Introduction to Risk Comparisons

Resource Type: Curriculum: Classroom

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Abstract

Students compare risks, which they convert from different formats (typically fractions) into decimal then exponential numbers, and plot them on a logarithmic scale. Sample data are given for selected diseases and cancers; other commonly cited risks are also included. Students may collect information from various professional safety organizations. The experience incorporates cooperative learning, problem solving, and critical thinking.

Activity

Invitation for User Feedback. If you have used the activity and would like to provide feedback, please send an e-mail to MicrobeLibrary@asmusa.org. Feedback can include ideas which complement the activity and new approaches for implementing the activity. Your comments will be added to the activity under a separate section labeled "Feedback." Comments may be edited.

INTRODUCTION

These activities were designed to introduce students to the Paling Perspective Scale, a method for comparing risks presented in mass media and putting the information in perspective. It gives them practice with mathematical conversion of numbers into scientific notation and additional practice with logarithmic graphing.

Learning Objectives.
At the completion of these activities students should be able to:

- understand the difference between common and uncommon risks.
- convert a fraction into scientific notation.
- use a logarithmic scale.
- realize that different people have different views of acceptable and unacceptable risks.

Background.
Basic mathematics: some experience with scientific notation and logarithmic graphs.

PROCEDURE

Materials.

- Paling Perspective Scale:
  Paling Perspective Scale (PDF)
  Paling Perspective Scale website
- blank paper for calculations (calculators are discouraged!)
- overhead projector
- blank acetate sheets
- acetate/overhead copy of Paling Perspective Scale
- felt-tip marker appropriate for acetates
- 5-cycle log paper (Students may use 1 or 2 sheets of 5-cycle log paper; a single sheet can be cut into strips and used to supply several groups of students.)

Student Version.
Student instructions for "Introduction to Risk Comparison"
Student worksheet
Lists of risks:
Comparing Risks worksheet

Instructor Version.

1. Go to the Paling Perspective Scale website and print the Scale (you will need to register to access the Scale) or use the PDF of the Scale.
2. I recommend instructors work through the problems themselves. Solutions with all steps shown are provided in Appendix 3, but I find my own long-division skills need a periodic booster.
3. In class, introduce the topic of risks (see Appendix 1 for notes and Appendix 2 for an outline suitable for presentation in class).
4. Distribute materials: Paling Perspective Scale, student handouts, and blank paper for calculations.
5. Demonstrate conversion from fraction to decimal to scientific notation. Give two examples and their solutions. Use blank acetate and an overhead projector.
6. Demonstrate placement of the number on logarithmic scale. Use acetate copy of Scale and overhead projector. Repeat with student assistance and participation if appropriate or necessary.
7. Have students work singly, in pairs, or in small groups on a subset of items on the Comparing Risks worksheet.
8. Have students compare and discuss results within small groups. Debriefing: have students plot values on the Paling Scale on an overhead projector (or instructor plots values as indicated by students) and share their findings with the group.
9. Students may be asked to turn in the Scale and sheet(s) with calculations.

Students usually need a couple of exposures before they grasp logarithmic scales. If this is their first time with such scales, additional time will be needed to explain the ten-fold differences between lines.

Safety Issues. None.

ASSESSMENT and OUTCOMES

Suggestions for Assessment.

- Peer oral assessment is incorporated into the activities through group discussion and whole class discussion and feedback.
- Students record results and answer questions directly related to the activity. In addition, two to six questions can be presented to stimulate further evaluation and integration of information.
- Concepts can be included on a subsequent quiz or exam.

Field Testing.
This activity has been in use since fall 1995. I originally developed this exercise for a General Education course entitled "Science, Technology, and Society"; the course was required of all undergraduates from fall 1994 through spring 1999. At least 17 different instructors in four different departments (Biological Sciences, Chemistry, Geology, and Physics/Astronomy) have used a long form of this activity.

My intention was to empower students to compare risks, as well as to provide an interesting way for them to practice math skills. Over 8,000 students have had a form of this assignment. Students often object to the math until they have seen and/or completed a couple of examples. Thereafter, students are capable of correctly completing these items; further, they enjoy looking up information to construct their own examples. By having the students work in groups either to complete the activity or to review individual examples before having a class wide debriefing, there is significant peer interaction; whether assigned or self selected, the membership of groups almost always contained someone who understood these problems immediately, as well as someone who took longer but was still able to follow the solution.

There is also the aspect of looking at a risk and thinking oneself superior for never having had a particular hazard happen; this is frequently followed by the turn of a page and the realization that one has experienced, or knows someone who has suffered, a separate hazard. Both instructors and students find the exercise very straightforward and yet intriguing via this peek into other people's problems.

Student Data.
JPG image showing a sample of student results.
Student sample

SUPPLEMENTARY MATERIALS

Possible Modifications.
This activity is easily modified.

- Assign the activity as either an individual or small group exercise.
- Ask students to collect alternative examples before class or develop their own examples after class (search for safety information, write up problem, write out answer, and submit).
- Ask or assign students to give reasons why a risk is particularly high or low. Have students identify factors that increase or decrease risk and divide them into those over which we have direct control (personal choice), indirect control (e.g., laws and regulations), or no control (e.g., genetics or weather).
- Have students give reasons why there are differences in risk for one hazard between two groups (e.g., economics: cholera in Uganda versus U.S.; location: earthquakes in Japan versus Nebraska).
- Have students estimate the risk for a particular hazard (such as cancer or sexually transmitted diseases) and collect the answers anonymously. Compare the range for the group and then calculate the risk based on data from one or more sources. Have students suggest reasons (biases) for why predictions were high (e.g., personal knowledge of cancer in family or extensive bad press about cancer) or low (e.g., sexually transmitted diseases as an inappropriate discussion topic).

An anecdote: I took students in my major's Microbiology class to the student health center. When we reached the medical

technician station, the technician explained the need for using American Type Culture Collection strains as controls for various tests. The students were stunned into speechlessness when the technician pulled out a control plate for a sexually transmitted disease from the incubator; it was needed for a test being performed that day.

References.

The central resource
Paling, J., and S. Paling. 1994. Up to your armpits in alligators? How to sort out what risks are worth worrying about! The Environmental Institute, Gainesville, Fla.

This book is from a smaller press; the address is:

> The Environmental Institute
> 5822 N.W. 91st Boulevard
> Gainesville, Florida 32653

Another excellent resource
Murray, D., J. Schwartz, and S. R. Lichter. 2001. It ain't necessarily so: how media make and unmake the scientific picture of reality. Rowman & Littlefield, Lanham, Md.
See also information available at: http://www.stats.org.

Background reading

> *Examples*

> 1. 1996. A fistful of risks. Discover **5:**82-83.
> 2. **Burke, J.** 1993. What are the chances? Risks and odds in everyday life. Citadel Press, New York, N.Y.
> 3. **Copp, N., and A. Zanella.** 1993. Discovery, innovation, and risk: case studies in science and technology. MIT Press, Cambridge, Mass.

> > Chapter 8. Vaccines: good intentions are not enough, p. 245-288.
> > Chapter 10. Atomic power: difficulty in estimating cancer risks, p. 321-374.

> 4. **Krantz, L.** 1992. What the odds are: A-Z odds on everything you hoped or feared could happen. Harper & Row, New York, N.Y.
> 5. **Laudan, L.** 1994. The book of risks: fascinating facts about the chances we take every day. John Wiley & Sons, Inc., New York, N.Y.

> > Infections and epidemics, p. 68-72.
> > Cancer and heart disease, p. 72-77.
> > General health and disease, p. 77-82.
> > Conception, abortion, and pregnancy, p. 83-85.
> > Exercise and health risk, p. 85-86.
> > Malpractice, p. 86-87.
> > Sexually transmitted diseases, p. 114-117.

> 6. **Laudan, L.** 1997. Danger ahead: the risks you really face on life's highway. John Wiley & Sons, New York, N.Y.
> 7. **Orkin, M.** 2000. What are the odds? Chance in everyday life. W. H. Freeman & Co., New York, N.Y.
> 8. **Siskin, B., J. Staller, and D. Rorvik.** 1993. What are the chances? Risks, odds, and likelihood in everyday life. Signet Publishing, New York, N.Y.
> 9. **Urquhart, J., and K. Heilmann.** 1984. Risk watch: the odds of life. Facts on File, Inc., New York, N.Y.
> 10. **Walsh, J.** 1996. True odds: how risk affects your everyday life. Silver Lake Publishers, Los Angeles, Calif.

> *Broader issues*

> 1. **Carey, S. S.** 1998. A beginner's guide to scientific method, 2nd ed. Wadsworth Publishing Co., Belmont, Calif.

> > Chapter 4. Extraordinary claims and anecdotal evidence, p.93-112.

> 2. **Cohl, H. A.** 1997. Are we scaring ourselves to death? How pessimism, paranoia and a misguided media are leading us toward disaster. St. Martin's Griffin, New York, N.Y.
> 3. **Douglas, M.** 1994. Risk and blame: essays in cultural theory. Routledge, Florence, Ky.
> 4. **Flynn, J., P. Slovic, and H. Kunreuther (ed.).** 2001. Risk, media and stigma: understanding public challenges to modern science and technology. Earthscan Publications Ltd., London, England.
> 5. **Foster, K. R., D. E. Bernstein, and P. W. Huber.** 1999. Phantom risk: scientific inference and the law. MIT Press, Cambridge, Mass.
> 6. **Glassner, B.** 2000. The culture of fear: why Americans are afraid of the wrong things. Basic Books, Scranton, Pa.
> 7. **Graham, J. D., J. B. Wiener, and C. R. Sunstein (ed.).** 1997. Risk versus risk: tradeoffs in protecting health and the environment. Harvard University Press, Cambridge, Mass.
> 8. **Huber, P. W.** 1993. Galileo's revenge: junk science in the courtroom. Basic Books, Scranton, Pa.
> 9. **Kammen, D. A., and D. M. Hassenzahl.** 1999. Should we risk it? Exploring environmental, health, and technological problem solving. Princeton University Press, Lawrenceville, N.J.
> 10. **Lipton, D.** 1999. Risk: key ideas. Routledge, Florence, Ky.
> 11. **Margolis, H.** 1997. Dealing with risk: why the public and the experts disagree on environmental issues. University of Chicago Press, Chicago, Ill.
> 12. **Powell, D., and W. Leiss.** 1997. Mad cows and mother's milk: the perils of poor risk communication. McGill

Queens University Press, Montreal, Canada.
13. **Ross, J. F.** 1999. The polar bear strategy: reflections on risk in modern life. Perseus Books, Boulder, Co.
14. **Singer, E., and P. M. Endreny.** 1993. Reporting on risk: how the mass media portray accidents, diseases, disasters, and other hazards. Russell Sage Foundation, New York, N.Y.
15. **Slovic, P.** 2001. The perception of risk (Risk, society and policy series). Earthscan Publications Ltd., London, England.
16. **Slovic, P.** 2000. Perception of risk. Stylus Publishing, Herndon, VA.
17. **Wynn, C. M., and A. W. Wiggins.** 1997. The biggest ideas in science. John Wiley & Sons, Inc., New York, N.Y.

Chapter 8. Benefit/risk analysis: potential applications of scientific knowledge, p. 119-138.

Appendices and Answer Keys.
Appendix 1. Background for instructor: "An Introduction to Risk"
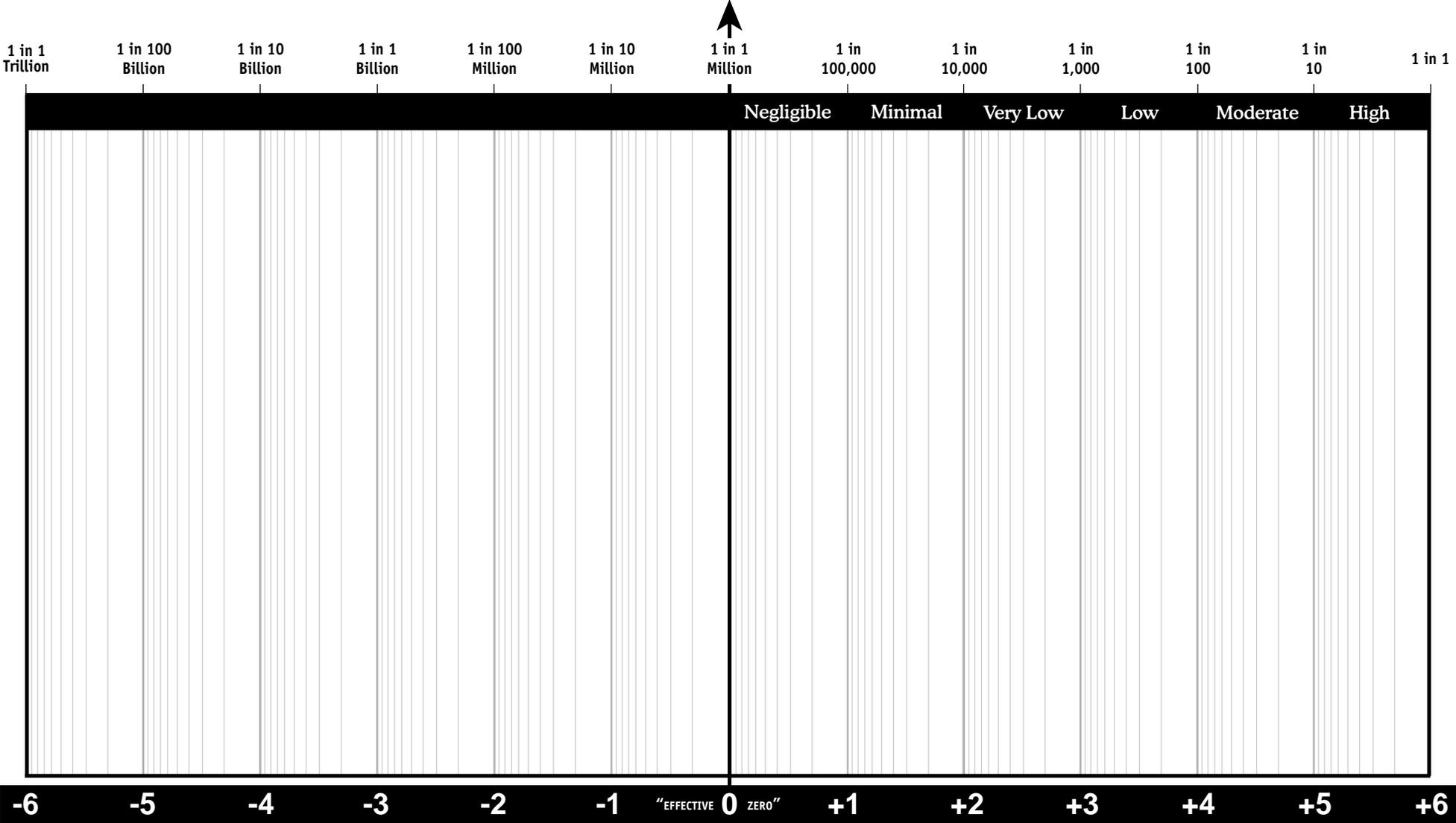Appendix 2. Outline of "An Introduction to Risk" (suitable for lecture notes)
Appendix 3. Answers for Comparing Risks worksheet
Appendix 4. Useful websites for further sources of data for risk calculations

The Paling Perspective Scale© for Physicians and Patients

"Helping the Public Put Life Into Perspective"

| 1 in 1 Trillion | 1 in 100 Billion | 1 in 10 Billion | 1 in 1 Billion | 1 in 100 Million | 1 in 10 Million | 1 in 1 Million | 1 in 100,000 | 1 in 10,000 | 1 in 1,000 | 1 in 100 | 1 in 10 | 1 in 1 |

| | | | | | | Negligible | Minimal | Very Low | Low | Moderate | High |

| -6 | -5 | -4 | -3 | -2 | -1 | "EFFECTIVE 0 ZERO" | +1 | +2 | +3 | +4 | +5 | +6 |

We encourage you to use the Scale to compare the odds of different options.
Contact us for your Free License.

/||| Curriculum Resources

Figure 1. Student Instructions for Handout "Introduction to Risk Comparisons"

Scientists make predictions based on accumulated data and their current understanding of relationships between these known and studied variables. The success of their predictions will be a function of how "good" the data are, how well defined the interactions are, and the number of variables (the fewer, the better). Since we don't know everything, scientists make predictions with less than complete knowledge, usually as a tool to gain more knowledge (deduction), but also as a tool to inform others about possible future outcomes.

In the field of risk assessment, predictions are made of the chances of something (usually bad) happening to inform safety professionals, legislators, and the general public. There are many problems in this field, one of which is that the reports are fairly meaningless to the average person. Journalists deliver regular reports from scientists and health professionals of risks to our health and well being, but it is difficult to determine the importance of these reports - a variety of variables contribute to most outcomes and rarely are their contributions of equal weight. How can we as educated citizens understand and prioritize reports of risks in personal, professional, and societal contexts, without having extensive experience in this area?

John Paling, a former biology professor and documentary producer and photographer, developed one approach. Frustrated by reports in the news media about different risks, Dr. Paling tried to translate the information to a form that could be viewed on a graph. Because humans are visually oriented, it is an inherently easy way for us to analyze information. Paling developed a scale (the Paling Perspective Scale) that allows us to compare most types of risk predictions both mathematically and visually. Risks are converted to a frequency using scientific (exponential) notation and then plotted on a logarithmic scale, giving a "relative" measure of vastly different events. Events that map to the far right of the scale are guaranteed to occur; events that map to the extreme left are so rare that virtually everyone on the planet is safe from such occurrences; and events in the center are the real "one in a million" type events. Using this system helps us compare and understand risks via three key factors: (i) risks are converted to the same format, (ii) risks can be compared directly, and (iii) risks can be represented visually.

Steps for using the Paling Perspective Scale:

1. Set up a **ratio** to determine frequency of past occurrences.
(number of times an event **did** occur) ¸ (number of times an event **could have** occurred)

2. Convert the frequency in fraction form to **decimal** form.

3. Convert the frequency in decimal form to **exponential notation** form.

4. **Plot** frequency in exponential notation form on logarithmic Paling Perspective Scale.

For this session, you will be assigned a number of events on the list. Your task will be to calculate the frequency of each risk. Be sure to write your calculation on the page. (Of course you have entered your name and section number, so I don't need to mention that here.) After you complete your individual calculations, join in a group of four to six others. Each of you in turn should present your example and your calculation for peer review. As each of you completes your example, write the calculations on the group sheet, plot the location of the event on the Paling Perspective Scale and submit the group sheet for grading.

Demonstrations:

How does the Paling Perspective Scale work? It is a visual representation of the risk of various events, distributed across a logarithmic scale. Events on the right-hand side of the scale represent events with a high

degree of certainty, events in the middle are literally the "one in a million risk that doesn't really scare me." The exceptionally miniscule risks (10^{-12}) are "out in left field," literally and figuratively. To use this scale, we need to convert predictions of risk into the same mathematical format.

1. Set up a **ratio** to determine frequency of past occurrence.
(number of times an event **did** occur) ¸ (number of times event **could have** occurred)

2. Convert the frequency in fraction form to **decimal** form.

3. Convert the frequency in decimal form to **exponential notation** form.

4. **Plot** frequency in exponential notation form on logarithmic Paling Perspective Scale.

Example 1. Risk of being killed by lightning in any given year.

National Center for Health Statistics reports that 89 people died by being struck by lightning in 1990. According to the 1990 U.S. Census, there were 248,709,873 people in the population at that time.

(1) Set up ratio: 89 : 248,709,873

(2) Convert to decimal: 89 : 248,709,873 =

0.000000357846670606437887570309683685135

(3) Convert to scientific notation:

0.000000357846670606437887570309683685135 =

3.57846670606437887570309683685135e-7   3.6 x 10^{-7}

Once we have this number, we can plot it on the scale (the other handout); it goes between the 1 x 10^{-7} and the 1 x 10^{-6} lines; thus it is a remote risk.

Example 2. Risk of dying in any given year.

National Center for Health Statistics reports that there were 864.7 deaths per 100,000 population in the year 1998.

(1) Set up ratio: 864.7 _ 100,000

(2) Convert to decimal: 864.7 _ 100,000 = 0.008647

(3) Convert to scientific notation: 0.008647 = 8.647 x 10^{-3}

Once we have this number, we can plot it on the scale (the other handout); it goes between the 1 x 10^{-3} and the 1 x 10^{-2} lines; thus it is a risk of much higher probability.

Examples for this activity were adapted from: (i) "*Up to Your Armpits in Alligators? How to Sort Out What Risks Are Worth Worrying About!*" by John and Sean Paling, 1994. The Environmental Institute, Gainesville, Fla.; and (ii) "A Fistful of Risks" p. 82-83 in the May 1996 issue of *Discover* magazine.

/III Curriculum Resources

Introduction to Risk Comparison Worksheet.

Item #	Item description	Ratio	Decimal form	Exponential notation
sample				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Comparing Risks Worksheet

Steps for using the Paling Perspective Scale (PPS):

1. Set up a **ratio** to determine frequency of past occurrences.

(number of times an event **did** occur) ¸ (number of times event **could have** occurred)

2. Convert the frequency in fraction form to **decimal** form.

3. Convert the frequency in decimal form to **exponential notation** form.

4. **Plot** frequency in exponential notation form on logarithmic PPS.

"… but nothing in this world is certain but death and taxes." Benjamin Franklin, 1789

1. Risk of dying sometime from something: 1 in 1

2. Risk of cancer being the ultimate cause of death: 1 in 4

3. Risk equivalent to one person in whole of U.S.: 1 in 250 million

4. Risk equivalent to one person in whole of world: 1 in 5.6 billion

5. Risk of death while playing Russian roulette: 1 in 6

6. Risk of dying from cancer from smoking 1 pack of cigarettes per day for 30 years: $3.6 \times 30 \times 10^{-3}$

7. Risk of death driving motor vehicles, per year: 2×10^{-4}

8. Risk of death from radon, per year: 14,000 in U.S. population of 250 million

9. Risk of dying from accidents at home: 1.1×10^{-4}

"I think I had better bathe before I drink the poison…." Socrates, 399 B.C.E.

10. Risk of drowning in a tub this year: 1 in 685,000

11. Risk of lung cancer related to asbestos in schools: 5 per million lifetimes

12. Risk of resident of U.S. being struck by a crashing airplane: p = 0.000004

13. Risk of woman in U.S. dying in childbirth (single pregnancy): 0.66×10^{-4}

14. Risk of being struck by lightning: 1 in 9,100

"Dig the grave and let me lie." Robert Louis Stevenson

Risk of cancer based on personal dietary choices.

15. Extra incidence of death from cancer from drinking one light beer per day for 1 year: 20 in a million

16. Extra chance of death from cancer from living in Denver compared to living in New York for 1 year: 10 in a million

17. Extra risk from cancer from eating 4 tablespoons full of peanut butter per day for a year: 4×10^{-5}

18. Extra incidence of cancer from eating 1/2 lb. of charcoal-broiled steak once a week for 1 year: 4×10^{-7}

19. The point below which the U.S. Food and Drug Administration considers the risk from a food additive too small to be considered (**not** including the "Delaney Clause" pertaining to carcinogens): 1 cancer per million lifetimes

20. The point below which the U.S. Environmental Protection Agency (EPA) considers the risk from a chemical too small to be considered: 1 in a thousand to 1 in a million (EPA intentionally sets this as range; value depends on type of chemical)

"These are the people in your neighborhood" Bob, on Sesame Street

21. Odds that a U.S. citizen will die by committing suicide: 1 in 67

22. Odds that a U.S. citizen will die by committing suicide with a firearm: 1 in 135

23. Likelihood there is a gun in a U.S. home: 1 in 2

24. Annual death toll from alcohol abuse: 150,000 deaths out of 250,000,000

25. Risk of being in an alcohol-related traffic accident in a lifetime: 2 in 5

26. Odds of a family living below the poverty line: 35.4 million out of 250 million

27. Odds that a student will drop out of high school: 1 in 10

28. Odds of a person under 18 years of age being arrested: 1 in 35

29. Risk that a child will be criminally abused or neglected: 1 in 100

30. Odds of a prison inmate having been abused as a child: 4 out of 5

31. Risk of marriage ending in divorce in U.S.: 2 out of 5

"Is everybody ready for 'Tool Time'?" Heidi, on Home Improvement

Risk of injury at home, associated with consumer products and requiring emergency treatment in U.S. hospitals. For these items, assume a U.S. population of 250 million.

Consumer product injuries in 1989

32. Refrigerators and freezers: 31,630

33. Television sets: 34,949

34. Lawn mowers: 61,864

35. Power home tools: 93,076

36. Bathtubs and showers: 121,600

37. Ladders and stools: 131,551

38. Beds, mattresses, and pillows: 302,190

39. Carpets and rugs: 87,738

40. Stairs, ramps, and landings: 1,450,421

41. Nails and carpet tacks: 214,123

42. Drinking glasses: 114,683

43. Cans, glass bottles, and jars: 250,542

44. Exercise equipment: 67,028

45. Toys: 147,898

46. Sinks and toilets: 43,162

"History is little else than a picture of human crimes and misfortunes." Voltaire, 1767

Risk of becoming a crime statistic. For these items, assume a U.S. population of 227,131,000.

Crime incidents in 1989

47. Being murdered with a firearm: 12,847

48. Being murdered: 20,930

49. Being burglarized: 2,793,447

50. Having motor vehicle stolen: 1,515,364

"What is food to one man may be fierce poison to another." Lucretius

Risk of getting sick while eating out in Minnesota.

Locals risk

51. Italian restaurant: 1 in 1,400,000

52. Fast-food restaurant: 1 in 440,000

53. Business meeting: 1 in 400,000

54. Family gathering: 1 in 388,000

55. Delicatessen: 1 in 240,000

56. Mexican restaurant: 1 in 136,000

"I do not love him because he is good, but because he is my little child." Rabindranath Tagore

57. Risk of a minor being kidnapped by a stranger: 1 in 560

58. Risk of a minor being kidnapped by a family member: 1 in 180

59. Risk of a child dying before the age of five in the U.S.: 1 in 100

60. Risk of a child dying before the age of five in South Asia: 1 in 8

"Work, and your house shall be duly fed: / Work, and rest shall be won." Alice Cary

Risk of an adult (> age 16) losing her/his job in next year.

61. In general: 1 in 33

By profession

62. Doctor: 1 in 116

63. Lawyer: 1 in 82

64. Postal worker: 1 in 41

65. Accountant: 1 in 40

66. Bus driver: 1 in 22

67. Farmworker: 1 in 8

"And now I see with eye serene / The very pulse of the machine." Wordsworth, 1804.

Risk of dying from an accident on the job.

68. In 1934 (before Occupational Safety and Health Administration [OSHA]): 390 in 1 million

69. In 1994 (with OSHA): 40 in 1 million

70. Risk of being injured in an elevator ride: 1 in 6 million

"Nature, red in tooth and claw." Tennyson, 1850.

Risk of dying from natural phenomena.

71. Earthquake or volcano: 1 in 11 million

72. Leaking gas: 1 in 12 million

73. Dog bite: 1 in 20 million

74. Drinking detergent: 1 in 23 million

75. Snakebite: 1 in 36 million

"Healing is a matter of time, but it is sometimes also a matter of opportunity." Hippocrates

76. Risk of being struck by lightning in any given year: 1 in 750,000

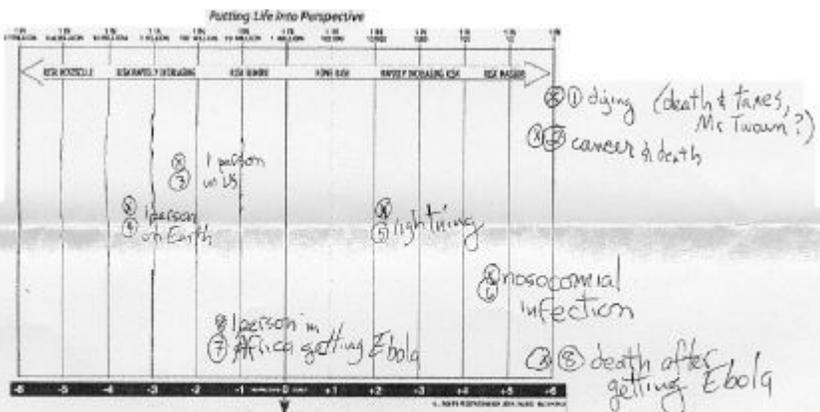77. Chances of surviving **after** being struck by lightning: 3 in 4

78. Risk of contracting a nosocomial infection (contracted **during** stay) at a U.S. hospital: 1 in 15

79. Risk of being infected with the "flesh-eating bacteria": 1 in 170,000

80. Risk of dying once infected with the "flesh-eating bacteria": 1 in 4

81. Risk, for an African, of contracting the Ebola virus: 1 in 14 million

82. Risk of dying once infected with the Ebola virus: (2 in 3) to (9 in 10) (depends on specific strain of virus)

Putting Life Into Perspective

Handwritten annotations:
- ② ① dying (death & taxes, Mr. Twain?)
- ② ② cancer & death
- ③ 1 person in US
- ④ 1 person on Earth
- ⑤ lightning
- ⑥ nosocomial infection
- ⑧ 1 person in Africa getting Ebola
- ③ ⑧ death after getting Ebola

#	Description	Ratio	Decimal	Exponential
1.	Risk of dying	1 in 1	1.00	1×10^{0}
2.	Risk of cancer being cause of death	1 in 4	0.25	2.5×10^{-1}
3.	Risk 1 person in US	1 in 250 million		
4.	Risk 1 person in world	1 in 6 billion		
5.	Risk struck by lightning	1 in 9,100	$0.000\overline{10989}$	1.1×10^{-4}
6.	Risk of nosocomial infection	1 in 15	$0.0\overline{6}$	6.7×10^{-2}
7.	Risk for African contracting Ebola	1 in 1/4 million		
8.	Risk dying after getting Ebola $\frac{2}{3}$ to $\frac{9}{10}$		$\frac{2}{3} = 0.\overline{6}$	6.7×10^{-1}
			$\frac{9}{10} = 0.9$	9.0×10^{-1}

Curriculum Resources

Appendix 1. Background for Instructor: "An Introduction to Risk"

Undesirable events happen to each of us periodically; safety professionals call these **hazards**. However, not every bad thing will happen to every person; a negligible or a large number of events may occur within any one year to any one person in any one place. Thus there is a degree of uncertainty in the occurrence of hazards. **Risk** is defined as the likelihood or probability of a hazard happening. If we study previous times a hazard has occurred, we can potentially identify factors that led to the hazard or increased its probability. Once identified, these factors could be altered or removed so that the probability of occurrence would be lowered or eliminated. Sounds easy, but obviously it isn't.

Each individual has some degree of control over his or her own behavior. Thus, humans may choose to act upon feelings related to the risk they perceive in various activities. People can be identified as risk averse (avoid perceived risks), risk seeking (actively pursue perceived risks), or risk neutral. Background, experience, peer pressure, and other factors (genetic, physiological, and social) will affect each person in each situation. If one lives alone ("an island") and has the ability to choose ("free will," "personal choice"), they may experience life highly enriched or relatively devoid of risk.

However, most humans live in social groups - crowded ones, at that. One of the tradeoffs of living in a group is the surrender of control over some aspects of one's existence. Personal choice is absent or limited by laws and regulations in exchange for efficiency. Further, not every individual viewpoint can be used; depending on the society, many will never be heard. In the U.S., we fluctuate in policy based on majority votes of elected officials, which may or may not reflect the majority opinions of citizens.

Living in a society has other effects. We are exposed to the wastes of ourselves and our neighbors, including industrial and commercial facilities; in fact, we may earn money to pay for our food and housing by working at such places. All of these contribute to waste in the environment and to increased interactions, both positive and negative. While you can choose to control your own behavior, you alone may have little control over your neighbors, small or big. To limit wildly abusive behavior, our government sponsors regulatory agencies. These groups analyze problems, make recommendations to Congress regarding laws and regulations, and aid in implementation and enforcement of such controls. Three agencies are of particular interest to microbiologists: Environmental Protection Agency (www.epa.gov), Occupational Safety and Health Administration (www.osha-slc.gov), and Food and Drug Administration (www.fda.gov/fdahomepage.html).

How do these agencies go about managing risks? To manage risks, information is needed about the risk. **Risk analysis** is the process of hazard identification. Once the hazard has been identified, data are gathered from current events or review of past events in a process called **risk assessment**. Some parameters may be unequivocally documented (number of dead, or onset of symptoms); other factors may not be known. In the latter situation, estimates may be applied. While less desirable than actual measurements, these estimates can be narrowed to within one or two orders of magnitude. Once data have been collected or estimated, **risk evaluation** is performed to weight various factors to complete the risk analysis. **Risk management** then involves combining (or attempting to combine) the results of risk analysis with societal input (e.g., clean water and high costs for processing or contaminated water and low costs).

Thus far we've focused on data gathering and analysis. Risk management also includes acting upon the knowledge gained through those steps. There are three stages for this: providing options, aiding

in implementation of the selected option, and enforcing the conditions included in that option. There are obviously practical, pragmatic limits to which options are selected, cost usually being first and foremost. Other limits include the amount of training required and the number of people who would need training, as well as the need to track all the records of what was done when and by whom. There are also a wide range of social limits, such as the subjectivity of our values, compliance, personal experience, and the scale of time, geography, and politics.

In making a decision, we can place no limits, we can place rigid and narrow limits, or we can place limits falling somewhere within the continuum between these endpoints. Making informed decisions on what to do (or not to do) requires data. These data ideally are then used to develop knowledge, perform calculations, and make comparisons.

Next problem: although we are regularly told about the dangers of foods, chemicals, and social practices, few people (including microbiologists) are familiar with more than the mass media presentation, in which we perceive yet another favorite food, drink, or activity as having been labeled dangerous. Further complicating the situation, these public reports are delivered in different formats, presuming either that people will comprehend or, more cynically, that no one cares if the public understands.

There are three forms in which most risks are publicized, showing the number of events anticipated within a total population. The first form is the simple fraction (e.g., 1 in 6), converted to the lowest common denominator, rendering them difficult if not impossible to compare. (Quick! Which is more likely: 1 in 8 or 3 in 11?) As the parent of a third grader just beginning fractions and of a seventh grader working on complex fractions and calculations, I am very aware that indeed our college students **should** have had plenty of practice and **should** be able to work them out, but this takes time, a commodity most people won't waste on fractions when it is easier to ignore it all.

The second commonly used format expresses risk as a statistical probability ($p = 0.003$). This is at least in a decimal form: much easier for microbiologists, but a death knell for the general public. The third form places risks in scientific notation – again, easy for us and impregnable for nonscientists.

A biologist named John Paling realized that these forms could be combined sequentially (fraction to decimal to scientific notation), and had the crucial insight that these values could be graphically displayed! Obviously, the phenomenal range of risks negates the use of a geometric graph, but by placing the risks along a logarithmic scale, vastly different items can be compared or (much more strikingly) contrasted. Paling wrote a book about the system ("Up to Your Armpits in Alligators?"); information is also available at his website http://www.healthcarespeaker.com.

The exercise published with this page provides you with this simple method for comparing risks of different events in a graphical format.

|||| Curriculum Resources
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Appendix 2. Outline of " An Introduction to Risk"

I. Definitions

    A. Risk = hazard + uncertainty

    B. "Free will and personal choice" versus "Islands"

        1. Individual exposure

            a. Risk averse
            b. Risk neutral
            c. Risk seeking

        2. Societal exposure

            a. Lack or limit of personal choice
            b. Societal values
            c. Sources
            d. Controls (regulatory agencies) = EPA, OSHA, FDA

    C. Risk management

        1. Risk assessment = collection + estimation
        2. Risk evaluation = weighting
        3. Risk analysis = hazard identification + risk assessment + risk evaluation
        4. Risk management = risk analysis + societal input

II. Decisions

    A. Risk management = options + implementation + enforcement

    B. Practical limits: cost, training, and record-keeping

    C. Social limits: subjective views, control, compliance, personal experience, scale
(time, geography, politics)

    D. Range of decisions: limit nothing < (intermediate) < limit everything

    E. Making informed decisions requires data

        1. Fractions
        2. Decimals or statistical probability
        3. Scientific notation

    F. Knowledge, calculations, and comparisons

        1. John Paling and the PPS
        2. Logarithmic scale enables visual comparisons

Appendix 3. Answers for Comparing Risks Worksheet

1. Dying sometime from something: 1 in 1

$$1 \div 1 = 1 = 1 \times 10^0$$

2. Cancer being the ultimate cause of death: 1 in 4

$$1 \div 4 = 0.25 = 2.5 \times 10^{-1} = 2.5 \times 10^{-1}$$

3. Risk equivalent to one person in whole of U.S.: 1 in 250 million

$$1 \div 250 \text{ million} = 1 \div 2.50 \times 10^8 = 4 \times 10^{-8} = 4 \times 10^{-8}$$

4. Risk equivalent to one person in whole of world: 1 in 5.6 billion

$$1 \div 5.6 \text{ billion} = 1.8 \times 10^{-10} = 1.8 \times 10^{-10}$$

5. Death while playing Russian roulette: 1 in 6

$$1 \div 6 = 0.167 = 1.6 \times 10^{-1} = 1.6 \times 10^{-1}$$

6. Cancer from smoking 1 pack of cigarettes per day for 30 years: $3.6 \times 30 \times 10^{-3}$

$$3.6 \times 30 \times 10^{-3} = 108 \times 10^{-3} = 1.1 \times 10^{-1} = 1.1 \times 10^{-1}$$

7. Risk of death driving motor vehicles, per year: 2×10^{-4}

$$2 \times 10^{-4} = 2 \times 10^{-4}$$

8. Risk of death from radon, per year: 14,000 of 250 million

$$1.4 \times 10^4 \div 2.5 \times 10^8 = 5.6 \times 10^{-5} = 5.6 \times 10^{-5}$$

9. Risk of dying from accidents at home: 1.1×10^{-4}

$$1.1 \times 10^{-4} = 1.1 \times 10^{-4}$$

10. Risk of drowning in a tub this year: 1 in 685,000

$$1 \div 685,000 = 0.0000014 = 1.4 \times 10^{-6} = 1.4 \times 10^{-6}$$

11. Risk of lung cancer related to asbestos in schools: 5 per million lifetimes

$$5 \div 1,000,000 = 5 \div 1 \times 10^6 = 0.5 \times 10^{-5} = 5 \times 10^{-6} = 5 \times 10^{-6}$$

12. Risk of resident of U.S. being struck by a crashing airplane: $p = 0.000004$

$$0.000004 = 4 \times 10^{-6} = 4 \times 10^{-6}$$

13. Risk of woman in U.S. dying in childbirth (single pregnancy): 0.66×10^{-4}

    $0.66 \times 10^{-4} = 6.6 \times 10^{-5} = 6.6 \times 10^{-5}$

14. Risk of being struck by lightning: 1 in 9,100

    $1 \div 9100 = 0.0001098 = 1.1 \times 10^{-4} = 1.1 \times 10^{-4}$

15. Extra incidence of death from cancer from drinking one light beer per day for 1 year: 20 in a million

    $20 \div 1{,}000{,}000 = 20 \div 10^{6} = 2 \div 10^{5} = 0.2 \times 10^{-4} = 2 \times 10^{-5} = 2 \times 10^{-5}$

16. Extra chance of death from cancer from living in Denver compared to living in New York for 1 year: 10 in a million

    $10 \div 1{,}000{,}000 = 10 \div 10^{6} = 10^{-5}$

17. Extra risk from cancer from eating 4 tablespoons full of peanut butter per day for a year: $4 \times 10^{-5} = 4 \times 10^{-5}$

18. Extra incidence of cancer from eating 1/2 lb. of charcoal broiled steak once a week for one year: $4 \times 10^{-7} = 4 \times 10^{-7}$

19. The point below which the U.S. Food and Drug Administration considers the risk from a food additive too small to be considered (**not** including the "Delaney Clause" pertaining to carcinogens): 1 cancer per million lifetimes

    $1 \div 1{,}000{,}000 = 1 \div 10^{6} = 10^{-6}$

20. The point below which the U.S. Environmental Protection Agency considers the risk from a chemical too small to be considered: 1 in a thousand to 1 in a million

    $1 \div 1000 = 1 \div 10^{3} = 10^{-3}$

    $1 \div 1{,}000{,}000 = 1 \div 10^{6} = 10^{-6}$

21. Odds that a U.S. citizen will die by committing suicide: 1 in 67

    $1 \div 67 = 0.0149 = 1.5 \times 10^{-2} = 1.5 \times 10^{-2}$

22. Odds that a U.S. citizen will die by committing suicide with a firearm: 1 in 135

    $1 \div 135 = 0.0074 = 7.4 \times 10^{-3} = 7.4 \times 10^{-3}$

23. Likelihood there is a gun in a U.S. home: 1 in 2

    $1 \div 2 = 0.5 = 5 \times 10^{-1} = 5 \times 10^{-1}$

24. Annual U.S. death toll from alcohol abuse: 150,000 deaths out of 250,000,000

$$150,000 \div 250,000,000 = 1.5 \div 2,500 = 0.0006 = 6 \times 10^{-4} = 6 \times 10^{-4}$$

25. Risk of being in an alcohol-related traffic accident in a lifetime: 2 in 5

$$2 \div 5 = 4 \div 10 = 0.4 = 4 \times 10^{-1} = 4 \times 10^{-1}$$

26. Odds of a family living below the poverty line: 35.4 million out of 250 million

$$35,400,000 \div 250,000,000 = 35.4 \div 250 = 0.1416 = 1.4 \times 10^{-1} = 1.4 \times 10^{-1}$$

27. Odds that a student will drop out of high school: 1 in 10

$$1 \div 10 = 0.1 = 10^{-1}$$

28. Odds of a person under 18 years of age being arrested: 1 in 35

$$1 \div 35 = 0.028 = 3 \times 10^{-2} = 3 \times 10^{-2}$$

29. Risk that a child will be criminally abused or neglected: 1 in 100

$$1 \div 100 = 0.01 = 10^{-2}$$

30. Odds of a prison inmate having been abused as a child: 4 out of 5

$$4 \div 5 = 0.8 = 8 \times 10^{-1} = 8 \times 10^{-1}$$

31. Risk of marriage ending in divorce in U.S.: 2 out of 5

$$2 \div 5 = 0.4 = 4 \times 10^{-1} = 4 \times 10^{-1}$$

32. Injury and refrigerators/freezers: 31,630

$$31,630 \div 250,000,000 = 3.16 \div 25,000 = 0.0001264 = 1.3 \times 10^{-4} = 1.3 \times 10^{-4}$$

33. Injury and television sets: 34,949

$$34,949 \div 250,000,000 = 3.5 \div 25,000 = 0.00014 = 1.4 \times 10^{-4} = 1.4 \times 10^{-4}$$

34. Injury and lawn mowers: 61,864

$$61,864 \div 250,000,000 = 6.2 \div 25,000 = 0.000248 = 2.5 \times 10^{-4} = 2.5 \times 10^{-4}$$

35. Injury and power home tools: 93,076

$$93,076 \div 250,000,000 = 9.3 \div 25,000 = 0.000372 = 3.7 \times 10^{-4} = 3.7 \times 10^{-4}$$

36. Injury and bathtubs and showers: 121,600

$$121,600 \div 250,000,000 = 1.2 \div 2,500 = 0.00048 = 4.8 \times 10^{-4} = 4.8 \times 10^{-4}$$

37. Injury and ladders and stools: 131,551

$131,551 \div 250,000,000 = 1.3 \div 2,500 = 0.00052 = 5.2 \text{ x } 10^{-4} = 5.2 \text{ x } 10^{-4}$

38. Injury and beds, mattresses, and pillows: 302,190

$302,190 \div 250,000,000 = 3 \div 2,500 = 0.0012 = 1.2 \text{ x } 10^{-3} = 1.2 \text{ x } 10^{-3}$

39. Injury and carpets and rugs: 87,738

$87,738 \div 250,000,000 = 8.8 \div 25,000 = 0.000352 = 3.52 \text{ x } 10^{-4} = 3.52 \text{ x } 10^{-4}$

40. Injury and stairs, ramps, and landings: 1,450,421

$1,450,421 \div 250,000,000 = 1.45 \div 250 = 0.0058 = 5.8 \text{ x } 10^{-3} = 5.8 \text{ x } 10^{-3}$

41. Injury and nails, carpet tacks: 214,123

$214,123 \div 250,000,000 = 2.14 \div 2,500 = 0.000856 = 8.56 \text{ x } 10^{-4} = 8.56 \text{ x } 10^{-4}$

42. Injury and drinking glasses: 114,683

$114,683 \div 250,000,000 = 1.15 \div 2,500 = 0.00046 = 4.6 \text{ x } 10^{-4} = 4.6 \text{ x } 10^{-4}$

43. Injury and cans, glass bottles, and jars: 250,542

$250,542 \div 250,000,000 = 2.5 \div 2,500 = 0.001 = 10^{-3}$

44. Injury and exercise equipment: 67,028

$67,028 \div 250,000,000 = 6.7 \div 25,000 = 0.00027 = 2.7 \text{ x } 10^{-4} = 2.7 \text{ x } 10^{-4}$

45. Injury and toys: 147,898

$147,898 \div 250,000,000 = 1.5 \div 2,500 = 0.0006 = 6 \text{ x } 10^{-4} = 6 \text{ x } 10^{-4}$

46. Injury and sinks and toilets: 43,162

$43,162 \div 250,000,000 = 4.3 \div 25,000 = 0.00017 = 1.7 \text{ x } 10^{-4} = 1.7 \text{ x } 10^{-4}$

47. Being murdered with a firearm: 12,847

$12,847 \div 227,131,000 = 1.3 \div 22,713 = 0.0000572 = 5.7 \text{ x } 10^{-5} = 5.7 \text{ x } 10^{-5}$

48. Being murdered: 20,930

$20,930 \div 227,131,000 = 2.1 \div 22,713 = 0.0000924 = 9.2 \text{ x } 10^{-5} = 9.2 \text{ x } 10^{-5}$

49. Being burglarized: 2,793,447

$2,793,447 \div 227,131,000 = 2.8 \div 227 = 0.012 = 1.2 \text{ x } 10^{-2} = 1.2 \text{ x } 10^{-2}$

50. Having motor vehicle stolen: 1,515,364

$1{,}515{,}364 \div 227{,}131{,}000 = 1.5 \div 227 = 0.066 = 6.6 \times 10^{-2} = 6.6 \times 10^{-2}$

51. Foodborne illness in Minnesota at Italian restaurant: 1 in 1,400,000

$1 \div 1{,}400{,}000 = 0.0000007 = 7 \times 10^{-7} = 7 \times 10^{-7}$

52. Foodborne illness in Minnesota at fast-food restaurant: 1 in 440,000

$1 \div 440{,}000 = 0.0000022 = 2.2 \times 10^{-6} = 2.2 \times 10^{-6}$

53. Foodborne illness in Minnesota at business meeting: 1 in 400,000

$1 \div 400{,}000 = 0.0000025 = 2.5 \times 10^{-6} = 2.5 \times 10^{-6}$

54. Foodborne illness in Minnesota at family gathering: 1 in 388,000

$1 \div 388{,}000 = 0.0000025 = 2.5 \times 10^{-6} = 2.5 \times 10^{-6}$

55. Foodborne illness in Minnesota at delicatessen: 1 in 240,000

$1 \div 240{,}000 = 0.0000041 = 4.1 \times 10^{-6} = 4.1 \times 10^{-6}$

56. Foodborne illness in Minnesota at Mexican restaurant: 1 in 136,000

$1 \div 136{,}000 = 0.0000073 = 7.3 \times 10^{-6} = 7.3 \times 10^{-6}$

57. Risk of a minor being kidnapped by a stranger: 1 in 560

$1 \div 560 = 0.00178 = 1.8 \times 10^{-3} = 1.8 \times 10^{-3}$

58. Risk of a minor being kidnapped by a family member: 1 in 180

$1 \div 180 = 0.0055 = 5.5 \times 10^{-3} = 5.5 \times 10^{-3}$

59. Risk of a child dying before the age of five in the U.S.: 1 in 100

$1 \div 100 = 0.01 = 10^{-2}$

60. Risk of a child dying before the age of five in South Asia: 1 in 8

$1 \div 8 = 0.125 = 1.25 \times 10^{-1} = 1.25 \times 10^{-1}$

61. Risk of losing job in next year, in general: 1 in 33

$1 \div 33 = 0.03030 = 3 \times 10^{-2} = 3 \times 10^{-2}$

62. Risk of losing job in next year, if doctor: 1 in 116

$1 \div 116 = 0.0086 = 8.6 \times 10^{-3} = 8.6 \times 10^{-3}$

63. Risk of losing job in next year, if lawyer: 1 in 82

$$1 \div 82 = 0.012 = 1.2 \text{ x } 10^{-2} = 1.2 \text{ x } 10^{-2}$$

64. Risk of losing job in next year, if postal worker: 1 in 41

$$1 \div 41 = 0.024 = 2.4 \text{ x } 10^{-2} = 2.4 \text{ x } 10^{-2}$$

65. Risk of losing job in next year, if accountant: 1 in 40

$$1 \div 40 = 0.025 = 2.5 \text{ x } 10^{-2} = 2.5 \text{ x } 10^{-2}$$

66. Risk of losing job in next year, if bus driver: 1 in 22

$$1 \div 22 = 0.04545 = 4.5 \text{ x } 10^{-2} = 4.5 \text{ x } 10^{-2}$$

67. Risk of losing job in next year, if farm worker: 1 in 8

$$1 \div 8 = 0.125 = 1.3 \text{ x } 10^{-1} = 1.3 \text{ x } 10^{-1}$$

68. Risk of dying on the job in 1934 (before Occupational Safety and Health Administration [OSHA]): 390 in 1 million

$$390 \div 1,000,000 = 0.00039 = 3.9 \text{ x } 10^{-4} = 3.9 \text{ x } 10^{-4}$$

69. Risk of dying on the job in 1994 (with OSHA): 40 in 1 million

$$40 \div 1,000,000 = 0.00004 = 4 \text{ x } 10^{-5} = 4 \text{ x } 10^{-5}$$

70. Risk of being injured in an elevator ride: 1 in 6 million

$$1 \div 6,000,000 = 0.00000016666 = 1.7 \text{ x } 10^{-7} = 1.7 \text{ x } 10^{-7}$$

71. Death from earthquake or volcano: 1 in 11 million

$$1 \div 11,000,000 = 9.09 \text{ x } 10^{-8} = 9.1 \text{ x } 10^{-8}$$

72. Death from leaking gas: 1 in 12 million

$$1 \div 12,000,000 = 8.33 \text{ x } 10^{-8} = 8.3 \text{ x } 10^{-8}$$

73. Death from dog bite: 1 in 20 million

$$1 \div 20,000,000 = 5 \text{ x } 10^{-8} = 5 \text{ x } 10^{-8}$$

74. Death from drinking detergent: 1 in 23 million

$$1 \div 23,000,000 = 4.3 \text{ x } 10^{-8} = 4.3 \text{ x } 10^{-8}$$

75. Death from snakebite: 1 in 36 million

$$1 \div 36,000,000 = 2.777 \text{ x } 10^{-8} = 2.8 \text{ x } 10^{-8}$$

76. Risk of being struck by lightning in any given year: 1 in 750,000

   $1 \div 750{,}000 = 0.0000013 = 1.3 \times 10^{-6} = 1.3 \times 10^{-6}$

77. Chances of surviving **after** being struck by lightning: 3 in 4

   $3 \div 4 = 0.75 = 7.5 \times 10^{-1} = 7.5 \times 10^{-1}$

78. Risk of contracting a nosocomial infection at a U.S. hospital: 1 in 15

   $1 \div 15 = 0.06666 = 6.7 \times 10^{-2} = 6.7 \times 10^{-2}$

79. Risk of being infected with the "flesh-eating bacteria": 1 in 170,000

   $1 \div 750{,}000 = 0.0000058 = 5.8 \times 10^{-6} = 5.8 \times 10^{-6}$

80. Risk of dying once infected with the "flesh-eating bacteria": 1 in 4

   $1 \div 4 = 0.25 = 2.5 \times 10^{-1} = 2.5 \times 10^{-1}$

81. Risk, for an African, of contracting the Ebola virus: 1 in 14 million

   $1 \div 14{,}000{,}000 = 7.14 \times 10^{-8} = 7.14 \times 10^{-8}$

82. Risk of dying once infected with the Ebola virus: (2 in 3) to (9 in 10)

   $2 \div 3 = 0.666 = 6.7 \times 10^{-1} = 6.7 \times 10^{-1}$

   $9 \div 10 = 0.9 = 9 \times 10^{-1} = 9 \times 10^{-1}$

Curriculum Resources

Appendix 4. Websites for further sources of data for risk calculations

Potential web sources – selected exceptional sites with health related information and statistics

1. Statistical Assessment Service (STATS) – a non profit, non partisan organization concerned with presentation of science in the media.

> Home page http://www.stats.org

> Interesting topics http://www.stats.org/spotlight/index.html

2. National Center for Health Statistics http://www.cdc.gov/nchs/

This is a **key site**!! Part of Centers for Disease Control and Prevention with gateways to a wide variety of data!

> NHANES = National Health and Nutrition Examination Survey

> NCHS = National Center for Health Statistics

> NHIS = National Health Interview Survey

> NIS = National Immunization Survey

> NSFG = National Survey of Family Growth

> SLAITS = State and Local Area Integrated Survey

> Vital Statistics = National Vital Statistics System

3. U.S. Centers for Disease Control and Prevention (CDC) www.cdc.gov

4. National Center for Infectious Diseases http://www.cdc.gov/ncidod/index.htm

5. National Safety Council www.nsc.org

6. Health Effects Institute http://www.healtheffects.org/

7. American Cancer Society (ACS) www.cancer.org

8. World Health Organization (WHO) www.who.int

9. Bureau of Labor Statistics http://www.bls.gov

10. American Public Health Association www.apha.org

Potential web sources – U.S. government websites with related information

1. U.S. Environmental Protection Agency (EPA) http://www.epa.gov/

2. Occupational Safety and Health Administration (OSHA)

http://www.osha-slc.gov/OshAct_toc/OshAct_toc_by_sect.html

3. Food and Drug Administration (FDA) http://www.fda.gov/fdahomepage.html

4. Agency for Toxic Substances and Disease Registry http://atsdrl.atsdr.cdc.gov:8080/atsdrhome.html

     search HazDat database http://atsdrl.atsdr.cdc.gov:8080/hazdat.html#A3.1.2a

Potential web sources – additional U.S. government websites

First Gov: Your First Click to the U.S. Government http://63.240.14.150/index.html

GovBot Database of U.S. Government and Military Web Sites http://pardoo.cs.umass.edu/GovBot/

Federal Information Exchange (FIE) http://web.fie.com/
(Working to improve communication between federal agencies and institutions of higher education)

U.S. Government Printing Office (GPO) http://www.access.gpo.gov/

National Archives & Records Administration (NARA) http://www.nara.gov

Library of Congress http://www.loc.gov/
http://lcweb.loc.gov/
http://lcweb2.loc.gov/catalog/
(experimental web catalog)

U.S. Department of Agriculture http://www.usda.gov/

U.S. Department of Commerce http://www.doc.gov/

U.S. Department of Energy http://www.doe.gov/

U.S. Department of Health and Human Services (HHS) http://www.os.dhhs.gov/

U.S. Department of the Interior http://www.doi.gov/

U.S. Department of Justice http://www.usdoj.gov/

Bureau of Justice Statistics http://www.ojp.usdoj.gov/bjs/welcome.html

U.S. Department of Transportation (DOT) http://www.dot.gov/

Federal Bureau of Investigation (FBI) http://www.fbi.gov/

U.S. Copyright Office http://lcweb.loc.gov/copyright/

U.S. Patent & Trademark Office http://www.uspto.gov/

U.S. National Park Service http://www.nps.gov/

U.S. Geological Survey http://www.usgs.gov/

National Academy Press www.nap.edu

National Institutes of Health (NIH) http://www.nih.gov

National Laboratories http://www.larc.nasa.gov:80/nasaonline/gov.html

National Science Foundation (NSF) http://stis.nsf.gov

Nuclear Regulatory Commission (NRC) http://www.nrc.gov

Potential web sources – Canadian government websites

Canadian Safety Council http://www.safety-council.org

Canadian Centre for Occupational Health and Safety (CCOHS) http://www.ccohs.ca

Health Canada http://www.hc-sc.gc.ca/

Potential web sources – Mexican government websites

Secretaria de Medio Ambiente y Recursos Naturales (SEMARNAT) http://www.semarnat.gob.mx/index1.shtml

Potential web sources – Australian government websites

Australia's National Occupational Health and Safety Commission http://www.worksafe.gov.au