Confusion Between Odds and Probability, a Pandemic?

Lawrence V. Fulton
Texas State University

Francis A. Mendez
Texas State University

Nathaniel D. Bastian
University of Maryland University College

R. Muzaffer Musal
Texas State University

Journal of Statistics Education Volume 20, Number 3 (2012),
www.amstat.org/publications/jse/v20n3/fulton.pdf

Key Words: Statistical Literacy; Statistical Competence; Odds; Probability.

Abstract

This manuscript discusses the common confusion between the terms probability and odds. To emphasize the importance and responsibility of being meticulous in the dissemination of information and knowledge, this manuscript reveals five cases of sources of inaccurate statistical language imbedded in the dissemination of information to the general public. The five cases presented are: Texas Lottery, Texas PowerBall, the Discovery Education Website, ScienceNews, and the Oregon State website.

1. Introduction

The practice of clearly and precisely defined terminology is central to the evolution of science, and statistical science is not an exception. The need for understanding basic statistical concepts and terminology is essential to the idea of *statistical competence* introduced by Rumsey (2002). The terminology of statistical science is often abused, as terms like *significance, correlation,* *accuracy*, *precision*, *confidence*, *probability*, and *odds* have very specific definitions in statistical science. Unfortunately, the popular media and even purported statistically-oriented businesses often fail to adhere to rigor, particularly when discussing the use of the term *odds* (Schwartz, Woloshin & Welch, 1999). People could be misled into equating the terms *odds* and *probability*. Relying on accessible dictionaries, such as online dictionaries, might not help clarify the meaning of these terms.

The following is a list of definitions for the term *probability* as it appears in eight English dictionaries of common use:

Table 1: Dictionary Definitions of Probability

Definition	**Reference**
"a measure or estimate of the degree of confidence one may have in the occurrence of an event, measured on a scale from zero (impossibility) to one (certainty)"	(Collins Dictionary, 2012)
"the ratio of the number of outcomes in an exhaustive set of equally likely outcomes that produce a given event to the total number of possible outcomes"	(Merriam-Webster Dictionary, 2012)
"the extent to which an event is likely to occur, measured by the ratio of the favorable cases to the whole number of cases possible"	(Oxford Dictionary, 2012)
"a measure of how likely something is to happen"	(Macmillan British Dictionary, 2012)
"the relative possibility that an event will occur, as expressed by the ratio of the number of actual occurrences to the total number of possible occurrences"	(Random House Dictionary, 2012)
"the level of possibility of something happening or being true; likelihood"	(Cambridge Dictionary, 2012)
"probability refers to the likelihood of something occurring or the chance of something happening"	(American Heritage Dictionary, 2012)
"the relative likelihood of an event happening"	(Wiktionary, 2012)

The eight sources quoted provide a consistent definition of the term probability and some provide a general form of computation.

The etymology of the noun *probability* has its origin in the mid 15th Century, derived from the Old French *probabilité* (14th Century) and originating directly from Latin *probabilitatem* (noun. *Probabilitas* meaning "probability", "credibility"), which is derived from *probabilis*. The term *probabilis* means probable, plausible, likely, commendable and originates from the Latin word *probare*, meaning, "to try, to test, to prove worthy, to examine". Probare is derived from the Latin word *proba*, meaning, "proof" or "evidence." The term probability acquired its meaning "something likely to be true" in the 1570s and its mathematical sense in 1718 (Online Etymology Dictionary, 2012; Oxford Reference Online Premium, 2012; JM Latin Dictionary, 2012).

The following is a list of definitions for the term *odds* as it appears in eight English dictionaries of common use:

Table 2: Dictionary Definitions of Odds

Definition	**Reference**
"the likelihood of a thing occurring rather than not occurring"	(Memidex Online Dictionary, 2012)
"the chances of something happening"	(Macmillan British Dictionary, 2012)
"the ratio between the amounts staked by the parties to a bet, based on the expected probability either way"	(Oxford Dictionary, 2012)
"the probability that one thing is so or will happen rather than another; the ratio of the probability of one event to that of an alternative event"	(Merriam-Webster Dictionary, 2012)
"the probability that something is so, will occur, or is more likely to occur than something else"	(Random House Dictionary, 2012)
"the probability that a particular thing will or will not happen"	(Cambridge Dictionary, 2012)
"the ratio of the probability of an event's occurring to the probability of its not occurring; the likelihood of the occurrence of one thing rather than the occurrence of another thing, as in a contest"	(American Heritage Dictionary, 2012)
"the ratio of the probabilities of an event happening to that of it not happening"	(Wiktionary, 2012)

Unfortunately, the eight sources quoted provide inconsistent and computationally different definitions of the term odds. Four of these references define odds as probabilities or chances. Three of these definitions are consistent with the odds calculation familiar to statisticians. Despite the common, incorrect use of the term *odds*, the definition of odds refers to the ratio of the probability occurring to the probability of it not occurring, rather than vice versa.

The etymology of the noun *odds* dates from the early 16th Century. The origin of the modern sense of odds is more uncertain. It is first found being used in its wagering sense in 1597 in Shakespeare's 2 Henry IV. It is likely to be derived from an earlier sense of 'amount by which one thing exceeds or falls short of another' (1540s). The adjective *odd* dates from the 1300s, "constituting a unit in excess of an even number", from Old Norse *oddi* "third or additional number" and *oddr*, meaning "point, spot, place" (Online Etymology Dictionary, 2012). The sense of the term *odd* as "strange, peculiar" was first attested 1580s (Collins Dictionary, 2012).

In statistics, odds are defined from two ways: *odds in favor* of an event A (or odds on A), and *odds against* an event A (Berry & Lindgren, 1996). The expression "the odds of A" by itself could be controversial. In popular jargon (e.g., sports wagering), one might construe that "the odds of A" implies the odds *against* A occurring. Such a definition itself might be a bit vague for some. Once it is clear that one is dealing with the odds against A, then one definition is: the number of ways A does not occur against the number of ways A does occur, usually denoted as $n(A^c)$:n(A) where n(A) is a function indicating the count of ways event A can happen and $n(A^c)$ denotes the ways event A does not happen; in other words, A^c stands for "not A".

$$\text{odds on A} = \text{k to N-k; odds against A} = \text{N-k to k} \tag{1}$$

where k denotes the number of outcomes that favor event A, N is the total number of possible outcomes, and N-k denotes the number of outcomes that do not favor event A (the complement of A or A^c). A colon is usually used as notation to denote odds:

$$\text{odds on A} = k : N\text{-}k\text{; odds against A} = N\text{-}k : k \tag{2}$$

The expression odds on A conveys the odds in favor of A. The number of ways an event A is favored, n(A) or k; divided by the total number of events that do not favor A, $n(A^c)$ or N-k.

The classical probability of event A, P(A), is expressed as:

$$P(A) = \frac{n(A)}{N} \tag{3}$$

This expression corresponds to saying "n(A) ways in n(A) + $n(A^c)$", and it would define a probability favoring event A. The odds in favor of A can be defined in terms of probabilities, for instance:

$$\text{odds in favor of A} = \frac{n(A)}{n(A^c)} = \frac{P(A)}{P(A^c)} \tag{4}$$

Therefore, the odds in favor of A can be expressed as the ratio of the probability of event A and the probability of the complement of A.

Based on the previous discussion, it is brought to the attention of the reader the difference between the meaning of expressions (3) and (4); where the former is the probability of event A and the latter are the odds in favor of A.

Strictly speaking, the probability of an event is expressed as a real number within the interval [0,1] (Ross, 2000). Chances, a term used as a synonym of probability, are usually expressed as percentages. Strictly speaking, a percentage is a fraction (a real number within the interval [0,1]) expressed in hundredths; from the Latin *per centum* (Merriam-Webster Dictionary, 2012; Online Etymology Dictionary, 2012). Therefore, chances are probabilities expressed in a scale "by the hundred". The scale of measurement of probabilities and chances differ. For instance, if the probability of A occurring is 3/4, then the chance of A occurring is 75% (3/4 times 100 percent). Therefore, a chance of 75% would literally mean that 75 of every one hundred trials turn in favor of A. The discussion of the correctness of this last statement is not the focus of this manuscript.

Odds are ratios, specifically, ratios of probabilities. The units of the odds of an event A (a ratio) are expressed in orders of magnitude relative to event A not occurring. Orders of magnitude are not strictly confined to the continuum of the real line in the interval [0,1]. Therefore, the scaling of probability, chances and odds are not the same. For instance, the odds in favor of A are P(A) / $P(A^c) = (3/4)/(1/4) = 3/1$. It is said that the odds in favor of A are 3:1 or that A is an event twice as likely as "not A". Therefore, the odds of A occurring are expressed in the scale of the probability of "A not occurring".

Understandably, confusion about the definitions of probability and odds is widespread. That said, one would expect that the confusion would not extend to disciplines that have significant fiducial or social responsibilities (and liabilities).

2. Five Cases

2.1. Texas Lottery Commission

A lottery is a means of raising money by selling numbered tickets. These tickets are often referred to as *chances*. For instance, a single ticket has "one chance in N" of being selected (winning). An individual holding k of the N tickets has "k chances in N" of winning. The holders of the ticket with the numbers drawn at random win a prize. The selection of the numbers is assumed to be random, meaning that each number has an equal chance of being selected. Therefore, each ticket has a probability "one in N" of being drawn.

Governments allow and regulate lotteries as an additional means to raise revenues. In the United States, state and local laws govern lotteries and these regulations vary throughout the nation. Lotteries come in many formats, but the usual format in the United States consists of numbered tickets sold for a prize that constitutes a large amount of cash.

The Texas Lottery is a gambling game where individuals, for the "bargain" cost of a dollar, attempt to match 6 numbered balls that are randomly drawn from a group of 54. A prize is awarded for matching 3, 4, 5, or 6 balls, and the order the balls are selected makes no difference. In other words, {1,2,3,4,5} matches {2,3,4,5,1}. The lottery payout is complicated, as matching four or more numbers results in pari-mutuel prize distribution. The lottery advertises the odds and winnings as shown in Figure 1 (http://www.txlottery.org/export/sites/lottery/Images/lotto_how-to-win.gif).

Figure 1: Texas lottery advertisement

The problem with this advertisement, however, is that the calculations are flawed. The figure presented as odds is indeed *not* odds. Let's define a simple event $A_{n.}$ Event A_n is the event that we match exactly n out of the 6 winning numbers. Then event A_n^c is the event that we do not match exactly n balls. The number of ways in which one can match n balls when order does not matter is defined as a simple combination. I have 6 winning balls from which I will choose n and 48 losing balls from which I will choose 6-n. Using the rule of product (or multiplication rule), the number of ways to obtain n successes is then:

$$\binom{6}{n} \times \binom{48}{6-n} \tag{5}$$

The easiest way to determine the number ways to obtain a failure is to calculate the total ways in which one can achieve any outcome and subtract out the number of ways in which success can be achieved. Specifically, we have the following:

$$\binom{54}{6} - \binom{6}{n} \times \binom{48}{6-n} \tag{6}$$

Since successes and failures are mutually exclusive and categorically exhaustive, it is known that:

the number of successes + the number of failures = total number of events
and (7)
the total number of events - the number of successes = the number of failures

According to the Texas Lottery Commission, the "Odds of Winning" for six numbers should be 1:25,827,165; however, this is wrong. The number of ways to obtain a success is given by $\binom{6}{6} \times \binom{48}{0} = 1$. The number of ways to obtain a failure is $\binom{54}{6} - \binom{6}{6} = 25{,}827{,}164$. The odds is then 1 : 25,827,164.

The mistake is unlikely to be a typographical error. It is evident, from the announcement and Table 3, that the Commission has been systematically wrong in their publication of the odds. Since the events of getting n balls are mutually exclusive, we can sum the ways to win for all balls, calculate ways to lose from Equation 6, and determine classical odds of winning anything.

Table 3. Comparison of true odds with reported odds.

# of Balls	**# Ways to Win**	**# Ways to Lose**	**True Odds**	**Reported Odds**
6	1	25,827,164	1 : 25,827,164	1 : 25,827,165
5	288	25,826,877	1 : 89,677	1 : 89,678
4	16,920	25,810,245	1 : 1,525	1 : 1,526
3	345,920	25,481,245	1 : 74	1 : 75
Total	363,129	25,464,036	1 : 70	1 : 71

Therefore, the odds of winning are actually a bit better than those reported, although not by much. The mistake consisted of not considering the number of ways to lose (subtracting the number of ways to win from the number of possible outcomes). The mistake can be replicated by dividing the total number of ways to have any outcome, $\binom{54}{6} = 25{,}827{,}165$ by the number of ways to win. The reported odds is *not* such but the probability of winning which is $1/25{,}827{,}165$.

For instance, in rolling a balanced six-sided die, the odds on 3 are 1 : 5, but the probability of an outcome of 3 is $1/6$.

2.2. Texas Powerball® / Power Play® Lottery

The Powerball® / Power Play® Lottery is a game of chance, where individuals pay $2 to select 5 numbered white balls from 59 total. Individuals also select a single red "PowerBall," a separate draw from 35 *different* numbered, red balls. Individuals may increase the prize value by paying an additional dollar, and this is called a "Power Play." The odds of winning and associated prizes are reported in http://www.powerball.com/powerball/pb_prizes.asp.

Calculating the odds of winning is again fairly trivial. Given that we match n white balls and either match or do not match the red ball and given the fact that the draws of red and white balls are independent of each other, the recursive formula for success is Equation 8. The equation represents the number of ways that we select n winning white numbers from 5 possible winners multiplied by the number of ways we select 5-n losers from 54 losing numbers further multiplied by the number of ways to select either 0 or 1 (m) winning red number from one possible winner times the number of ways to select 1-m losers from the 34 losing red balls. Equation 9 is then the number of failures calculated as the total number of ways to obtain 5 white balls and 1 red ball minus the number of successes.

$$\binom{5}{n}\times\binom{54}{5-n}\times\binom{1}{m}\times\binom{34}{1-m} \quad (8)$$

$$\left[\binom{59}{5}\times\binom{35}{1}\right]-\left[\binom{5}{n}\times\binom{54}{5-n}\times\binom{1}{m}\times\binom{34}{1-m}\right] \quad (9)$$

Table 4 represents the ways to have successes and failures, as well as the calculated odds compared with the reported odds. Similar to the previous discussion, the reported odds are slightly less favorable than the actual classical odds. Table 4 shows that the Powerball Lottery is reporting probabilities rather than odds, for instance the case of five white balls and one red ball, for one success: there are 175,223,509 possible ways of failing but the odds reported are 1 : 175,223,510.

Table 4. Classical odds versus reported odds of winning the Powerball Lottery

White Balls	**Red?**	**Successes**	**Failures**	**Calculated Odds**	**Reported Odds**
5	1	1	175,223,509	1 : 175,223,509	1 : 175,223,510
5	0	34	175,223,476	1 : 5,153,632	1 : 5,153,633
4	1	270	175,223,240	1 : 648,975	1 : 648,976
4	0	9180	175,214,330	1 : 19,087	1 : 19,088
3	1	14310	175,209,200	1 : 12,244	1 : 12,245
3	0	486540	174,736,970	1 : 359	1 : 360
2	1	248040	174,975,470	1 : 705	1 : 706
1	1	1581255	173,642,255	1 : 110	1 : 111
0	1	3162510	172,061,000	1 : 54	1 : 55
Total		5502140	169,721,370	1 : 31	1 : 32

2.3. Discovery Education WebMath Website

A similar situation can be found in the solver "Calculate Your Chance of Winning the Lottery" depicted in http://www.webmath.com/lottery.html (Discovery Education WebMath, 2012). Indeed, the solver calculates the chances, or probabilities, of having a winning ticket. However, on the left hand side of the page it is stated: "This page will calculate your odds of winning." Not exactly. Again the ideas of probabilities and odds are confused.

When a person enters the number of correct numbers that must be chosen, the lowest number and highest number to choose, the result is a probability of winning and not the odds of winning as implied by the execution button: "What are my odds?". The code correctly proceeds and describes the correct procedure of computing the probability of winning. The only problem is that it claims to be producing the odds in favor of winning, and this is incorrect. Figure 2 depicts a snapshot of the page.

Figure 2: Calculating the Odds of Winning

So, to figure out your odds of winning, multiply together all of the fractional odds of picking a given number correctly, as stated by the red fractions above.

$^1/_{54} \times {}^1/_{53} \times {}^1/_{52} \times {}^1/_{51} \times {}^1/_{50} \times {}^1/_{49} = {}^1/_{18595558800}$

So, at this point, your odds of winning are 1 in 18595558800.

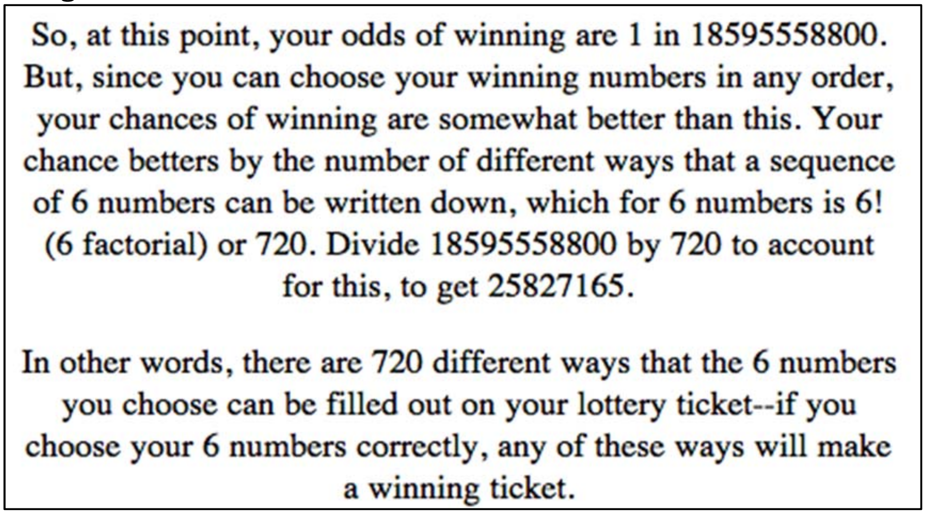
Shown in this excerpt from the *Discovery Education WebMath* website are represented the number of permutations of 54 numbers taken 6 at a time:

$$\frac{N!}{(N-n)!} = \frac{54!}{(54-6)!} = 18595558800 \tag{10}$$

Therefore, each of these permutations of 6 numbers has a probability of 1 in 18,595,558,800; but the odds in favor of choosing any of these permutations is 1 on 18,595,558,799. These probabilities are computed assuming a random experiment in which selection occurs without replacement. What is shown in the box is the way to calculate the probability of randomly selecting six balls (one in each instance), without replacing the selected one into the pool, from a total of 54 balls in the initial pool. The probability of choosing any specific ball in the first trial is one out of 54 balls that are in the initial pool. On the second trial, there are 53 balls left in the pool, of which we will select one. After the first and second selections are done 52 balls are left in the pool, and so on until 6 balls have been selected without replacement and only 48 balls are left in the pool. What is shown in the numerator of Equation 10 is the way in which one can sequence 54 different balls. However, the experiment will not sequence all 54 balls but only the selected 6. The denominator of Equation 10 represents the number of sequences for the remaining 48 (54-6) balls that will not be selected. This operation results in the product: $54 \times 53 \times 52 \times 51 \times 50 \times 49$. The operation as shown in the Discovery website and Equation 10 are equivalent.

Up to this point, all possible permutations of the same six items are considered *unexchangeable* or distinct from each other. However, for the purpose of the game, any orderings of the same numbers are considered exchangeable or non-distinct. Therefore, all possible orderings of six items (6!) are considered as one and the same. The correct explanation proceeds from the *Discovery Education* website in Figure 3.

Figure 3: Permutation Game from the Discover Education Website


So, at this point, your odds of winning are 1 in 18595558800. But, since you can choose your winning numbers in any order, your chances of winning are somewhat better than this. Your chance betters by the number of different ways that a sequence of 6 numbers can be written down, which for 6 numbers is 6! (6 factorial) or 720. Divide 18595558800 by 720 to account for this, to get 25827165.

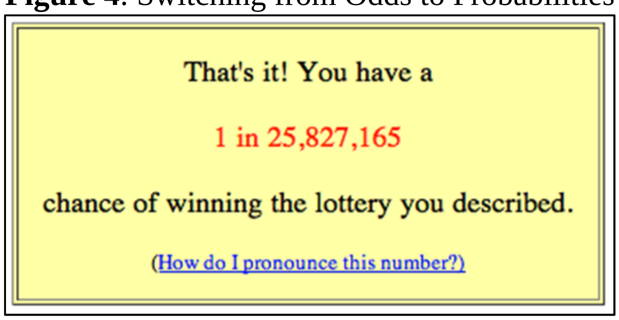
In other words, there are 720 different ways that the 6 numbers you choose can be filled out on your lottery ticket--if you choose your 6 numbers correctly, any of these ways will make a winning ticket.

Therefore, the probability of winning of one in 25,827,165 combinations; where the odds in favor are 1 on 25,827,164.

$$\frac{N!}{n!(N-n)!} = \frac{54!}{6!(54-6)!} = 25827165 \qquad (11)$$

The explanation in the *Discovery Education* website finalized with a "switch" from everything being expressed in terms of "odds" back to "chances" or "probabilities".

Figure 4: Switching from Odds to Probabilities


That's it! You have a

1 in 25,827,165

chance of winning the lottery you described.

(How do I pronounce this number?)

The procedure exits with a final solution that is correct in all respects, after a trail of confusion between odds and probability. Along the whole explanation, probabilities are computed but they are constantly, consistently, and incorrectly referred to as "odds".

2.4. ScienceNews Article

Unfortunately, scientists promulgate the confusion between odds and probability. In an aptly titled ScienceNews article, the writer points out how the interpretation of p-values is often wrong

(Odds Are, It's Wrong, 2011). Indeed, the author is correct that misinterpretation of this concept exists, but unfortunately provides fodder for the argument regarding the misconception between odds and probability:

"Correctly phrased, experimental data yielding a p-value of .05 means that there is only a 5 percent chance of obtaining the observed (or more extreme) result if no real effect exists (that is, if the no-difference hypothesis is correct). But many explanations mangle the subtleties in that definition. A recent popular book on issues involving science, for example, states a commonly held misperception about the meaning of statistical significance at the .05 level: 'This means that it is 95 percent certain that the observed difference between groups, or sets of samples, is real and could not have arisen by chance.' That interpretation commits an egregious logical error (technical term: 'transposed conditional'): confusing the odds of getting a result (if a hypothesis is true) with the odds favoring the hypothesis if you observe that result."

Without pointing out the limitations of the author's argument regarding the "correctly phrased" p-value (e.g., omission of repeated independent random sampling of the same size from the same population), we point out the use of "odds" as a p-value. The confusion is not with odds as the author suggests. The confusion rests with a misunderstanding of p-values which are a statistic in a distribution. We would like to agree with the author, however, that "Odds are, it's Wrong."

2.5. Quaking University

Even universities promulgate the misconception of odds and probability. In a 2010 article posted to the Oregon State website, the title proclaims that, "Odds are 1 in 3 that a Huge Quake will hit Northwest in the Next 50 Years." Here is the claim from the scientists (Goldfinger, 2010):

"Based on historical averages, Goldfinger says the southern end of the fault – from about Newport, Ore., to northern California – has a 37 percent chance of producing a major earthquake in the next 50 years. The odds that a mega-quake will hit the northern segment, from Seaside, Ore., to Vancouver Island in British Columbia, are more like 10 to 15 percent."

We find several issues here. First, one must assume that the title references only the region from Newport, Oregon to northern California. If the probability that an earthquake will occur in this region is 37%, then the odds for having an earthquake are 37% / 63% = 0.58. Rounding would suggest that odds of 1 to 2 would have been more appropriate for the title (albeit still inaccurate). The revised odds would have the added benefit of providing additional tremors in the readership. Apparently, the article writer confused 37% chance as 1 in 3 odds.

Next, we see significant confusion in the reporters if not the scientists themselves. Odds are not percentages, so stating that the odds are "10 to 15 percent" is blatantly wrong.

3. Summary

In this paper, we discussed the commonplace confusion between the terms probability and odds. In an effort to demonstrate that the terminology of statistical science is often misunderstood, we highlighted five cases of imprecise statistical language imbedded in the dissemination of information to the general public.

In the first case, the Texas Lottery Commission publically announced the "odds of winning" when the actual statistical computations expressed the "probability of winning." The mistake is unlikely to be a typographical error. In the second case, the Texas PowerBall also incorrectly calculated odds, and, thus, reported probabilities of winning rather than odds of winning. In the case of the Discovery Education website, probabilities were computed throughout the explanations but they are continually referred to as "odds." In the fourth case, the author of the ScienceNews article correctly identifies the frequent misinterpretation of p-values, but then incorrectly states that this confusion is due to the use of "odds" as a p-value. Finally, in the case of Quaking University, the odds for an earthquake occurring where inaccurately portrayed in the title of an article, and then the odds were reported as percentages, which is blatantly incorrect.

From these cases, we clearly see how statistical terms like *probability* and *odds* can be easily misconceived and mis-portrayed to the general public. Therefore, the need for understanding and practicing basic yet precisely defined statistical concepts and terminology is central to the development of statistical science and is essential to the idea of statistical competence.

References

Altbach, P.G. (2011). "The Past, Present, and Future of the Research University," *Economic & Political Weekly*, 46, 16, 65-73.

Berry, D. A. & Lindgren, B. W. (1996). *Statistics: Theory and Methods*, 2nd ed. Duxbury Press, p. 15.

Discovery Education WebMath: Calculate Your Chance of Winning the Lottery. Accessed 03 April 2012. Available from http://www.webmath.com/lottery.html.

Free Live Odds. Odds & Probabilities. Accessed 03 July 2012. Available from http://www.free-live-odds.com/articles/odds-and-probabilities.php.

Goldfinger, C. (2010). Odds are 1-in-3 that a Huge Quake Will Hit Northwest in Next 50 Years. Accessed 05 August 2012. Available from http://oregonstate.edu/ua/ncs/node/13426.

Martin, K. G. Logistic Regression Analysis: Understanding Odds and Probability. Accessed 03 July 2012. Available from http://www.theanalysisfactor.com/understanding-odds-and-probability/.

odds. (2012). *Memidex Online Dictionary*. Accessed 05 July 2012. Available from http://www.memidex.com/odds.

odds. (2012). *Macmillan British Dictionary*. Accessed 05 July 2012. Available from http://www.macmillandictionary.com/dictionary/british/odds.

odds. (2012). *Oxford Dictionary*. Accessed 05 July 2012. Available from http://oxforddictionaries.com/definition/odds.

odds. (2012). *Merriam-Webster Dictionary*. Accessed 05 July 2012. Available from http://www.merriam-webster.com/dictionary/odds.

odds. (2012). *Random House Dictionary*. Accessed 05 July 2012. Available from http://dictionary.infoplease.com/odds.

odds. (2012). *Cambridge Dictionary*. Accessed 05 July 2012. Available from http://dictionary.cambridge.org/dictionary/british/odds.

odds. (2012). *American Heritage Dictionary*. Accessed 05 July 2012. Available from http://www.yourdictionary.com/odds.

odds. (2012). *Wiktionary*. Accessed 05 July 2012. Available from http://en.wiktionary.org/wiki/odds.

odds. (2012). *Online Etymology Dictionary*. Accessed 05 July 2012. Available from http://www.etymonline.com/index.php?term=odds.

odds. (2012). *Collins Dictionary*. Accessed 05 July 2012. Available from http://www.collinsdictionary.com/dictionary/english/odds.

Odds Are, It's Wrong. *ScienceNews*. November 8, 2011. Accessed 06 August 2012. Available from http://www.sciencenews.org/view/feature/id/335872/title/Odds_Are,_Its_Wrong.

percentage. (2012). *Merriam-Webster Dictionary*. Accessed 15 July 2012. Available from http://www.merriam-webster.com/dictionary/percentage.

percentage. (2012). *Online Etymology Dictionary*. Accessed 15 July 2012. Available from http://www.etymonline.com/index.php?allowed_in_frame=0&search=percent&searchmode=none.

proba. (2012). *JM Latin Dictionary*. Accessed 07 July 2012. Available from http://www.latin-dictionary.org/Latin-English-Dictionary.../proba.

probabilis. (2012). *Online Etymology Dictionary*. Accessed 05 July 2012. Available from http://www.etymonline.com/index.php?search=probabilis.

probabilis. (2012). *Oxford Reference Online Premium*. Accessed 07 July 2012.

probare. (2012). *Oxford Reference Online Premium*. Accessed 07 July 2012.

probable. (2012). *Online Etymology Dictionary*. Accessed 05 July 2012. Available from http://www.etymonline.com/index.php?term=probable.

probability. (2012). *Collins Dictionary*. Accessed 05 July 2012. Available from http://www.collinsdictionary.com/dictionary/english/probability.

probability. (2012). *Merriam-Webster Dictionary*. Accessed 05 July 2012. Available from http://www.merriam-webster.com/dictionary/probabilities.

probability. (2012). *Oxford Dictionary*. Accessed 05 July 2012. Available from http://oxforddictionaries.com/definition/english/probability.

probability. (2012). *Macmillan British Dictionary*. Accessed 05 July 2012. Available from http://www.macmillandictionary.com/dictionary/british/probability.

probability. (2012). *Random House Dictionary*. Accessed 05 July 2012. Available from http://dictionary.infoplease.com/probability.

probability. (2012). *Cambridge Dictionary*. Accessed 05 July 2012. Available from http://dictionary.cambridge.org/dictionary/british/probability.

probability. (2012). *American Heritage Dictionary*. Accessed 05 July 2012. Available from http://www.yourdictionary.com/probability.

probability. (2012). *Wiktionary*. Accessed 05 July 2012. Available from http://en.wiktionary.org/wiki/probability.

probability. (2012). *Online Etymology Dictionary*. Accessed 05 July 2012. Available from http://www.etymonline.com/index.php?term=probability.

Powerball®/Power Play® Lottery. Accessed 03 April 2012. Available from http://www.powerball.com/pb_home.asp.

Powerball®/Power Play® Lottery. Accessed 03 July 2012. Available from http://www.powerball.com/powerball/pb_prizes.asp.

Ross, S.M. (2000). *Introduction to Probability Models*, 7th ed., Harcourt Academic Press: San Diego, p. 4.

Rumsey, D. (2002). “Statistical Literacy as a Goal for Introductory Statistics Courses,” *Journal of Statistics Education* [online], 10, 3. Available from http://www.amstat.org/publications/jse/v10n3/rumsey2.html.

Schwartz, L. M., Woloshin, S., & Welch, H. G. (1999) Misunderstandings about the Effects of Race and Sex on Physicians' Referrals for Cardiac Catheterization. *New England Journal of Medicine* 341, 279-283.

Texas Lottery. Accessed 03 April 2012. Available from http://www.txlottery.org/.

Addendum

Volume 21, Number 1, of the *Journal of Statistics Education* contains a Letter to the Editor concerning this article and a Rejoinder by the authors of this article.

Lawrence V. Fulton
Texas State University
601 University Drive
San Marcos, TX 78666
mailto: lf25@txstate.edu
Phone: 512-245-3237

Francis A. Mendez
Texas State University
601 University Drive
San Marcos, TX 78666
mailto: fm16@txstate.edu
Phone: 512-245-3303

Nathaniel D. Bastian
University of Maryland University College
3501 University Blvd. East
Adelphi, MD 20783
mailto: nathaniel.bastian@faculty.umuc.edu
Phone: 570-809-3619

R. Muzaffer Musal
Texas State University
601 University Drive
San Marcos, TX 78666
mailto: rm84@txstate.edu
Phone: 512-245-1452
