten years earlier.)

There are two important points to be drawn from this:

1. Preventing early life mortality has a much larger effect on increasing average life expectancy than reducing mortality at older ages. Many people assume we doubled life expectancy in developed societies from ≈40 years to ≈80 years by building hospitals that helped large numbers of people survive from 50 to 60, or from 75 to 80, using life-saving medical and surgical treatments. In fact, much of the improvement came from reducing neonatal mortality, which occurred due to low-tech care in the period before, during, and the first week after birth. Nearly 80% of neonatal deaths are due to prematurity, low birth weight, asphyxia, and birth trauma (WHO, 2016).

2. A ***65 year old has already survived the high risk of the neonatal period as well as all the causes of death of children, adolescents, and early and middle-aged adults***. With that kind of survival success, it's no wonder a 65 year old today will live to an older age (on average) than a baby today.

So, **the ideal statistic to judge the longevity of being a conductor would be the life expectancy of non-conductors starting at the same age(s) as people become conductors, which is usually in the thirties**, although Maestro Stokowski was 27. When this is done, the survival advantage of conductors is much smaller – about 1.4 years in one re-analysis (see[1] for an extended statistical discussion of this issue).

QUESTION 10

Even the appropriate life expectancy statistic would not make this a problem-free analysis. There are ***important differences between symphony orchestra conductors and members of the general population that might affect their life expectancy***. Can you name some? Refer to your earlier answer about the role of controls (Q1) in the scientific method.

LACK OF CONTROLS AND APPLYING LOGIC TO CAUSAL INFERENCES

We know that conductors are at the top of the socioeconomic hierarchy of their occupational group: compared to other orchestra musicians, they occupy the i) top position of authority, ii) are better paid, iii) have higher prestige, and iv) have more decision latitude regarding what pieces of music the orchestra will play, when the rehearsals will be, who will get to play the solos, and even who gets fired. ***There is a huge literature showing gradients in health advantage across various measures of socioeconomic status (Google 'social determinants of health').*** But professional orchestra ***musicians*** are exposed to the same 'glorious overarching melodies' as the conductors. Comparing survival in conductors to other orchestral musicians would control for the effect of the overarching melodies but not the different socioeconomic status. Controlling for arm-waving is difficult because violinists move their bow arm a fair bit too.

TESTABLE PREDICTIONS

A strong part of the epidemiological method involves making ***testable predictions***. If the vigorousness of the arm-waving is supposed to be causal, we could predict longer survival in conductors who conduct more compositions written with *molto allegro* (fast) tempos than conductors who conduct more pieces with slower *andante* or plodding *largo* tempos, but this still leaves a problem: classical musicians are probably not representative of other occupations in society, particularly those in dangerous occupations, regarding their life expectancy. So, even if we used the appropriate life expectancy statistic, all of these very complex socioeconomic effects have been completely ignored and would have to be considered before we could begin to conclude that i) orchestra conductors really do live longer, ii) because they move their arms a lot, and iii) in the presence of beautiful melodies.

SOURCE OF OBSERVATIONS

Finally, we ought to consider where these observations come from. Because the 'long-lived orchestra conductor' is fairly well-known in newsmedia circles, any time a conductor dies at an old age there is a good chance it will make the lighter side of the day's news.

Confirmation bias: "In psychology and cognitive science, confirmation bias (or confirmatory bias) is a tendency to search for or interpret information in a way that confirms one's preconceptions, leading to statistical errors" (ScienceDaily, n.d.).

[1] Ableson RP. Statistics as Principled Argument. 1995:4. New York: Taylor & Francis.

By contrast, conductors dying at ages under the average life expectancy are less likely to be reported on because they do not support the original myth. Exceptions can be seen in serious papers like *The Guardian*. In 2001, after Guiseppe Sinopoli died suddenly *while conducting* at age 54, reporter Norman Lebrecht (2001) wrote an article listing the following conductors' premature deaths. That some died while conducting (i.e. exposed to the melodies), and of cardiovascular causes, would seem to directly contradict the original theory:

- Felix Motl, 56
- Guiseppi Patane, 57
- Eduard van Beinum, 58
- Joseph Keilberth, 59
- Fran Konwitchny, 60
- Dmitri Mitropolous, 64

SUMMARY POINTS

1. Inappropriate outcome measures applied to small uncontrolled groups can yield causal inferences that are probably incorrect.
2. Controls are important, and choosing appropriate controls is one of the more difficult parts of the application of the scientific method to epidemiology.
3. Apparent replications of an original observation may actually be the result of confirmation bias, especially in the absence of controls.
4. A biologically plausible theory does not make it true.
5. One can make testable predictions from a presumed underlying causal mechanism and systematically critically test them, but this requires a familiarity with logic and availability of suitable data, and is often not done.

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Schulich
MEDICINE & DENTISTRY

INSTRUCTOR GUIDANCE

The Case of the Long-Lived Orchestra Conductors

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BACKGROUND

There may be no part of epidemiology more central to public health practice than the evaluation of causal claims about exposures that keep us healthy, make us sick, and help us get better again. Some causal claims are sufficiently self-evident that we learn them as toddlers: hot stoves cause "owwies". But causal questions in public health are much more complex, and to approach them we need to learn to 'think like an epidemiologist'.

This requires us to think critically about causal claims as we develop our skills in applying the logic of causal inference. When faced with a causal claim most epidemiologists immediately question the source of data, the appropriateness of the measures, and the soundness of the analysis underlying the causal claim. Epidemiology is firmly grounded in the scientific method, but the components of the scientific method have been modified for use outside the laboratory, as applied to large groups of 'free range' humans. Learning these adaptations can be challenging.

This case introduces causal critical appraisal using, as an example, the claim that orchestra conductors live longer than members of other occupational groups *because they are conductors*. It is a suitable introductory case because it does not require subject matter expertise in theories of longevity or causes of death. Learners progress from basic to higher-level concepts, beginning by recalling parts of the scientific method (e.g. control groups), and thinking about how each might be applied to this causal question. A mid-level objective is evaluating the appropriateness of the outcome measure, which requires understanding how average age at death is a poor measure compared to average life expectancy at birth, which in turn is less appropriate than average life expectancy at the age people typically become orchestra conductors. The case concludes by introducing confounding and confirmation bias.

OBJECTIVES

To get learners to start 'thinking like an epidemiologist' about:

1. The epidemiological application of the scientific method.
2. Causal claims and the logic of causal inferences.
3. Source and appropriateness of data and measures.

DISCUSSION QUESTIONS

Nine questions suitable for individual or group work are included in the Case Note. For example, "How would you apply the scientific method to thinking about a causal question?"

KEYWORDS

Causation; causal claims; causal mechanism; life expectancy; average life expectancy (at birth; at age X); average age at death; bias (measurement/ascertainment, sampling, confirmation); scientific method (randomization/random assignment, blinding/masking, biological plausibility; control group).

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