

## CHAPTER 2

Evidence-based  
Public Health

## LEARNING OBJECTIVES

By the end of this chapter the student will be able to:

- explain the steps in the evidence-based public health process.
- describe a public health problem in terms of morbidity and mortality.
- describe the approach used in public health to identify a contributory cause of a disease or other condition and establish the efficacy of an intervention.
- describe the process of grading evidence-based recommendations.
- use an approach to identify options for intervention based on “when, who, and how.”
- explain the role that evaluation plays in establishing effectiveness as part of evidence-based public health.

Tobacco was introduced to Europe as a new world crop in the early 1600s. Despite the availability of pipe tobacco and later, cigars, the mass production and consumption of tobacco through cigarette smoking did not begin until the development of the cigarette rolling machine by James Duke in the 1880s. This invention allowed mass production and distribution of cigarettes for the first time. Men were the first mass consumers of cigarettes. During World War I, cigarettes were widely distributed free of charge to American soldiers.

Cigarette smoking first became popular among women in the 1920s—an era noted for changes in the role and attitudes of women—and at this time advertising of cigarettes began to focus on women. The mass consumption of cigarettes by women, however, trailed that of men by at least two decades. By the 1950s, over 50 percent of adult males and approximately 25 percent of adult females were regular cigarette smokers.

*The health problems of cigarette smoking were not fully recognized until decades after the habit became widespread. As late as the 1940s, R.J. Reynolds advertised that “more doctors smoke Camels than any other cigarette.”*

*Epidemiologists observed that lung cancer deaths were increasing in frequency in the 1930s and 1940s. The increase in cases did not appear to be due to changes in efforts to recognize the disease, ability to recognize the disease, or the definition of the disease. Even after the increasing average life span and aging of the population was taken into account, it was evident that the rate of death from lung cancer was increasing—and more rapidly for men than women. In addition, it was noted that residents of states with higher rates of smoking had higher rates of lung cancer. In the 1950s, the number of lung cancer deaths in females also began to increase and by the 1960s, the disease had become the most common cause of cancer-related deaths in males and was still rising among women.<sup>1, 2</sup>*

This type of information was the basis for describing the problems of cigarette smoking and lung cancer and developing ideas or hypotheses about its etiology, or cause. Let us take a look at how the evidence-based public health approach has been used to address the problem of cigarette smoking. There are four basic questions that we need to ask that together make up what we will call the evidence-based public health approach.<sup>3</sup>

1. **Problem:** What is the health problem?
2. **Etiology:** What is/are the contributory cause(s)?
3. **Recommendations:** What works to reduce the health impacts?
4. **Implementation:** How can we get the job done?

These four questions provide a framework for defining, analyzing, and addressing a wide range of public health issues and can be applied to cigarette smoking for the purposes of this chapter.<sup>4</sup> We will call this framework the **P.E.R.I. process**. This process is really circular as illustrated in Figure 2-1. If the evaluation suggests that more needs to be done, the cycle can and should be repeated. Thus, it is an ongoing process.

Using cigarette smoking as an example, we will illustrate the steps needed to apply the evidence-based public health approach.

### HOW CAN WE DESCRIBE A HEALTH PROBLEM?

The first step in addressing a health problem is to describe its impact. That is, we need to begin by understanding the occurrence of disability and death due to a disease, which we call the **burden of disease**. In public health, disability is often called **morbidity** and death is called **mortality**. We also need to determine whether there has been a recent change in the impact of the disease. Thus, the first question we ask in describing a health problem is: what is the burden of disease in terms of morbidity and mortality and has it changed over time?

The second question we need to ask is: are there differences in the distribution of disease and can these differences generate ideas or hypotheses about the disease's etiology (cause)? That is, we need to examine how the disease is spread out or distributed in a population. We call this the **distribution of disease**. Public health professionals called **epidemiologists** investigate factors known as "person" and "place" to see if they can find patterns or associations in the frequency of a disease. We call these **group associations**. Group associations may suggest ideas or hypotheses about the cause, or etiology of a disease.

"Person" includes demographic characteristics which describe people, such as age, gender, race, and socioeconomic factors. It also includes behaviors or exposures, such as cigarette smoking, exercise, radiation exposure, and use of medications. "Place" implies geographic location, such as a city or state, but it also includes connections between people, such as a university community or a shared Internet site. When these types of factors occur more frequently among groups with the disease than among groups without the disease we call them **risk indicators** or **risk markers**.<sup>a</sup>

Finally, epidemiologists take a scientific approach to addressing public health problems. They are often skeptical of initial answers to a question and ask: could there be another explanation for the differences or changes in the distribution of disease? They often ask: are the differences or changes real or are they artifactual? **Artifactual** implies that the apparent association is actually the result of the data collection process.

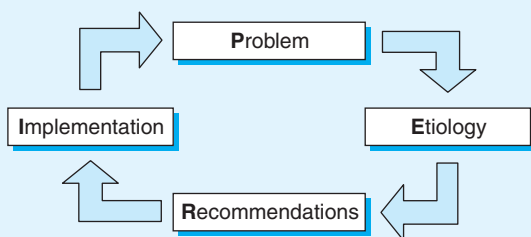
When trying to determine whether an association is artifactual or real, epidemiologists ask whether, the observed changes or differences may be due to comparing apples to oranges—for example comparing groups of subjects of different average ages. Age is especially important to epidemiologists because it is very strongly related to the occurrence of disease. Thus, the third question that we need to ask in describing a problem is: are the differences or changes used to suggest group associations artifactual or real?

Before we can answer these three questions we need to understand more about the measurements that epidemiologists use to describe a health problem. We need to look carefully at how we measure the changes or differences in disease, disability, and death. In public health, we use **rates** to summarize our measurement. Let us begin by looking at what we mean by rates and then we will return to the three questions that need to be addressed when describing a health problem.

### WHAT DO WE NEED TO KNOW ABOUT RATES IN ORDER TO DESCRIBE A HEALTH PROBLEM?

The term "rate" will be used to describe the types of measurements that have a numerator and a denominator where the numerator is a subset of the denominator—that is, the numerator includes only individuals who are also included in the denominator. In a rate, the numerator measures the number of times an event, such as the diagnosis of lung cancer, occurs. The denominator measures the number of times the event

**FIGURE 2-1** Evidence-based public health: The P.E.R.I. approach



Source: Adopted from Riegelman RK. Evidence-Based Public Health: The Population Health Approach—Cigarettes and Health. Available at: <http://www.aptrweb.org/undergraduatepublichealth/Evidence-Based%20Public%20Health.doc>. Accessed December 18, 2008.

<sup>a</sup> The term risk indicator or risk marker needs to be distinguished from the term risk factor. A risk factor is a candidate for being a contributory cause and implies that at least an association at the individual level has been established as we will discuss later in this chapter. We will also add "time" to "person" and "place" as a basic characteristic for generating hypotheses.

could occur. We often use the entire population in the denominator, but at times we may only use the **at-risk population**. For instance, when measuring the rate of cervical cancer we would only use the population of women in the denominator and when measuring rates of prostate cancer we would only use the population of men in the denominator.<sup>b</sup>

There are two basic types of rates that are key to describing a disease.<sup>5,6</sup> These are called **incidence** rates and **prevalence**. Incidence rates measure the chances of developing a disease over a period of time—usually one year. That is, incidence rates are the number of new cases of a disease that develop during a year divided by the number of people in the at-risk population, as in the following equation:

$$\text{Incidence rate} = \frac{\# \text{ of new cases of a disease in a year}}{\# \text{ of people in the at-risk population}}$$

We often express incidence rates as the number of events per 100,000 population in the denominator. For instance, the incidence rate of lung cancer might be 100 per 100,000 per year. In evidence-based public health, comparing incidence rates is often a useful starting point when trying to establish the cause of a problem.

Mortality rates are a special type of incidence rate that measure the incidence of death due to a disease during a particular year. When most people who develop a disease die from the disease, as is the situation with lung cancer, the mortality rate and the incidence rates are very similar. Thus, if the incidence rate of lung cancer is 100 per 100,000 per year, the mortality rate might be 95 per 100,000 per year. When mortality rates and incidence rates are similar and mortality rates are more easily or more reliably obtained, epidemiologists may substitute mortality rates for incidence rates.<sup>c</sup>

The relationship between the incidence rate and the mortality rate is important since it estimates the chances of dying from the disease once it is diagnosed. We call this the **case-fatality**. In our example, the chances of dying from lung cancer—the mortality rate divided by the incidence rate—is 95 percent, which indicates that lung cancer results in a very poor prognosis once it is diagnosed.

<sup>b</sup> When talking about the term “rate,” many epidemiologists also include a unit of time, such as a day or a year, over which the number of events in the numerator is measured. This may also be called a **true rate**. The term “rate,” as used in this book includes true rates, as well as proportions. A **proportion** is a fraction in which the numerator is a subset of the denominator. A time period is not required for a proportion, however, it often reflects the situation at one point in time.

<sup>c</sup> This is an example of the pragmatic approach that is often taken by epidemiologists when they are limited by the available data. The question facing epidemiologists is frequently: is the data good enough to address the question? Thus, epidemiology can be thought of as an approximation science.

Prevalence is the number of individuals who have a disease at a particular time divided by the number of individuals who could potentially have the disease. It can be represented by the following equation:

$$\text{Prevalence} = \frac{\# \text{ living with a particular disease}}{\# \text{ in the at-risk population}}$$

Thus, prevalence tells us the proportion or percentage of individuals who have the disease.<sup>5,6</sup>

Despite the fact that lung cancer has become the most common cancer, the prevalence will be low—perhaps one-tenth of one percent or less—because those who develop lung cancer do not generally live for a long period of time. Therefore, you will rarely see people with lung cancer. The prevalence of chronic diseases of prolonged duration, such as asthma or chronic obstructive pulmonary disease (COPD), is often relatively high, hence you will often see people with these diseases.<sup>d</sup>

Prevalence is often useful when trying to assess the total impact or burden of a health problem in a population and can help identify the need for services. For example, knowledge that there is a high prevalence of lung cancer in a certain region may indicate that there is a need for healthcare services in that area. Prevalence is also very useful in clinical medicine as the starting point for screening and diagnosis, as we will discuss in Chapter 6. Now that we have addressed rates, we can return to the three questions for describing a health problem.

## WHAT IS THE BURDEN OF DISEASE IN TERMS OF MORBIDITY AND MORTALITY AND HAS IT CHANGED OVER TIME?

As we have seen, lung cancer is a disease with a very poor prognosis; therefore, the burden of disease is high as measured by its high mortality rate. This was the situation in the past and to a large extent continues to be the situation.

Mortality rates have been obtained from death certificates for many years. The cause of death on death certificates is classified using a standardized coding system known as the International Classification of Diseases (ICD). No equally complete or accurate system has been available for collecting data on the incidence rate of lung cancer. However, as we learned in

<sup>d</sup> The relationship between incidence and prevalence rates is approximately: the incidence rate  $\times$  average duration of the disease = the prevalence rate. Both the incidence rate and the average duration affect the prevalence of the disease. Together, the incidence, prevalence, and case-fatality rates provide a population-based summary of the course of a disease. Incidence reflects the chance of developing the disease, prevalence indicates the chances of having the disease, and case-fatality indicates the prognosis or chance of dying from the disease.

our discussion of rates, the incidence rates and mortality rates for lung cancer are very similar. Therefore, we can use mortality data as a substitute for incidence data when evaluating the overall burden of lung cancer in a population.

By the 1930s, epidemiologists had concluded from the study of death certificates that lung cancer deaths were rapidly increasing. This increase continued through the 1950s—with cancer occurring two decades or more after the growth in consumption of cigarettes. Therefore, it was not immediately obvious that the two were related. In order to hypothesize that cigarettes were a cause of lung cancer, one needed to conclude that there was a long delay and/or a need for long-term exposure to cigarettes before lung cancer developed. There was a need for more evidence linking cigarettes and lung cancer. Let us turn our attention to the second question to see where this evidence came from.

### ARE THERE DIFFERENCES IN THE DISTRIBUTION OF DISEASE AND CAN THESE DIFFERENCES GENERATE IDEAS OR HYPOTHESES ABOUT THEIR ETIOLOGY OR CAUSE?

In looking at the distribution of disease and the potential risk factors, epidemiologists found some important relationships.

In terms of “person,” the increases in lung cancer mortality observed in the 1930s through 1950s were far more dramatic among men than among women, though by the 1950s the mortality rate among women had begun to increase as well. It was noted that cigarette use had increased first in men and later among women. There appeared to be a delay of several decades between the increase in cigarette smoking and the increase in lung cancer mortality among both men and women. This illustrates that “time” along with “person” and “place” is important in generating hypotheses.

In terms of “place,” it was found that the relationship between cigarette smoking and lung cancer mortality was present throughout the United States, but was strongest in those states where cigarette smoking was most common. Therefore, changes over time and the distribution of disease using “person” and “place” led epidemiologists to the conclusion that there was an association between groups of people who smoked more frequently and the group’s mortality rates due to lung cancer. These relationships generated the idea that cigarettes might be a cause of lung cancer. Box 2-1 illustrates some other examples of how distributions of disease by “person,” “place,” and “time” can generate hypotheses about their cause.

#### BOX 2-1 Generating Hypotheses from Distributions of Person and Place.

An increased frequency of disease based upon occupation has often provided the initial evidence of a group association based upon a combination of “person” and “place.” The first recognized occupational disease was found among chimney sweeps often exposed for long periods of time to large quantities of coal dust who were found to have a high incidence of testicular cancer.

The Mad Hatter described in *Alice’s Adventures in Wonderland* by Lewis Carroll made infamous the 19th century recognition that exposure to mercury fumes was associated with mental changes. Mercury fumes were created when making the felt used for hats, hence the term “mad as a hatter.”

The high frequency of asbestosis among those who worked in shipyards suggested a relationship decades before the dangers of asbestos were fully recognized and addressed. A lung disease known as silicosis among those who worked in the mining industry likewise suggested a relationship that led to in-depth investigation and greater control of the risks.

More recently, a rare tumor called angiosarcoma was found to occur among those exposed over long periods to polyvinyl chloride (PVC), a plastic widely used in construction. The initial report of four cases of this unusual cancer among workers in one PVC plant was enough to strongly suggest a cause-and-effect relationship based upon “place” alone.

An important example of the impact that “place” can have on generating ideas or hypotheses about causation is the history of fluoride and cavities. In the early years of the 20th century, children in the town of Colorado Springs, Colorado, were found to have a very high incidence of brown discoloration of the teeth. It was soon recognized that this condition was limited to those who obtained their water from a common source. Ironically, those with brown teeth were also protected from cavities. This clear relationship to “place” was followed by over two decades of research that led to the understanding that fluoride in the water reduces the risk of cavities, while very high levels of the compound also lead to brown teeth. Examination of the levels of fluoride in other water systems eventually led to the establishment of levels of fluoride that could protect against cavities without producing brown teeth.

Such strong and clear-cut relationships are important, but relatively unusual. Often, examinations of the characteristics of “person,” “place,” and “time” in populations suggests hypotheses that can be followed-up among individuals to establish cause and effect relationships.<sup>5, 6</sup>



It is important to realize that these mortality rates are group rates. This data did not include any information about whether those who died from lung cancer were smokers. It merely indicated that groups who smoked more, such as males, also had higher mortality rates from lung cancer. The most that we can hope to achieve from this data is to generate hypotheses based on associations between groups or group associations. When we try to establish causation or etiology, we will need to go beyond group association and focus on associations at the individual level. However, before addressing etiology, we need to ask our third question:

### ARE THE DIFFERENCES OR CHANGES USED TO SUGGEST GROUP ASSOCIATIONS ARTIFACTUAL OR REAL?

As we have seen from the 1930s through the 1950s, a large number of studies established that lung cancer deaths were increasing among men, but not among women. That is, there was a change over time and a difference between groups. When epidemiologists observe these types of changes and differences in rates, they ask: are the changes or differences in rates real or could they be artificial or artifactual? There are three basic reasons that changes in rates may be artifactual rather than real:

- Changes in the interest in identifying the disease
- Changes in the ability to identify the disease
- Changes in the definition of the disease

For some conditions, such as HIV/AIDS, these changes have all occurred. New and effective treatments have increased the interest in detecting the infection. Improved technology has increased the ability to detect HIV infections at an earlier point in time. In addition, there have been a number of modifications of the definition of AIDS based on new opportunistic infections and newly recognized complications. Therefore, with HIV/AIDS we need to be especially attentive to the possibility that artifactual changes have occurred.

With lung cancer, on the other hand, the diagnosis at the time of death has been of great interest for many years. The ability to diagnose the disease has not changed substantially. In addition, the use of ICD codes on death certificates has helped standardize the definition of the disease. Epidemiologists concluded that it was unlikely that changes in interest, ability, or definition explained the changes in the rates of lung cancer observed in males, thus they concluded that the changes were not artifactual, but real.<sup>e</sup>

However, it was still possible that the increased mortality rates from lung cancer were due to the increasing life span that

was occurring between 1930 and 1960, along with the subsequent aging of the population. Perhaps older people are more likely to develop lung cancer and the aging of the population itself explains the real increase in the rates. To address this issue, epidemiologists use what is called **age adjustment**. To conduct age adjustment, epidemiologists look at the rates of the disease in each age group and also the **age distribution** or the number of people in each age group in the population. Then, they combine the rates for each age group taking into account or adjusting for the age distribution of a population.<sup>f</sup>

Taking into account the age distribution of the population in 1930 and 1960 did have a modest impact on the changes in the mortality rates from lung cancer, but large differences remained. As a result, epidemiologists concluded that lung cancer mortality rates changed over this period especially among men; the changes in rates were real; and the changes could not be explained simply by the aging of the population. Thus, epidemiologists had established the existence of a group association between groups that smoked more cigarettes and groups that developed lung cancer.

### WHAT IS THE IMPLICATION OF A GROUP ASSOCIATION?

Group associations are established by investigations that use information on groups or a population without having information on the specific individuals within the group. These studies have been called **population comparisons** or **ecological studies**. Having established the existence of a group association, we still don't know if the individuals who smoke cigarettes are the same ones who develop lung cancer. We can think of a group association as a hypothesis that requires investigation at the individual level. The group association between cigarettes and lung cancer was the beginning of a long road to establish that cigarettes are a cause of lung cancer.

Not all group associations are also individual associations. Imagine the following situation: the mortality rates from drowning are higher in southern states than northern states. The per capita consumption of ice cream is also higher in southern states than northern states. Thus, a group association was established between ice cream consumption and drowning. In thinking about this relationship, you will soon realize that there is another difference between southern and northern states. The average temperature is higher in southern states and higher temperatures are most likely associated with

<sup>e</sup> There are actually several types of lung cancer defined by the ICD codes. Most, but not all, types of lung cancer are strongly associated with cigarette smoking.

<sup>f</sup> Adjustment for age is often performed by combining the rates in each age group using the age distribution of what is called a standard population. The age distribution of the U.S. population in 2000 is currently used as the standard population. Adjustment is not limited to age and may at times be conducted using other characteristics that may differ among the groups, such as gender or race, which may affect the probability of developing a disease.

more swimming and also more ice cream consumption. Ice cream consumption is therefore related both to swimming and to drowning. We call this type of factor a **confounding variable**. In this situation, there is no evidence that those who drown actually consumed ice cream. That is, there is no evidence of an association at the individual level. Thus group associations can be misleading if they suggest relationships that do not exist at the individual level.

Epidemiology research studies that look at associations at the individual level are key to establishing etiology, or cause. Etiology is the second component of the P.E.R.I. approach. Let us turn our attention to how to establish etiology.

### ETIOLOGY: HOW DO WE ESTABLISH CONTRIBUTORY CAUSE?

Understanding the reasons for disease is fundamental to the prevention of disability and death. We call these reasons etiology or causation. In evidence-based public health, we use a very specific definition of causation—**contributory cause**. The evidence-based public health approach relies on epidemiological research studies to establish a contributory cause. This requires that we go beyond group association and establish three definitive requirements.<sup>7</sup>

1. The “cause” is associated with the “effect” at the individual level. That is, the potential “cause” and the potential “effect” occur more frequently in the same individual than would be expected by chance. Therefore, we need to establish that individuals with lung

cancer are more frequently smokers than individuals without lung cancer.

2. The “cause” precedes the “effect” in time. That is, the potential “cause” is present at an earlier time than the potential “effect.” Therefore, we need to establish that cigarette smoking comes before the development of lung cancer.
3. Altering the “cause” alters the “effect.” That is, when the potential “cause” is reduced or eliminated, the potential “effect” is also reduced or eliminated. Therefore, we need to establish that reducing cigarette smoking reduces lung cancer rates.

Box 2-2 illustrates the logic behind using these three criteria to establish a cause-and-effect relationship, as well as what the implications of a contributory cause are.

These three definitive requirements are ideally established using three different types of studies, all of which relate potential “causes” to potential “effects” at the individual level. That is, they investigate whether individuals who smoke cigarettes are the same individuals that develop lung cancer.<sup>6</sup> The three basic types of investigations are called **case-control** or **retrospective studies**, **cohort studies** or **prospective studies**, and **randomized clinical trials** or **experimental studies**.

Case-control studies are most useful for establishing requirement #1 previously, i.e., the “cause” is associated with the “effect” at the individual level. Case-control studies can demonstrate that cigarettes and lung cancer occur together more

#### BOX 2-2 Lightning, Thunder, and Contributory Cause.

The requirements for establishing the type of cause-and-effect relationship known as contributory cause used in evidence-based public health can be illustrated by the cause-and-effect relationship between lightning and thunder that human beings have recognized from the earliest times of civilization.

First, lightning is generally associated with thunder, that is, the two occur together far more often than one would expect if there were no relationship. Second, with careful observation it can be concluded that the lightning is seen a short time before the thunder is heard. That is, the potential “cause” (the lightning) precedes in time the “effect” (the thunder). Finally, when the lightning stops, so does the thunder—thus, altering the “cause” alters the “effect.”

Notice that lightning is not always associated with thunder. “Heat lightning” may not produce audible thunder or the lightning may be too far away for the thunder to be heard. Lightning is not sufficient in and of itself to guarantee that our ears will subsequently always hear thunder. Conversely, in recent years it has been found that the sound of thunder does not always require lightning. Other reasons for rapidly expansion of air, such as an explosion, can also create a sound similar or identical to thunder.

The recognition of lightning as a cause of thunder came many centuries before human beings had any understanding of electricity or today’s appreciation for the science of light and sounds. Similarly, cause-and-effect relationships established by epidemiological investigations do not always depend on understanding the science behind the relationships.

frequently than would be expected by chance alone. To accomplish this, cases with the disease (lung cancer) are compared to controls without the disease to determine whether the cases and the controls previously were exposed to the potential “cause” (cigarette smoking).

When a factor such as cigarettes has been demonstrated to be associated on an individual basis with an outcome such as lung cancer, we often refer to that factor as a **risk factor**.<sup>g</sup>

During the 1940s and early 1950s, a number of case-control studies established that individuals who developed lung cancer were far more likely to be regular smokers compared to similar individuals who did not smoke cigarettes. These case-control studies established requirement #1—the “cause” is associated with the “effect” at the individual level. They established that cigarettes are a risk factor for lung cancer.

Cohort studies are most useful for establishing requirement #2 previously—the “cause” precedes the “effect.” Those with the potential “cause” or risk factor (cigarette smoking) and those without the potential “cause” are followed over time to determine who develops the “effect” (lung cancer).<sup>h</sup>

Several large scale cohort studies were conducted in the late 1950s and early 1960s. One conducted by the American Cancer Society followed nearly 200,000 individuals over three or more years to determine the chances that smokers and nonsmokers would develop lung cancer. Those who smoked regularly at the beginning of the study had a greatly increased chance of developing lung cancer over the course of the study, thus establishing requirement #2, the “cause” precedes the “effect” in time.

Randomized clinical trials are most useful for establishing requirement #3—altering the “cause” alters the “effect.” Using a chance process known as **randomization**, individuals are assigned to be exposed or not exposed to the potential “cause” (cigarette smoking). Individuals with and without the potential “cause” are then followed over time to determine who develops the “effect.” Conducting a randomized clinical trial of cigarettes and lung cancer would require investigators to randomize individuals to smoke cigarettes or not smoke cigarettes

<sup>g</sup> A risk factor, as we just discussed, usually implies that the factor is associated with the disease at the individual level. At times it may be used to imply that the factor not only is associated with the disease at the individual level, but that it precedes the disease in time. Despite the multiple uses of the term, a risk factor does not in and of itself imply that a cause-and-effect relationship is present, though it may be considered a possible cause.

<sup>h</sup> It may seem obvious that cigarette smoking precedes the development of lung cancer. However, the sequence of events is not always so clear. For instance, those who have recently quit smoking cigarettes have an increased chance of being diagnosed with lung cancer. This may lead to the erroneous conclusion that stopping cigarette smoking is a cause of lung cancer. It is more likely that early symptoms of lung cancer lead individuals to quit smoking. The conclusion that stopping cigarette smoking causes lung cancer is called **reverse causality**. Thus, it was important that cohort studies followed smokers and nonsmokers for several years to establish that the cigarette smoking came first.

and follow them over many years. This illustrates the obstacles that can occur in seeking to definitively establish contributory cause. Once there was a strong suspicion that cigarettes might cause lung cancer, randomized clinical trials were not practical or ethical as a method for establishing cigarette smoking as a contributory cause of lung cancer. Therefore, we need to look at additional criteria that we can use to help us establish the existence of contributory cause.<sup>i</sup>

Figure 2-2 illustrates the requirements for definitively establishing contributory cause and the types of studies that may be used to satisfy each of the requirements. Notice that the requirements for establishing contributory cause are the same as the requirements for establishing **efficacy**. Efficacy implies that an intervention works, that is, it increases positive outcomes or benefits in the population being investigated.

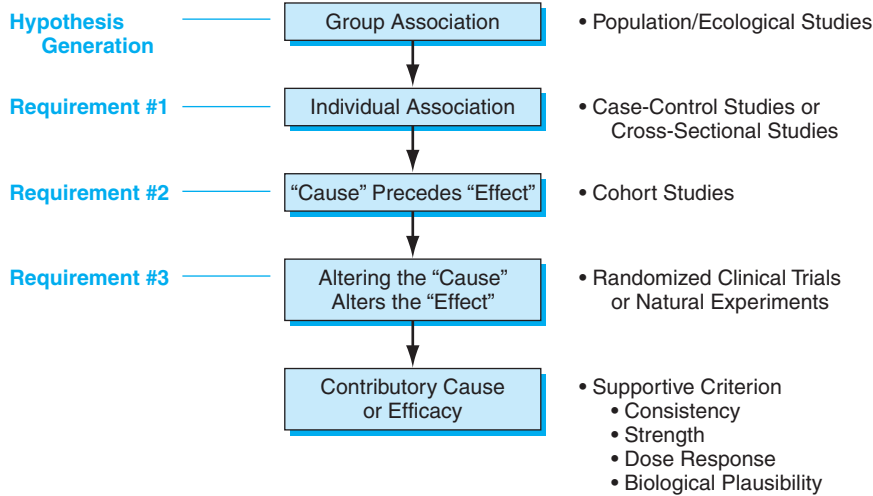
### WHAT CAN WE DO IF WE CANNOT DEMONSTRATE ALL THREE REQUIREMENTS TO DEFINITELY ESTABLISH CONTRIBUTORY CAUSE?

When we cannot definitively establish a contributory cause, we often need to look for additional supportive evidence.<sup>7</sup> In evidence-based public health, we often utilize what have been called **supportive or ancillary criteria** to make scientific judgments about cause and effect. A large number of these criteria have been used and debated. However, four of them are widely used and pose little controversy. They are:

- Strength of the relationship
- Dose-response relationship
- Consistency of the relationship
- Biological plausibility

Let us examine what we mean by each of these criteria. The **strength of the relationship** implies that we are interested in knowing how closely related the risk factor (cigarette smoking) is to the disease (lung cancer). In other words, we want to know the probability of lung cancer among those who smoke cigarettes compared to the probability of lung cancer among those who do not smoke cigarettes. To measure the strength of the relationship we calculate what we call the **relative risk**. The

<sup>i</sup> At times, a special form of a cohort study called a **natural experiment** can help establish that altering the cause alters the effect. A natural experiment implies that an investigator studies the results of a change in one group, but not in another similar group that was produced by forces outside the investigator’s control. For instance, after the Surgeon General’s *1964 Report on Smoking and Health* was released, approximately 100,000 physicians stopped smoking. This did not happen among other professionals. Over the next decade, the rates of lung cancer among physicians dropped dramatically, but not among other professionals. Despite the fact that natural experiments can be very useful, they are not considered as reliable as randomized clinical trials. Randomization, especially in large studies, eliminates differences between groups or potential confounding differences, even when these differences in characteristics are not recognized by the investigators.

**FIGURE 2-2** Fulfilling requirements for establishing contributory cause or efficacy

ask whether smoking more cigarettes is associated with a greater chance of developing lung cancer. If it is, then we say there is a **dose-response relationship**. For instance, smoking one pack of cigarettes per day over many years increases the chances of developing lung cancer compared to smoking half a pack per day. Similarly, smoking two packs per day increases the chances of developing the disease compared to smoking one pack per day. These examples show that a dose-response relationship is present.<sup>k</sup>

**Consistency** implies that studies in different geographic areas and among a wide range of groups produce similar results. A very

large number of studies of cigarettes and lung cancer in many countries and among those of nearly every race and socioeconomic group have consistently demonstrated a strong individual association between cigarette smoking and lung cancer.

relative risk is the probability of developing the disease if the risk factor is present compared to the probability of the disease if the risk factor is not present. Therefore, the relative risk for cigarette smoking is calculated as:

$$\text{Relative risk} = \frac{\text{probability of lung cancer for cigarette smokers}}{\text{probability of lung cancer for nonsmokers}}$$

The final support criterion is **biological plausibility**. This term implies that we can explain the occurrence of disease based upon known and accepted biological mechanisms. We can explain the occurrence of lung cancer by the fact that cigarette smoke contains a wide range of potentially toxic chemicals which reach the locations in the body where lung cancer occurs.

The relative risk for cigarette smoking and lung cancer is approximately ten. A relative risk of ten is very large. It tells us that the chances or probability of developing lung cancer are ten times as great for the average smoker compared to the average nonsmoker.<sup>j</sup>

Thus, the ancillary criteria add support to the argument that cigarette smoking is a contributory cause of lung cancer. Table 2-1 summarizes the use of ancillary or support criteria in making scientific judgments about contributory cause and illustrates these principles using the cigarette smoking and lung cancer scenario. It also cautions to use these criteria carefully because a cause-and-effect relationship may be present even when some or all of these criteria are not fulfilled.<sup>7</sup>

In addition to looking at the strength of the overall relationship between smoking cigarettes and lung cancer, we can

We have now summarized the approach used in evidence-based public health to establish a contributory cause. We

<sup>j</sup> A relative risk of ten does not tell us the **absolute risk**. The absolute risk is the actual chance or probability of developing the disease (lung cancer) in the presence of the risk factor (cigarette smoking), expressed numerically—for example, as 0.03 or 3%. A relative risk of ten might imply an increase from 1 in 1000 individuals to 1 in 100 individuals. Alternatively it might imply an increase from 1 in 100 individuals to 1 in 10 individuals. A relative risk can be calculated whenever we have follow-up data on groups of individuals; therefore, it does not in and of itself imply that a contributory cause is present. We need to be careful not to imply that the risk factor will increase the chances of developing the disease or that reducing or eliminating the risk factor will reduce or eliminate the disease unless we have evidence of contributory cause. For case-control studies, a measure known as the **odds ratio** can be calculated and is often used as an approximation of relative risk.

<sup>k</sup> A dose-response relationship may also imply that greater exposure to a factor is associated with reduced probability of developing the disease, such as with exercise and coronary artery disease. In this case, the factor may be called a **protective factor** rather than a risk factor.



**TABLE 2-1** Ancillary or Supportive Criteria—Cigarettes and Lung Cancer

Criteria	Meaning of the criteria	Evidence for cigarettes and lung cancer	Cautions in using criteria
Strength of the relationship	The relative risk for those with the risk factor is greatly increased compared to those without the risk factor	The relative risk is large or substantial. The relative risk is greater than 10 for the average smoker implying that the average smoker has more than 10 times the probability of developing lung cancer compared to nonsmokers	Even relatively modest relative risks may make important contributions to disease when the risk factor is frequently present. A relative risk of 2 for instance implies a doubling of the probability of developing a disease.
Dose-response relationship	Higher levels of exposure and/or longer duration of exposure to the “cause” is associated with increased probability of the “effect”	Studies of cigarette and lung cancer establish that smoking half a pack a day over an extended period of time increases the risk compared to no smoking. Smoking one pack per day and two packs per day further increases the risk	No dose-response relationship may be evident between no smoking and smoking one cigarette a day or between smoking three and four packs per day
Consistency of the relationship	Studies at the individual level produce similar results in multiple locations among populations of varying socioeconomic and cultural backgrounds	Hundreds of studies in multiple locations and populations consistently establish an individual association between cigarettes and lung cancer	Consistency requires the availability of numerous studies that may not have been conducted
Biological plausibility	Known biological mechanisms can convincingly explain a cause-and-effect relationship	Cigarette smoke directly reaches the areas where lung cancer appears	Exactly which component(s) of cigarette smoking produce lung cancer are just beginning to be understood

started with the development of group associations that generate hypotheses and moved on to look at the definitive requirements for establishing contributory cause. We also looked at the ancillary or supportive criteria that are often needed to make scientific judgments about contributory cause. Table 2-2 summarizes this process and applies it to cigarette smoking and lung cancer.

### WHAT DOES CONTRIBUTORY CAUSE IMPLY?

Establishing a contributory cause on the basis of evidence is a complicated, and often a time, consuming job. In practice, our minds often too quickly jump to the conclusion that a cause-

and-effect relationship exists. Our language has a large number of words which may subtly imply a cause-and-effect relationship, even in the absence of evidence. Box 2-3 illustrates how we often rapidly draw conclusions about cause and effect.

It is important to understand what the existence of a contributory cause implies and what it does not imply. Despite the convincing evidence that cigarette smoking is a contributory cause of lung cancer, some individuals never smoke and still develop lung cancer. Therefore, cigarettes are not what we call a **necessary cause** of lung cancer. Others smoke cigarettes all their lives and do not develop lung cancer. Thus, cigarettes are not what we call a **sufficient cause** of lung cancer.

**TABLE 2-2** Cigarettes and Lung Cancer—Establishing Cause and Effect

Requirements for contributory cause	Meaning of the requirements	Types of studies that can establish the requirement	Evidence for cigarette smoking and lung cancer
Associated at a population level (Group association)	A group relationship between a “cause” and an “effect.”	Ecological study or population comparison study: a comparison of population rates between an exposure and a disease.	Men began mass consumption of cigarettes decades before women and their rates of lung cancer increased decades before those of women.
Individual association: “Requirement #1”	Individuals with a disease (“effect”) also have an increased chance of having a potential risk factor (“cause”).	Case-control studies: cases with the disease are compared to similar controls without the disease to see who had the exposure.	Lung cancer patients were found to have 10 times or greater chance of smoking cigarettes regularly compared to those without lung cancer.
Prior association: “Requirement #2”	The potential risk factor precedes—in time—the outcome.	Cohort studies: exposed and similar nonexposed individuals are followed over time to determine who develops the disease.	Large cohort studies found that those who smoke cigarettes regularly have a 10 times or greater chance of subsequently developing lung cancer.
Altering the “cause” alters the “effect”: “Requirement #3”	Active intervention to expose one group to the risk factor results in a greater chance of the outcome.	Randomized clinical trials allocating individuals by chance to be exposed or not exposed are needed to definitively establish contributory cause. Note: these studies are not always ethical or practical.	Alternatives to randomized clinical trials, such as “natural experiments” established that those who quit smoking have greatly reduced chances of developing lung cancer. In addition, the four supportive criteria also suggest contributory cause.

The fact that not every smoker develops lung cancer implies that there must be factors that protect some individuals from lung cancer. The fact that some nonsmokers develop lung cancer implies that there must be additional contributory causes of lung cancer. Thus, the existence of a contributory cause implies that the “cause” increases the chances that the “effect” will develop. Its presence does not guarantee that the disease will develop. In addition the absence of cigarette smoking does not guarantee that the disease will not develop.

Despite the fact that cigarettes have been established as a contributory cause of lung cancer, they are not a necessary or a sufficient cause of lung cancer. In fact, the use of the concepts of necessary and sufficient cause is not considered useful in the evidence-based public health approach because so few, if any, diseases fulfill the definitions of necessary and sufficient

cause. These criteria are too demanding to be used as standards of proof in public health or medicine.

By 1964, the evidence that cigarette smoking was a contributory cause of lung cancer was persuasive enough for the Surgeon General of the United States to produce the first Surgeon General’s *Report on Smoking and Health*. The report concluded that cigarettes are an important cause of lung cancer. Over the following decades, the Surgeon General’s reports documented the evidence that cigarette smoking not only caused lung cancer, but other cancers—including cancer of the throat and larynx. Cigarette smoking is also a contributory cause of chronic obstructive pulmonary disease (COPD) and coronary artery disease. Smoking during pregnancy poses risks to the unborn child and passive or second-hand smoke creates increased risks to those exposed—especially children.<sup>8</sup> Based on the Surgeon

### BOX 2-3 Words that Imply Causation.

Often when reading the newspaper or other media you will find that conclusions about cause and effect are made based upon far less rigorous examination of the data than we have indicated are needed to definitively establish cause and effect. In fact, we often draw conclusions about cause and effect without even consciously recognizing we have done so. Our language has a large number of words that imply a cause-and-effect relationship, some of which we use rather casually.

Let's take a look at the many ways that a hypothetical newspaper article might imply the existence of a cause-and-effect relationship or a contributory cause even when the evidence is based only upon a group association or upon speculation about the possible relationships.

*Over several decades the mortality rates from breast cancer in the United States were observed to increase each year. This trend was **due to** and can be **blamed on** a variety of factors including the increased use of estrogens and exposure to estrogens in food. The recent reduction in breast cancer **resulted from** and can be **attributed to** the declining use of estrogens for menopausal and post-menopausal women. The declining mortality rate was also **produced by** the increased use of screening tests for breast cancer that were **responsible for** early detection and treatment. These trends **demonstrate that** reduced use of estrogens and increased use of screening tests have **contributed to** and **explain** the reduction in breast cancer.*

While these conclusions sound reasonable and may well be cause-and-effect relationships, note that they rely heavily on assertions for which there is no direct evidence provided. For instance, the following words are often used to imply a cause-and-effect relationship when evidence is not or cannot be presented to support the relationship:

- due to
- blamed on
- result from
- attributable to
- produced by
- responsible for
- contributed to
- explained by

It is important to be aware of conscious or unconscious efforts to imply cause-and-effect relationships when the data suggest only group associations and do not meet our more stringent criteria establishing cause and effect.

General's findings, there is clearly overwhelming evidence that cigarette smoking is a contributory cause of lung cancer and a growing list of other diseases. Thus, let us turn our attention to the third component of the P.E.R.I. process: recommendations.

### RECOMMENDATIONS: WHAT WORKS TO REDUCE THE HEALTH IMPACT?

The evidence for cigarette smoking as a cause of lung cancer, as well as other diseases, was so strong that it cried out for action. In evidence-based public health, however, action should be grounded in **recommendations** that incorporate evidence. That is, evidence serves not only to establish contributory cause, but is central to determining whether or not specific interventions work.<sup>9, 10</sup> Recommendations are built upon the evidence from studies of interventions. Thus, recommendations are summaries of the evidence of which interventions

work to reduce the health impacts and they indicate whether actions should be taken. These studies utilize the same types of investigations we discussed for contributory cause. In fact, the requirements of contributory cause are the same as those for establishing that an intervention works or has efficacy on the particular population that was studied.

In the decades since the Surgeon General's initial report, a long list of interventions have been implemented and evaluated. As we have discussed, the term intervention is a very broad term in public health. Interventions range from individual counseling and prescription of pharmaceutical drugs which aid smoking cessation; to group efforts, such as peer support groups; to social interventions, such as cigarette taxes and legal restriction on smoking in restaurants.

Recommendations for action have been part of public health and medicine for many years. Evidence-based recom-

mentations, however, are relatively new. They have been contrasted with the traditional *eminence-based* recommendation, which uses the opinion of a respected authority as its foundation. Evidence-based recommendations ask about the research evidence supporting the benefits and harms of potential interventions. In evidence-based recommendations the opinions of experts are most important when research evidence does not or cannot provide answers.

Before looking at the evidence-based recommendations on cigarette smoking made by the Centers for Disease Control and Prevention (CDC), let us look at how they are often made and can be graded. Evidence-based recommendations are based upon two types of criteria—the quality of the evidence and the magnitude of the impact. Each of these criteria is given what is called a **score**.<sup>9,10</sup> The quality of the evidence is scored based in large part upon the types of investigations and how well the investigation was conducted. Well-conducted randomized clinical trials that fully address the health problem are considered the highest quality evidence. Often, however, cohort and case control studies are needed and are used as part of the recommendation.

Expert opinion, though lowest on the hierarchy of evidence, is often essential to fill in the holes in the research evidence.<sup>9,10</sup> The quality of the evidence also determines whether the data collected during an intervention is relevant to its use in a particular population or setting. Data from young adults may not be relevant to children or the elderly. Data from severely ill patients may not be relevant to mildly ill patients. Thus, high quality evidence needs to be based not only on the research which can establish efficacy in one particular population, but on the **effectiveness** of the intervention in the specific population in which it will be used.

In evidence-based public health the quality of the evidence is often scored as good, fair, or poor. Good quality implies that the evidence fulfills all the criteria for quality. Poor quality evidence implies that there are fatal flaws in the evidence and recommendations cannot be made. Fair quality lies in between having no fatal flaws.<sup>1</sup>

In addition to looking at the quality of the evidence, it is also important to look at the magnitude of the impact of the intervention. The magnitude of the impact asks the question: how much of the disability and/or death due to the disease can be potentially removed by the intervention? In measuring the magnitude of the impact, evidence-based recommendations take into account the potential benefits of an intervention, as well as the

potential harms. Therefore, we can regard the magnitude of the impact as the benefits minus the harms, or the “net benefits.”<sup>m</sup>

The magnitude of the impact, like the quality of the evidence, is scored based upon a limited number of potential categories. In one commonly-used system, the magnitude of the impact is scored as substantial, moderate, small, and zero/negative.<sup>9</sup> A substantial impact may imply that the intervention works extremely well for a small number of people, such as a drug treatment for cigarette cessation. These are the types of interventions that are often the focus of individual clinical care. A substantial impact may also imply that the intervention has a modest net benefit for any one individual, but can be applied to large numbers of people, such as in the form of media advertising or taxes on cigarettes. These are the types of interventions that are most often the focus of traditional public health and social policy.

Evidence-based recommendations combine the score for the quality of the evidence with the score for the impact of the intervention.<sup>9</sup> Table 2-3 summarizes how these aspects can be combined to produce a classification of the strength of the recommendation—graded as A, B, C, D, and I.

It may be useful to think of these grades as indicating the following:

- A = Must—A strong recommendation
- B = Should—In general, the intervention should be used unless there are good reasons or contraindications for not doing so.
- C = May—The use of judgment is often needed on an individual-by-individual basis. Individual recommendations depend on the specifics of an individual’s situation, risk-taking attitudes, and values.
- D = Don’t—There is enough evidence to recommend against using the intervention.
- I = Indeterminant, insufficient or I don’t know—The evidence is inadequate to make a recommendation for or against the use of the intervention at the present time.

Notice that evidence-based public health and medicine rely primarily on considerations of benefits and harms.

<sup>m</sup> The magnitude of the impact can be measured using the relative risk calculation. When dealing with interventions, the people who receive the intervention are often placed in the numerator. Thus, an intervention that reduces the bad outcomes by half would have a relative risk of 0.5. The smaller the relative risk is, the greater the measured impact of the intervention. If the relative risk is 0.20, then those with the intervention have only 20 percent of the risk remaining. Their risk of a bad outcome has been reduced by 80 percent. The reduction in bad outcome is called the **attributable risk percentage** or the **percent efficacy**. The intervention can only be expected to accomplish this potential reduction in risk when a contributory cause is present and the impact of the “cause” can be immediately and completely eliminated.

<sup>1</sup> To fulfill the criteria for good quality data, evidence is also needed to show that the outcome being measured is a clinically important outcome. Short-term outcomes called **surrogate outcomes**, such as changes in laboratory tests, may not reliably indicate longer term or clinically important outcomes.

**TABLE 2-3** Classification of Recommendations

	Magnitude of the impact			
	Net benefit: substantial	Net benefit: moderate	Net benefit: small	Net benefit: zero/negative
<b>Quality of the evidence</b>				
Good	A	B	C	D
Fair	B	B	C	D
Poor (insufficient evidence)	I	I	I	I

Source: Agency for Healthcare Research and Quality, U.S. Preventive Services Task Force Guide to Clinical Preventive Services Vol 1, AHRQ Pub. No.02-500.

However, recently issues of financial cost have begun to be integrated into evidence-based recommendations. At this point, however, cost considerations are generally only taken into account for “close calls.” Close calls are often situations where the net benefits are small to moderate and the costs are large.

The evidence-based public health approach increasingly relies on the use of evidence-based recommendations that are graded based on the quality of the evidence and the expected impact of the intervention. The recommendations are made by a wide array of organizations as discussed in Box 2-4. It is im-

- Clean indoor air legislation prohibiting tobacco use in indoor public and private workplaces
- Federal, state, and local efforts to increase taxes on tobacco products as an effective public health intervention to promote tobacco use cessation and to reduce the initiation of tobacco use among youths
- The funding and implementation of long-term, high-intensity mass media campaigns using paid broadcast times and media messages developed through formative research

portant to appreciate the source of the recommendations, as well as the methods used to develop them.<sup>7</sup>

Let us take a look at some examples of how interventions to prevent smoking, detect lung cancer early, or cure lung cancer have been graded. The CDC publishes *The Guide to Community Prevention Services*.<sup>10</sup> This guide indicates that the following interventions are recommended, implying a grade of A or B:

### BOX 2-4 Who Develops Evidence-Based Recommendations?

Evidence-based recommendations may be developed by a range of groups including government, practitioner-oriented organizations, consumer-oriented organizations, organized health care systems, and even for-profit organizations. Organizations developing evidence-based recommendations, however, are expected to acknowledge their authorship and identify the individuals who participated in the process, as well as their potential conflicts of interest. In addition, regardless of the organization, the evidence-based recommendations should include a description of the process used to collect the data and make the recommendations.

For-profit organizations may make evidence-based recommendations. However, their obvious conflicts of interest often lead them to fund other groups to make recommendations. Thus, the funding source(s) supporting the development of evidence-based recommendations should also be acknowledged as part of the report.

One well-regarded model for development of evidence-based recommendations is the task force model used by the United States Preventive Services Task Force of the Agency for Healthcare Research and Quality (AHRQ), as well as by the Task Force on Community Preventive Services of the Centers for Disease Control and Prevention (CDC).<sup>9, 10</sup> The task force model aims to balance potential conflicts of interest and ensures a range of expertise by selecting a variety of experts, as well as community participants based upon a public nomination process. Once the task force members are appointed, their recommendations are made by a vote of the task force and do not require approval by the government agency.

Thus, as a reader of evidence-based recommendations, it is important that you begin by looking at which group developed the recommendations, whether they have disclosed their membership including potential conflicts of interest, and the groups' procedures for developing the recommendations.



- Proactive telephone cessation support services (quit lines)
- Reduced or eliminated copayments for effective cessation therapies
- Reminder systems for healthcare providers (encouraging them to reinforce the importance of cigarette cessation)
- Efforts to mobilize communities to identify and reduce the commercial availability of tobacco products to youths

Additional recommendations encourage clinicians to specifically counsel patients against smoking, prescribe medications for adults, encourage support groups for smoking cessation, and treat lung cancer with the best available treatments when detected.

Of interest is the grade of D for recommending against screening for early detection of lung cancer using traditional chest X-rays. The evidence strongly suggests that screening using this method may detect cancer at a slightly earlier stage, but not early enough to alter the course of the disease. Therefore early detection does not alter the outcome of the diseases. Research continues to find better screening methods to detect lung cancer in time to make a difference.

Recommendations are not the end of the process. There may be a large number of recommendations among which we may need to choose. In addition, we need to decide the best way(s) to put the recommendations into practice. Thus, implementation is not an automatic process. Issue of ethics, culture, politics, and risk-taking attitudes can and should have major impacts on implementation. A fourth step in the evidence-base public health approach requires us to look at the options for implementation and to develop a strategy for getting the job done.

## IMPLEMENTATION: HOW DO WE GET THE JOB DONE?

Strong recommendations based upon the evidence are ideally the basis of implementation. At times, however, it may not be practical or ethical to obtain the evidence needed to establish contributory cause and develop evidence-based recommendations. Naturally-occurring implementation itself may be part of the process of establishing causation, as it was for cigarette smoking in the 1960s when 100,000 physicians stopped smoking and their rates of lung cancer declined rapidly, as compared to other similar professionals who did not stop smoking.

Today, there are often a large number of interventions with adequate data to consider implementation. Many of the interventions have potential harms, as well as potential bene-

fits. The large and growing array of possible interventions means that health decisions require a systematic method for deciding which interventions to use and how to combine them in the most effective and efficient ways. One method for examining the options for implementation uses a structure we will call the “When-Who-How” approach.

“When” asks about the timing in the course of disease in which an intervention occurs. This timing allows us to categorize interventions as **primary**, **secondary**, and **tertiary**. Primary interventions take place before the onset of the disease. They aim to prevent the disease from occurring. Secondary interventions occur after the development of a disease or risk factor, but before symptoms appear. They are aimed at early detection of disease or reducing risk factors while the patient is asymptomatic. Tertiary interventions occur after the initial occurrence of symptoms, but before irreversible disability. They aim to prevent irreversible consequences of the disease. In the cigarette smoking and lung cancer scenario, primary interventions aim to prevent cigarette smoking. Secondary interventions aim to reverse the course of disease by smoking cessation efforts or screening to detect early disease. Tertiary interventions diagnose and treat diseases caused by smoking in order to prevent permanent disability and death.

“Who” asks: at whom should we direct the intervention? Should it be directed at individuals one at a time as part of clinical care? Alternatively, should it be directed at groups of people, such as vulnerable populations, or should it be directed at everyone in a community or population?<sup>7</sup>

Finally, we need to ask: how should we implement interventions? There are three basic types of interventions when addressing the need for behavioral change. These interventions can be classified as: information (education), motivation (incentives), and obligation (requirements).<sup>8</sup>

<sup>7</sup> The CDC defines four levels of intervention: the individual, the relationship (e.g., the family), the community, and society or the population as a whole. This framework has the advantage of separating immediate family interventions from community interventions. The group or at-risk group relationship used here may at times refer to the family unit or geographic communities. It may also refer to institutions or at-risk vulnerable groups within the community. The use of group or at-risk group relationship provides greater flexibility allowing application to a wider range of situations. In addition, the three levels used here correlate with the measurements of relative risk, attributable risk percentage, and population attributable percentage, which are the fundamental epidemiological measurements applied to the magnitude of the impact of an intervention.<sup>7</sup>

<sup>8</sup> An additional option is innovation. Innovation implies a technical or engineering solution. The development of a safer cigarette might be an innovation. A distinct advantage of technical or engineering solutions is that they often require far less behavior change. Changing human behavior is frequently difficult. Nonetheless, it is an essential component of most, if not all, successful public health interventions. Certainly, that is the case with cigarette smoking.

**TABLE 2-4** Framework of Options for Implementation

	When	Who	How
Levels	<ol style="list-style-type: none"> <li>1) Primary—Prior to disease or condition</li> <li>2) Secondary—Prior to symptoms</li> <li>3) Tertiary—Prior to irreversible complications</li> </ol>	<ol style="list-style-type: none"> <li>1) Individual</li> <li>2) At-risk group</li> <li>3) General population/community</li> </ol>	<ol style="list-style-type: none"> <li>1) Information (education)</li> <li>2) Motivation (incentives)</li> <li>3) Obligation (requirement)</li> </ol>
Meaning of levels	<ol style="list-style-type: none"> <li>1) Primary—Remove underlying cause, increase resistance, or reduce exposure</li> <li>2) Secondary—Post-exposure intervention, identify and treat risk factors or screen for asymptomatic disease</li> <li>3) Tertiary—Reverse the course of disease (cure), prevent complications, restore function</li> </ol>	<ol style="list-style-type: none"> <li>1) Individual often equals patient care</li> <li>2) At-risk implies groups with common risk factors</li> <li>3) General population includes defined populations with and without the risk factor</li> </ol>	<ol style="list-style-type: none"> <li>1) Information—Efforts to communicate information and change behavior on basis of information</li> <li>2) Motivation—Rewards to encourage or discourage without legal requirement</li> <li>3) Obligation—Required by law or institutional sanction</li> </ol>
Cigarette smoking example	<ol style="list-style-type: none"> <li>1) Primary—Prevention of smoking, reduction in second-hand exposure</li> <li>2) Secondary—Assistance in quitting, screening for cancer if recommended</li> <li>3) Tertiary—Health care to minimize disease impact</li> </ol>	<ol style="list-style-type: none"> <li>1) Individual smoker</li> <li>2) At-risk—Groups at risk of smoking or disease caused by smoking, e.g., adolescents as well as current and ex-smokers</li> <li>3) Population—Entire population including those who never have or never will smoke</li> </ol>	<ol style="list-style-type: none"> <li>1) Information—Stop smoking campaigns, advertising, warning on package, clinician advice</li> <li>2) Motivation—Taxes on cigarettes, increased cost of insurance</li> <li>3) Obligation—Prohibition on sales to minors, exclusion from athletic eligibility, legal restrictions on indoor public smoking</li> </ol>

An information or education strategy aims to change behavior through individual encounters, group interactions, or the mass media. Motivation implies use of incentives for changing or maintaining behavior. It implies more than strong or enthusiastic encouragement, it implies tangible reward. Obligation relies on law and regulations requiring specific behaviors. Table 2-4 illustrates how options for intervention for cigarettes might be organized using the “When-Who-How” approach. To better understand the “who” and “how” of the options for intervention when behavior change is needed, refer to Table 2-5, which outlines nine different options.

Deciding when, who, and how to intervene depends in large part upon the available options and the evidence that

they work. They also depend in part on our attitudes toward different types of interventions. In American society, we prefer to rely on information or educational strategies. These approaches preserve freedom of choice which we value in public, as well as private, decisions. Use of mass media informational strategies may be quite economically efficient relative to the large number of individuals they reach though messages often need to be tailored to different audiences. However, information is often ineffective in accomplishing behavioral change—at least on its own.

Strategies based upon motivation, such as taxation and other incentives, may at times be more effective than information alone, though educational strategies are still critical to justify and rein-

**TABLE 2-5** Examples of “Who” and “How” Related to Cigarette Smoking

	Information	Motivation	Obligation
<b>Individual</b>	Clinician provides patient with information explaining reasons for changing behavior	Clinician encourages patient to change behavior in order to qualify for a service or gain a benefit, e.g., status or financial	Clinician denies patient a service unless patient changes behavior
	<i>Example: Clinician distributes educational packet to a smoker and discusses his or her own smoking habit</i>	<i>Example: Clinician suggests that the financial savings from not buying cigarettes be used to buy a luxury item</i>	<i>Example: Clinician implements recommendation to refuse birth control pills to women over 35 who smoke cigarettes</i>
<b>High-risk group</b>	Information is made available to all those who engage in a behavior	Those who engage in a behavior are required to pay a higher price	Those who engage in a behavior are barred from an activity or job
	<i>Example: Warning labels on cigarette packages</i>	<i>Examples: Taxes on cigarettes</i>	<i>Example: Smokers banned from jobs that will expose them to fumes that may damage their lungs</i>
<b>Population</b>	Information is made available to the entire population, including those who do not engage in the behavior	Incentives are provided for those not at risk to discourage the behavior in those at risk	An activity is required or prohibited for those at risk and also for those not at risk of the condition
	<i>Example: Media information on the dangers of smoking</i>	<i>Example: Lower health care costs for everyone results from reduced percentage of smokers</i>	<i>Example: Cigarettes sales banned for those under 18</i>

force motivational interventions. Motivational interventions should be carefully constructed and judiciously used or they may result in what has been called **victim blaming**. For example, victim blaming in the case of cigarette smoking implies that we regard the consequences of smoking as the smokers' own fault.

The use of obligation or legally-required action can be quite effective if clear-cut behavior and relatively simple enforcement, such as restrictions on indoor public smoking, are used. These types of efforts may be regarded by some as a last resort, but others may see them as a key to effective use of other

strategies. Obligation inevitably removes freedom of choice and if not effectively implemented with regard for individual rights, the strategy may undermine respect for the law. Enforcement may become invasive and expensive, thus obligation requires careful consideration before use as a strategy.

Understanding the advantages and disadvantages of each type of approach is key to deciphering many of the controversies we face in deciding how to implement programs to address public health problems; however, implementation is not the end of the evidence-based public health process.

## WHAT HAPPENS AFTER IMPLEMENTATION?

Public health problems are rarely completely eliminated with one intervention—there are few magic bullets in this field. Therefore, it is important to evaluate whether an intervention or combination of interventions has been successful in reducing the problem. It is also critical to measure how much of the problem has been eliminated by the intervention(s).

For instance, studies of cigarette smoking between the mid-1960s and the late 1990s demonstrated that there was nearly a 50 percent reduction in cigarette smoking in the United States and that the rates of lung cancer were beginning to fall—at least among males. However, much of the problem still existed because the rates among adolescent males and females remained high and smoking among adults was preceded by smoking as adolescents nearly 90 percent of the time. Thus, an evaluation of the success of cigarette smoking interventions led to a new cycle of the P.E.R.I. process. It focused on how to address the issue of adolescent smoking and nicotine addiction among adults. Many of the interventions being used today grew out of this effort to cycle once again through the evidence-based public health process and look for a new understanding of the problem, its etiology, evidence-based recommendations, and options for implementation as illustrated in Figure 2-3.

Deciding the best combination of approaches to address a public health problem remains an important part of the judgment needed for the practice of public health. In general, multiple approaches are often needed to effectively address a complex problem like cigarette smoking. Population and high risk group approaches, often used by public health professionals, and individual approaches, often used in as part of health care, should be seen as complementary. Often using both types of interventions is more effective than either approach alone. Social interventions, such as cigarette taxes and restrictions on public smoking are also important interventions to consider when asking how to intervene.

The scope of public health problems and the options for intervention are expanding rapidly and now include global, as well as local and national efforts. In China, for instance, 75 percent of adult males are reported to be smokers making China—with its large population—number one in terms of the number of smokers, as well as the number of deaths caused by smoking. An important example of a social intervention is

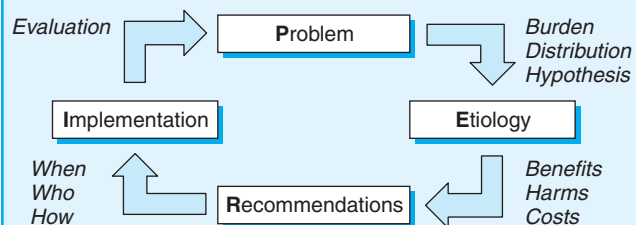
global collaboration to address smoking and health. World Health Organization's (WHO) efforts have led to what the WHO calls the Framework Convention on Tobacco Control (WHO FCTC).<sup>11</sup>

Today, an enormous body of evidence exists on the relationship between tobacco and health. Understanding the nature of the problems, the etiology or cause-and-effect relationships, the evidence-based recommendations, and the approaches for implementing and evaluating the options for interventions, remain key to the public health approach to smoking and health.<sup>4</sup> Figure 2-3 diagrams the full P.E.R.I. approach. Table 2-6 summarizes the questions to ask in the evidence-based public health approach.

The P.E.R.I. process summarizes as a mnemonic the steps in evidence-based public health. It emphasizes the need to understand the nature of the problem and its underlying causes. It also helps structure the use of evidence to make recommendations and decide on which options to put into practice. Finally the circular nature of the P.E.R.I. process reminds us that the job of improving health goes on often requiring multiple efforts to understand and address the problem.<sup>12</sup>

Now that we have an understanding of the basic approach of evidence-based public health let us turn our attention in Section II to the fundamental tools at our disposal for addressing public health problems.

**FIGURE 2-3** Evidence-based public health: The complete P.E.R.I. approach



Source: Adopted from Riegelman RK. Evidence-Based Public Health: The Population Health Approach—Cigarettes and Health. Available at: <http://www.aptrweb.org/undergraduatepublichealth/Evidence-Based%20Public%20Health.doc>. Accessed December 18, 2008.

**TABLE 2-6** Questions to Ask—Evidence-Based Public Health Approach

1. **Problem**—What is the health problem?
  - What is the burden of disease and has it changed over time?
  - Are there differences in the distribution of disease and can these differences generate ideas or hypotheses about their etiology?
  - Are the differences or changes used to suggest group associations artifactual or real?
2. **Etiology**—What are the contributory cause(s)?
  - Has an association been established at the individual level?
  - Does the “cause” precede the “effect”?
  - Has altering the “cause” been shown to alter the “effect” (if not use ancillary criteria)?
3. **Recommendations**—What works to reduce the health impacts?
  - What is the quality of the evidence for the intervention?
  - What is the impact of the intervention in terms of benefits and harms?
  - What grade should be given indicating the strength of the recommendation?
4. **Implementations**—How can we get the job done?
  - When should the implementation occur?
  - At whom should the implementation be directed?
  - How should the intervention(s) be implemented?

Source: Adapted from Riegelman RK. Evidence-Based Public Health: The Population Health Approach—Cigarettes and Health. Available at: <http://www.aptrweb.org/undergraduatepublichealth/Evidence-Based%20Public%20Health.doc>. Accessed December 18, 2008.

## Key Words

- |                                     |   |  |  |
|-------------------------------------|---|--|--|
| ■ P.E.R.I. process                  | ■ Incidence rate                        | ■ Randomized clinical trials or experimental studies | ■ Biological plausibility                                |
| ■ Burden of disease                 | ■ Prevalence rate                       | ■ Risk factor  | ■ Necessary cause  |
| ■ Morbidity                         | ■ Case-fatality                         | ■ Reverse causality                                  | ■ Sufficient cause                                       |
| ■ Mortality                         | ■ Age adjustment                        | ■ Randomization                                      | ■ Effectiveness  |
| ■ Distribution of disease           | ■ Age distribution                      | ■ Natural experiment                                 | ■ Surrogate outcomes                                     |
| ■ Epidemiologists                   | ■ Standard population                   | ■ Efficacy   | ■ Attributable risk percentage (or the percent efficacy) |
| ■ Group associations                | ■ Population comparisons                | ■ Supportive criteria                                | ■ Primary, secondary, and tertiary interventions         |
| ■ Risk indicators (or risk markers) | ■ Ecological studies                    | ■ Ancillary criteria                                 | ■ Victim blaming   |
| ■ Artifactual                       | ■ Confounding variable                  | ■ Relative risk                                      | ■ Proportion   |
| ■ Rate                              | ■ Contributory cause                    | ■ Absolute risk                                      | ■ Consistency  |
| ■ At-risk population                | ■ Case-control or retrospective studies | ■ Odds ratio   | ■ Recommendation   |
| ■ True rate                         | ■ Cohort or prospective studies         | ■ Dose-response relationship                         | ■ Evidence   |
|                                     |   | ■ Protective factor                                  |  |





## Discussion Questions

1. Use the P.E.R.I. framework and the list of questions to outline how each step in the P.E.R.I. process was accomplished for cigarette smoking.
2. How would you use the P.E.R.I. process to address the remaining issues of cigarette smoking?

## REFERENCES

1. Cable News Network. Focus: Tobacco Under Attack. Available at: <http://www.cnn.com/US/9705/tobacco/history/#cigars.htm>. Accessed December 20, 2008.
2. Johnson, Dr. G. A Long Trail of Evidence Links Cigarette Smoking to Lung Cancer. ON SCIENCE column. Available at: <http://www.txtwriter.com/Onscience/Articles/smokingcancer2.html>. Accessed March 12, 2009.
3. Centers for Disease Control and Prevention. The Public Health Approach to Violence Prevention. Available at: [http://www.cdc.gov/ncipc/dvp/PublicHealthApproachTo\\_ViolencePrevention.htm](http://www.cdc.gov/ncipc/dvp/PublicHealthApproachTo_ViolencePrevention.htm). Accessed March 12, 2009.
4. Riegelman RK. The Population Health Approach—Cigarettes and Health. Available at: <http://www.teachprevention.org/>. Accessed March 12, 2009.
5. Gordis L. *Epidemiology*, 4th ed. Philadelphia: Elsevier Saunders; 2009.
6. Friis RH, Sellers TA. *Epidemiology for Public Health Practice*, 4th ed. Sudbury, MA: Jones and Bartlett Publishers; 2009.
7. Riegelman RK. *Studying a Study and Testing a Test: How to Read the Medical Evidence*, 5th ed. Philadelphia: Lippincott, Williams & Wilkins; 2005.
8. United States Department of Health and Human Services. Surgeon General's Reports on Smoking and Tobacco Use. Available at: [http://www.cdc.gov/tobacco/data\\_statistics/sgr/index.htm](http://www.cdc.gov/tobacco/data_statistics/sgr/index.htm). Accessed March 12, 2009.
9. Agency for Healthcare Research and Quality, *U.S. Preventive Services Task Force Guide to Clinical Preventive Services*. 2002; Vols. 1 and 2, AHRQ Pub. No. 02-500.
10. Centers for Disease Control and Prevention. The Community Guide. Available at: <http://www.thecommunityguide.org/>. Accessed March 12, 2009.
11. World Health Organization. Global tobacco treaty enters into force with 57 countries already committed. Available at: <http://www.who.int/mediacentre/news/releases/2005/pr09/en/index.html>. Accessed March 12, 2009.
12. Centers for Disease Control and Prevention. The Social-Ecological Model: A Framework for Prevention. Available at: [http://www.cdc.gov/ncipc/dvp/social-ecological-model\\_dvp.htm](http://www.cdc.gov/ncipc/dvp/social-ecological-model_dvp.htm). Accessed March 12, 2009.



## Section I: Cases and Discussion Questions

### HIV/AIDS Determinants and Control of the Epidemic

A report appeared in the CDC's Morbidity and Morbidity Weekly Report (MMWR) on June 5, 1981 describing a previously unknown deadly disease in five young homosexual males all in Los Angeles. The disease was characterized by dramatically reduced immunity allowing otherwise innocuous organisms to become "opportunistic infections," rapidly producing fatal infections or cancer. Thus, acquired immune deficiency syndrome (AIDS) first became known to the public health and medical communities. It was soon traced to rectal intercourse, blood transfusions, and reuse of injection needles as methods of transmission. Reuse of needles was a common practice in poor nations. It was also widespread among intravenous drug abusers. Within several years the disease was traced to a previously unknown retrovirus which came to be called the human immunodeficiency virus (HIV).

A test was developed to detect the disease and was first used in testing blood for transfusion. Within a short period of time, the blood supply was protected by testing all donated blood and transmission of HIV by blood transfusion became a rare event. Diagnostic tests for HIV/AIDS soon became available for testing individuals. For many years, these were used by clinicians only for high risk individuals. More recently, the CDC has moved toward recommending universal testing as part of routine health care.

In subsequent years, much has been learned about HIV/AIDS. Today it is primarily a heterosexually-transmitted disease with greater risk of transmission from male to females than females to males. In the United States, African-Americans are at the greatest risk. Condoms have been demonstrated to reduce the risk of transmission. Abstinence and monogamous sexual relationship likewise eliminate or greatly reduce the

risk. Even serial monogamy reduces the risk compared to multiple simultaneous partners. Male circumcision has been shown to reduce the potential to acquire HIV infection by approximately 50 percent.

In major U.S. cities, the frequency of HIV is often greater than 1 percent of the population fulfilling the CDC definition of high risk. In these geographic areas the risk of unprotected intercourse is substantially greater than in most suburban or rural areas. Nearly everyone is susceptible to HIV infection despite the fact that a small number of people have well documented protection on a genetic basis.

Maternal-to-child transmission is quite frequent and has been shown to be largely preventable by treatments during pregnancy and at the time of delivery. CDC recommendations for universal testing of pregnant women and intervention for all HIV-positive patients has been widely implemented by clinicians and hospitals and have resulted in greatly reduced frequency of maternal-to-child transmissions in the developed countries and in developing countries as well in recent years.

Medication is now available that greatly reduces the load of HIV present in the blood. These medications delay the progression of HIV, and also reduce the ease of spread of the disease. These treatments were rapidly applied to HIV/AIDS patients in developed countries, but it required about a decade before they were widely used in most developing countries. Inadequate funding from developed countries and controversies over patent protection for HIV/AIDS drugs delayed widespread use of these treatments in developing countries.

New and emerging approaches to HIV prevention include use of antiviral medications during breast feeding, postcoital treatments, and rapid diagnosis and follow-up to detect and treat those recently exposed.

### Discussion Questions

1. Use the BIG GEMS framework to examine the factors in addition to infection that have affected the spread of HIV and control or failure to control the HIV/AIDS epidemic.
2. What roles has health care played in controlling or failing to control the HIV/AIDS epidemic?
3. What roles has traditional public health played in controlling or failing to control the HIV/AIDS epidemic?

4. What roles have social factors (beyond the sphere of health care or public health) played in controlling or failing to control the HIV/AIDS epidemic?

### Smoking and Adolescents— The Continuing Problem

The rate of smoking in the United States has been reduced by approximately one-half since the 1960s. However, the rate of smoking among teenagers increased in the 1980s and 1990s, especially among teenage females. This raised concerns that young women would continue smoking during pregnancy. In addition, it was found that nearly 90 percent of those who smoked started before the age of 18, and in many cases at a considerably younger age.

In the 1980s and most of the 1990s, smoking was advertised to teenagers and even preteens or “tweens,” through campaigns such as Joe Camel. In recent years, a series of interventions directed at teenagers and tweens were put into effect. These included elimination of cigarette vending machines, penalties for those who sell cigarettes to those under 18, and elimination of most cigarette advertising aimed at those under 18. In addition, the Truth<sup>®</sup> campaign aimed to convince adolescents that not smoking was a sign of independence from the tobacco companies who sought to control their behavior, rather than seeing smoking as a sign of independence from their parents. Evaluation studies concluded that these interventions have worked to reduce adolescent smoking by about one-third.

Despite the successes of the early years of the 21<sup>st</sup> century in lowering the rates of cigarette smoking among adolescents, the rates have now stabilized at over 20 percent. Evidence indicates that adolescents who smoke generally do not participate in athletics, more often live in rural areas, and more often white and less often African-American. Males and females smoke about the same amount overall, but white females smoke more and Asian females smoke less than their male counterparts.

New drugs have recently been shown to increase the rates of success in smoking cessation among adults with few side effects. Evidence that the benefits are greater than the harms in adolescents is insufficient to recommend them for widespread use because of increased potential for adverse effects including suicide. A series of interventions has been suggested for addressing the continuing problem of adolescent smoking. These include:

- Expulsion from school for cigarette smoking
- Focus on adolescents in tobacco warning labels
- Selective use of prescriptions for cigarette cessation drugs
- No smoking rules for sporting events, music concerts, and other adolescent-oriented events
- Fines for adolescents who falsify their age and purchase cigarettes
- Higher taxes on tobacco products
- Rewards to students in schools with the lowest smoking rates in a geographic area
- Higher auto insurance premiums for adolescents who smoke
- Application of technology to reduce the quantity of nicotine allowed in tobacco products to reduce the potential for addiction
- Testing of athletes for nicotine and exclusion from competition if they test positive
- Research to develop safer types of cigarettes
- Provision of tobacco counseling as part of medical care covered through insurance

As a recent high school graduate, you are asked to participate in a focus group to determine which of these interventions is likely to be most successful.

### Discussion Questions

1. How does this case illustrate the P.E.R.I. process?
2. Which of these interventions do you think would be most successful? Explain.
3. How would you classify each of these potential interventions as education (information), motivation (incentives), obligation (required), or innovation (technological change)?
4. What other interventions can you suggest to reduce adolescent smoking?

### Reye’s Syndrome: A Public Health Success Story

Reye’s Syndrome is a potentially fatal disease of childhood which typically occurs in the winter months at the end of an episode of influenza, chicken pox, or other acute viral infection. It is characterized by progressive stages of nausea and vomiting, liver dysfunction, and mental impairment that progress over hours to days and result in a range of symptoms from irritability to confusion to deepening stages of loss of consciousness. Reye’s Syndrome is diagnosed by putting together a pattern of signs and symptoms. There is no definitive diagnostic test for the disease.

Reye’s Syndrome was first defined as a distinct condition in the early 1960s. By the 1980s, over 500 cases per year were being diagnosed in the United States. When Reye’s Syndrome was diagnosed there was over a 30 percent case-fatality rate. Early diagnosis and aggressive efforts to prevent brain dam-

age were shown to reduce the deaths and limit the mental complications, but there is no cure for Reye's Syndrome.

In the late 1970s and early 1980s, a series of case-control studies compared Reye's Syndrome children with similar children who also had an acute viral infection, but did not develop the syndrome. These studies suggested that use of aspirin, then called "baby aspirin," was strongly associated with Reye's Syndrome with over 90 percent of those children afflicted with the syndrome having recently used aspirin.

Cohort studies were not practical because they would require observing very large numbers of children who might be given or not given aspirin by their caretakers. Randomized clinical trials were neither feasible nor ethical. Fortunately, it was considered safe and acceptable to reduce or eliminate aspirin use in children because there was a widely-used alternative—acetaminophen (often used as the brand name Tylenol)—that was not implicated in the studies of Reye's Syndrome.

As early as 1980, the CDC cautioned physicians and parents about the potential dangers of aspirin. In 1982, the U.S. Surgeon General issued an advisory on the danger of aspirin for use in children. By 1986, the U.S. Food and Drug Administration required a Reye's Syndrome warning be placed on all aspirin-containing medications. These efforts were coupled with public service announcements, informational

brochures, and patient education by pediatricians and other health professionals who cared of children. The use of the term "baby aspirin" was strongly discouraged.

In the early 1980s, there were over 500 cases of Reye's Syndrome per year in the United States. In recent years, there have often been less than 5 per year. The success of the efforts to reduce or eliminate the use of "baby aspirin" and the subsequent dramatic reduction in the frequency of Reye's Syndrome provided convincing evidence that aspirin was a contributory cause of the condition and its removal from use was an effective intervention.

### Discussion Questions

1. How does the Reye's Syndrome history illustrate the use of each of the steps in the P.E.R.I process?
2. What unique aspects of Reye's Syndrome made it necessary and feasible to rely on case-control studies to provide the evidence to help reduce the frequency of the syndrome?
3. What types of methods for implementation were utilized as part of the implementation process? Can you classify them in terms of when, who, and how?
4. How does the Reye's Syndrome history illustrate the use of evaluation to demonstrate whether the implementation process was successful?