University of Waterloo

W. H. Cherry

TABLES: How to Construct Effective Tables

1. Introduction

Tables are a common method of presenting data; familiarity with tables from an early age makes it easy to forget that constructing *effective* tables is an *onerous* task. Discussion of *how* to achieve effectiveness is provided in the following reference.

Journal of the Royal Statistical Society A 140, Part 3, pp. 277-297, 1977.

Rudiments of Numeracy

A. S. C. EHRENBERG
London Business School

SUMMARY

Many tables of data are badly presented. It is as if their producers did not know what the data were saying or were not letting on. Some precepts for improved data presentation are discussed.

Keywords: NUMERACY, TABLES, GRAPHS, DATA PRESENTATION, ROUNDING

PEOPLE who say they are not numerate usually do not mean that they cannot do arithmetic. Nor should they mean that they cannot do mathematics. Instead, they are really saying that they cannot cope with numerical data – tables, graphs, percentages, and so on.. But since such data are often badly presented – requiring much effort even for sophisticated users to understand – the fault is that of the *producers* of the data. This is the starting-point of this paper.

Numeracy has two facets – reading and writing, or *extracting* numerical information and *presenting* it. The skills of data presentation may at first seem *ad hoc* and judgemental, a matter of style rather than technology, but certain aspects can be formulated into explicit rules, the equivalent of elementary syntax. Such precepts have largely been ignored in statistical practice and teaching.

This paper raises for discussion some rules or guidelines for improved data presentation. In doing so, the immediate concern is not with the general public but with supposedly numerate people like statisticians – producers and more or less regular users of numerical information. There is less concern about the less numerate fringe (*e.g.*, challenged school-children or apocryphal company chairpeople); they also need help but will not do much with numerical information however well it is presented.

This paper is in five sections. Section 1 gives two examples of how the presentation of data can be improved. Specific rules for doing so are then set out in Section 2, followed by a brief assessment of the relevant literature in Section 3. Possible objections and problems of implementing the rules are discussed in Sections 4 and 5.

Interested readers can consult Ehrenberg's paper for details; the remainder of this Highlight #103 are illustrations of using his ideas. Illustration 1 arose from the following newspaper article EM9004 and is the work of the writer's colleague, Prof. R. W. Oldford; this work was included in an early version (maybe 1995) of the STAT 231 Course Notes but was gone by 2004.

EM9004: The Globe and Mail, January 16, 1990, pages A1 and A2

Plant, animal life damaged by acid rain in 19,000 lakes in Ontario, report reveals

BY CRAIG McINNES
The Globe and Mail

Acid rain is damaging plant and animal life in about 19,000 Ontario lakes, says a study released yesterday by the provincial Environment Ministry.

The report, which is the first to estimate with any accuracy the extent of acid rain damage to lakes in Ontario, found that there are more than 7,000 very acidic lakes in which most of the common fish have died, according to Bernie Neary, supervisor of Lake Management Studies at Dorset, Ont.

The other 12,000 lakes are acidic enough to damage other forms of plant and animal life, said the report, which is a statistical extrapolation of data collected between 1978 and 1989 from 6,000 of Ontario's more than 250,000 lakes.

Recent research is showing that biological damage is occurring in lakes that would not be considered acidified under the old definition, Mr. Neary said.

"The traditional yardstick was whether or not there are fish in a lake. We find that they are among the more tolerant organisms in a lake," Mr. Neary said.

"The take-home message here ... is that there are many parts of an aquatic food chain and there are varying levels of sensitivity."

Michael Perley of the Canadian Coalition on Acid Rain said yesterday that he was not surprised by the high number of damaged lakes. The study confirms rough estimates made five years ago by the department of Fisheries and Oceans.

"I don't think it will surprise very many people when they hear that order of magnitude, unfortunately."

About 7,300 of the lakes are in the Sudbury region, where acidification has been caused primarily by emissions from local Inco and Falconbridge smelters.

Another 11,000 are in areas affected by the long-range transport of sulphur pollution and delivered in the form of acid rain and snow.

The U.S. Congress will start again next week considering the clean-air bill sponsored by the administration of President George Bush. The bill is designed to cut sulphur dioxide emissions by 10 million tonnes a year by the year 2000 or, at the latest, 2004.

The Canadian government is counting on that legislation to cut U.S. acid rain emissions which damage Canadian lakes.

Last week, however, several governors from western states called a news conference to say that they did not want to have to pay for what they perceived to be a problem caused by eastern states.

Electrical utilities opposed to the bill have been exploiting the differences between states in an effort to scuttle the legislation, Mr. Perley said.

"I think what you are seeing is the battle lines forming up and the warning shots being fired across the bows," Mr. Perley said.

"We're really down to the very, very rough and ready struggle now."

(*continued overleaf*)

2. Illustration 1: Acid Sensitivity Sample Survey of Lakes in Ontario, 1989

The article EM9004 reprinted overleaf on page HL103.1 appears to be based on a 1989 Government of Ontario report, which used available data from more than one source – for example:

∗ Ontario Ministry of the Environment, *Acid sensitivity of lakes in Ontario*, 27 pages, publication date Jan. 1, 1988, announcement date, May 13, 2001, Report no. OME-APIOS-1988; MICROLOG-89-02261, Reference no. CANM-89-002694; EDB-89-134099.

∗ Neary, B.P., Dillon, P.J., Munro, J.R. and B.J. Clark. *The Acidification of Ontario Lakes: As Assessment of Their Sensitivity and Current Status with Respect to Biological Damage.* Limnology Section, Dorset Research Centre, January, 1990, ISBN 0-7729-6550-1.

Information about *how* the data were collected is:

- Lakes were selected haphazardly, *not* probabilistically, possibly on the basis of criteria like accessability and degree of (apparent) damage; this (of course) increases the limitations on answers about the population (*ca.* 262,000 lakes) based on *sample* estimates.
- The investigation was *not* a ‘snapshot’ in time, because the data were collected over a period of years – the second reference above refers to 1976 to 1989; this means that a higher number of lakes in a damage category in the tables which follow likely reflects on-going data *accumulation* more than increasing damage over time – see also the *last* sentence in the last paragraph in the left-hand column on the facing page HL103.3, *The Ministry of the Environment, ...*
- The second reference above mentions 6,467 lakes investigated; the tables which follow in this Illustration 1 show (supposedly) 6,722 lakes; this would suggest about a year’s more lakes investigated here than in the second reference.

Background

One of the most pressing environmental problems facing large areas of North America is acidic precipitation. All of southern Ontario receives a steady bombardment of acids, acid-forming gases and associated pollutants. The acids come down with rain, snow, fog and small particles in the air.

Human activities are responsible for the large majority of these acids. Smelters and coal-fired electric generating stations, both in Canada and the United States, spew millions of tonnes of sulphur dioxide into the atmosphere annually. Cars, trucks and trains contribute more millions of tonnes of nitrogen dioxides. These gases react with sunlight, oxygen, ozone, water and other gases to form sulphuric and nitric acid – strong, corrosive acids.

In unpolluted areas, rain and snow are naturally slightly acidic since carbon dioxide, which is a natural component of the atmosphere, dissolves in water to form weak carbonic acid. Water quality of lakes has developed in response to weathering processes induced by this weak acid. Rocks and minerals react with carbonic acid to form bicarbonate, which is found in natural waters everywhere.

The complex biological communities in lakes, streams and forests have adapted and evolved in equilibrium with these natural conditions and processes. However, acid rain has seriously disturbed this equilibrium.

Levels of Acidity

The acidity of a solution is measured on a logarithmic pH scale. This logarithmic scale means that a one-unit change on the pH scale corresponds to a ten-fold increase or decrease in acidity. Thus, a solution with a pH of 4.0 is ten times more acidic than a solution of pH 5.0 and one hundred times more acidic than a solution of pH 6.0.

Distilled water is considered to be neither acidic nor alkaline, and has a pH of 7.0. The carbon dioxide in the atmosphere will cause rain to have a pH of sbout 5.6 if no other factors are affecting the pH.

Rainfall with a pH of less than 5.6 is termed "acid rain", but significant amounts of acid are also deposited as gases and particles through processes called "dry deposition". Over most of southern Ontario, the average pH of the rain is about 4.2. In the remote northwest, the average pH is above 5.0. Because acid deposition is higher in southern Ontario than in the northern parts, more acid lakes are found in the south.

Sample Survey of Lakes

There are about 262,000 lakes in Ontario. Of these, a recent study indicates at least 19,000 have been affected by acid rain, many of them in the Muskoka-Haliburton region, where there is a substantial cottage and tourist industry.

Most lakes have the ability to neutralize a certain amount of acid. This neutralizing capacity of a lake is measured by the level of bicarbonate alkalinity in the water. If a lake has a high alkalinity level, it can resist pH changes caused by acid inputs. Lakes with low alkalinities can experience pH depressions during spring snowmelt or after heavy rain, times when large acid loads enter the lakes.

A lake with zero or less alkalinity is an acid lake. A negative reading of alkalinity means that the lake contains mineral acidity. These lakes usually have a pH less than 5.0, and if they have any fish at all, it will be a hardy, acid-tolerant species like yellow perch. As a lake acidifies, sensitive species such as bass and trout will probably not reproduce, although some adult fish may still survive until they die of old age or other causes.

The neutralizing capacity of a lake is dependent on a number of factors. Lakes in limestone regions usually have a very high alkalinity, since bicarbonate alkalinity results as limestone slowly dissolves. Alkalinity can also be generated in soils, so that groundwater and soil runoff inputs to some lakes can be an important supply of neutralizing capacity. In some cases, alkalinity levels can be reduced by naturally occurring acids. These acids are formed during the decomposition of leaves and other organic material. The presence of these acids is usually observed as a brown colouration in water, and can be quite noticable in areas with extensive swamps or bogs.

While lakes and streams vary with respect to their pH, effects on aquatic life begin at around pH 6.0. Smaller organisms such a phytoplankton (microscopis plants), zooplankton (microscopic animals), insects and their larvae are affected not far below this level. As the pH of the lakes falls gradually over time with increased acid loadings, larger life forms are affected. Crayfish are damaged at about pH 5.7. Spotted salamanders can lose 65% of their embryos at pH 5.0, and bullfrogs may lose all their eggs at pH 4.1. Most fish species cannot reproduce below pH 5.0. Some minnow species (*e.g.*, fathead minnow, common shiner and pearl dace) disappear below pH 6.

Certain species may increase in number and size. For some, this will be due to the elimination of their competition or predators. Others will flourish because they actually prefer more acidic conditions. Both are possible explanations for the excessive growth of acid-tolerant filamentous algea in many lakes affected by acidification. This type of growth can affect fish and plant life by reducing the swimming quality of the lake, as well as blocking sunlight and consuming oxygen in the water.

But the pH doesn’t need to drop to lethal levels to affect or even eliminate many aquatic populations. Disruptions in the food web automatically affect the higher organisms which depend on the extinct populations for food and younger organisms tend to be more

(*continued*)

TABLES: How to Construct Effective Tables (continued 1)

acid-sensitive than adults. Eggs, embryos and young-of-the-year (newborn) fish are especially at risk at lower pH levels, and some fish species have been completely or all-but eleminated from lakes due to repeated loss of recruiting populations.

The release, in unprecedented numbers, of metal ions, previously part of the underlying soil or rock, into water or soil solution is an effect of acid rain which has major implications for the environment. Many fish die of suffocation due to the clogging of their gills with excess aluminum ions or aluminum hydroxide released into the water.

Finally, spring shock occurs when sulphuric and nitric acids retained in snow are suddenly released into river and lake systems during the spring thaw, resulting simultaneously in a sudden drop in pH and an increase of aluminum ions. This toxic shock has sometimes resulted in mass kills of adult fish, but more commonly had drastic effects on the success of the spring hatching, with which it often coincides.

Examples of lakes with large anounts of neurtralizing capacity are the Great Lakes, the Kawarthas, and lakes around the Rideau system. Lakes on the Canadian Shield typically have low acid neutralizing capacity. This region is underlain by granite, and has many exposed rock outcrops. Granite is insoluble and can supply little alkalinity. The soils are usually shallow and sandy or acidic. These acidic soils are not the result of acid deposition, but are formed by the decomposition of organic material such as forest litter. Runoff from these soils cannot contribute neutralizing capacity to lakes, so that most lakes on the Shield have low alkalinity levels.

The Ministry of the Environment, in co-operation with the Ministry of Natural Resources, conducts lake surveys to determine the sensitivity of Ontario lakes to acidic precipitation. This sixth summary of the results of this survey includes information on 6,722 lakes throughout the province, and is issued by the Ministry of the Environment as part of its Acidic Precipitation in Ontario Study (APIOS). This list is cumulative, so changes in the number of acidic lakes from previous brochures reflect new lakes that have been identified, rather than lakes turning acidic since the last listing was published.

This brochure presents an alphabetical list by county or district of the lakes sampled to date, with an indication of the relative sensitivity of each of the lakes to the acidification process. The table provides a summary of the number and percentage of lakes in each alkalinity class organized by county or district.

For example, 24.7% or 1,660 of the lakes were found to be not sensitive to acidification, and a further 17.6% or 1,185 lakes had low sensitivity. 37.8% or 2,539 of the lakes had moderate sensitivity, and 14.9% or 1,002 lakes were extremely sensitive. Five per cent or 336 lakes were classified as acidic.

Level 1 lakes have zero or negative alkalinity; they have already become acidic. Many or all fish species may be absent from such lakes. Clam, snail and many amphibian species may also be absent. Level 1 lakes, unless naturally high in organic colour, are exceptionally clear. Clouds of algae may accumulate in inshore areas.

Level 2 lakes have very low alkalinity and are extremely sensitive to heavy acid loadings. Depressions in pH may occur during spring runoff, and algae clouds are also common in these lakes. These lakes are around pH 6 and therefore are biologically damaged.

Level 3 lakes are moderatery sensitive to heavy acid loadings. Fish and other biota are generally less at risk in comparison to level 2 lakes.

Level 4 lakes are of low sensitivity and have likely experienced no biological damage due to acid precipitation.

Level 5 lakes are not sensitive to acid loadings and are capable of withstanding heavy acid loading during spring runoff without biological damage. Such lakes contain sufficient buffering capacity to neutralize acid rain for an indefinite period of time.

For the tables at the right and on pages HL103.4 and HL103.5:

- tables are numbered for *this* Highlight #103;
- Table HL103.1 is likely missing some entries because the column totals all exceed the sum of their column entries (shown in small print below the table); row totals add correctly, except for occasional rounded percentages. However, some missing data does not materially affect the purpose for which Table HL103.1 is used in this Highlight #103;
- to reduce table width and so facilitate comparisons among tables, column headings overleaf use the following abbreviations:

Table HL103.1 . . . Number and percentage of lakes in five alkalinity classes . . .

County or district	Acidic No.	Acidic %	Extreme sensitivity No.	Extreme sensitivity %	Moderate sensitivity No.	Moderate sensitivity %	Low sensitivity No.	Low sensitivity %	No sensitivity No.	No sensitivity %	Total no. of lakes
Algoma	68	6.3	162	15.0	425	39.2	194	17.9	234	21.6	1,083
Bruce	0	0.0	0	0.0	0	0.0	0	0.0	7	100.0	7
Cochrane	2	0.7	6	2.1	10	3.5	27	9.6	237	84.0	282
Durham	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0	1
Frontenac	0	0.0	0	0.0	2	2.5	12	15.0	66	82.5	80
Grey	0	0.0	0	0.0	0	0.0	0	0.0	3	100.0	3
Haliburton	9	2.4	124	32.5	167	43.7	46	12.0	36	9.4	382
Hastings	0	0.0	7	4.5	68	43.6	27	17.3	54	34.6	156
Huron	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0	1
Kenora	0	0.0	1	0.3	106	27.7	128	33.5	147	38.5	382
Lanark	0	0.0	0	0.0	0	0.0	1	2.5	39	97.5	40
Leeds	0	0.0	0	0.0	0	0.0	0	0.0	32	100.0	32
Lennox & Add.	0	0.0	4	4.4	26	28.6	21	23.1	40	44.0	91
Manitoulin	27	49.1	21	38.2	2	3.6	1	1.8	4	7.3	55
Middlesex	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0	1
Muskoka	11	3.4	91	28.5	193	60.5	13	4.1	11	3.4	319
Nipissing	23	2.8	187	22.5	506	60.8	103	12.4	13	1.6	832
Northumberland	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0	1
Parry Sound	18	4.2	147	34.1	233	54.1	27	6.3	6	1.4	431
Peel	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0	1
Peterborough	0	0.0	3	4.5	10	14.9	9	13.4	45	67.2	67
Prince Edward	0	0.0	0	0.0	0	0.0	0	0.0	9	100.0	9
Rainy River	0	0.0	15	5.4	159	57.4	67	24.2	36	13.0	277
Renfrew	2	0.5	29	8.0	174	47.8	98	26.9	61	16.8	364
Simcoe	0	0.0	0	0.0	8	38.1	2	9.5	11	52.4	21
Stormont	0	0.0	0	0.0	0	0.0	0	0.0	1	100.0	1
Thunder Bay	2	0.3	29	4.1	166	23.2	218	30.5	299	41.9	714
Timiskaming	20	9.5	20	9.5	45	21.3	66	31.3	60	28.4	211
Victoria	0	0.0	1	2.6	22	56.4	2	5.1	14	35.9	39
York	0	0.0	0	0.0	0	0.0	0	0.0	2	100.0	2
	336	5.0	1,002	14.9	2,539	37.8	1,185	17.6	1,660	24.7	6,722
	182		847		2,322		1,062		1,472		5,885

(*continued overleaf*)

Ac. Acidic
Ex. Extreme
Mo. Moderate
Lo. Low
sen. sensitivity
alk. alkalinity

Applying Ehrenberg's precepts to Table HL103.1 results in the following *succession* of modifications:

- In Table HL103.2, the five columns of *numbers* of lakes have been omitted.
- In Table HL103.3, the percentages have been rounded to integers.
- In Table HL103.4, the rows have been ordered by acidity and then by extreme sensitivity.
- In Table HL103.5, the rows have been grouped in five levels of acidity and extreme sensitivity.
- In Table HL103.6 (on the facing page HL103.5), the last alkalinity level 'No sensitivity' has been omitted.
- In Table HL103.7, the four sensitivity classes have been reduced to two *broader* classes.
- In Table HL103.8, only the more extreme of the two broad sensitivity classes has been retained.

○ Footnotes have been added to Tables HL103.7 and HL103.8 to show which counties have *smelters* located in them.

There are minor disagreements among the percentages

Table HL103.2 . . . Percentage of lakes in five . . . alkalinity classes

County or district	Ac. %	Ex. sen. %	Mo. sen. %	Lo. sen. %	No sen. %	Total no. of lakes
Algoma	6.3	15.0	39.2	17.9	21.6	1,083
Bruce	0.0	0.0	0.0	0.0	100.0	7
Cochrane	0.7	2.1	3.5	9.6	84.0	282
Durham	0.0	0.0	0.0	0.0	100.0	1
Frontenac	0.0	0.0	2.5	15.0	82.5	80
Grey	0.0	0.0	0.0	0.0	100.0	3
Haliburton	2.4	32.5	43.7	12.0	9.4	382
Hastings	0.0	4.5	43.6	17.3	34.6	156
Huron	0.0	0.0	0.0	0.0	100.0	1
Kenora	0.0	0.3	27.7	33.5	38.5	382
Lanark	0.0	0.0	0.0	2.5	97.5	40
Leeds	0.0	0.0	0.0	0.0	100.0	32
Lennox & Add.	0.0	4.4	28.6	23.1	44.0	91
Manitoulin	49.1	38.2	3.6	1.8	7.3	55
Middlesex	0.0	0.0	0.0	0.0	100.0	1
Muskoka	3.4	28.5	60.5	4.1	3.4	319
Nipissing	2.8	22.5	60.8	12.4	1.6	832
Northumberland	0.0	0.0	0.0	0.0	100.0	1
Parry Sound	4.2	34.1	54.1	6.3	1.4	431
Peel	0.0	0.0	0.0	0.0	100.0	1
Peterborough	0.0	4.5	14.9	13.4	67.2	67
Prince Edward	0.0	0.0	0.0	0.0	100.0	9
Rainy River	0.0	5.4	57.4	24.2	13.0	277
Renfrew	0.5	8.0	47.8	26.9	16.8	364
Simcoe	0.0	0.0	38.1	9.5	52.4	21
Stormont	0.0	0.0	0.0	0.0	100.0	1
Thunder Bay	0.3	4.1	23.2	30.5	41.9	714
Timiskaming	9.5	9.5	21.3	31.3	28.4	211
Victoria	0.0	2.6	56.4	5.1	35.9	39
York	0.0	0.0	0.0	0.0	100.0	2
	5.0	14.9	37.8	17.6	24.7	6,722

Table HL103.3 . . Percentage of lakes in . . five alkalinity classes

County or district	Ac. %	Ex. sen. %	Mo. sen. %	Lo. sen. %	No sen. %	Total no. of lakes
Algoma	6	15	39	18	22	1,083
Bruce	0	0	0	0	100	7
Cochrane	1	2	4	10	84	282
Durham	0	0	0	0	100	1
Frontenac	0	0	3	15	82	80
Grey	0	0	0	0	100	3
Haliburton	2	32	44	12	9	382
Hastings	0	4	44	17	35	156
Huron	0	0	0	0	100	1
Kenora	0	0	28	34	38	382
Lanark	0	0	0	2	98	40
Leeds	0	0	0	0	100	32
Lennox & Add.	0	4	29	23	44	91
Manitoulin	49	38	4	2	7	55
Middlesex	0	0	0	0	100	1
Muskoka	3	29	61	4	3	319
Nipissing	3	22	61	12	2	832
Northumberland	0	0	0	0	100	1
Parry Sound	4	34	54	6	1	431
Peel	0	0	0	0	100	1
Peterborough	0	4	15	13	67	67
Prince Edward	0	0	0	0	100	9
Rainy River	0	5	57	24	13	277
Renfrew	1	8	48	27	17	364
Simcoe	0	0	38	10	52	21
Stormont	0	0	0	0	100	1
Thunder Bay	0	4	23	31	42	714
Timiskaming	9	9	21	31	28	211
Victoria	0	3	56	5	36	39
York	0	0	0	0	100	2
	5	15	38	18	25	6,722

Table HL103.4 . . Percentage of lakes in . . five alkalinity classes

County or district	Ac. %	Ex. sen. %	Mo. sen. %	Lo. sen. %	No sen. %	Total no. of lakes
Manitoulin	49	38	4	2	7	55
Timiskaming	9	9	21	31	28	211
Algoma	6	15	39	18	22	1,083
Parry Sound	4	34	54	6	1	431
Muskoka	3	29	61	4	3	319
Nipissing	3	22	61	12	2	832
Haliburton	2	32	44	12	9	382
Renfrew	1	8	48	27	17	364
Cochrane	1	2	4	10	84	282
Rainy River	0	5	57	24	13	277
Peterborough	0	4	15	13	67	67
Hastings	0	4	44	17	35	156
Lennox & Add.	0	4	29	23	44	91
Thunder Bay	0	4	23	31	42	714
Victoria	0	3	56	5	36	39
Simcoe	0	0	38	10	52	21
Kenora	0	0	28	34	38	382
Frontenac	0	0	3	15	82	80
Lanark	0	0	0	2	98	40
Leeds	0	0	0	0	100	32
Prince Edward	0	0	0	0	100	9
Bruce	0	0	0	0	100	7
Grey	0	0	0	0	100	3
York	0	0	0	0	100	2
Durham	0	0	0	0	100	1
Huron	0	0	0	0	100	1
Middlesex	0	0	0	0	100	1
Northumberland	0	0	0	0	100	1
Peel	0	0	0	0	100	1
Stormont	0	0	0	0	100	1
	5	15	38	18	25	6,722

Table HL103.5 . . Percentage of lakes in . . five alkalinity classes

County or district	Ac. %	Ex. sen. %	Mo. sen. %	Lo. sen. %	No sen. %	Total no. of lakes
Manitoulin	49	38	4	2	7	55
Timiskaming	9	9	21	31	28	211
Algoma	6	15	39	18	22	1,083
Parry Sound	4	34	54	6	1	431
Muskoka	3	29	61	4	3	319
Nipissing	3	22	61	12	2	832
Haliburton	2	32	44	12	9	382
Renfrew	1	8	48	27	17	364
Cochrane	1	2	4	10	84	282
Rainy River	0	5	57	24	13	277
Peterborough	0	4	15	13	67	67
Hastings	0	4	44	17	35	156
Lennox & Add.	0	4	29	23	44	91
Thunder Bay	0	4	23	31	42	714
Victoria	0	3	56	5	36	39
Simcoe	0	0	38	10	52	21
Kenora	0	0	28	34	38	382
Frontenac	0	0	3	15	82	80
Lanark	0	0	0	2	98	40
Leeds	0	0	0	0	100	32
Prince Edward	0	0	0	0	100	9
Bruce	0	0	0	0	100	7
Grey	0	0	0	0	100	3
York	0	0	0	0	100	2
Durham	0	0	0	0	100	1
Huron	0	0	0	0	100	1
Middlesex	0	0	0	0	100	1
Northumberland	0	0	0	0	100	1
Peel	0	0	0	0	100	1
Stormont	0	0	0	0	100	1
	5	15	38	18	25	6,722

(*continued*)

University of Waterloo

W. H. Cherry

TABLES: How to Construct Effective Tables (continued 2)

in Tables HL103.6 and HL103.7 because those in the latter have been recalculated from the *frequencies* in Table HL103.1, *not* by adding *percentages* in Table HL103.6.

Table HL103.6 Percentage of lakes in four alkalinity classes

County or district	Ac. %	Ex. sen. %	Mo. sen. %	Lo. sen. %	Total no. of lakes
Manitoulin	49	38	4	2	55
Timiskaming	9	9	21	31	211
Algoma	6	15	39	18	1,083
Parry Sound	4	34	54	6	431
Muskoka	3	29	61	4	319
Nipissing	3	22	61	12	832
Haliburton	2	32	44	12	382
Renfrew	1	8	48	27	364
Cochrane	1	2	4	10	282
Rainy River	0	5	57	24	277
Peterborough	0	4	15	13	67
Hastings	0	4	44	17	156
Lennox & Add.	0	4	29	23	91
Thunder Bay	0	4	23	31	714
Victoria	0	3	56	5	39
Simcoe	0	0	38	10	21
Kenora	0	0	28	34	382
Frontenac	0	0	3	15	80
Lanark	0	0	0	2	40
Leeds	0	0	0	0	32
Prince Edward	0	0	0	0	9
Bruce	0	0	0	0	7
Grey	0	0	0	0	3
York	0	0	0	0	2
Durham	0	0	0	0	1
Huron	0	0	0	0	1
Middlesex	0	0	0	0	1
Northumberland	0	0	0	0	1
Peel	0	0	0	0	1
Stormont	0	0	0	0	1
	5	15	38	18	6,722

Table HL103.7 Percentage of lakes in two alkalinity classes

County or district	Ac./Ex. sen. %	Mo./Lo. sen. %	Total no. of lakes
Manitoulin[3]	87	5	55
Parry Sound[1]	38	60	431
Haliburton[1]	35	56	382
Muskoka[1]	32	65	319
Nipissing[1]	25	73	832
Algoma[3]	21	57	1,083
Timiskaming[2]	19	53	211
Renfrew[1]	9	75	364
Rainy River	5	82	277
Peterborough	4	28	67
Hastings	4	61	156
Thunder Bay	4	54	714
Lennox & Add.	4	52	91
Victoria	3	62	39
Cochrane[2]	4	13	282
Kenora	0	61	382
Simcoe	0	48	21
Frontenac	0	18	80
Lanark	0	2	40
Leeds	0	0	32
Prince Edward	0	0	9
Bruce	0	0	7
Grey	0	0	3
York[4]	0	0	2
Durham	0	0	1
Huron	0	0	1
Middlesex	0	0	1
Northumberland	0	0	1
Peel[4]	0	0	1
Stormont	0	0	1
	30	56	6,722

1. Non-ferrous smelters in Sudbury
2. Non-ferrous smelter in Timmins
3. Smelters in Algoma/Wawa
4. Smelters in Hamilton

A smelter in Nanticoke is not close to any counties surveyed in the study.

Table HL103.8 Lakes with low alk.

County or district	Ac./Ex. sen. %	Total no. of lakes
Manitoulin[3]	87	55
Parry Sound[1]	38	431
Haliburton[1]	35	382
Muskoka[1]	32	319
Nipissing[1]	25	832
Algoma[3]	21	1,083
Timiskaming[2]	19	211
Renfrew[1]	9	364
Rainy River	5	277
Peterborough	4	67
Hastings	4	156
Thunder Bay	4	714
Lennox & Add.	4	91
Victoria	3	39
Cochrane[2]	4	282
Kenora	0	382
Frontenac	0	80
Lanark	0	40
Leeds	0	32
Simcoe	0	21
Prince Edward	0	9
Bruce	0	7
Grey	0	3
York[4]	0	2
Durham	0	1
Huron	0	1
Middlesex	0	1
Northumberland	0	1
Peel[4]	0	1
Stormont	0	1
	30	6,722

1. Non-ferrous smelters in Sudbury
2. Non-ferrous smelter in Timmins
3. Smelters in Algoma/Wawa
4. Smelters in Hamilton

A smelter in Nanticoke is not close to any counties surveyed in the study.

Based on Ehrenberg's precepts, a 'good' (mnimal) tabular presentation of the Illustration 1 data would be Table HL103.1 and Table HL103.7 or HL103.8.

- There is (unfortunately) no easy resolution of the competing advantages of ordering Table HL103.1 alphabetically and grouping it like Tables HL103.7 and HL103.8.

Ehrenberg also discussed his precepts in *The American Statistician*, May, 1981, **35**(#2). pages 67-71; his summary is:

1. Give marginal averages to provide a visual focus.
2. Order the rows or columns of the table by the marginal averages or some other measure of size (keeping the same order if there are many tables).
3. Put figures to be compared into columns rather than rows (with with the larger numbers on top if possible).
4. Round to two effective digits.
5. Use layout to guide the eye and facilitate comparisons.
6. Give brief verbal summaries to lead the reader to the main patterns and exceptions.

The following two illustrations use material from Ehrenberg's article referenced above. Illustration 2 involves sales data from the U.K; its three tables are given overleaf at the top of page HL103.6.

∗ In Ehrenberg's article, Table HL103.9 (on the left) has somewhat larger print and more white space, so it occupies the full page width and nearly half its height.

∗ Table HL103.10 (on the middle) is Ehrenberg's improved table (somewhat compacted for convenience here).

∗ Table HL103.11 is added here to provide a comparison of white space rather than lines as separators within a table (like Table HL103.10, Table HL103.11 is also compacted here – in normal contexts, these tables would be presented in larger formats).

– In Table HL103.11, the third digit of the sales for the three largest cities has been retained (rounded).

NOTE: To avoid bias when rounding a decimal .5, one way is to always round to the *even* (or the odd if preferred) preceding digit. Rounding involves choices beyond the 'even (or odd)' rule. In Table HL103.10, the averages for the rounded data may differ from the averages that come from Table HL103.9 – for instance, its average for Bolton is 28.725 (which does

(*continued overleaf*)

3. Illustration 2: U.K. Sales Data

Table HL103.9: Quarterly Sales of Product X in 8 Cities

£'000	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Boltron	31.3	29.1	25.2	29.3
Edinburgh	135.1	126.9	132.1	208.3
Hull	70.3	81.3	70.9	84.0
Leeds	276.8	258.6	223.0	336.2
Luton	23.5	27.5	22.7	27.1
Plymouth	41.4	44.0	33.2	50.2
Sheffield	233.4	220.1	193.6	220.9
Swansea	62.3	66.4	61.8	76.7

Table HL103.10: Cities Ordered by Population Size
(Rounded and with Averages)

Sales in £'000	Q1	Q2	Q3	Q4	Av.
Sheffield	230	220	190	220	220
Leeds	280	260	220	340	270
Edinburgh	140	130	130	210	150
Hull	70	81	71	84	76
Swansea	62	66	62	77	67
Plymouth	41	44	33	50	42
Luton	23	27	23	27	25
Boltron	31	29	25	29	29
Average	110	107	94	130	110

Table HL103.11: Product X Sales in 8 Cities
(Rounded quarterly sales;
cities ordered by population size)

Sales in £'000	**Q1**	**Q2**	**Q3**	**Q4**	**Av.**
Sheffield	233	220	194	221	217
Leeds	277	259	223	336	274
Edinburgh	135	127	132	208	150
Hull	70	81	71	84	76
Swansea	62	66	62	77	67
Plymouth	41	44	33	50	42
Luton	23	27	23	27	25
Boltron	31	29	25	29	29
Average	109	107	95	129	**110**

NOTE: (cont.) round to 29), for Edinburgh 150.6 (which rounds to 151) and for Sheffield the average is (correctly) 217.0. By rounding, it is assumed that the gain in table interpretability outweights any (hopefully minor) distortions of the data.

Rounded percentages have (of course) the property that their sum may not be 100.

4. Illustration 3: Correlations Among Programs For U.K. Television Watchers

In addition to dealing with four decimal places for the correlations, their hundred values in Table HL103.12:

– include the ten diagonal *un*informative values of 1 – any variate has correlation 1 with itself;
– involve 45 pairs of the same number – the correlation of **X** and **Y** is the *same* as that of **Y** and **X**.

Table HL103.12: Adults who "Really Like to Watch": Correlations to 4 Decimal Places
(Programs ordered alphabetically with channel)

ITV	PrB	1.0000	0.1064	0.0653	0.5054	0.4741	0.0915	0.4732	0.1681	0.3091	0.1242
	ThW	0.1064	1.0000	0.2701	0.1424	0.1321	0.1885	0.0815	0.3520	0.0637	0.3946
	Tod	0.0653	0.2701	1.0000	0.0926	0.0704	0.1546	0.0392	0.2004	0.0512	0.2437
	WoS	0.5054	0.1424	0.0926	1.0000	0.6217	0.0785	0.5806	0.1867	0.2963	0.1403
BBC	Grs	0.4741	0.1321	0.0704	0.6217	1.0000	0.0849	0.5932	0.1813	0.3412	0.1420
	LnU	0.0915	0.1885	0.1546	0.0785	0.0849	1.0000	0.0487	0.1973	0.0969	0.2661
	MoD	0.4732	0.0815	0.0392	0.5806	0.5932	0.0487	1.0000	0.1314	0.3267	0.1221
	Pan	0.1681	0.3520	0.2004	0.1867	0.1813	0.1973	0.1314	1.0000	0.1469	0.5237
	RgS	0.3091	0.0637	0.0512	0.2963	0.3412	0.0969	0.3267	0.1469	1.0000	0.1212
	24H	0.1242	0.3946	0.2437	0.1403	0.1420	0.2661	0.1211	0.5237	0.1212	1.0000

Like Table HL103.9 at the left above, Table HL103.12 occupies a full page-width in Ehrenberg's article.

Table HL103.13 at the right is Ehrenberg's (greatly) improved version of Table HL103.12 – the correlations have been rounded to one decimal place, the ten correlations of 1 have been removed and there is better labelling and spacing. [Line separators (as in Table HL103.10 above) have largely been omitted here.]

More astutely, the programs have been grouped to show how there are clusters within five sports programs and five public affairs programs, as well showing gradients within clusters and three locally high correlations of 0.2 between Panorama and some sports programs.

Table HL103.13 does not address the (difficult) presentation dilemma of half its 90 entries being duplicates – are the extra 45 entries useful to the viewer or are they a waste of space and/or a distraction?

Table HL103.13: Correlations for 10 TV Programs Rounded and Reordered

Programs	WoS	MoD	Grs	PrB	RgS	24H	Pan	ThW	Tod	LnU
World of Sport		.6	.6	.5	.3	.1	.2	.1	.1	.1
Match of the Day	.6		.6	.6	.3	.1	.1	.1	.0	.0
Grandstand	.6	.6		.5	.3	.1	.2	.1	.1	.1
Prof. Boxing	.5	.5	.5		.3	.1	.2	.1	.1	.1
Rugby Special	.3	.3	.3	.3		.1	.1	.1	.1	.1
24 Hours	.1	.1	.1	.1	.1		.5	.4	.2	.2
Panorama	.2	.1	.2	.2	.1	.5		.4	.2	.2
This Week	.1	.1	.1	.1	.1	.4	.4		.3	.2
Today	.1	.0	.1	.1	.1	.2	.2	.3		.2
Line-up	.1	.0	.1	.1	.1	.2	.2	.2	.2	

5. Other Illustrations

Statistical Highlight #104 shows how four-figure tables can, with little extra effort, yield one or two more figures, how to deal compactly with decimal numbers beginning with multiple nines, and how the extreme tails of the normal distribution behave.

The table in Statistical Highlight #105 demonstrates how the information needed by most users of the *K* distribution can be contained on two sides of a sheet of U.S. letter paper; secondarily, is shows how (much) *K* distribution values change with probabilities (area under the p.d.f.) and with degrees of freedom, by looking down the columns or across the rows.

- The features of this table, including its compactness, are less available when a computer is made the source of statistical distribution values, although one sheet of paper is more easily lost, destroyed or rendered unuseable than a computer like a laptop.

To avoid printing single-use copies to attatch to tests and examinations, it should be routine for students to bring to these tasks their *own* clean copies of the statistical tables available in these Materials. Also, careful students could conserve by keeping their personal set of tables to use in more than one statistics course.