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Attributable Risk Applications in Epidemiology

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Contents

Lesson Plan

TITLE: Attributable Risk Applications in Epidemiology

SUBJECT AREA: Social studies, biology, mathematics, statistics, environmental and health sciences

GOAL: To appreciate the public health value of knowing the risk attributable to a specific exposure

OBJECTIVES:

1. Explain the value of knowing the risk that is attributable to a specific exposure
2. Introduce students to the methods for calculating and interpreting attributable risks
3. Calculate the attributable risks to assess the fraction and portion of the risk due to exposure and predict the impact on the incidence of disease when a causal risk factor is removed
4. Identify the questions that the four measures of attributable risk answer

TIME FRAME: Two 45- to 60-minute classes, with 1 hour of work outside class for readings

PREREQUISITE KNOWLEDGE:

1. Basic knowledge of algebra
2. An understanding of elementary measures of disease frequency, measures of association and the cohort study design

MATERIALS NEEDED: Copies of article on exposure to smoking in movies (included in this module), worksheets (assessment and in-class exercise, included with module) and calculator

EPIDEMIOLOGIC PRINCIPLES: Attributable risk, cohort study, relative risk

PROCEDURE: The module has three major sections:

1. The teacher's notes includes information about basic ideas and procedures related to the concept of attributable risk and the calculation and interpretation of each of the four measures of attributable risk. The teacher can use these notes to prepare a lecture of 45–60 minutes and to provide an in-class example that may take an additional 45–60 minutes.
2. The teacher's narrative includes practical materials, such as transparencies, that can be used directly with students to teach the concept, applications and interpretation of the attributable risk in a step-by-step manner with practical examples.

3. The assessment provides questions that can be used as an in-class examination or as a take-home assessment. A teacher's key is provided. An in-class exercise follows the assessment and also has a teacher's key.

Recommended References

Friis RH, Sellers TA. *Epidemiology for Public Health Practice*. Gaithersburg, MD: Aspen Publishers; 1996.

Kelsey LJ, et al. *Methods in Observational Epidemiology*. 2nd ed. Monographs in Epidemiology and Biostatistics. New York: Oxford University Press; 1996.

Lilienfeld DE, Stolley PD. *Foundations of Epidemiology*. 3rd ed. New York: Oxford University Press; 1994.

NATIONAL SCIENCE EDUCATION STANDARDS:

Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Science in Personal and Social Perspectives

- Personal and community health
- Natural and human induced hazards

Unifying Concepts and Processes

- Systems, order, and organization
- Evidence, models, and measurement

National Science Education Standards, Chapter 6, available at:
http://www.nap.edu/readingroom/books/nses/html

NATIONAL STANDARDS FOR SCHOOL HEALTH EDUCATION:

- Students will comprehend (selected) concepts related to health promotion and disease prevention.
- Students will demonstrate the ability to access valid health information and health promoting products and services.
- Students will analyze the influence of culture, media, technology and other factors on health.
- Students will demonstrate the ability to use goal-setting and decision-making skills to enhance health.

The National Standards for School Health Education available at:
http://www.ericfacility.net/ericdigests/ed387483.html

PRINCIPLES AND STANDARDS FOR SCHOOL MATHEMATICS

- Use mathematical models to represent and understand quantitative relationships.
- Understand measurable attributes of objects and the units, systems, and processes of measurement.
- Apply appropriate techniques, tools, and formulas to determine measurements.
- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.
- Select and use appropriate statistical methods to analyze data.
- Develop and evaluate inferences and predictions that are based on data.
  http://standards.nctm.org/document
- Build new mathematical knowledge through problem solving.
- Solve problems that arise in mathematics and in other contexts.
- Apply and adapt a variety of appropriate strategies to solve problems.
- Monitor and reflect on the process of mathematical problem solving.
  http://standards.nctm.org/document

Glossary

Attributable risk measures

Attributable risk (AR): AR is the portion of the incidence of a disease in the exposed that is due to the exposure. It is the incidence of a disease *in the exposed* that would be eliminated if exposure were eliminated.

Attributable risk percent (AR%): AR% is the percent of the incidence of a disease in the exposed that is due to the exposure. It is the percent of the incidence of a disease *in the exposed* that would be eliminated if exposure were eliminated.

Population attributable risk (PAR): PAR is the portion of the incidence of a disease in the population (exposed and nonexposed) that is due to exposure. It is the incidence of a disease *in the population* that would be eliminated if exposure were eliminated.

Population attributable risk percent (PAR%): PAR% is the percent of the incidence of a disease in the population (exposed and nonexposed) that is due to exposure. It is the percent of the incidence of a disease *in the population* that would be eliminated if exposure were eliminated.

Cohort study

A study in which a group of people who have the exposure and a group of people without the exposure of interest are followed over time to determine whether or not they experience the outcome. The purpose is to compare and contrast the results between the two groups to evaluate if the exposure is associated with the outcome.

Contingency table (2 × 2)

A table commonly used in epidemiologic studies to calculate measures of disease frequency and association from dichotomous categorical variables. A 2×2 table is commonly used to calculate the odds ratio ($OR = ad/cb$) and the relative risk ($RR = a(c + d)/c(a + b)$). A typical 2×2 table in epidemiologic studies is as follows:

	Cases	Noncases
Exposed	*a*	*b*
Nonexposed	*c*	*d*

Incidence rate

It is a measure of disease frequency that assesses the force of morbidity, or the *probability* of developing a disease in a given period of time. It is calculated by dividing the number of new cases by the product of the total number of susceptible people at the beginning of the study period and the time of observation.

Relative risk

The relative risk (RR) is a measure of association between a disease or condition and a factor under study. It is calculated by dividing the incidence rate among those exposed to the factor by the incidence rate among those not exposed to the factor.

$$RR = \frac{\text{Incidence in the exposed}}{\text{Incidence in the nonexposed}}$$

From a 2×2 table of a cohort study, the relative risk could also be calculated as follows:

	Cases	Noncases
Exposed	*a*	*b*
Nonexposed	*c*	*d*

Incidence in the exposed: $a/a + b$

Incidence in the nonexposed: $c/c + d$

$$RR = \frac{\text{Incidence in the exposed}}{\text{Incidence in the nonexposed}} = \frac{a\,/a\ + b}{c\,/c\ + d}$$

The RR is a measure of the relationship between the incidence in the exposed and that in the nonexposed. $RR = 1$ means that the incidence in the exposed is the same as that in the nonexposed, and so there is no association between exposure and disease. $RR > 1$ denotes a larger incidence in the exposed than in the nonexposed—thus exposure to the factor seems to increase the probability of developing the disease. With the same reasoning, $RR < 1$ denotes a smaller incidence in the exposed as compared to the nonexposed—thus exposure to the factor seems to decrease the probability of developing the disease.

Risk

The probability that an event will occur, for example, that an individual will become ill or die, within a period of time.[1]

Reference

1. Last JM, ed., et al. *A Dictionary of Epidemiology*. 4th ed. New York: Oxford University Press; 2000.

Teacher's Notes

Introduction

Many diseases are caused by more than one exposure. For example, lung cancer is caused by exposure to smoking, asbestos, radiation or some chemical products. Public health programs to prevent disease are directed toward reducing or eliminating such causal exposures.

Epidemiologic research not only focuses on the identification and assessment of risk factors but also is concerned with planning and evaluating public health interventions or control measures to reduce the incidence of disease in the population. Being able to predict the impact of removing a particular exposure on the risk of developing a disease is an important public health consideration. It allows those who are responsible for protecting the public's health to make decisions about allocating scarce resources (time, energy, money and political capital) where they will have the most impact. It helps them answer the following questions:

1. What amount of the risk of developing a disease is attributable to a particular exposure?
2. By what percent would the risk of developing disease be reduced if the exposure were eliminated?

If smoking were eliminated, what would happen to the incidence of lung cancer? Would smokers' risk of lung cancer disappear if they stopped smoking?

For public health decision-making purposes, it is valuable to be able to answer these questions from two perspectives: from the perspective of the impact of eliminating the exposure on only those who are exposed and from the perspective of the impact of eliminating the exposure on the entire population, those who are exposed and those who are not exposed.

Note that for purposes of this teaching unit risk and incidence rate (or incidence) can be considered interchangeable. Strictly speaking, however, incidence rate (or incidence) denotes the rate of new cases per unit time whereas risk denotes the rate of new cases in a fixed interval of time.

Measures of Attributable Risk in the Exposed

Attributable risk (AR): AR is the portion of the incidence of a disease in the exposed that is due to the exposure. It is the incidence of a disease *in the exposed* that would be eliminated if exposure were eliminated.

The AR is calculated by subtracting the incidence in the unexposed (I_u) from the incidence in the exposed (I_e):

$$AR = I_e - I_u$$

Attributable risk percent (AR%): AR% is the percent of the incidence of a disease in the exposed that is due to the exposure. It is the proportion of the incidence of a disease *in the exposed* that would be eliminated if exposure were eliminated.

The AR% is calculated by dividing the attributable risk (AR) by the incidence in the exposed (I_e) and then multiplying the product times 100 to obtain a percentage:

$$AR\% = \frac{I_e - I_u}{I_e} \times 100$$

or

$$AR\% = \frac{AR}{I_e} \times 100$$

Measures of Attributable Risk in the Population

Population attributable risk (PAR): PAR is the portion of the incidence of a disease in the population (exposed and nonexposed) that is due to exposure. It is the incidence of a disease *in the population* that would be eliminated if exposure were eliminated.

The PAR is calculated by subtracting the incidence in the unexposed (I_u) from the incidence in total population (exposed and unexposed) (I_p):

$$PAR = I_p - I_u$$

Population attributable risk percent (PAR%): PAR% is the percent of the incidence of a disease in the population (exposed and nonexposed) that is due to exposure. It is the percent of the incidence of a disease *in the population* that would be eliminated if exposure were eliminated.

The PAR% is calculated by dividing the population attributable risk (PAR) by the incidence in the total population and then multiplying the product times 100 to obtain a percentage:

$$PAR\% = \frac{I_p - I_u}{I_p} \times 100$$

or

$$PAR\% = \frac{PAR}{I_p} \times 100$$

Example

The preventive advantages of eating fish have been reported in numerous studies. A recent cohort study[1] reported that not eating fish increased the risk for stroke. The table below shows the results of this study:

Eating Fish and Stroke

Eating Fish	Cases of Stroke	Noncases of Stroke	Total
Never	82 (*a*)	1,549 (*b*)	1,631
Almost daily	23 (*c*)	779 (*d*)	802
Total	105	2,328	2,433

Incidence in the exposed (I_e): $a/a + b = 82/1{,}631 = 0.0503$, or 5.03 per 100
Incidence in the unexposed (I_u): $c/c + d = 23/802 = 0.0287$, or 2.87 per 100
Incidence in both combined (I_p): $a + c/(a + b + c + d) = 105/2{,}433$
$= 0.0432$, or 4.32 per 100

$$RR = \frac{\text{Incidence in the exposed}}{\text{Incidence in the unexposed}} = \frac{a/a + b}{c/c + d}$$

$$RR = \frac{a(c + d)}{c(a + b)} = 5.03/2.87 = 1.75$$

Applying the formulas above to these data (and disregarding the fact that some members of the population may eat fish more than "never" and less than "almost daily") results in the following measures of attributable risk.

$AR = I_e - I_u = 5.03 - 2.87 = 2.16$ per 100
$AR\% = (AR/I_e)\ 100 = (2.16/5.03)\ 100 = 43\%$
$PAR = I_p - I_u = 4.32 - 2.87 = 1.45$ per 100
$PAR\% = (PAR/I_p)\ 100 = (1.45/4.32)\ 100 = 33.6\%$

Assuming that this and many other studies present enough evidence about the preventive advantages of eating fish to reduce stroke, we could interpret the above data as follows:

- Those who never eat fish have 1.75 times as much risk (higher incidence) as those who eat fish almost daily ($RR = 1.75$).

- If those who do not eat fish change their eating habits and begin to eat fish almost daily, their incidence of strokes will decrease by 2.16 per 100 individuals (*AR* = 2.16 per 100), which would represent a 43% reduction of their stroke incidence (*AR*% = 43%).
- A reduction of 1.45 new cases of stroke per 100 population (exposed and unexposed) is expected if everybody eats fish almost daily (*PAR* = 1.45 per 100). Such reduction represents a 33.6% reduction of the incidence in the population (*PAR*% = 33.6%).

Reference

1. Sauvaget C, Nagano J, Allen N, et al. Intake of animal products and stroke mortality in the Hiroshima/Nagasaki Life Span Study. *International Journal of Epidemiology*. 2003;32:536–543.

Teacher's Narrative

Class 1

Chris Robinson, the epidemiologist for the American Lung Society (ALS), gave Jose Rodriguez, ALS's executive director, an article to read—"Effect of Viewing Smoking in Movies on Adolescent Smoking Initiation: A Cohort Study"—about an association between adolescents viewing movies in which smoking occurred and their starting to smoke. **(Transparency 1)** Chris suggested that given the association the ALS should advocate that all movies that depict smoking be given a rating of "R" for "adult content" (children under 17 not admitted without a parent). **(Transparency 2)**

Chris reasoned that an R rating for smoking in movies would not have much effect on the movies that children see because smoking in movies does not sell movie tickets, and movie producers would simply stop putting smoking in movies made for adolescents.

After Mr. Rodriguez read the article, he wrote Chris the following note **(Transparency 3):**

Chris,

As you know, ALS has a limited amount of time, energy, money and political capital to invest in advocating for policy change to prevent lung disease. Given those limitations, it is important that we invest our resources in those prevention strategies that will actually result in the greatest reduction in the incidence of lung disease.

That said, I would like you to make the following assumptions:

1. Assume that the association between adolescents' watching smoking in movies and starting to smoke is causal.
2. Assume we are successful in getting a strategy implemented that will have all movies that depict smoking rated "R."
3. Assume that this strategy, although not successful in preventing all adolescents from viewing all such movies, does reduce the frequency of viewing smoking occurrences so that all adolescents view between 0 and 531 occurrences or what the article refers to as the "first quartile."

Given the above assumptions, I would like you to answer four questions for me:

1. How much of the *total incidence* of starting to smoke among adolescents who view 532 or more smoking occurrences in movies is due to viewing such movies?
2. What *percent* of the incidence of starting to smoke among adolescents who view 532 or more smoking occurrences in movies is due to viewing such movies?
3. How much of the *total incidence* of starting to smoke *among all adolescents* is due to viewing 532 or more smoking occurrences in movies?
4. What *percent* of the total incidence of starting to smoke *among all adolescents* is due to viewing 532 or more smoking occurrences in movies?

I am preparing a list of ALS goals for the coming year and am considering including your "R" rating strategy if I can justify its inclusion.

Jose

Ask students to read the article "Effect of Viewing Smoking in Movies on Adolescent Smoking Initiation: A Cohort Study," and consider how they would go about answering Mr. Rodriguez's first question **(Transparency 4):** "How much of the *total incidence* of starting to smoke among adolescents who view 532 or more smoking occurrences in movies is due to viewing such movies?"

To ensure students' understanding of the article, review their answers to the following questions:

1. Why might viewing movies that depict smoking induce adolescents to start to smoke?

   Movie images link smoking with celebrity and depict it as a behavior associated with characteristics that many adolescents find attractive—toughness, sexiness and rebelliousness.

2. What epidemiologic study design was used to test the hypothesis?

   Cohort study.

3. How was the study implemented?

   The investigators assessed exposure to smoking shown in movies in 3,547 adolescents, aged 10–14 years, who reported in a baseline survey that they had never tried smoking. Exposure to smoking in movies was estimated for individual respondents on the basis of the number of smoking occurrences viewed in a sample of 50 movies randomly selected from a larger sample pool of popular contemporary movies. The investigators recontacted 2,603 (73%) students 13–26 months later for a follow-up interview to determine whether they had begun to smoke.

4. What were the results of the study?

   Overall, 10% ($n = 259$) of students initiated smoking during the follow-up period. In the highest quartile of exposure to movie smoking, 17% (107) of adolescents had initiated smoking, compared with only 3% (22) in the lowest quartile. After controlling for possible confounders, adolescents in the highest quartile of exposure to movie smoking were 2.71 times as likely to initiate smoking compared with those in the lowest quartile.

5. For what potential confounders did the investigators account?

   At baseline the investigators measured the following potent confounders of the association between movie exposure and adolescent smoking initiation: child characteristics (sex, age, school, self-reported school performance, sensation seeking, rebelliousness and self-esteem), social influences (parent, sibling and friend smoking; receptivity to tobacco promotions) and parenting characteristics (parent education, two measures of authoritative parenting and adolescents' perception of parental disapproval of smoking).

6. What does the relative risk of 2.25 mean for "Either Parent Smokes—Yes" in Table 1?

   Adolescents who had a parent who smoked were 2.25 times as likely to start smoking as adolescents who had parents who did not smoke. (Transparency 5):

7. What does the relative risk of 0.55 mean for "Maternal Responsiveness—Fourth Quartile" in Table 1*?*

   Adolescents who scored in the fourth quartile for maternal responsiveness were 0.55 times as likely to start smoking as adolescents who scored in the first quartile. In other words adolescents who scored in the fourth quartile for maternal responsiveness were 45% less likely to start smoking as adolescents who scored in the first quartile. (Transparency 6):

8. What characteristic shown in Table 1 had the strongest association with smoking initiation?

   "Movie Smoking Exposure—Fourth Quartile"

9. What does the relative risk of 4.31 mean for "Movie Smoking Exposure—Fourth Quartile" in Table 1?

   Adolescents who scored in the fourth quartile for movie smoking exposure were 4.31 times as likely to start smoking as adolescents who scored in the first quartile. (Transparency 7)

10. What does the following statement mean? "Although the relative risks were attenuated, the relation between exposure to movie smoking and smoking initiation remained significant after adjustment for all baseline covariates."

    When the data were adjusted for possible confounders for smoking initiation and analyzed, the relative risk for adolescents in the fourth quartile for movie smoking exposure was 2.71. Although the relative risk of 2.71 was not as strong as the unadjusted relative risk of 4.31, it was unlikely to have been due to chance.

Ask students to complete the 2 × 2 Table A below **(Transparency 8)** by using the "Movie Smoking Exposure" data shown at the bottom of Table 1 in the article. They should consider all adolescents in the second, third and fourth quartiles (having viewed movies with 532–5,308 occurrences of smoking) as exposed and all adolescents in the first quartile (having viewed movies with 0–531 occurrences of smoking) as unexposed.

2 × 2 Table A

	Tried Smoking	**Did Not Try Smoking**	**Total**
Exposed (second, third and fourth quartiles: 532–5,308 occurrences)	*a*	*b*	
Unexposed (first quartile: 0–531 occurrences)	*c*	*d*	
Total			

Compare students' answers with 2 × 2 Table B below **(Transparency 9):**

2 × 2 Table B

	Tried Smoking	Did Not Try Smoking	Total
Exposed (second, third and fourth quartiles: 532–5,308 occurrences)	237 *a*	1,715 *b*	1,952
Unexposed (first quartile: 0–531 occurrences)	*c* 22	*d* 629	651
Total	259	2,344	2,603

Ask students the following question: Based on the data in 2 × 2 Table B, what is the probability that these adolescents, regardless of their movie viewing status, would start to smoke during the study?

Probe until students conclude that because 259 of the 2,603 adolescents in the study started to smoke, the probability was 259/2,603 = 0.0995 = 99.5/1,000.

Tell students that epidemiologists call what they just calculated a risk, which is defined as "the probability that an event will occur, for example, that an individual will become ill or die, within a period of time."[1] **(Transparency 10)**

Ask students to rephrase this definition so it is applicable to the article they read for homework. **(The probability of starting to smoke among the adolescents included in the study was 99.5/1,000.)**

Ask students to develop a formula for calculating the risk where **(Transparency 11):**

- *R* represents the risk
- *E* represents the number of people who experienced the event
- *N* represents the study population

Compare students' answers with the formula below **(Transparency 12):**

$$R = \frac{E}{N}$$

Ask students, using the data in Table B, to calculate the risk of smoking among adolescents *exposed* to movies with 532 or more occurrences of smoking.

Compare students' answers with the calculation below **(Transparency 13):**

$$237/1{,}952 = 0.121 = 121/1{,}000 \text{ adolescents}$$

Ask students, using the data in Table B, to calculate the risk of smoking among adolescents *unexposed* to movies with 532–5,308 occurrences of smoking.

Compare students' answers with the calculation below **(Transparency 14):**

$$22/651 = 0.0338 = 34/1{,}000 \text{ adolescents}$$

Note that the relative risk is 3.6:

$$RR = 0.121/0.0338 = 3.6$$

Ask students to identify reasons why people smoke.

Probe until students conclude that although viewing movies depicting smoking may be one cause of adolescent smoking, there are other reasons why adolescents begin to smoke—for example, peer pressure, advertising and imitating parents who smoke.

(Transparency 15) Ask students which of the two columns represents the risk of starting to smoke in adolescents exposed to 532 or more occurrences of smoking in movies. (See page 17 for chart.) **(A)**

Ask students which of the two columns represents the risk of starting to smoke in adolescents unexposed to 532 or more occurrences of smoking in movies. **(B)**

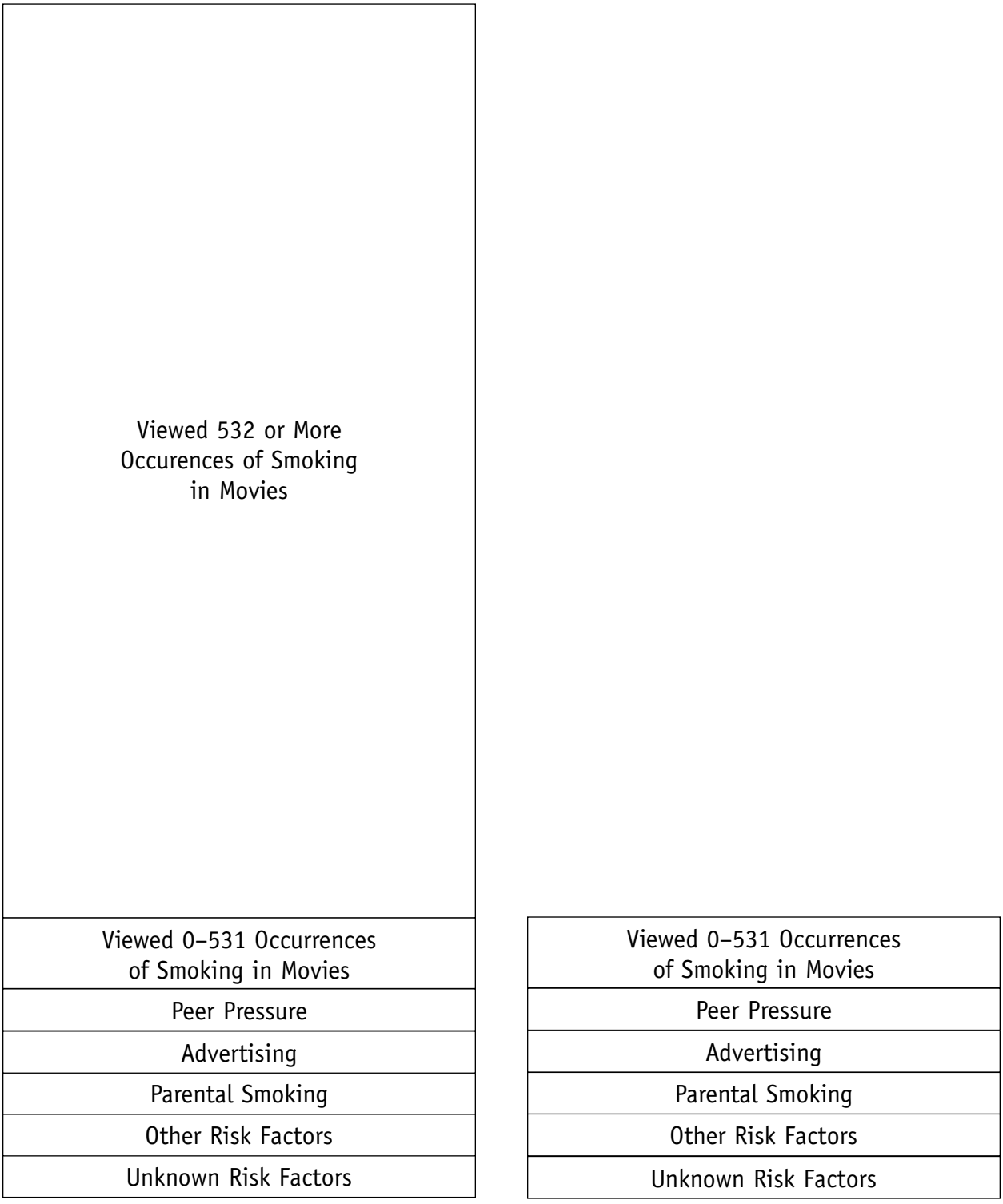
Point out that being unexposed does not mean that the adolescents in that group are not exposed to any risk factors for starting to smoke. It means that they are unexposed to the risk factor being investigated, in this case viewing 532 or more occurrences of smoking in movies. (Please note that for this example the relative thickness of the lowest five strata is identical. In reality the contributions of unknown risk factors and advertising to the overall risk are unknown, and the statistical adjustment made by the investigators had the effect of equalizing the contributions of peer pressure, parental smoking and other risk factors to smoking initiation in the exposed and nonexposed groups.)

Tell students that the risk in the unexposed group is referred to as the **background risk.**[2] **(Transparency 16)**

Also point out that these columns assume that the risk factors not being investigated are equally distributed between the exposed and unexposed groups.

Ask students which of the two columns on page 17 in Transparency 15 represents the total risk of starting to smoke among those who have been exposed. (See page 17 for chart) **(A)**

Ask students, given the above, how they would go about answering Mr. Rodriguez's first question **(Transparency 17):** "How much of the *total incidence* of starting to smoke among adolescents who view 532 or more smoking occurrences in movies is due to viewing such movies?"



Column A

121 of 1,000
adolescents try smoking

Column B

34 of 1,000
adolescents try smoking

Probe until students conclude that this question can be answered by subtracting the risk of starting to smoke among unexposed adolescents (34/1,000) from the total risk among exposed adolescents (121/1,000).

Ask students how much of the risk of starting to smoke among adolescents who viewed 532 or more smoking occurrences in movies is due to viewing those movies. **(121/1,000) – (34/1,000) = 87/1,000**

Ask students what the difference of 87/1,000 means.

Of the total risk of starting to smoke among adolescents who view movies with 532 or more smoking occurrences, 121 per 1,000 adolescents, 87 per 1,000 are a result of having viewed such movies, given the assumption that the association is causal.

Tell students that epidemiologists call what they just calculated the **attributable risk** (AR) for the exposed group, which is defined as the portion of the incidence of a disease or other health-related outcome in the exposed that is due to the exposure. **(Transparency 18):**

Ask students to rephrase this definition so it is applicable to the article they read for homework.

Among adolescents who viewed 532 or more smoking occurrences in movies, the portion of the incidence of starting to smoke that can be attributed to viewing such movies was 87/1,000. That is 87 new smokers for every 1,000 adolescents who viewed 532 or more smoking occurrences in movies.

Ask students to develop a formula for calculating the attributable risk where **(Transparency 19):**

- AR represents the attributable risk
- I_e represents the incidence in the exposed
- I_u represents the incidence in the unexposed

Compare students' answers with the formula below **(Transparency 20).**

$$AR = I_e - I_u$$

Ask students how they would go about answering Mr. Rodriguez's second question **(Transparency 21):** "What *percent* of the incidence of starting to smoke among adolescents who view 532 or more smoking occurrences in movies is due to viewing such movies?"

Probe until students conclude that in this case the total risk among adolescents who view 532 or more smoking occurrences in movies (121/1,000) is the denominator and the numerator is the portion of total risk that is due to viewing 532 or more smoking occurrences in movies (87/1,000).

Ask students what proportion of the total risk of starting to smoke among adolescents who view 532 or more smoking occurrences in movies is due to viewing 532 or more smoking occurrences in movies.

Compare students' answers with the calculation below **(Transparency 22):**

$$\frac{(22/1{,}000 - (34/1{,}000)}{121/1{,}000} = \frac{87/1{,}000}{121/1{,}000} = 0.719$$

Ask students what the proportion of 0.719 means.

It means that 71.9% of the total risk of starting to smoke among adolescents who view 532 or more smoking occurrences in movies ("exposed" group) is due to viewing these 532 or more occurrences.

Tell students that epidemiologists call what they just calculated the **attributable risk percent** (AR%), which is defined as the percent of the incidence of a disease in the exposed that is due to the exposure. **(Transparency 23)**

Ask students to rephrase this definition so it is applicable to the article they read for homework.

Among adolescents who view 532 or more smoking occurrences in movies, the percent of the incidence of starting to smoke that can be attributed to viewing such movies was 71.9%.

Ask students to develop a formula for calculating the attributable risk percent where **(Transparency 24):**

- *AR%* represents attributable risk percent
- I_e represents the incidence in the exposed
- I_u represents the incidence in the unexposed

Compare students' answers with the formula below **(Transparency 25):**

$$AR\% = \frac{I_e - I_u}{I_e} \times 100$$

Ask students to consider Mr. Rodriguez's third question **(Transparency 26):** "How much of the *total incidence* of starting to smoke *among all adolescents* is due to viewing 532 or more smoking occurrences in movies?"

Point out to students that there is a difference in perspective between Mr. Rodriguez's third question and his first and second. In the first and second questions, Mr. Rodriguez was interested in learning the impact of reducing adolescents' viewing of smoking occurrences in movies on *only those adolescents who were exposed* to 532 or more smoking occurrences in movies. Now, in the third question Mr. Rodriguez has broadened his interest and wants to learn the impact of reducing adolescents' viewing of smoking occurrences in movies on the *entire adolescent population,* those who were exposed to 532 or more smoking occurrences in movies as well as those who were not.

Ask students to refer back to 2 × 2 Table B. **(Transparency 27)**

2 × 2 Table B

	Tried Smoking	Did Not Try Smoking	Total
Exposed (second, third and fourth quartiles: 532–5,308 occurrences)	237 *a*	1,715 *b*	1,952
Unexposed (first quartile: 0–531 occurrences)	*c* 22	*d* 629	651
Total	259	2,344	2,603

Ask students what the total incidence of starting to smoke among all adolescents in the study sample is. **(259/2,603 = 0.0995)**

Ask students how they would determine how much of that total incidence was due to viewing 532 or more smoking occurrences in movies.

Probe until students realize that it is necessary to subtract the incidence of starting to smoke among the adolescents who did not view 532 or more smoking occurrences in movies (22/651 = 0.0338) from the total incidence of starting to smoke among all adolescents (259/2,603 = 0.0995).

Therefore, the answer to Mr. Rodriguez's third question is 0.0995 − 0.0338 = 0.0657, or 65.7 per 1,000.

Tell students that epidemiologists call what they just calculated the **population attributable risk** (PAR), which is defined as the portion of the incidence of a disease in the population (exposed and nonexposed) that is due to exposure. **(Transparency 28)**

Ask students to rephrase this definition so it is applicable to the article they read for homework.

The portion of the incidence of starting to smoke among all adolescents in a population that can be attributed to viewing movies with 532 or more smoking occurrences is 65.7 per 1,000.

Ask students to develop a formula for calculating the population attributable risk where **(Transparency 29):**

- *PAR* represents population attributable risk
- I_u represents the incidence in the unexposed
- I_p represents the incidence in the population

Compare students' answers with the formula below **(Transparency 30).**

$$PAR = I_p - I_u$$

Finally, ask students to consider Mr. Rodriguez's fourth question **(Transparency 31):** "What *percent* of the total incidence of starting to smoke *among all adolescents* is due to viewing 532 or more smoking occurrences in movies?"

Point out to students that Mr. Rodriguez is again interested in the impact of reducing adolescents' viewing of smoking occurrences in movies on the *entire adolescent population*.

Ask students to refer back to 2 × 2 Table B. **(Transparency 32).**

Ask students what the denominator is in the proportion for which Mr. Rodriguez is asking.

The total risk of starting to smoke among all adolescents, 259/2,603 = 0.0995.

Ask students what the numerator is in the proportion for which Mr. Rodriguez is asking.

The total risk of starting to smoke among all adolescents, 259/2,603 = 0.0995, less the incidence of starting to smoke among the adolescents who did not view 532 or more smoking occurrences in movies, 22/651 = 0.0338, or the population attributable risk, 0.0657.

Ask students what proportion of the incidence of starting to smoke is due to viewing 532 or more smoking occurrences in movies *in the total population of adolescents*.

$$\frac{0.0657}{0.0995} = 0.6603$$

Ask students what the proportion of 0.6603 means.

If no adolescents viewed 532 or more smoking occurrences in movies, 66% fewer adolescents would start to smoke.

Tell students that epidemiologists call what they just calculated a **population attributable risk percent** (PAR%), which is defined as the percent of the incidence rate of a disease in the population (exposed and nonexposed) that is due to an exposure. **(Transparency 33)**

Ask students to rephrase this definition so it is applicable to the article they read for homework.

The percent of the incidence of starting to smoke among adolescents that is due to viewing 532 or more smoking occurrences in movies was 66%.

Ask students to develop a formula for calculating the population attributable risk percent where **(Transparency 34):**

- *PAR*% represents the population attributable risk percent
- I_p represents the incidence in the total population
- I_u represents the incidence in the unexposed

Compare students' answers with the formula below **(Transparency 35):**

$$PAR\% = \frac{I_p - I_u}{I_p} \times 100$$

Class 2

Tell students that in response to Jose's note Chris wrote the following **(Transparency 36):**

Jose,

Given your assumptions and based on the results of the study "Effect of Viewing Smoking in Movies on Adolescent Smoking Initiation: A Cohort Study," the answers to your questions are as follows:

1. How much of the *total incidence* of starting to smoke among adolescents who view 532 or more smoking occurrences in movies is due to viewing such movies?

   Among a cohort of 1,000 adolescents, aged 10–14 years and followed for 13–26 months, the incidence of starting to smoke that is due to viewing 532 or more smoking occurrences in movies (attributable risk) is 87 per 1,000.
2. What *percent* of the incidence of starting to smoke among adolescents who view 532 or more smoking occurrences in movies is due to viewing such movies?

   The proportion of the total risk of starting to smoke among adolescents who view 532 or more smoking occurrences in movies that is due to viewing such movies (attributable risk percent) is 71.9%.
3. How much of the *total incidence* of starting to smoke *among all adolescents* is due to viewing 532 or more smoking occurrences in movies?

   Of the *total incidence* of starting to smoke *among all adolescents,* 65.7 cases per 1,000 are due to viewing 532 or more smoking occurrences in movies (population attributable risk).
4. What *percent* of the total incidence of starting to smoke *among all adolescents* is due to viewing 532 or more smoking occurrences in movies?

   The *proportion* of the total risk of starting to smoke *among all adolescents* that is due to viewing 532 or more smoking occurrences in movies (population attributable risk percent) is 66%.

Given ALS's limited amount of time, energy, money and political capital, I hope this is helpful in deciding whether or not ALS should advocate that all movies that depict smoking be given a rating of "R" for "adult content."

Chris

Ask students to assume the role of Jose Rodriguez, the executive director of the American Lung Society, in deciding whether they would or would not advocate that all movies that depict smoking be given a rating of "R" for "adult content."

If the following questions do not arise during class discussion, raise them at the appropriate times during the discussion:

1. Is this association really causal? Although Mr. Rodriguez asked Chris to assume that the association was causal, does it intuitively make sense that viewing movies in which smoking occurs would actually cause adolescents to start smoking? Is it possible that this association is not causal and was found because of chance, bias, confounding or reverse time order?
   - ***Chance:*** **This was one of the first studies that investigated this association. If several more studies found the same association in other similar populations, one would be more confident in ruling out the possibility that this association was found by chance. The results of this study were statistically significant, meaning that chance was an unlikely explanation for the findings.**
   - ***Bias:*** **The investigators were able to follow up on 73% of the original sample of adolescents. If the 27% of the sample for whom follow-up was missing had different movie viewing and smoking behaviors, selection bias could have influenced the results.**
   - ***Confounding:*** **The authors paid careful attention to possible confounders in their analysis. However, other unknown confounders could have influenced the magnitude of the association.**
   - ***Reverse time order:*** **Previous studies investigating this hypothesis were cross-sectional studies and could not rule out the possibility that the association had been found because adolescent smokers are more likely to have viewed movies in which smoking occurred. This investigation was a cohort study in which the participants had never previously tried smoking. Exposure to movies was reported at baseline, so onset of smoking occurred after that exposure.**

2. If the association were *not* causal, what would be the consequences of the ALS's getting all movies that depict smoking a rating of "R" for "adult content?"

   Only if the association between movie viewing and smoking initiation is causal will eliminating the exposure help prevent the outcome. If the association is due to any of the other above explanations, eliminating the hypothesized cause will not affect the outcome. If this were the case, valuable time, energy money and political capital would have been wasted, and the ALS would have lost credibility and may not be believed the next time it makes a suggestion.

3. What factors other than science would also influence the adoption of a policy that would give all movies that depict smoking a rating of "R" for "adult content"?

   Even if the association is causal, decisions about possible disease prevention strategies are based on more than the scientific evidence. Given competing values it seems likely that social, economic and political factors would also be considered: movie directors' artistic freedom; the reelection of political representatives from tobacco-growing and movie-producing states; and civil libertarians' questions about what behavior will be targeted next—sex, cursing or eating fatty food.

4. In summary how can we report the findings of this study as illustrated by attributable risk calculations?

   - **Those who watch movies with 532 or more smoking occurrences have 3.6 times as much risk of becoming smokers as those who watch movies with fewer occurrences (*RR* = 3.6).**
   - **If those who watch movies with 532 or more smoking occurrences do not watch these movies anymore, the rate of new smokers will decrease by 87 per 1,000 individuals among them (*AR* = 87 per 1,000), which represents a 71.9% reduction of the smoking rate among those who are currently watching movies with 532 or more smoking occurrences (*AR*% = 71.9%).**
   - **A reduction of 6.6 new smokers per 100 population (exposed and unexposed) is expected if nobody watches movies with 532 or more smoking occurrences (*PAR* = 65.7 per 1,000). Such reduction represents a 66% reduction in the rate of new smokers in the population (PAR% = 66.0%).**

References

1. Last JM, ed., et al. *A Dictionary of Epidemiology*. 4th ed. New York: Oxford University Press; 2000.
2. Gordis L, *Epidemiology*. 2nd ed. Philadelphia: WB Saunders; 1996.

Assigned Article

The article below was adapted from *The Lancet,* 2003;362:281–285, which was published online June 10, 2003, at http://image.thelancet.com/extras/03art1353web.pdf. *The Lancet* is a British medical journal and therefore observes the British spelling of certain words such as behaviour, recognise, modelled, and generalisability.

Effect of Viewing Smoking in Movies on Adolescent Smoking Initiation: A Cohort Study

Madeline A Dalton, James D Sargent, Michael L Beach, Linda Titus-Ernstoff, Jennifer J Gibson, M Bridget Ahrens, Jennifer J Tickle, Todd F Heatherton

Summary

Background: Exposure to smoking in movies has been linked with adolescent smoking initiation in cross-sectional studies. We undertook a prospective study to ascertain whether exposure to smoking in movies predicts smoking initiation.

Method: We assessed exposure to smoking shown in movies in 3,547 adolescents, aged 10–14 years, who reported in a baseline survey that they had never tried smoking. Exposure to smoking in movies was estimated for individual respondents on the basis of the number of smoking occurrences viewed in unique samples of 50 movies, which were randomly selected from a larger sample pool of popular contemporary movies. We successfully recontacted 2,603 (73%) students 13–26 months later for a follow-up interview to determine whether they had initiated smoking.

Findings: Overall, 10% (n = 259) of students initiated smoking during the follow-up period. In the highest quartile of exposure to movie smoking, 17% (107) of students had initiated smoking, compared with only 3% (22) in the lowest quartile. After controlling for baseline characteristics, adolescents in the highest quartile of exposure to movie smoking were 2·71 (95% CI 1·73–4·25) times more likely to initiate smoking compared with those in the lowest quartile. The effect of exposure to movie smoking was stronger in adolescents with non-smoking parents than in those whose parent smoked.

Interpretation: Our results provide strong evidence that viewing smoking in movies promotes smoking initiation among adolescents.

Introduction

Many studies have linked tobacco marketing with an increased risk of smoking uptake in adolescents. For example, owning tobacco promotional items and being able to recall cigarette advertisements can double the odds that an adolescent will become an established smoker. Movie images, like commercial advertising, associate smoking with celebrities and depict it as an attractive behaviour. In popular contemporary movies, smoking is frequently associated with characteristics many adolescents find appealing—such as toughness, sexiness, and rebelliousness. Endorsement of cigarette brands in movies by actors has also increased substantially over the past decade.

Several studies have described how smoking is portrayed in movies, but only a few have specifically assessed whether viewing smoking in movies affects adolescent smoking behaviour. In an experimental study, Pechmann and Shih showed that adolescents were more likely to report positive attitudes toward smoking after seeing smoking portrayed in movies. Results of two cross-sectional studies indicated that adolescents were more likely to have tried smoking if their favourite movie stars smoked on screen. In our previous study of adolescents in New England, USA, exposure to smoking in movies was associated with smoking experimentation, even after controlling for the effects of other social influences, parenting, and personality characteristics of the child.

Collectively, these results suggest that movie smoking influences adolescent smoking behaviour. However, the cross-sectional design of these studies precludes establishment of a temporal relation. To determine whether exposure to movie smoking predicts smoking initiation in adolescents, we did a longitudinal study of adolescents in New England, USA, who had never previously tried smoking.

Methods

PARTICIPANTS

In 1999, we distributed a self-administered written survey to adolescents (aged 10–14 years) enrolled in grades 5 through 8 at 14 schools in Vermont and New Hampshire, USA. The purpose of this baseline survey was to assess exposure to smoking in movies and investigate its association with lifetime smoking experience. Details of the methods for the survey have been published previously.

Through the baseline survey, we identified 3,547 adolescents who had never tried smoking cigarettes and were thus eligible for a follow-up 13–26 months later to assess risk factors for smoking initiation. The follow-up telephone interviews, accomplished for 2,603 (73%) eligible baseline participants, were done by trained interviewers using a computer-assisted telephone interview system. To protect confidentiality, students indicated their answers by pressing numbers on the telephone. We used a PC Telecom digit grabber (Metrotel, Milpitas, CA) so that

every time a student pressed a number, the answer was automatically entered into the database. The protocol for this study was approved by the Dartmouth committee for the protection of human subjects.

PROCEDURES

We assessed lifetime smoking experience at baseline and follow-up by asking "How many cigarettes have you smoked in your life?", to which respondents could answer "none," "just a few puffs," "one to 19 cigarettes," "20 to 100 cigarettes," or "more than 100 cigarettes." Only students who answered "none" at baseline were eligible for follow-up. Students who reported any cigarette smoking (just a few puffs, one to 100 cigarettes, more than 100 cigarettes) on the follow-up survey were classified as having initiated smoking during the follow-up period. Adolescents' exposure to smoking in movies was assessed at baseline by asking each student to indicate which films he or she had seen from a unique list of 50 movies. A list of 50 movies was randomly selected for each individual survey from a sample of 601 popular contemporary movies released between 1988 and 1999. The 601 movies included the top 25 box-office hits every year from 1988 to 1995 (n = 200); the top 100 box-office hits per year from 1996 to 1998 (300); the top 50 box-office hits from the first half of 1999; and 51 additional movies selected because they featured stars popular among adolescents. We stratified the random selection of movies so that each list of 50 had the same distribution of ratings as the larger sample of top box-office hits: 45% R (restricted, younger than 17 years requires accompanying parent or adult guardian), 31% PG-13 (parents strongly cautioned, some material might be inappropriate for children younger than 13 years), 20% PG (parental guidance suggested, some material might not be suited for children), 4% G (general audiences, all ages admitted). On average, every movie title was included in 470 questionnaires. Trained coders counted the number of occurrences of smoking in each movie using methods previously described. We calculated exposure to movie smoking for each respondent by summing the number of smoking occurrences for each movie the respondent had seen. We adjusted for possible variation in the movie lists by expressing individual exposure to movie smoking as a proportion of the total number of possible smoking occurrences each student could have seen on the basis of the movies included in their survey. Exposure to movie smoking was classified in quartiles with the following cutoffs: 0–531 occurrences for the 1st quartile, 532–960 for the 2nd quartile, 961–1,664 for the 3rd quartile, and 1,665–5,308 for the 4th quartile.

We also measured at baseline, through questions adapted from previously validated questionnaires, variables that could potentially confound the association between movie exposure and adolescent smoking initiation. These variables included child characteristics (sex, age, school, self-reported school performance, sensation seeking, rebelliousness, and self-esteem), social influences (parent, sibling, and friend smoking; receptivity to tobacco promotions), and parenting characteristics (parent education, two measures of authoritative parenting, and adolescents' perception of parental disapproval of smoking). Individual items used to measure student personality and parenting characteristics have been reported previously. Students used a

four-point response scale to indicate how well specific statements described themselves or their mothers (or primary caregiver if they did not have a mother). Summary measures were created by adding their responses to each of the individual items, so that higher scores signify more of each characteristic. We then divided the scores into quartiles.

STATISTICAL ANALYSIS

Preliminary analyses consisted of descriptive frequencies, χ^2 tests to compare differences in proportions, and *t* tests to compare mean differences by group. We used generalised linear models to assess smoking initiation as a function of both movie exposure and baseline covariates. We used a log link, rather than a logistic regression, so that relative risks could be estimated directly. An overdispersion variable was used to account for possible clustering by schools. Exposure to movie smoking was treated as a categorical variable. The dependent variable was whether the respondent had initiated smoking during the follow-up period. We did multivariate analyses with both minimally adjusted (age, sex, and school) and fully adjusted models. The fully adjusted models included all terms for child characteristics, social influences, and parenting characteristics as described above, as well as the time elapsed between the baseline and follow-up surveys. We assessed model fit and interaction terms with changes in deviances and standard diagnostic plots. Results were judged significant if $p<0{\cdot}05$, in a two-sided test. Simulation methods, similar to those used by Connors and colleagues, were used to test whether an unmeasured confounder could falsely implicate movie exposure.

ROLE OF THE FUNDING SOURCE

The sponsor of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

Our final sample of 2,603 adolescents was mainly white (94%, n = 2,392), as was the underlying population (96%); equally distributed by sex; with a mean age at baseline of 12 years (SD 1.1). Participants who were followed up were much the same as non-participants in age, sex, grade, and exposure to movie smoking, but non-participants were more likely than participants to have parents who smoke (41% [383] *vs* 30% [773], respectively) and slightly more likely to be susceptible to smoking at baseline (27% [257] *vs* 23% [592]); report average or below average school performance (25% [237] *vs* 19% [484]); have friends who smoke (30% [282] *vs* 26% [671]); and have siblings who smoke (14% [134] *vs* 10% [267]). Reasons for non-participation included refusal to provide contact information at baseline (35%, 326), refusal to participate in the interview at the time of follow-up (31%, 288), and lost-to-follow-up (35%, 330).

On average, students had seen 16 of the 50 movies they were asked about, from which they were exposed to an average of $98{\cdot}5$ (SD $75{\cdot}1$) smoking occurrences. Exposure to movie smoking increased with age and was higher in boys than in girls. Girls saw a mean of $14{\cdot}6$ movies ($7{\cdot}4$), from which they viewed a mean of $85{\cdot}1$ smoking occurrences ($66{\cdot}4$), whereas boys saw a mean

of 17·1 movies (8·2), from which they viewed 113·5 smoking occurrences (81·2). Exposure to movie smoking was positively associated with sensation seeking ($p<0·0001$) and rebelliousness ($p<0·0001$), and inversely associated with school performance and measures of authoritative parenting ($p<0·0001$)).

10% (259) of participants initiated smoking during the follow-up period. Most (80%, n = 208) of those who initiated smoking reported that they had smoked "just a few puffs" of a cigarette. Only 2% (six) of those who initiated smoking had smoked more than 100 cigarettes during follow-up. Analyses adjusted for age, sex, and school showed significant associations between baseline characteristics, including exposure to movie smoking, and smoking initiation (Table 1 [on pages 31–33]). Relative to the lowest quartile of movie smoking exposure, the risk for smoking initiation increased with each successive quartile of exposure (Table 1). Although the relative risks were attenuated, the relation between exposure to movie smoking and smoking initiation remained significant after adjustment for all baseline covariates. Compared with the lowest exposure level, adolescents in the second, third and fourth quartiles were two to three times more likely to initiate smoking during follow-up.

We assessed potential interactions between exposure to movie smoking and age, sex, and social influences (friend, sibling, and parent smoking) on smoking initiation and identified a significant interaction between exposure and parental smoking behaviour ($p=0·003$). In adolescents with non-smoking parents, the risk of smoking initiation increased substantially with greater exposure to movie smoking. Those with smoking parents had an overall higher risk of smoking initiation, but were less influenced by exposure to movie smoking than those whose parents did not smoke.

Our simulation studies indicate it is unlikely that an unmeasured covariate was responsible for the association between exposure to movie smoking and smoking initiation. To raise the relative risk to the magnitude we recorded, a potential confounder would need to be associated with both movie exposure (with a minimum correlation of 0·2) and smoking initiation (minimum relative risk of 1·2) and be independent of all other covariates we measured. An unmeasured independent covariate would have to have p values of less than 0·00001 associated with both movie exposure and smoking initiation. This is unlikely because any covariate we did not measure would almost certainly be associated with at least one of the measured covariates, so that a substantial proportion of the variability would already be accounted for.

Discussion

Our results suggest that viewing smoking in movies strongly predicts whether or not adolescents initiate smoking, and the effect increases significantly with greater exposure. Adolescents who viewed the most smoking in movies were almost three times more likely to initiate smoking than those with the least amount of exposure. The magnitude of this association is consistent with the results of our cross-sectional study of adolescents in New England, USA. It is also consistent with the results of other cross-sectional studies that have linked actor smoking with adolescent smoking and visual media exposure with high risk behaviour in adolescents.

The data suggest that children with non-smoking parents are especially susceptible to the effect of movie smoking exposure. Children with parents who smoke might have a more realistic view of smoking, so they are less likely to be influenced by the glamorous portrayal of smoking in movies. However, an equally plausible explanation is that children with parents who smoke are already at a higher risk for smoking initiation, so their risk is less likely to be raised by other social influences. Further research is needed to understand this interaction fully.

Although it is not feasible to completely measure an adolescent's total lifetime exposure to smoking in movies, every survey in our study contained 50 randomly selected movies from a larger sample of 601 films, stratified by rating. Thus, our assessment is an unbiased estimate of adolescents' exposure to smoking in popular, contemporary movies. Unlike most measures of exposure to tobacco marketing, this assessment reflects actual exposure rather than adolescents' attention, attitudes or predispositions to smoking. However, because almost all R-rated movies contain smoking, we could not separate the effects of an R-rating and smoking content. Consequently, we cannot exclude the possibility that some other aspect of R-rated movies influences smoking initiation. However, more than 40 years of research shows that observers imitate specific behaviours they see modelled. Thus, our inference that adolescents imitate smoking behaviour seen in movies seems reasonable. The generalisability of our findings might be restricted because our sample included a mainly white, rural population.

The effect of exposure to movie smoking is important, both because the effect on smoking initiation is moderately strong and because the exposure is almost universal. Based on the lists of 50 randomly selected movies, only five (0·2%) participants were unexposed to movie smoking. If the link between exposure to smoking in movies and smoking initiation proves to be causal, our data suggest that eliminating adolescents' exposure to movie smoking could reduce smoking initiation by half. However, we recognise that the equation might not be that simple, since many factors affect movie exposure and its effect on adolescent behaviour. We controlled for as many of these factors as possible, and our sensitivity analysis suggests that an unmeasured variable is unlikely to account for the association between exposure to movie smoking and smoking initiation. Because the follow-up period for this study was brief, we could not assess the possibly greater effects of longer term exposure. Consequently, the effect of reducing exposure to smoking in movies over many years could be larger than that we recorded. Nonetheless, it is important to point out that this study links movie smoking exposure with smoking initiation, and not all initiators will become established smokers. Further research is needed to assess the effect of exposure to smoking in movies on long-term smoking behaviour.

Table 1: Predictors of Smoking Initiation

Characteristic	Total (n = 2,603)	Tried Smoking	Relative Risk* (95% CI)
Sociodemographic			
Age			
10 to <12 years	809	50 (6%)	1·00
12 to <13 years	804	68 (8%)	1·40 (0·98–2·01)
13 to <15 years	990	141 (14%)	2·31 (1·67–3·19)
Sex			
Male	1,234	119 (10%)	1·00
Female	1,369	140 (10%)	1·09 (0·87–1·38)
Social Influences			
Either Parent Smokes			
No	1,830	133 (7%)	1·00
Yes	773	126 (16%)	2·25 (1·77–2·86)
Any Friends Smoke			
No	1,932	147 (8%)	1·00
Yes	671	112 (17%)	1·87 (1·46–2·41)
Any Siblings Smoke			
No	2,336	210 (9%)	1·00
Yes	267	49 (18%)	1·91 (1·42–2·59)
Receptive to Tobacco Promotions			
No	2,161	179 (8%)	1·00
Yes	442	80 (18%)	2·09 (1·62–2·71)
Child Characteristics			
School Performance			
Excellent	1,113	53 (5%)	1·00
Good	1,006	114 (11%)	2·29 (1·67–3·13)
Average/Below Average	484	92 (19%)	3·65 (2·62–5·09)

(Continued)

Characteristic	Total (n = 2,603)	Tried Smoking	Relative Risk* (95% CI)
Sensation Seeking			
First quartile	792	40 (5%)	1·00
Second quartile	709	59 (8%)	1·60 (1·09–2·35)
Third quartile	484	55 (11%)	2·21 (1·49–3·27)
Fourth quartile	618	105 (17%)	3·27 (2·28–4·68)
Rebelliousness			
First quartile	771	37 (5%)	1·00
Second quartile	549	39 (7%)	1·48 (0·96–2·27)
Third quartile	668	71 (11%)	2·24 (1·53–3·29)
Fourth quartile	615	112 (18%)	4·10 (2·84–5·91)
Self-Esteem			
First quartile	676	100 (15%)	1·00
Second quartile	747	68 (9%)	0·64 (0·48–0·86)
Third quartile	760	71 (9%)	0·68 (0·51–0·92)
Fourth quartile	420	20 (5%)	0·35 (0·22–0·56)
Parent Characteristics			
Maternal Demandingness			
First quartile	617	68 (11%)	1·00
Second quartile	666	71 (11%)	0·97 (0·70–1·33)
Third quartile	755	74 (10%)	0·86 (0·63–1·18)
Fourth quartile	565	46 (8%)	0·72 (0·50–1·04)
Maternal Responsiveness			
First quartile	526	78 (15%)	1·00
Second quartile	571	60 (11%)	0·76 (0·55–1·05)
Third quartile	679	63 (9%)	0·69 (0·50–0·94)
Fourth quartile	827	58 (7%)	0·55 (0·39–0·76)

(Continued)

Characteristic	Total (n = 2,603)	Tried Smoking	Relative Risk* (95% CI)
Parent Education			
Both Completed HS	2,223	206 (9%)	1·00
Neither or One Completed HS	380	53 (14%)	1·55 (1·15–2·08)
Parental Disapproval of Smoking			
Both Disapprove	2,157	197 (9%)	1·00
Neither or One Disapproves	446	62 (14%)	1·53 (1·16–2·01)
Movie Smoking Exposure†			
First quartile	651	22 (3%)	1·00
Second quartile	651	56 (9%)	2·39 (1·49–3·83)
Third quartile	651	74 (11%)	2·99 (1·89–4·72)
Fourth quartile	650	107 (16%)	4·31 (2·76–6·75)

* Relative risk for age at baseline is adjusted for sex and school. Relative risk for sex is adjusted for age and school. All other relative risks are adjusted for age at baseline, sex, and school.

† First quartile, 0–531 occurrences of smoking; second quartile, 532–960 occurrences; third quartile, 961–1,664 occurrences; and fourth quartile, 1,665–5,308 occurrences.