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# The Most Dangerous Profession: A Note on Nonsampling Error

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Nonsampling errors are subtle, and strategies for dealing with them are not particularly well known within psychology. This article provides a compelling example of an incorrect conclusion drawn from a nonrandom sample: H. C. Lomard's (1835) mortality data. This example is augmented by a second example (A. Wald, 1980) that shows how modeling the selection mechanism can correct for the bias introduced by nonsampling errors. These 2 examples are then connected to modern statistical methods that through the method of multiple imputation allow researchers to assess uncertainty in observational studies.

The APA's task force on Statistical Inference has received comments and suggestions from interested parties throughout the entire time I have served on it. These comments have always been treated by the task force with careful attention. In the most recent batch was a one-page missive from John Tukey containing seven suggestions. In the course of my professional life I have made many errors, but happily, ignoring statistical advice from John Tukey is not one of them.

Tukey's fifth suggestion, in its entirety, is, "nonsampling errors deserve greater attention, especially when randomization is absent. The formal statistical analysis treats only some of the uncertainties" (J. W. Tukey, personal communication, June 16, 1997). Indeed, but nonsampling errors are subtle, and strategies for dealing with them are not particularly well known within psychology. Thus, I think it would be worthwhile to provide a particularly interesting illustration of one and point the way toward alternative methodologies for interested readers.

This article was helped by information provided by S. M. Stigler (1996) and P. R. Rosenbaum (1989). For further discussions the interested reader is referred to Wainer (1986, 1989a, 1989b) and Wainer, Palmer, and Bradlow (1998). This research was supported in part by the Educational Testing Service research allocation to the Research Statistics Group.

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## Illustration: The Most Dangerous Profession

In 1835 the Swiss physician H. C. Lombard published the results of a study on the longevity of various professions. His data were very extensive, consisting of 8,496 death certificates gathered over more than a half century in Geneva. Each certificate contained the name of the deceased, his profession, and age at death. Lombard used these data to calculate the mean longevity associated with each profession. Lombard's methodology was not original with him but instead was merely an extension of a study carried out by R. R. Madden, Esq., published 2 years earlier. Lombard found that the average age of death for the various professions ranged principally from the 40s to the mid 70s. Those were somewhat younger than those found by Madden, but this result was expected, because Lombard was dealing with ordinary people rather than the "geniuses" in Madden's study (the positive correlation between fame and longevity was well known even then). But Lombard's study yielded one surprise, the most dangerous profession—the one with the lowest longevity—was that of "student" with an average age of death of only 20.2! Lombard's data are reproduced almost exactly in Table 1 ("almost exactly" in that I corrected one typographical error and a couple of numerical errors).

It doesn't take John Tukey to figure out what's the cause of the problem; even Lombard recognized the reason for the anomaly (but apparently did not connect it to his other results). But what is to be done about it? Note that sampling error is not the issue. Although 70 of Lombard's 145 professions have small sample sizes ($n < 20$), the error introduced by small $n$ does not yield a bias; it just increases the variance (the mean longevity for the 70 professions with $n < 20$ is 56.5, with a variance of 66.3; the corresponding values for the 75 professions with $n \geq 20$ are 55 and 51.2). Thus, focusing on sample size by using such strategies as collapsing across categories with small *ns* will not do it. At best (at worst?) such a strategy will only hide the problem.

Obviously the error we must deal with is a selection effect that occurs because of the nonrandom sample that Lombard (1835) collected.[1] People pass from one profession to another throughout their lives, and if the sample is drawn from an early profession anomalies will result—although Lombard didn't include it, I suspect that the prize for greatest longevity would go to "retiree" (*retraiteé*). How do we correct for it?

## A Model for Nonresponse

Sadly there is no general answer, although there is a general strategy. Getting a correct answer when data are chosen in a nonrandom way requires a model for the selection process. If the model is accurate so too will be the result. But, because the model must describe what was not observed, there is often no way to check it. One wonderful example of such a model was developed by Abraham Wald (Mangel & Samaniego, 1984; Wald, 1980) in some work he did during World War II, in which he was trying to determine where to add extra armor to planes on the basis of the pattern of bullet holes in returning aircraft. His conclusion was to determine carefully where returning planes had been shot and put extra armor every place else!

Wald made his discovery by drawing an outline of a plane (crudely shown in Figure 1, from Wainer, 1997, p. 60) and then putting a mark on it where a returning aircraft had been shot. Soon the entire plane had been covered with marks except for a few key areas. It was at this point that he interposed a model for the missing data, the planes that did not return. He assumed that planes had been hit more or less uniformly, and hence those aircraft hit in the unmarked places had been unable to return and thus were the areas that required more armor.

Wald's key insight was his model for the nonresponse. From his observation that planes hit in certain areas were still able to return to base, Wald inferred that the planes that didn't return must have been hit somewhere else. Note that if he used a different model analogous to "those people in professions that are dead have the same longevity as those who are still alive" (i.e., that the planes that returned were hit about the same as those that didn't return), he would have arrived at exactly the opposite (and wrong) conclusion.

To test Wald's model requires heroic efforts. Planes that did not return must be found, and the patterns of bullet holes in them must be recorded. In short, to test the validity of Wald's model for missing data requires that we sample from the unselected population. In other words, we must try to get a random sample, even if it is a small one. This strategy remains the basis for the only empirical solution to making inferences from nonrandom samples.

## Conclusion

I do not mean to suggest that it is impossible to gain useful insights from nonrandomly selected data; only that it is difficult and that great care must be taken in drawing inferences. James Thurber's (1939) *Fables for Our Time* tells the story of "The Glass in the Field." It seems that a builder left a huge pane of window glass standing upright in a field one day. Flying at high speed, a goldfinch struck the glass and was struck senseless. Later, on recovering his wits, he told a seagull, a hawk, an eagle, and a swallow about his injuries caused by crystallized air. The gull, the hawk, and the eagle laughed and bet the goldfinch a dozen worms that they could fly the same route without encountering crystallized air, but the swallow declined and was alone in escaping injury. Thurber's moral: "He who hesitates is sometimes saved." This is my main point: that a degree of safety can exist when one makes inferences from nonrandomly selected data, if those inferences are made with caution. There are some simple methods available that help us draw inferences when caution is warranted; they ought to be used.

This is an inappropriate vehicle to discuss these special methods for inference in detail. For such details the interested reader is referred to Little and Rubin (1987), Rosenbaum (1995), and Wainer (1986) for

[1] Thinking about nonrandom samples, I am drawn inexorably to the sort of inferences about language development that would evolve if cross-sectional rather than longitudinal samples were used. For example, in a tour of North Miami, I inferred that people speak Spanish when they are young but Yiddish when they are old. This theory received some confirmation when I noted that adolescents who worked in local stores spoke mostly Spanish but a little Yiddish.

Table 1

**Table**
of longevity for various professions in Geneva
(from 1776 until 1830)

| Professions | Total Number of Deaths | Average Longevity | | | |
|---|---|---|---|---|---|
| | | Calculated on the total num. of deaths | Calculated after eliminating violent deaths | | |
| | | | Number of cases of violent death | | Average longevity |
| | | | suicide | accidental | |
| Farmers | 267 | 54.7 | 2 | 16 | 55.4 |
| Lawyers | 12 | 64.3 | | | |
| Apothecaries | 19 | 64.3 | 1 | 1 | 69.2 |
| Money changers | 12 | 61.5 | | | |
| Businessmen | 7 | 57.5 | | | |
| Architects | 7 | 62.1 | | 1 | 68.5 |
| Innkeepers | 8 | 53.4 | | 1 | 63.8 |
| Armorer | 7 | 57.2 | | | |
| Butchers | 77 | 53.0 | | 3 | 53.1 |
| Bakers | 82 | 49.8 | | 4 | 50.3 |
| Boatmen | 46 | 49.2 | | 6 | 51.3 |
| Brushmakers | 11 | 50.1 | | | |
| Barbers | 16 | 47.4 | | 1 | 49.3 |
| Street sweepers | 6 | 56.0 | | | |
| Laundry workers | 11 | 63.5 | | | |
| Harness makers | 10 | 60.4 | | 1 | 60.4 |
| Shepherds | 9 | 40.8 | | | |
| Cartwrights | 21 | 54.7 | | | |
| Hat makers | 39 | 50.9 | | 2 | 51.6 |
| Surgeons | 41 | 54.0 | | 1 | 54.0 |
| Consignees | 17 | 64.8 | | | |
| Cutlers | 10 | 57.4 | | | |
| Kettle makers | 20 | 51.8 | 1 | 1 | 48.6 |
| Carpenters | 176 | 55.1 | | 12 | 55.7 |
| Woodcutters | 99 | 58.8 | | 4 | 59.4 |
| Candy makers | 28 | 55.2 | | 2 | 57.1 |
| Coal merchant | 12 | 55.1 | | | |
| Wine merchant | 120 | 56.3 | 2 | 5 | 56.3 |
| Shoe makers | 376 | 54.2 | | 5 | 54.4 |
| Chamois makers | 13 | 61.2 | | | |
| Brokers | 15 | 58.4 | | | |
| Carters | 15 | 55.3 | 1 | | 57.1 |
| Chocolate makers | 9 | 73.6 | | | |
| Cooks | 12 | 54.1 | | | |
| Roofers | 26 | 47.7 | | 7 | 48.8 |
| Pants maker | 12 | 63.2 | | | |
| Merchants assistant | 58 | 38.9 | 1 | 5 | 39.4 |
| Coachmen | 12 | 45.0 | 1 | 4 | 60.3 |
| Playing card makers | 7 | 57.3 | | | |
| Blanket makers | 10 | 53.0 | | | |
| Servants | 177 | 45.4 | | 7 | 46.0 |
| Gilders | 15 | 51.7 | 1 | 1 | 53.8 |
| Draftsmen | 24 | 57.5 | | | |
| Enamel worker | 75 | 48.7 | 2 | 5 | 49.7 |
| Cellar storers | 28 | 53.4 | | 2 | 54.3 |
| Public writers & writing teachers | 46 | 51.0 | | 1 | 50.5 |

Table 1
*Continued*

| Professions | Total Number of Deaths | Average Longevity | | | |
|---|---|---|---|---|---|
| | | Calculated on the total num. of deaths | Calculated after eliminating violent deaths | | |
| | | | Number of cases of violent death | | Average longevity |
| | | | suicide | accidental | |
| Assemblers | 7 | 42.9 | | | |
| Bureaucrats | 67 | 61.9 | | 2 | 62.3 |
| Students | 39 | 20.2 | 1 | 3 | 20.7 |
| Packers | 7 | 58.3 | | | |
| Pin-makers | 7 | 65.4 | | | |
| Secondhand clothes dealers | 17 | 56.0 | | | |
| Tinsmiths | 39 | 45.6 | | 4 | 47.0 |
| Hosiery makers | 38 | 69.0 | 1 | | 69.1 |
| Casters | 47 | 59.4 | 1 | 3 | 60.4 |
| Spring makers | 117 | 54.7 | 1 | | 55.3 |
| Blacksmiths | 63 | 54.5 | | 2 | 55.3 |
| File makers | 37 | 53.6 | 1 | 3 | 54.0 |
| Furbishers | 10 | 55.4 | | 1 | 58.8 |
| Dial makers | 15 | 53.9 | | | |
| Candle makers | 11 | 63.9 | | 1 | 63.8 |
| Fountain makers | 10 | 50.5 | | 1 | 53.2 |
| Watch stem makers | 8 | 56.1 | | | |
| Engravers | 179 | 54.7 | | 5 | 45.6 |
| Small wage-earners | 48 | 52.3 | | 2 | 52.2 |
| Chequerers | 14 | 58.2 | | | |
| Policemen | 17 | 34.8 | 2 | 4 | 35.2 |
| Nurses | 13 | 53.6 | | | |
| Men of Letters | 15 | 52.7 | 1 | | 52.8 |
| Clocksmiths | 1,073 | 55.3 | 5 | 53 | 55.9 |
| Bailiffs | 40 | 59.1 | 1 | 1 | 59.3 |
| Lawmen | 12 | 59.7 | 1 | 1 | 61.9 |
| Calico makers | 125 | 52.1 | 1 | 1 | 52.1 |
| Printers | 41 | 54.3 | | | |
| Teachers | 7 | 58.4 | | | |
| Gaugers | 7 | 65.9 | | | |
| Gardeners | 202 | 60.1 | 2 | 10 | 61.8 |
| Jewelers | 138 | 49.6 | 2 | 8 | 50.3 |
| Lapidaries | 29 | 57.8 | | | |
| Cafe owners | 16 | 48.7 | | | |
| Booksellers | 11 | 55.5 | | 1 | 59.2 |
| Millers | 27 | 42.0 | | 5 | 45.1 |
| Day laborers | 171 | 52.4 | | 8 | 52.4 |
| Ebinistes | 143 | 49.7 | 1 | 11 | 49.8 |
| Watch case fitters | 370 | 52.2 | | | |
| Masons | 124 | 55.2 | 2 | 12 | 55.6 |
| Magistrates | 71 | 69.1 | | | |
| Doctors | 18 | 66.4 | | | |
| Coal measurers | 15 | 59.1 | | 1 | 59.2 |
| Messengers | 35 | 57.9 | | 1 | 59.2 |
| Mattress makers | 20 | 60.3 | | | |
| Musicians | 27 | 61.1 | | | |
| Clergymen | 52 | 63.8 | | | |

Table 1
*Continued*

| Professions | Total Number of Deaths | Average Longevity: Calculated on the total num. of deaths | Calculated after eliminating violent deaths: Number of cases of violent death: suicide | accidental | Average longevity |
|---|---|---|---|---|---|
| Mechanics | 37 | 50.4 | 3 | 1 | 50.6 |
| Spice merchants | 33 | 57.7 | 1 | 1 | 57.7 |
| Cloth merchants | 21 | 56.7 | | | |
| Ironware merchants | 16 | 55.9 | | 1 | 57.5 |
| Tobacconists | 11 | 58.3 | 1 | 1 | 63.2 |
| Wood merchants | 10 | 60.0 | | | |
| Cheese merchants | 8 | 68.5 | | | |
| Miscellaneous merchants | 53 | 55.7 | | 1 | 55.4 |
| Casters | 7 | 59.7 | | | |
| Merchants | 476 | 62.0 | 5 | 15 | 63.0 |
| Cleaners | 52 | 60.0 | | 7 | 59.1 |
| Notaries | 15 | 62.1 | | | |
| Silversmiths/Goldsmiths | 152 | 61.6 | 1 | 1 | 68.8 |
| Retired Military Officers | 80 | 63.6 | | 1 | 63.8 |
| Grooms | 27 | 57.2 | | | |
| Painters/varnishers | 65 | 44.3 | | 4 | 45.0 |
| Metal polishers | 35 | 53.7 | | | |
| Wigmakers | 94 | 57.5 | | 5 | 57.9 |
| Furnishing makers | 24 | 68.1 | | | |
| Road pavers | 10 | 58.2 | | 1 | 58.2 |
| Potters | 14 | 51.8 | | 1 | 53.1 |
| Laundry deliverymen | 15 | 54.1 | | | |
| Professors | 10 | 66.6 | | | |
| Porters | 25 | 65.9 | | 1 | 66.3 |
| Funeral bearers | 9 | 75.0 | | | |
| Sedan bearers | 11 | 53.7 | | | 56.3 |
| Furriers | 8 | 70.0 | | | |
| Pastry makers | 13 | 46.0 | | | |
| Binders | 18 | 50.9 | | 1 | 50.7 |
| School masters | 18 | 64.4 | | | |
| Chimney sweeps | 8 | 45.0 | | 1 | 45.3 |
| Person of private means | 275 | 65.8 | 2 | 2 | 66.2 |
| Soldiers | 338 | 48.4 | | 33 | 46.6 |
| Locksmiths | 62 | 47.2 | 2 | 4 | 49.1 |
| Clog makers | 21 | 55.0 | | 1 | 55.0 |
| Saddler | 29 | 52.6 | | 1 | 53.5 |
| Sculptors | 6 | 36.3 | | | |
| Tailors | 247 | 54.2 | 3 | 9 | 54.9 |
| Coopers | 97 | 54.2 | 3 | 7 | 54.2 |
| Dyers | 25 | 63.4 | | 1 | 63.7 |
| Tool makers | 22 | 52.4 | | 2 | 53.7 |
| Lathe workers | 26 | 57.4 | | | |
| Weavers | 41 | 60.5 | | | |
| Tanners | 43 | 55.2 | | 1 | 54.6 |
| Bookkeepers | 35 | 58.9 | | 3 | 61.6 |
| Stone workers | 10 | 34.4 | 1 | 2 | 36.3 |
| Road workers | 6 | 58.0 | | | |

Table 1
*Continued*

| Professions | Total Number of Deaths | Average Longevity | | | |
|---|---|---|---|---|---|
| | | Calculated on the total num. of deaths | Calculated after eliminating violent deaths | | |
| | | | Number of cases of violent death | | Average longevity |
| | | | suicide | accidental | |
| Carriers | 78 | 51.4 | 1 | 3 | 52.4 |
| Glaziers | 18 | 57.3 | | | |
| Basket makers | 9 | 54.3 | | | |
| Pasta makers | 6 | 66.7 | | | |
| Wine growers | 8 | 54.8 | | | |
| Total | 8,496 | 55.7 | 58 | 354 | 54.8 |

*Note.* This table is a translation from the original French. Lombard ordered his table alphabetically, which eases the task of locating specific vocations. This benefit does not come through in the translation. Not only would reordering of this table by "average age of death" have been far more informative, but the information in the ordering would have survived translation intact; such a table is available from Howard Wainer. From "De l'Influence des Professions Sur la Durée de la Vie," by H. C. Lombard, 1835, *Annales d'Hygiéne Publique et de Médecine Légale* (Vol. 14, pp. 88–131). Translated by William J. Berg and Howard Wainer.

a beginning. Instead let me describe the general character of any "solution." First, no one should be deluded into thinking that when there is a nonrandom sample unambiguous inferences can be made. They can't. The magic of statistics cannot create information when there is none. We cannot know for sure the longevity of those who are still alive. Any inferences that involve such information are doomed to be equivocal.

What can we do? One approach is to make up data that might plausibly have come from the unsampled population and include them with our sample as if they were real. Then see what inferences we would draw. Next make up some other data and see what inferences are suggested. Continue making up data until all plausible possibilities are covered. When this is done see how stable were the inferences you drew

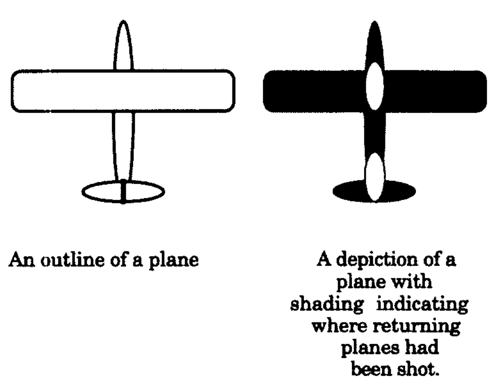


*Figure 1.* A stylized depiction of where Wald found bullet holes on returning aircraft.

over the entire range of these data imputations. The multiple imputations may not give you a good answer, but they can provide you with an estimate of how sensitive your inferences are to the unknown. If you do not do this you have not dealt with possible selection biases; you have only ignored them.

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## New Editors Appointed, 2001–2006

The Publications and Communications Board of the American Psychological Association announces the appointment of seven new editors for 6-year terms beginning in 2001. As of January 1, 2000, manuscripts should be directed as follows:

- For the **Journal of Abnormal Psychology,** submit manuscripts to Timothy B. Baker, PhD, Department of Psychology and CTRI, 7255 Medical Sciences Center, 1300 University Avenue, University of Wisconsin Medical School, Madison, WI 53706.
- For the **Journal of Comparative Psychology,** submit manuscripts to Meredith West, PhD, Department of Psychology, 1101 E. 10th Street, Indiana University, Bloomington, IN 47405-7007.
- For the **Journal of Experimental Psychology: Learning, Memory, and Cognition,** submit manuscripts to Thomas O. Nelson, PhD, Psychology Department, University of Maryland, College Park, MD 20742-4411.
- For the **Journal of Personality and Social Psychology: Attitudes and Social Cognition** section, submit manuscripts to Patricia Devine, PhD, Department of Psychology, University of Wisconsin—Madison, 1202 West Johnson Street, Madison, WI 53706-1696.
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- For **Psychological Review,** submit manuscripts to Walter Mischel, PhD, Department of Psychology, 406 Schermerhorn Hall, Columbia University, New York, NY 10027.
- For **Psychology, Public Policy, and Law,** submit manuscripts to Jane Goodman-Delahunty, JD, PhD, 2407 Calle Madiera, San Clemente, CA 92672.

Manuscript submission patterns make the precise date of completion of the 2000 volumes uncertain. Current editors, Milton E. Strauss, PhD; Charles T. Snowdon, PhD; James H. Neely, PhD; Arie Kruglanski, PhD; Patrick H. DeLeon, PhD, JD; Robert A. Bjork, PhD; and Bruce D. Sales, JD, PhD, respectively, will receive and consider manuscripts through December 31, 1999. Should 2000 volumes be completed before that date, manuscripts will be redirected to the new editors for consideration in 2001 volumes.