Data Analysis

WITH SPREADSHEETS

David A. Patterson
Randall E. Basham

Data Analysis with Spreadsheets

David A. Patterson
University of Tennessee

Randall E. Basham
University of Texas–Arlington

Boston ■ New York ■ San Francisco
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To Eunice Fisher Patterson, who after
nearly ninety-nine trips around the sun and a life of service to others,
slipped the bonds of the physical world in May of 2004.

—D. A. P.

To my wife, Sharon, and to my writing companion, Wylie.

—R. E. B.

PREFACE

Social workers and human services professionals are increasingly called on to evaluate the outcomes of their practice, to measure changes in their clients over time, to determine if one type of approach to services delivery in an agency is better than another, and to respond to requests for evaluative data from managed care companies and other funding sources. Unfortunately, one of the great deficits in the educational preparation of students in social work and the human services is that they are commonly taught limited data analysis skills using conventional statistical analysis software such as SPSS. The problem with this approach is that social service and health care agencies seldom have expensive statistical software such as SPSS available for agency research projects and program evaluation. Conversely, most personal computers have installed spreadsheet software.

While the utility of spreadsheet software in budgetary procedures is commonly recognized, the social work and human services professions have been slow to recognize the efficacy of spreadsheets in data analysis. There exist a number of textbooks in business and science that describe the use of spreadsheets in data analysis for business and scientific applications. We wrote *Data Analysis with Spreadsheets* and created the accompanying CD-ROM as a comprehensive guide to the application of spreadsheets to commonly encountered data analysis problems in practice evaluation, statistical analysis, and program evaluation. In this text and on the CD-ROM, we demonstrate the use of spreadsheets in the full-spectrum of data analysis skills requisite for the evaluation of practice, agency-based research, and program evaluation.

Microsoft Excel

As is described in Chapter 1, there are both commercial and noncommercial publishers of spreadsheets. Most of them are roughly equivalent in appearance and functionality. The most widely used spreadsheet around the globe is Microsoft Excel. This market dominance means that social work and human services professionals are far more likely to have Microsoft Excel on their home and office computers than any other spreadsheet. For that reason, we have limited our description of spreadsheet data analysis procedures to how to perform these procedures in Microsoft Excel. Many of the procedures we describe here can be readily adapted for other types of spreadsheets, depending on the feature richness of the particular spreadsheet.

Microsoft Excel for Windows was originally released in 1987. Since that time there have been at least eight subsequent versions of this spreadsheet software. The challenge in writing any book about information technology is that it is a bit like trying to comprehend and describe a river by examining the contents of a cup recently dipped into the river. One can carefully observe the temperature, clarity, purity, acidity, salinity, and taste of the water in the cup. However, by the time one has come to know and write about the qualities of the river in the cup, the river at one's feet is no longer the same water. In *Data Analysis with Spreadsheets* we have consciously chosen to not link our description of data analysis procedures with Excel to a particular version of this software. While successive versions of Excel have added features, enhanced the functionality, and improved its appearance, the operation of the data analysis tools of Excel, listed in Chapter 1, has remained relatively consistent in the last three or four iterations of this software. We believe that almost all of the data analysis procedures described in the text and demonstrated on the accompanying CD-ROM can be accomplished with very little adaptation on versions of Excel released in this millennium.

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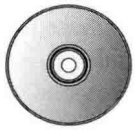
Data Analysis with Spreadsheets: Multimedia Modules CD-ROM



The *Data Analysis with Spreadsheets: Multimedia Modules* CD-ROM that comes with this book contains videos demonstrating the spreadsheet data analysis procedures described in the 12 chapters. The CD-ROM has a "Read me first" file that should be read before using the CD-ROM for the first time. It will acquaint you with the procedures for viewing the videos and spreadsheets found under Bonus Materials on the CD-ROM.

The web browsers Microsoft Internet Explore or Netscape Navigator will open the file on the CD-ROM entitled *Data Analysis with Spreadsheets,* from which you can start your exploration of the content of the CD-ROM. All of the videos on the CD-ROM are recorded in the QuickTime format. If your computer does not have QuickTime player installed, you can download a free copy from www.apple.com/quicktime/download/standalone. QuickTime players are available for Windows and Apple Macintosh operating systems. The QuickTime videos of this CD-ROM will play within the Microsoft Internet Explore or Netscape Navigator browser windows. Be sure to turn up the sound on your computer. Listening with headphones may be particularly helpful. The videos are 800 × 600 pixels in size, so expand your web browser window to its largest size in order to fully see the videos.

The Application of Spreadsheets to Practice-Related Data Analysis

The utility spreadsheets in data analysis extend beyond research applications into the everyday challenges of information management for social work and human service practitioners. A quick reference of the linkage between the chapters of this book and the practice-related issues addressed within them follows:

Chapter 1

- The role of data collection, analysis, and information dissemination in practice
- Uses of spreadsheets in practice settings as tools of practice
- Evaluation of practice
- Spreadsheets as a practice alternative to statistical software

Chapter 2

- The use of spreadsheets for information/data collection in practice settings
- Levels of measurement common to practice settings
- Sources of practice information/data

Chapter 3

- Selecting samples in social services agency data

Chapter 4

- Data cleaning challenges of information from practice settings

Chapter 5

- Graphically representing frequency distributions such as observations or behaviors
- Evaluating educational efforts that may be applied to service settings that provide education

Chapter 6

- Describing caseloads, performance, and productivity using descriptive statistics
- Measures of central tendency and variation in evaluating interventions

Chapter 7
- Evaluating practice interventions
- Spreadsheets as a tool for developing evidence-based practice
- Practice-level research sample selection and evaluating distributions

Chapter 8
- Comparing sample means to population means in practice
- Comparing observed versus expected frequencies across group services

Chapter 9
- Using pivot tables for social service data summary and exploration

Chapter 10
- Single system designs for practice evaluation
- Advantages of spreadsheets in single system design practice evaluation
- Single system design data collection with spreadsheets
- Single system design charting with spreadsheets
- Evaluating change in practice outcomes with single system design spreadsheets
- Spreadsheets for evaluating groups using single system designs

Chapter 11
- Determining change through evaluating associations between variables in interventions
- Using spreadsheet graphing tools to evaluate distributions and trends
- Evaluating and predicting change using regression analysis capabilities within spreadsheets

Chapter 12
- Spreadsheet production of practice graphics
- Applications of graphics in social service practice
- Spreadsheet-produced ecomaps
- Spreadsheet-produced genograms

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CHAPTER

1 An Introduction to Spreadsheets

Spreadsheets—First Facts

An inescapable task of the early 21st century in social service practice is the management of information. Most social workers, counselors, and human service workers likely enter their respective professional roles with the desire to provide necessary services to a particular client population, having neither the intention nor the wish to devote their time and energy to the collection, analysis, and dissemination of information. The emerging practice reality is that data have to be collected that document to whom what specific services are delivered, for what duration, in what quantity, and resulting in what outcomes. Governmental agencies, public and private insurers, managed care companies, as well as agency administrators and program evaluators, require the capture, analysis, and reporting of social services delivery information. Further, budgetary analysis and financial reporting requirements of social service agencies require skills in the evaluation of possible budget scenarios, the preparation of viable budget reports, and the monitoring of resources and expenditures over the life of the budget. Computers and the spectrum of information technology software and hardware now available are the essential tools for each of these information management tasks. Consequently, the ability to use information technology in the gathering, examination, and presentation of information regarding the provision of social services is now a requisite skill set for social service professionals.

Spreadsheet applications, or simply "spreadsheets," are computer programs that display a matrix of rows and columns of cells into which information, in the form of numbers, text, or formulas, is entered and displayed. The size of this rows and columns matrix is generally only limited by the available memory of the computer in which the spreadsheet software resides. As a result of the ever-growing power of personal computers, manifest in processing speed, storage capacity, and memory (RAM), spreadsheets are now capable of holding and manipulating vast amounts of information. Beyond the simple storage of information, the usefulness of spreadsheets stems from the ease with which they allow users to interact with data. For instance, spreadsheets can be used in social services practice settings to (a) record and graph the changes clients make over the course of service delivery, (b) collect and analyze data on how groups and individuals within the groups change over time, (c) record and analyze agency income and expenses, and (d) generate graphs and tables reporting agency service delivery and financial status to private and governmental funding sources, oversight boards, and constituents.

Spreadsheets are a rather neglected tool for the evaluation of social service practice and practice-based research. Social service practice settings have seen a growing movement toward greater accountability over the last generation. Accountability standards have been recommended for the purposes of determining intervention effectiveness, reducing risk of harm to clients, providing cost-effectiveness information on services provided, and for tracking overall program progress at various levels in social service agencies. Spreadsheets, which are commonly found on almost all modern-day computers, are a ready instrument for

accomplishing each of these data analysis tasks. The inattention in social service practice to the utility and versatility of spreadsheets is explored below.

The Brief History of Spreadsheets

The history of spreadsheets is paradoxically both long and short. Over the course of civilization dating back to the Babylonian Empire (4,500 B.C), the recording of information in ledgers or registers has been a means to account for financial transactions, inventory objects, assess taxes, and list the births, actions, and deaths of individuals. Such ledgers were pragmatic tools for recording and tracking information, both fiscal and demographic, as well as means to preserve and convey the actions and transactions of individuals, families, communities, businesses, and nations. More recently, though prior to the advent of electronic computers, accountants and others have used worksheets composed of matrices of columns and rows to record credits and debts, to note financial transactions, and to track the fiscal well-being of individuals, enterprises, and institutions.

The trouble with paper-based ledgers or spreadsheets is that they are static. A change of a number in a column or the removal or addition of information located in a row requires the recalculation of the bottom line, the manual re-entry of new figures. It is hardly surprising that prior to the introduction of the electronic spreadsheet, two of the essential tools of any accountant were an eraser and a sharp pencil, requisite instruments of the impermanent tasks of preliminary calculations. Further, it is of little wonder that with the advent of computers, researchers and academics turned their attention to how the tasks of accounting and inventory control might be automated and made more flexible.

It is generally recognized that one of the pioneers in the development of computer-based spreadsheets was Richard Mattessich. Mattessich's groundbreaking work appeared first in a paper (Mattessich, 1961) and later in two books (Mattessich, 1964a; Mattessich, 1964b). In these publications he laid out the basic elements of computerized financial spreadsheets, including the use of matrices, formulas calculating cell values, and simulations of "what if" scenarios (Gaffikin, 1996; Legg, 1988; Murphy, 1997). The fundamental limitation of Mattessich's early work was not conceptual but instead pragmatic. His methods required mainframe computers (the only type available at the time) and complex programming, both of which had significant associated costs.

The birth of modern, personal computer-based spreadsheets occurred in 1978 when a Harvard Business School student, Dan Bricklin, balked at the complexity involved in doing a "case study" project either by hand or on a mainframe computer (Power, 2000). As an alternative he envisioned an interactive electronic spreadsheet. He initially created a "working prototype" composed of 20 rows and 5 columns in which a user could input numbers and produce calculations. He then joined with Bob Frankston, whom he knew from MIT, to improve the functioning of the original prototype by adding the ability to scroll, increase the speed of calculations, enhance the arithmetic, and optimize the program code so it would run on an affordable personal computer, one of the first Apple Computer machines. The resulting program was called VisiCalc, which was short for "visible calculator."

Bricklin (2003) points out that prior to the development of VisiCalc, there existed other row and column tabulation programs. VisiCalc, however, was unique as the first "electronic spreadsheet" having interactive features including scrolling, automatic recalculation of values in cells based on stored formulas, and ease of data input, formatting, and output. The introduction of VisiCalc had a catalytic sales effect on the blossoming personal computer industry, as it was a software product with real utility for organizations in the business and finance sectors of the economy. Further, the VisiCalc user interface became the prototype for all spreadsheet programs subsequently developed. Bricklin and Frankston formed Software Arts in January, 1979 and eventually sold over 500,000 copies of this first "electronic spreadsheet." Readers interested in seeing screenshots of the original VisiCalc program should visit Bricklin's website, www.bricklin.com/firstspreadsheetquestion.htm. A

copy of the original VisiCalc is available for downloading at www.bricklin.com/history/vcexecutable.htm.

The VisiCalc dominance of the spreadsheet market was eclipsed in the early 1980s by a new product, Lotus 1-2-3, which offered an easier to use interface, the ability to create charts, and database functions. Lotus 1-2-3 soon became a best-selling software application and the de facto standard for spreadsheets during that time period (Power, 2000). In the mid-1980s Microsoft introduced Excel, which was developed for an early version of the Apple Macintosh. At that time, the Apple Macintosh was the only personal computer with a graphical user interface and a pointing device, the now ubiquitous mouse. The software programmers of Excel took advantage of these features unique to the Macintosh by incorporating into Excel design elements such as pulldown menus and point-and-click data entry. Microsoft released its first version of Windows in 1987 along with an early version of Excel for Windows. In 1989, Version 3.0 of Windows was released along with a much-improved version of Excel, which was the only Windows spreadsheet until 1992. Lotus 1-2-3 and other spreadsheet applications ran on the MS-DOS operating system.

Over the course of the mid- to late-1990s, there were three major spreadsheets available for the Windows operating system: Microsoft Excel, Lotus 1-2-3, and Quattro Pro. Each of these spreadsheets was incorporated into an office suite of software by its respective publisher. Software office suites usually contain a word processor, spreadsheet, presentation software, and sometimes a database. Lotus 1-2-3 was purchased in 1995 (Power, 2000) by IBM and included in its Lotus SmartSuite software package. Quattro Pro became part of Corel's WordPerfect Office suite. Excel, which has long been a part of the Microsoft Office suite, became the dominant spreadsheet on the market, accounting for about 90 percent of all spreadsheet sales (Krazit, 2002; Walkenbach, 2003).

More recently, low-cost and open source office suites have become available over the web that include spreadsheets. Open source software is developed collectively by volunteers in the worldwide programming community and made freely available to the public. Sun Microsystems' StarOffice 7.0 is available at no cost to academic and research institutions and is very competitively priced for businesses (www.sun.com/software/star/staroffice/index.xml). OpenOffice is an open source, feature-rich office suite that contains Calc, a fully functional spreadsheet. It is available at www.openoffice.org/product. The spreadsheets in these two office suites contain the full array of common spreadsheet tools; can read, write, and export Microsoft Excel files; and represent viable alternatives for individuals and agencies seeking lower-cost options in spreadsheet software.

The brief history of personal computer spreadsheets evidences three noteworthy trends. First, since the development of VisiCalc, spreadsheets have continued to expand the array of tools and features available to users. Spreadsheet users are no longer limited to simply calculating formulas for columns and rows of numbers. They can import data from multiple sources including databases and other types of spreadsheets. They can analyze complex data sets with descriptive and inferential statistics and then graphically represent the results with the charting tools of spreadsheets. Moreover, the tables, charts, and diagrams that users can now create with modern-day spreadsheets can be readily exported to other tools of electronic communication, including word processing, presentation, and web-authoring software (Patterson, 2000).

This integration of spreadsheets with other types of software is the second noteworthy trend in the history of spreadsheets. Early spreadsheets could generally produce printed output, but had no capacity to interact with other forms of software in sharing information. This electronic isolation was partially a function of the limitations of the MS-DOS and early Windows operating systems. The barrier between word processing and spreadsheets was broken by the release of Microsoft Word and Excel for the Apple Macintosh, which allowed for the cutting and pasting of charts and tables from Excel to Word. Since then, spreadsheet publishers have continued to expand the range of data and graphics exchange capabilities of their respective products. Most spreadsheets can now import data in a wide range of spreadsheet, database, and text file formats and export or share data, summary tables,

charts, and graphics to word processors, databases, and web pages, and many other applications. These capabilities are described in greater depth in subsequent chapters.

The third trend evident over the history of spreadsheets is their increasingly widespread utilization. Though it is difficult to measure directly the change over time in the use of spreadsheets by either professionals or in the general population, several facts are suggestive of their increased utilization. A search of www.amazon.com database using "spreadsheet" as the search term found listings for 3,058 available books. An identical search of www.barnesandnoble.com resulted in a list of 3,373 books related to spreadsheets. A search of Business Source Premier, an electronic database of business publications, found 4,253 articles that included the terms "spreadsheet" or "spreadsheets." A search of PsychInfo, an electronic database of journal articles, dissertations, and books related to psychology, found 177 listings of sources using the terms "spreadsheet" or "spreadsheets." An identical search of Social Sciences Abstracts, a multidisciplinary index of journals in the social sciences, found 64 articles. Rather remarkably, a search of Social Work Abstracts found only four articles using either of the two search terms. A search of www.google.com using the term "spreadsheet" found 1,970,000 web pages in which the word appeared. When "social work" was added to the Google "spreadsheet" search, 8,600 web pages were found. A mere 0.004 percent of all references to spreadsheets on the World Wide Web also include content somehow related to social work. In contrast, if the term "psychology" is added to "spreadsheet" on a Google search, 47,000 web pages are located. A search of World Wide Web Resources for Social Workers (www.nyu.edu/socialwork/wwwrsw) found only three articles using the search term "spreadsheet," none of which was directly related to social work.

It seems safe to conclude this brief history of spreadsheets with two observations. First, the sheer volume of spreadsheet-related publications, whether electronic or hard copy, is indicative of the widespread interest in their use and applicability to a broad spectrum of data analysis and information dissemination tasks. Second, if the dearth of academic literature and low volume of web pages are valid indicators, then it appears that social workers have yet to fully appreciate the utility of spreadsheets and take them up as tools of social work practice. It is this unfortunate neglect of a highly versatile tool that we seek to redress with this text.

Why Use Spreadsheets for Data Analysis in the Social Services?

In order to address the robust potential of spreadsheets as data analysis tools in the social services, it is perhaps necessary to first address the question of why social service professionals should concern themselves with "data analysis" in the first place. In the opening paragraph of this chapter we describe how information management, manifest in the collection, analysis, and subsequent communication of findings or information, is becoming a required skill set for social service professionals.

The necessity of social service information management skills is driven by three key factors: professional and fiscal accountability, ethics, and decision making (Montcalm & Royse, 2002). Social service agencies and professionals are increasingly being called on by funding sources, whether local, state, federal, or private insurers, to demonstrate both the actual delivery of services and efficacy of the services provided. In other words, it has become increasingly important to measure the outcomes of services provided. The accountability expectations of funding sources necessitates the collection of service delivery information, its subsequent analysis and evaluation, and the lucid communication of results.

For social workers, the confluence of ethics and social services information management skills arises from their Code of Ethics. The 1999 revision of the National Association of Social Workers (NASW) Code of Ethics states in section 5.02, Evaluation and Research (2003):

(a) Social workers should monitor and evaluate policies, the implementation of programs, and practice interventions.

(b) Social workers should promote and facilitate evaluation and research to contribute to the development of knowledge.

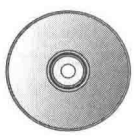
The ethical imperative conveyed in this section of the Code of Ethics is unequivocal. Social workers are expected to "monitor and evaluate" and "promote and facilitate evaluation and research." The intersection of this ethical obligation and information management is borne of pragmatism. The most efficient way to monitor and evaluate practice and facilitate research is with the employment of information technology.

The third factor driving the need for information management skills in the social services is the ever-present need to make decisions (Montcalm & Royse, 2002). Social workers and social services professionals are called on daily to make critical decisions on matters including child protection, staff allocation for service delivery, agency fiscal resources utilization, and governmental policy recommendations, just to name a few. There are of course many ways to make a decision. Caprice, gut hunches, and intuition are means to arrive at a decision, albeit perhaps an ill-informed and intellectually unsupportable one. Proctor (2002) states, "Decision making in social work is high-stakes work" (p. 3). She asserts as well that decision quality can be impaired by the lack of information, as well as other factors. All too often, social service agencies have a wealth of information that is collected and stored on paper, an unfortunate decision that amplifies the complexity of information retrieval and synthesis. The point here is that decision making in the social services can and should be improved by information management skills that include electronic data collection, analysis/synthesis, and reporting. As we will see, social service practitioners can employ spreadsheets in each of these three domains of information management.

One of the great advantages offered to social service practitioners by spreadsheets is that they are commonly available on most personal computers. Today they are almost always part of an office suite of software applications. Sometimes the office suite is included on the computer as part of the original software and in other instances the office suite is purchased separately and loaded onto the computer. As described previously, there are now low-cost and open source office suites that are downloadable from the World Wide Web. It is now increasingly difficult to find a personal computer without some form of spreadsheet software on it. Consequently, social service practitioners and agencies have the readily available potential to employ spreadsheets for a spectrum of information management tasks.

Spreadsheet Basics

The overarching purpose of this book is the demonstration of spreadsheets' flexibility and data analytic power as tools of practice. In preparation to do that, it may be helpful to review the basic elements of spreadsheets. A spreadsheet is essentially a table composed of rows, columns, and cells. A column is a vertical line of boxes with a letter identifying each column (maranGraphics, 1996). A row is a horizontal line of boxes with a number identifying each row. A cell is a single box in the spreadsheet, which is the intersection of a row and a column. The cell reference is the address of the cell, which is composed of the column letter and the row number. For instance, cell B4 is located in column B on row 4. Figure 1.1 shows a spreadsheet in which cell B4 is highlighted (see the accompanying CD-ROM video animation: "Spreadsheet Tour").



Three types of information may be entered into a cell: labels, values, and formulas. Labels are explanatory text such as the name of a variable that appears at the top of a column and identifies the information contained in the column. Values are the data, both numerical and text, that are collected in the spreadsheet. Formulas perform calculations,

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