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BROWNING, WILLIAM CHARLES

COMPUTER TECHNOLOGY AS A DIFFUSION OF INNOVATION IN HOSPITAL PHARMACY

THE UNIVERSITY OF ARIZONA M.S. 1983

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COMPUTER TECHNOLOGY AS A DIFFUSION OF INNOVATION IN HOSPITAL PHARMACY

by

William Charles Browning

A Thesis Submitted to the Faculty of the

DEPARTMENT OF PHARMACY PRACTICE

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE
WITH A MAJOR IN PHARMACY

In the Graduate College

THE UNIVERSITY OF ARIZONA

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APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Peter D. Hurd
PETER D. HURD
Assistant Professor of
Pharmacy Practice

12-12-83
Date

ACKNOWLEDGEMENTS

This project was the result of the cumulative efforts of a number of people to whom I wish to express my appreciation. Most closely involved were the members of the thesis committee Dr J. Lyle Bootman, Dr William McGhan and Dr David Tansik. Dr Peter Hurd is owed a special thanks for the extensive time, effort, and consideration he so freely gave as the thesis director. I also wish to thank Bud Parrett and Tom Einarson for their assistance and support in the completion of this project. As two fellow graduate students they were always available to discuss concepts and make valuable suggestions.

I also wish to express my appreciation to the members of my family. My parents were extremely influential in my early education by instilling a desire to learn and later by supporting me without reservation in any field I chose to apply myself. My wife and children are owed a special thanks for their support and tolerance of long absences while working on this project.

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ABSTRACT

The adoption of computer technology by hospital pharmacies was studied as a diffusion of innovation. A nation-wide mail survey determined how computers were used in hospital pharmacies and when computer use began.

The instrument was mailed to 501 hospital pharmacy directors that were randomly selected from hospitals in the United States. A response rate of 83.2% was attained and the instrument was found to have adequate reliability. The adoption of computers by hospital pharmacies was found to be higher than previously reported in the literature and much like the adoption of other technologies in widely diverse fields.

The curve for adoption of computers by hospital pharmacy was found to fit the expected curve previously described for diffusion of innovations. Computers had been proven to have definite advantages in hospital pharmacy and this study revealed that computers had been adopted to the greatest extent in patient billing, intravenous additives, and unit dose applications.

Wider dissemination of information on the usefullness of computers in specific applications is recommended.

CHAPTER 1

INTRODUCTION

The profession of pharmacy has undergone a period of rapid change during the last three decades. The changes that have taken place include the actual work the pharmacist performs, the diversity of drugs he handles, and the amount of information that he uses in the practice of a complex profession. For example, pharmacists spent more time in the preparation of medicines for dispensing thirty years ago when dosage forms were compounded by the pharmacist than today when almost all prescriptions are filled with commercially prepared products. The number of drug products has also increased, and new categories of important and useful drugs have been developed. An obvious example is the antibiotic drug category, which was not commercially available before the 1940's. Antibiotics account for the largest portion of all prescriptions dispensed in the 1980s (Lawrence and McLemore, 1983). The amount of information that a pharmacist has been required to learn, retain and use has increased more rapidly than the number of drugs. Research has expanded the knowledge base for established drugs as well as for the newer compounds. In particular, information about the pharmacology and kinetics of drugs has increased a great deal.

Both an increased intrusion by government agencies into the practice of pharmacy and a reliance on complex reimbursement systems have caused changes in the profession (Halperin, 1981). As a response to increased abuse of both legal and illegal drugs, the government has increased its regulation of prescription medications. These regulations have complicated pharmacy by changing storage, dispensing, and record keeping requirements for pharmacists many times in the last twenty years. Also, the government has dramatically increased its role in paying for medication and health care. Since the government became involved in reimbursing pharmacists for dispensed medication, it has become involved in determining what the maximum allowable price for the medication would be. This has largely determined the other pharmacy services which would be provided. For example, the government has decided to reimbuse pharmacists for prescription medications based on the average wholesale price of the drug and has made no allowance for other professional services, such as patient counselling.

Another significant change has been the pharmacist's actual face to face contact with the patient. The pharmacist at a corner drugstore decades ago was often the first person consulted on matters of health and illness. The gradual replacement of the corner drugstore with larger and busier retail outlets has placed both physical and psychological barriers between pharmacists and patients who are seeking health related information, services and supplies (Millis, 1975). Fortunately, this decline in patient orientation is now being reversed by an increasing interest in clinical pharmacy practice. As recently as seventeen years ago, the term clinical pharmacy did not exist. Within the last two decades the concept of a patient-oriented, rather than a drug product-oriented, pharmacy practitioner has become more firmly established (Miller, 1981).

With this movement towards clinical pharmacy, the pharmacist began to fill the role of an expert in drugs and drug therapy, not only to patients, but also to physicians and other health professionals. The pharmacist had always been in close contact with the patient, and physicians had occasionally referred to the pharmacist for drug information. But with the increase in the number and complexity of drugs available, physicians were more frequently consulting the pharmacist for current information. Through training and experience the pharmacist became an information expert.

All of these changes had two things in common: The pharmacist had an increased need for timely information as well as a need for assistance in performing many of the repetitive dispensing tasks. Pharmacy technicians and clerical personnel had helped to relieve pharmacists of some of the burden, but something more was needed.

At the same time as the profession of pharmacy was undergoing a rapid period of evolution, computer science was going through another type of change: The rapid expansion of computer technology. Although the science of computer technology was really an infant during the 1950s, subsequent expansion brought many benefits to society, such as the efficient processing of information and the effective performance of clerical tasks. The computer had proven itself to be a very efficient and accurate means of storing, manipulating, and providing information. Also, the ability to perform repetitive clerical tasks, such as accounting, was clearly superior to any previous method (Sanders, 1981).

At the same time that the profession of pharmacy needed better information and more assistance in performing repetitive clerical tasks, computer technology was evolving to meet just those needs. A marriage of computers and pharmacy would seem only natural, but a barrier did exist. Until only a few years ago, high costs still limited computer use in many places. The great advances in microcircuitry have largely overcome that disadvantage, so that today at least some level of computerization is available to nearly everyone. (Burleson, 1982)

A review of the pharmacy literature revealed that many computer uses had been developed for hospital pharmacy. These reports have described satisfactorily implemented systems, which provide great savings in time, money, and personnel. Knight and Conrad (1975) reviewed many applications of computers in hospital pharmacy, ranging from typing prescription and intravenous solution labels to assisting in drug utilization reviews. Preparation of the hospital formulary (Guernsey and others, 1983) has been described as saving both time and money while improving quality. The clerical portion of a nuclear pharmacy has been automated successfully with a savings in time and money (Fung, Basmadjian and Ice, 1983). A study done to determine the availability of computer systems for hospital pharmacy reported that thirty vendors marketed a hospital pharmacy system in 1982 (Swanson, Broekemeier, and Anderson, 1982).

Since computers have become affordable, available, and useful, many in the profession anticipated that the use of computers in pharmacy, especially in hospital pharmacy with its many clerical tasks, would be high. But this was not the case as reported in the literature. A national survey of hospital pharmacy services was conducted three times in the last eight years (Stolar, 1976, 1979, 1983). One question that these surveys asked was whether computers were used in the hospital pharmacy to maintain medication profiles, to collect drug use data, and to perform other key functions in the drug distribution system. Since these surveys were designed to measure many aspects of hospital pharmacy, only a narrow range of computer use in hospital pharmacy was measured. The response rates for computer use were 7.2% in 1975, 29% in 1978, and 35% in 1982.

Stolar's surveys showed that computers were in fact being used in hospital pharmacies, and that the rate of use was increasing over time. But the narrow range of use measured in those surveys reported a lower adoption rate of computers than a more comprehensive series of questions about computer usage could have measured.

Problem

In view of the advantages of using a computer in a hospital pharmacy, Stolar's rates of usage seemed to be rather low, especially those published in 1983. A few years ago the low usage rate could have been explained by high costs, limited availability, or lack of knowledge. All three of these difficulties have been overcome: the costs have declined rapidly, the availability has increased greatly, and the amount written about implementing computer systems has expanded to cover most needs. Thus, the question to be addressed was the actual rate of adoption of computer technology in hospital pharmacy.

Objectives

The objective of this study was to learn how computers were being used in hospital pharmacy, when the use of computers began, how the adoption curve would be shaped over time, and how the adoption of computers relates to innovative characteristics of the directors of the pharmacies studied.

Background and Hypotheses

The diffusion of innovations has been studied since the early 1900's (Tarde, 1903). Studies have been published on subjects as diverse as the adoption of hybrid corn or of CAT scanners (Rogers, 1983). In all of the innovations studied, when the percent of cumulative adoption has been plotted versus the time of adoption, an "S" shaped curve has resulted. This "S" shaped curve has been called the logistic function, and its general formula has been published (Russell, 1977, Olshavsky, 1980). This function allows for a different beginning and rate of adoption for each innovation. There is no reason to expect that the adoption of computer technology in hospital pharmacy would be any different than those technologies studied previously.

The Development of Medical Technology (1976) compared the diffusion of non-medical technology with that of pharmaceuticals. General technologies had diffusion lags averaging fourteen years, the petroleum industry averaged eleven years, new drugs averaged five years. In each case both the time and rate of adoption varied, but the shape of the curve predicted by the logistics function did not vary.

Russell (1977) and Banta (1980) studied the diffusion of CT scanners, intensive care units, and nuclear medicine services in hospitals. They found that these three technologies were all adopted at significantly different rates, but that all followed the same general adoption curve. Coleman (1957) studied the diffusion of a new drug in a community of physicians and noted the same general curve of adoption, the time period was different than that of complex and expensive technologies. Gray (1973) studied the adoption of state laws and described the same general normal distribution for the diffusion of innovations. Olshavsky (1980) studied the adoption of innovations specifically concerning consumer products. He found that the product life cycle was in fact shortening, but that the same distribution of adoption existed. Fliegel and Kivlin (1966) found that differences in innovation were important variables in explaining different rates of diffusion. The most rewarding and least risky innovations were adopted first, but all followed the same general curve for adoption with different rates. The studies cited above indicate that analysis of the data from the three Stolar studies should have yielded an adoption curve showing an accelleration of the rate of adoption of computers. Computers should have been used in at least some manner by at least fifty percent of the hospitals reporting by the time of the survey (Development of Medical Technology, 1976, Banta, 1980, Moch and Morse, 1977, Russell, 1977). This led to the following hypothesis:

Hypothesis I

There is no difference between the shape of the curve for the adoption of computer technology in hospital pharmacy and the shape of the curve for the adoption of other technologies.

The survey instrument used in this study determined where and how computers were being used in hospital pharmacies. The uses of computers were arranged so that lower level uses like typing labels or lists and higher level uses like research and forecasting were included. Computers were a new technology to hospital pharmacy and usage was expected to be predominantly at the lower levels. This led to the second hypothesis:

Hypothesis II

There is no difference between the number of hospital pharmacies using computers at low levels and at high levels.

Previous studies on diffusion of innovation have had success in predicting who would be an innovator by using personal characteristics of the individual. Ettlie and O'Keefe (1982) measured status and authority using the number of subordinates, salary, the amount of money the person could commit, and the number of years worked for the organization. Behavioral performance was measured by the number of people in the work group, the number of employees in the organization, age of the manager, education of the manager, and tenure in his position. By using these factors together, individuals could be ranked by their predicted innovativeness.

The Development of Medical Technology (1976) determined that the factors predicting a physician's adoption of an innovation were his own clinical experience, the experience of his colleagues, and his sources of information including advertising, other literature, and continuing education. Coleman (1957), in studying diffusion of a new drug among physicians, found that the individual attributes that affected diffusion rate were age, the number and kind of journals read, the outside communication with physicians in similar practices, and the physician's attitude towards innovation. Miller (1973) also studied physician prescribing habits and determined that the age, size of practice, cosmopoliteness, number and type of journals read, meetings attended, contact with peers, and change agent contact were all significant in predicting innovativeness. Hage and Dewar (1973) studied elite values and the relative predictive power of values versus structure for predicting innovativeness. They found that diversity of occupational specialties, activity in professional associations, and the values of an organization's director were good predictors of innovativeness. Ostlund (1974) found that cosmopoliteness, education, status, and income were all good predictors of innovativeness. Becker (1970) found that years in practice, years in the present position, contact with others in the profession, change agent contact, cosmopolitenss, the number of out of state meetings attended and the number and type of journals read were all good predictors of an individual's innovativeness.

All of the factors listed above could not practically be used in this study. The key factors with a positive correlation to innovativeness were a person's cosmopoliteness, change agent contact, status, and education. These factors were measured by the instrument, and a numerical value for predicted innovativeness of the director was determined. This score was compared to the director's innovative behavior in adopting new services and computer technology in the pharmacy. This led to the third and fourth hypotheses:

Hypothesis III

There is no correlation between a director of pharmacy's predicted innovativeness and his adoption time of computer technology.

Hypothesis IV

There is no correlation between a director of pharmacy's predicted innovativeness and his level of adoption of innovative services.

The availability of innovative services at each hospital pharmacy was measured by the instrument. Since these services were all developed by pharmacy personnel, they were more easily understood and communicated within the profession than new computer technology developed outside the profession. This should have yielded a higher rate of adoption for innovative pharmacy services developed within pharmacy than for adoption of computers developed outside of pharmacy. This led to the fifth hypothesis:

Hypothesis V

There is no difference between the number of innovative services offered by hospital pharmacies with low and high levels of computer adoption.

Scope

This study was a national survey of hospital pharmacy directors. The sample was selected from the American Hospital Association's Guide for 1982. Some categories of hospitals were excluded because they were not expected to have representative pharmacy departments. Examples of excluded hospitals were convalescent centers, tuberculosis hospitals, psychiatric hospitals, and other hospitals with less than one hundred beds.

Significance

This project was conducted to study a technology that did not appear to be used to the greatest benefit in the profession of pharmacy. It was hoped that gathering information about the use of computers in hospital pharmacies would add to the general wealth of knowledge about hospital pharmacy, computer usage, and the diffusion of innovation. It was further hoped that the problems discovered and clearly defined could be more easily solved once identified. Pharmacists reading the results of this study could learn how others were using computers and be encouraged to adopt the uses that would be most beneficial in their practices. The goal that many seek in the profession is to raise the general level of health care provided to patients. Computerization of many functions in pharmacy should relieve pharmacists of clerical tasks, provide accurate information, and make the provision of professional services more efficient, allowing a general increase in the level of health care provided.

Definitions

For the purpose of this study the following terms are defined:

1. Computer. An electronic memory device that is able to follow a set of instructions in a program.
2. Cosmopoliteness. An individual's level of awareness of information and events outside his/her immediate sphere or group.
3. CRT. Cathode Ray Tube: same as a television screen but located on a computer terminal.
4. Innovation. A piece of equipment, type of service, or even an idea or concept that has not been previously used in an organization. Something new and different.
5. Input. The instructions or data that are put in to the computer by an input device like a terminal or card reader.
6. Output. The data that a computer provides as an answer to a problem or in response to a request. Most common forms

are printed output on a CRT screen or printed output in a hard copy(paper).

7. Program. A set of instruction used to operate a computer.

8. Terminal. An input and output device for a computer. Usually looks like a typewriter keyboard with or without a screen or printing device.

CHAPTER 2

LITERATURE REVIEW

The practice of pharmacy has made great changes in the past three decades. This chapter briefly presents some of those changes, how they have affected hospital pharmacy, and how they apply to this study. The development of computer technology and how it has been useful in hospital pharmacy is also presented, along with many of the specific applications reported in the literature. Also, literature on the diffusion of innovation and its applicability to this study is presented.

Changes in Hospital Pharmacy

The practice of hospital pharmacy has gone through dramatic changes in the last three decades. Thirty years ago drugs in a hospital were mostly dispensed from a closet by nurses. As the complexity of the drugs increased, more pharmacists became involved with hospitals, mostly providing drugs in bulk packages out of pharmacies located in the basements of the hospitals. Many pharmacists have now moved out of that basement location and have become more involved in patient care rather than the supply function of providing drugs (White, 1983). Some examples of innovations in hospital pharmacy have been the unit dose method of drug distribution, decentralized methods of unit dose drug distribution, intravenous additive programs, total parenteral nutrition programs, drug information services, formulary production, utilization review functions, clinical pharmacy functions, controlled substances accounting, and various research activities. These services and activities have been widely reported in the literature (Burleson, 1982).

Unit Dose

Development of the unit dose method of drug distribution was an early innovation that had widespread effects on hospital pharmacy. Prior to the development of unit dose, most medication was sent to the patient wards in bulk containers for the nurses to dispense to the patients. Unit dose changed the dispensing of medications so that each dose was individually packaged and delivered to the patient wards labelled for a specific patient. The pharmacists became much more closely involved in the delivery of medication to patients and three way communication between the prescribers, nurses, and pharmacists became much more common.

The first report in the literature of the use of a unit dose drug distribution system was at the Shands Teaching Hospital of the University of Florida. The conclusion of that study was that unit dose could reduce medication errors and conserve nursing time (McConnel, 1961). More extensive studies at the University of Arkansas showed a reduction in medication errors, an expected increase in pharmacy salary cost, and a decrease in medication related nursing salary cost (Barker, 1969 and Barker 1963 & 1964).

Following soon after the development of unit dose came other changes in the practice of hospital pharmacy intented to improve the quality of patient care. Intravenous additives and clinical pharmacy are two examples. Changes were also prompted by increased government regulation, especially for controlled substances and reimbursed care. Even more changes were caused by the maturation of overseeing agencies like the Joint Commission on Accreditation of Hospitals, who presented new requirements such as drug audits, internal reviews and utilization reviews. Also, there were leaders in the profession advocating even more drastic steps by pharmacy including the administration of drugs to patients (Latiolais, 1970).

In all of these changes the pharmacist had an increased need for timely and accurate information as well as a need for assistance in performing many of the repetitive dispensing tasks. Pharmacy technicians and clerical personnel had helped to relieve some of this burden, but something more was still needed. At the same time as the profession of pharmacy was undergoing a rapid period of evolution, another science was making even larger advances.

Growth in Computer Technology

The science of computer technology was in its infancy thirty years ago. The first electronic computer , ENIAC, was produced in 1946. By 1950 there were only thirty computers in the world. The growth, in terms of numbers, was slow in the next twenty years because of the great cost, the limits in electronic circuitry and the need for basic research. By the year 1970 there were 30,000 computers in use in the United States, but cost and efficiency still limited their application to large business and government.

In 1975 the first very small computers became available because of the invention and mass manufacture of the first integrated circuit chips. These chips increased the electronic efficiency of computers, but, even more important, they provided a very substantial decrease in the cost of small computers. The growth of computer use from that point on was phenomenal. By 1980 there were 230,000 computers in use in the United States which accounted for 54% of all computers in the world, 80% of which were produced in the United States (Sanders, 1981).

Development of Computer Use in Hospital Pharmacy

About the same time that computers diffused into large business and industries, they were also adopted by hospitals. The initial applications were the same in hospitals as they were in other businesses: accounting and other purely clerical functions. Many hospital pharmacists gained some exposure to computers because the pharmacy was involved in billing patients for the medication which were dispensed. This brought the computer's efficiency at handling clerical tasks into focus and lead to attempts to use computer technology in hospital pharmacy.

Unit Dose

The first reported use of computers in hospital pharmacy was at the Saskatoon University Hospital in Canada. It was an experimental system of drug distribution at a 550 bed university hospital. Design was begun in April of 1968 and a trial period of 22 weeks was started on one ward in June 1969. That was followed by a satellite system of 120 beds per pharmacy. The researchers stated that computer utilization made handling of the information necessary to service over 100 beds feasible. They were able to provide printed copies of complete patient profiles, daily statistical reports, and narcotic inventories with the same equipment, a program using only 8K of memory per terminal, and a central capacity of 1 megabyte. This application was an iterative program that asked the users questions to input patient and medication data (Evans, 1971).

The first report in the literature of a completely computerized unit dose system in the United States was at the Johns Hopkins Hospital in Baltimore, Maryland. The development of the system began in 1966 and went into operation 24-hours a day in May of 1970. The three objectives in starting the system were: 1) A safer and more effective drug distribution system, 2) Improved medication records, 3) Improved drug utilization. An unusual aspect of the design was that the system would only make available a dose of medication for a given patient at a given time when that single dose was necessary; not even a 24 hour supply of the drug was dispensed, only a single dose.

The system was designed and the programs were written by a pharmacist, Darryl D. Zellers. The computer science staff of the hospital was unable to support the system, but this pharmacist was already self-trained in programming and systems analysis. The initial step was to develop a satellite pharmacy program that served 60 beds in the adult medicine service. When that initial project was a success, a second satellite pharmacy serving 120 pediatric beds was implemented.

The system was used for unit dose packaging, unit dose distribution, decentralized pharmacies, and medication administration recording. Also the computer was used to control the entire system through on-line computer terminals in the satellite pharmacies. Physicians' orders were carbon copies of the original. Patient admission data was entered by the pharmacists with a history number, name, unit, sex, age, and weight. The pharmacist who received the drug orders then entered any allergy data pertinent to the patient and the new drug order. The computer then automatically generated a labelled medication envelope one hour before a dose was needed, allowing the pharmacist time to prepare the dose and have it delivered. Trays of envelopes were delivered to the nursing station 30 minutes before doses were due. The system automatically printed a complete patient profile and medication administration record for the patient's chart each 24 hours. An additional profile or record could be requested at any time. On discharge, a complete medication administration record was printed for each patient and included in the patients permanent medical records.

This system accomplished its objectives and the researchers reached the following conclusions:

1. Computer technology can be successfully utilized in drug distribution and drug recording systems.

2. Nursing personnel were pleased and enthusiastic regarding the system. They were most vocal about expanding

the system throughout the hospital.

3. The medical staff, through the pharmacy and therapeutics committee, had endorsed the system for expansion throughout the hospital.

4. Decentralization of drug distribution on the basis of medical specialty and the utilization of computer technology had enhanced the development of clinical pharmacy services.

5. The utilization of computer technology in drug distribution systems was dependent upon the involvement of pharmacists in design and evaluation.(Derewicz and Zellers, 1973)

Soon after the completion of the above study, another was completed at the same hospital to compare the costs of the unit dose system and the traditional multiple dose system. The conclusion of this second study was that the distribution costs of unit dose were about 10% higher than the traditional system, but would be lower than the multiple dose system if expanded to the entire hospital. Additional benefits were the more effective control of drugs including the lack of necessity for a specialized system to distribute controlled substances, and a decrease in medication waste (Riley, Derewicz, and Lamy, 1973)

The entire system reported above was made possible because Johns Hopkins was a very large hospital (1100 beds), already had an IBM 370-145 computer in the facility, and permitted the pharmacy to link into the system. Also, the hospital was extremely fortunate to have a pharmacist on the staff with sufficient knowledge to write the required programs and implement the entire system.

The next computerized system to appear in the literature was again made possible because the hospital already had a computer with room for additional workload. In September 1969 the Robert Packer Hospital in Sayre, Pennsylvania began planning computerization of its ward stock system. The hospital already had an IBM 360-20 computer doing accounts, purchasing and central stores. The system that was developed was used to maintain perpetual inventory on controlled substances and floor stocked drugs, to calculate charges for floor stocked drugs, and to generate labels (Adams and Younker, 1974)

The next account of a computerized hospital pharmacy unit dose system was at the Bethesda Hospital, Cincinnati, Ohio. The goals in developing the system were to: 1) Develop an improved mechanism for pharmacy charges within four months, 2) Develop an improved method for fiscal inventories within six months, 3) Develop a computerized drug list within one year. The three objectives were met and the additional advantage of the ability to print the formulary was derived from the availability of a complete drug list (Reeme, 1974).

The costs of developing a computerized drug file were reviewed in a more recent article (Strand, Cipolle, and Darwin, 1981). In that report the programming was done by hospital employees at double the cost of purchasing a commercially available system, but the gains from a customized system were felt to offset the additional cost.

Drug Information and Formulary Applications

Drug information files and formulary printing were other areas of early use for computers in hospital pharmacies. The University of Iowa Hospitals and Clinics reported a system which generated the drug list and provided a camera ready formulary for printing. Prior to this project the limitation had been in creating a file with an excess of 500,000 characters, which was required for the entire drug list. Not only was the hospital provided with a printed formulary on a yearly basis, but the computer provided a constantly-updated, complete drug list for all drugs, whether on the formulary or not. Due to all the one time expenses of programming and keypunching, conversion to the automated system caused an increased printing cost during the first year, but subsequent versions could be produced at considerable savings. (Frankenfeld, Black, and Dick, 1971)

More recently (Guernsey, Doutre, Hokanson, Ingrim, Galvan and Bryant, 1983) there was a description of the production of the hospital formulary using an existing database management system. This updated system allowed monthly updating of the formulary and yearly production of camera ready copy for printing.

Drug-Drug Interaction and Drug-Test Interference Screening

Another area that had even broader implications for improving the quality of pharmacy care was the computerized screening for drug interactions. The first reported system was at Mercy Hospital (Bouchard, Bell, Freedy and Duffy, 1972). Approximately 7,000 specific drug induced modifications of laboratory tests and 10,000 drug-drug interactions had been collected from the literature. In this service the data were keypunched, one interaction or interference per card. The system consisted of four COBOL programs for: 1) Update of data; 2) Search of program to accept a patient profile, compare it to the interaction file, and print a list of possible interactions; 3) A list program that provided users with a summary of all interactions for a given drug or test; 4) A revise program to change or delete references on an interaction. The system operated by using a recording device accessed by telephone that accepted input to the system. A pharmacist coded in the recorded information at the end of each day and then reviewed the printout of interactions and interferences. With a sample of 173 hospital patients a total of 225 drug-laboratory test profiles were processed. Thirty one of these patients had a potential problem which was communicated to the physician. On 14 occasions the physician accepted the information given and used it in his analysis of the patient's reported laboratory results. This system had many obvious disadvantages, but it was an early attempt to provide a beneficial service.

A large improvement was made in the next system to appear in the literature. Stanford University Medical Center reported an online drug interraction surveillance system that informed pharmacists, nurses, and physicians as to the severity and speed of onset of potential drug interactions. The system was named MEDIPHOR for Monitoring and Evaluation of Drug Interactions by a Pharmacy-Oriented Reporting System. The advantage of this system was its ability to inform pharmacists, nurses or physicians about potential and clinically significant drug interactions prior to the administration of a dose of that drug. Additionally, the system printed prescription labels and patient drug profiles in the pharmacy (Tatro, Briggs, Chavez-Pardo, Feinberg, Hannigan, Moore, and Cohen, 1975).

An improvement of the above system was reported at the University of Utah Hospital. This system integrated computerized data on each hospital patient (medications, clinical laboratory, blood gas, ECG, allergies, diagnosis) and returned warning messages and suggestions regarding patient drug therapy to the pharmacist. The broad data base allowed for nearly complete drug therapy monitoring. When a warning message was received, the pharmacist contacted the physican or nurse and explained the potential problem. This system also printed labels and profiles. On the initial trial 5% of the patients monitored had drug alerts , 77% of these requiring a change in the patient´s drug therapy by the physician.

Three additional reports of computerized drug-drug interactions or drug-test interferences have appeared in the literature and are essentially the same as those described above (Friedman, Young, and Beatty,1978; Greenlaw and Zellers, 1978; Tatro, Moore, and Cohen, 1979). One of these studies (Greenlaw, and Zellers, 1981) included an analysis of the cost of computerized drug interaction screening for one year after the program was firmly established. The cost of preventing 341 clinically significant drug interactions was $16.43 each or $0.42 per patient day. This cost was evaluated as an inexpensive means of detecting and preventing drug interactions.

Utilization Review

The role of computers in drug utilization review has concentrated on enhancing the quality of drug therapy.

Utilization Review consists of selecting a category of drugs or a specific disease group and reviewing the medical charts of the patients falling into that group. The computer has assisted in the collection of data so that the pharmacist or the medical staff did not have to review the chart of every patient in the hospital, just those receiving one of the drugs selected for review. Two reports in the literature (Jacinto, Kleinmann, and Margolin, 1974 and Rucker, 1972) describe systems where the computer printed lists of patients taking specific drugs. The studies concluded that computer technology can assist in review programs, but is governed in part by the cost of the service provided. One suggestion was for insurance companies and other third party payers to bear part of the expense, because they were one of the main beneficiaries of an effective utilization review program.

Intravenous Admixture & TPN Programs

Two reports appeared in the literature describing computer systems to assist in parenteral admixture programs. One was a description of the use of a Word-Processing System in a centralized intravenous admixture program at a 560 bed private hospital in Culver City, California (Kirschenbaum, 1982). The equipment was used to type, edit, store and print patient profiles and labels for total parenteral nutrition solutions, piggybacks, and large volume parenterals. This method was an extremely convenient way to handle both the large amount of data and the label typing in a busy admixture service.

The other TPN application demonstrated that a microcomputer could reduce the total time necessary to prepare total parenteral nutrition solutions (Rich, Karnack and Jeffrey, 1982). The study was conducted at Rhode Island hospital where the TPN solution preparation took about 4800 man hours per year. A significant reduction in time could be used to justify the cost of the computer. The results of the study reported significant savings in time for preparation of the solutions and for processing all the related paperwork and summary reports.

Clinical Pharmacy

Reports of computer usage in clinical pharmacy are mostly in the recent literature except for one by Russell, McNeely, Yost and O'Leary (1978). They confirmed that a computer derived nomogram to predict gentamycin serum concentrations in postsurgical patients was accurate and usable. Their study was an indication that additional applications would be forthcoming in the future.

Three additional reports, published in 1982, successfully applied computers to pharmacokinetic services. One report was from Hartford Hospital (Alberti, Walters, and Nightingale, 1982) where a pharmacist with programming experience wrote BASIC programs to compute the calculations for steady state and sequential dosing, which could be run on the Pathology Department's Wang computer. This application cost the hospital only the money needed to buy a microcomputer terminal and a printer since the memory and central processing unit were already in place in the Pathology Department.

Several additional benefits were realized. Pharmacists other than those with clinical training were encouraged to participate in the calculations (which were very easy with the computer), secretarial time in collecting workload data was significantly reduced, and intradepartmental communication improved.

The use of computers in theophylline dosing was one of the most successful applications of computers. A study early in 1982 had attempted to predict serum theophylline levels using a model recommended by Hendeles and Weinberger (Hughey, Yost, Robinson, and Harman, 1982). This study was not very successful because five of the six patients completing the study did not achieve the predicted serum theophylline concentrations. That study can be contrasted with two quite successful studies where computer simulation was successfully used for patient dosing. The first study applied a complicated mathematical model for theophylline kinetics, and was able to predict serum levels with a correlation of .91 over repeated trials on a variety of patients (Mungal, Bancroft, and Marshall 1982). The second study concentrated more on conversion from intravenous to sustained-release oral theophylline, and reported equivalent results (Iafrate, Gotz, Robinson, and Lupkiewicz, 1982). Both studies demonstrated that automation could make clinical pharmacy easier and more exact, a benefit to the patient.

A computerized nuclear pharmacy service has also been reported (Fung, Basmadjian, and Ice, 1983). The report described a computerized management information retrieval system using a microcomputer and a line printer. The functions were radiopharmaceutical dispensing, inventory control, and billing. Benefits of the computerized MIRS included savings in personnel time, fewer dispensing errors, facilitation of billing and record-keeping procedures, and less waste of radiopharmaceuticals.

Research

In the area of research, computers definitely have a significant role, but applications in pharmacy have had very limited exposure in the literature. In one published account of a computer assisted practitioner-response system for studying the use of cimetidine (Schwartz and Kennedy, 1982), the pharmacy maintained patient medication profiles on a computer. Instead of reviewing all patient charts in the hospital, the computer was programmed to provide a list with the names of all patients receiving the selected drug. The reviewing pharmacist could then call up each patients medication profile as time permitted.

Some research applications were illustrated in an article describing how computer systems could facilite management of the critically ill (Weiner, Weil, and Carlson, 1982). This article detailed a system used to monitor EKG, hemodynamic, respiratory, and biochemical signals from critically ill and injured patients. Plans were being made to automate sampling and measurement of arterial blood gases and infusion of fluids and medications in response to

Controlled Substances Distribution

Since a great deal of the problem involved in controlled substances distribution is an accounting function, automation was perfectly suited for this area. St. Vincent Hospital in Toledo, Ohio (Markin, Schwartz, and Sell, 1982) had a central computer system in a data processing department which had been overwhelmed by department requests to add projects. Therefore, the pharmacy decided to conduct inventory accounting of controlled substances with a tabletop computer. Prior to changeover the pharmacy had experienced trouble with narcotic inventory control and had lost time in discovering and correcting errors. Also, the whole manual procedure was monotonous and errors caused considerable anxiety amoung employees.

The tabletop computer chosen was an IBM-5285 with an IBM-5222 printer. This system produced the labels and maintained an up-to-date inventory for floor stock supplies, individual patient supplies and outpatient prescriptions. Files included master files of drug names and locations, patient data, sequential sign out numbers and pharmacist security codes. The program allowed a pharmacist to generate three documents: a pharmacy receipt, a nurse sign out sheet, and a drug package label. This avoided many of the previous mistakes such as transcribing incorrectly, math errors, and typing errors. Of greater significance to management were the reports that the system generated: a list of current floor supplies for every ward, a list of individual patient supply transactions, and an alphabetical inventory list of all controlled substances. This final list had asterisks on each item dispensed on that day and also on each drug whose inventory fell below a pre-determined level. The authors concluded that the computer saved time and improved accuracy. No mention was made of specific costs, but the improved inventory control and the removal of a problem that caused a lot of anxiety amoung the staff were definite benefits.

Current Use of Computers in Hospital Pharmacy

The 1982 National Survey of Hospital Pharmacy Services (Stolar, 1983) reported that 35% of all hospital pharmacies were using computers in their drug distribution systems. The breakdown was 15% for hospitals with 6 to 199 beds, 42% for hospital with 200 to 399 beds, and 66% for hospitals with over 400 beds. This same report showed that 45% of all hospitals reporting had at least a partial unit dose program. That meant that nearly half of the hospitals with unit dose had to be doing all of that tedious profile maintenance manually.

A review of the literature done by Knight and Conrad (1975) listed the following applications for computers in hospital pharmacy practice: Accounting and Drug Usage Review, Purchasing and Inventory Control, Controlled Substances, Outpatient Services, Drug Distribution, Drug Information, and Clinical Services.

When taken together the Stolar survey and the review done by Knight and Conrad are dissapointing. The first survey indicated that computer usage in hospital pharmacy was not extremely widespread, but the second report stated virtually every aspect of hospital pharmacy could use computers to everyone's advantage. These two articles generated a question: Why was there such limited use of computers in hospital pharmacy? The most obvious answer was probably high cost, but many of the reported applications actually could have saved money, especially since the price of microcomputers was dropping rapidly.

A lack of availability of hospital pharmacy computer systems was not part of the problem. A recent mail survey of hospital pharmacy computer systems was sent to 172 prospective venders in May of 1981 (Fitzpatrick, Broekemeier, and Anderson, 1982). While only 76 of those organizations responded in some way, 28 indicated that they marketed a hospital pharmacy computer system at that time, and 14 stated that they planned to market a system in the future. Seven of the respondents had marketed a system for five years or longer, and fourteen had offered systems for three years or less. Only six of the companies reported serving more than twenty different institutions. It was quite clear that there was not a single best source for computer applications in hospital pharmacy and no one brand was dominating the market. Price information was unfortunately not available in that survey.

Burleson (1982) reported even more uses for computers, greater benefits, and summarized 140 articles in his review of computer applications in institutional pharmacy. Neal (1981) analyzed the costs and savings of pharmacy computer information systems. His conclusion was that both tangible and intangible savings could be realized with computers. Casler (1981) went one step further in stating that, in addition to saving money, the computer could provide increased productivity and information.

Lopez (1982), in his comparison of hospital computer usage in the United States and England, stated that other industries have steadily expanded their use of the computer to improve operations and control costs, while hospitals seem to have stopped after implementing their basic accounting systems. Lopez viewed the computer as a management tool and a way to save time, money and other resources. The literature did not reflect that kind of an attitude towards computers by hospital pharmacy.

Another possible reason for limited diffusion of computers in hospital pharmacy was that computers had a lack of exposure within the profession. If this was true it was certainly not due to the lack of coverage in the literature. Many articles have been published giving general descriptive information about computers for pharmacists, the leader in this area being William A. Gouveia at the Massachusetts General Hospital. His regular column in the American Journal of Hospital Pharmacy has covered a broad range of topics. An early article edited by Gouveia described the role of the pharmacist in electronic data processing (Gouveia, 1970b). This summary listed the potential objectives that pharmacy had in the computer area and made clear the applications, advantages and limitations. In that same year Gouveia explained the steps involved in establishing a new computer application(Gouveia, 1970a). Careful attention was paid to the phases in the development process including problem definition, design, implementation and evaluation. He advocated this systematic approach to insure that programs were properly planned.

The following year Gouveia wrote an article explaining the terms and processes of computer programming (Gouveia, 1971). This explanation was part of his continuing project of educating pharmacy about computers and removing some of the fear, ingorance and hesitancy about computers in pharmacy. In 1972 Gouveia described the uses and benefits of minicomputers located in hospital pharmacy as an integrated system to be used by all areas within the department (Gouveia, 1972a). He expressed doubt that an integrated computer system, used throughout the entire hospital, would be implemented. Thus, pharmacy should not wait, but instead proceed on their own with smaller systems that were less expensive and could be used solely by pharmacy. He also wrote a detailed description of how to develop a computerized pharmacy control system (Gouveia, 1972b). This article was useful because it discussed costs of the minicomputers as well as all the other necessary steps in development.

In 1982 there were four articles published concerning the development and managment of computer systems in hospital pharmacy. Gouveia co-authored one article on managing the implementation of systems (Mildenberger and Gouveia, 1982). This article emphasized the personnel aspects of implementation and also discussed the expansion of systems. Two of the articles in 1982 had similar topics: developing the proposal for a system (Nold, 1982) and preparing to implement the system (Thielke, 1982). These two articles gave the necessary steps, the justification, and then commented on many of the details useful for anyone actually planning a system. The fourth article dealt with a topic not published in pharmacy literature up to that time: system maintenance issues (Moore and Ruhl, 1982). This was particularly interesting since one of the worst fears in starting a computer system was what to do when the system went down and more important how to keep the system from going down.

A final comment made in this area was that it was best to purchase hardware with an already operational software package (Austin, 1979). There was no sense in re-inventing the wheel with every new installation. But first, the entire system should have been observed in a hospital where it was successfully used.

Diffusion of Innovation

Diffusion of Innovation has been defined as the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 1983,p10). This definition contains four main elements: the innovation, communication channels, time and a social system.

An innovation is a technology or concept that is new to an individual or organization. This study dealt with the diffusion of computer technology as well as some concepts and services that were innovative to hospital pharmacy. All of these were judged by experts to be desirable innovations (Stolar, 1975, 1978, 1983). Stolar (1983) chose these same innovations for a national survey because they were considered an essential part of contempory pharmacy.

The four main elements in the diffusion of innovations were considered in relation to the specific subject of diffusion of computer technology in hospital pharmacy.

The Innovation

Innovation research has shown the five key characteristics of the innovation that affect its diffusion to be relative advantage, compatibility, complexity, trialability and observability (Rogers, 1983).

Technological innovation has generally brought an improvement in either equipment or technique and been considered desirable. The relative advantage of computer technology has been proven in many published studies in hospital pharmacy (Simon and Silverman, 1977; Braunstein and James, 1978). The compatibility of computer technology has been clearly shown by the number of applications that are available and the favorable comments that users have expressed (Knight and Conrad, 1975; Burleson, 1982). The complexity of computers has been one of the main causes of slow innovation. This has been partially overcome by increased public awareness of computers in general and more specifically by attempts within the profession of pharmacy to spread awareness (Gouveia, 1970, Gouveia, 1972, Nold, 1982, Thielke, 1982). The trialability of computer technology has appeared to be limited because many people thought only of large computers and big price tags. The technology, however, was available at low levels and low prices such as a memory typewriter or an inexpensive micro computer. The information that there was an inexpensive and easy way to try out a computer in a hospital pharmacy operation had just not spread to a large part of the population. The observability of computer use in hospital pharmacy has been quite low. In order to have seen a computer working well in another hospital pharmacy a potential innovator would have had to visit another hospital pharmacy with a working computer. Such visits were not extremely common. Other opportunities to see a computer system working could have been in colleges of pharmacy or continuing education seminars that taught informative classes or at pharmacy conventions where vendors displayed and explained computer uses. These opportunities for seeing an operating computer system provided exposure for only a small segment of the population.

Communication Channels

Communication is the process by which people share information with each other in order to reach a mutual understanding. Diffusion is a particular type of communication in which the information that is exchanged is concerned with new technology or ideas. This communication process involves an innovation, an individual with knowledge of the innovation, an individual without knowledge of the innovation, and a communication channel connecting the two individuals. A communication channel is the means by which messages pass from one individual to another. The nature of the relationship between the two individuals determines whether the information will be exchanged and what effect the exchange will have.

Diffusion investigations (Rogers, 1983, pg 166) have shown that most individuals do not evaluate new ideas or technologies on the basis of scientific reports. Most people depend on the opinions of other people like themselves who have previously adopted the innovation. The dependence on peers suggests that a key factor in innovation is modeling or imitation. Further research (Rogers, 1983, pg 306) has shown that individuals communicate most frequently with others who are similar in many ways to themselves. Also, individuals often seek communication with others who are slightly, but not too much, more technically competent about innovations than themselves. These slightly more competent individuals are opinion leaders who are also somewhat more innovative than the followers, but are seldom in the very first group of innovators.

Change agents (i.e., computer salesmen) are often considerably more competent than their clients. This difference in competence frequently leads to ineffective communication and a lack of success by the change agent trying to gain adoption of an innovation.

Time

The concept of time is involved in the study of diffusion in three ways. First, the time taken by an individual to adopt an innovation places him in a category of relatively early or late to adopt. Second, the steps in the innovation decision process describe what happens to an individual from first knowledge to the decision to adopt or reject an innovation. Third, the rate of adoption of an innovation is the relative speed with which an innovation is adopted by members of a social system. Innovations that are considered to have greater relative advantage and compatability have a more rapid rate of adoption. The rate of adoption of innovations and the shape of the curve when cumulative percent adopted is plotted versus time of adoption have both been studied extensively (Russell, 1977; Olshavsky, 1980). The typical "S" shaped curve from the plot of cumulative adoption can be predicted using formulas from the above referenced articles.

The Social System

A social system is a set of related individuals who are involved in problem solving to accomplish a common goal. The social system in this study was composed of directors of pharmacy departments in short term hospitals with over 100 beds in the United States. This group of individuals faced many similar problems on a daily basis. Their social system had no formal structure, but interpersonal links and a communication structure existed. Individuals in this social structure talked with each other and received much of their information about new products or technologies from each other or from common sources.

Diffusion of Innovations in Pharmacy and Medicine

Many diffusion studies have been done in the field of medicine. An early study on the diffusion of a new drug amoung a community of physicians is a typical example (Coleman, Katz and Menzel, 1957). The drug whose diffusion was studied had a wide potential for use and no significant adverse affects to prevent its adoption. The researchers found that there were social processes that intervened between initial trials of the drug by local innovators and its final use by virtually the whole medical community. The general curve of adoption of the new drug had a normal "S" shape with adoption starting slowly, gradually increasing in slope to a maximum at about 50%, followed by a gradual tapering off in slope until adoption was nearly complete. This same curve had been reported as early as 1903 by Tarde and also in many later studies. That drug diffusion study provided some insight into the specific area of diffusion of innovation in a medical community that should have some similarities with diffusion of computers in hospital pharmacy. Pharmacists have many similarities with physicians, especially concerning the literature they read and the group of people they associate with both at work and at social events. This study emphasized the importance of journals and person-to-person contacts as methods of spreading information about innovations.

Fliegel and Kivlin (1966) studied the attributes of innovations as factors in diffusion. They found that differences amoung innovations were important variables in explaining the diffusion process. The study confirmed the logical idea that innovations perceived as most rewarding and least risky were accepted most rapidly. As discussed earlier, computers were shown in many studies to have a high relative advantage and a low risk. That meant that computers should have been quickly adopted for use in hospital pharmacy, at least for the most easily recognizable advantage of typing labels for intravenous additives.

The Development of Medical Technology (1976) also commented on factors determining adoption of innovative technology by physicians. The most significant factors were a physician's own clinical experience, the experience of colleagues he communicated with frequently, and outside sources of information including current literature, advertising, and continuing education sources.

Russell studied the diffusion of technology much more thoroughly in an article on the patterns of diffusion over time (Russell, 1977). His regression calculations showed that the rates of diffusion of five technologies in hospitals were very similar to the rates of diffusion of new technology established for other industries. Later, he also wrote a book on diffusion of technology in hospitals where the same innovations were examined in depth (Russell, 1979). The technologies that were rapidly and nearly completely adopted had a strong appeal to common sense. The same "S" shaped curve of adoption was observed and closely followed the same formula as observed in the previous studies.

Another study published by Banta (1980) concerned the diffusion of CT scanners in hospitals in the United States. This study was unique in that data collection was started soon after invention of the technology and there were so few manufacturers that the author was able to account for nearly every device manufactured and sold for a significant period of time. The graph of cumulative diffusion over time again followed a line very close to the predicted line and very close to that of other technologies in hospitals and industry. The author concluded that technology that diffuses rapidly should be of extraordinary value and that the nature of the technology did not fully explain the rapidity of its spread.

Predicting Innovativeness

In order to predict which persons would be earliest and latest to adopt an innovation, a literature review was accomplished. Those articles which were most applicable to this study are summarized below.

Becker (1970) studied an individual's sociometric location and innovativeness. He predicted and subsequently showed a substantial correlation between the time of adoption of an innovation and the individual's relative position in a sociometric network. Also significantly correlated were the individual's cosmopoliteness and communication with outside sources, two factors found to be important in many subsequent studies. Ostlund (1974) researched characteristics of individuals relative to their innovativeness in purchasing consumer products. The personal characteristics with a significant positive correlation were cosmopoliteness, income, education and status. Age was a questionable variable as a predictor in this study and in most other studies reviewed.

Ettlie and O'Keefe (1982) studied the relationship between scales that had previously been used to correlate innovative attitudes with innovative behavior. In several different scales and methods of measurement, many factors were shown to be involved in predicting innovative behavior. The factors that appeared to be good predictors and accurately measurable were number of subordinates, years worked, number of employees in the organization, and individual education level.

Mahajan and Schoeman (1977) studied the adoption of computers by hospitals in Texas. The analysis of adopters versus nonadopters characterized the adopters as hospitals with a larger number of beds, higher expenses per bed, higher percent occupancy, and higher income in the local population.

Robertson and Wind (1980) studied hospital adoption of new technology and found that six significant factors in adopting innovations were size, budget, occupancy rate, teaching affiliation, prestige and size of the community.

Summary

The changes that have taken place in hospital pharmacy were made to improve the delivery of medication to patients and to raise the quality of patient care. Computer technology, as applied to hospital pharmacy, has been shown to improve the delivery of medication to patients and in other ways positively affect the quality of care patients receive. Computers have diffused in to hospital pharmacies and many of the applications have been shown to be advantageous with savings in time and money as well as improvement in services provided. The diffusion has been slower than literature on diffusion indicated it should be. This study was prompted by a desire to discover what the actual state of computer use was in hospital pharmacy.

CHAPTER 3

METHODOLOGY

This study was designed as a mail survey of hospital pharmacy directors. The mail survey determined how computers were used in the pharmacy and at what time that usage began, what other innovative services were offered by that pharmacy or were planned in the next year, and the personal characteristics of the director of the pharmacy that could be used to predict his innovativeness.

Operational Hypotheses

H_oI: There is no difference between the shape of the curve for the adoption of computer technology in hospital pharmacy and the adoption of other technologies.

H_oII: There is no difference between the number of hospital pharmacies using computers at low levels and at high levels.

H_oIII: There is no correlation between a director of pharmacy's predicted innovativeness and his adoption time of computer technology.

H_oIV: There is no correlation between a director of pharmacy's predicted innovativeness and his level of adoption of innovative services.

H_oV: There is no difference between the diffusion of computer technology and other innovative services in hospital pharmacy.

Instrument

The survey instrument was designed specifically for this study, and a copy of the instrument has been included as Appendix A. Questions one through eight determined which innovative services were offered by each pharmacy. Questions nine through twelve were designed to determine the cosmopoliteness of directors, their communication with other pharmacists, and their knowledge of developments outside their own institutions. Question thirteen was a chart where the director marked each box corresponding to the type of computer currently used to perform each of the tasks listed. Question fourteen asked the year and month that computers were first used in that pharmacy. The last page requested demographic data about the pharmacy director, such as age and sex.

Pretest of the Instrument

A pilot study was conducted on fifty hospitals in June 1983 to assist in determining the final sample size and to test the reliability of the computed variables. The sample was randomly selected from the American Hospital Association's 1982 Guide.

The pilot study surveys were mailed to the participants with a cover letter explaining the general purpose of the survey. A single reminder postcard was mailed to all non-responders ten days later. Thirty two of the fifty surveys were returned within the thirty day period allowed for response. This rapid response of sixty four percent indicated that the final response rate for a larger study could be expected to be at least sixty percent and this figure was used in calculating the required sample size.

The pilot study surveys were carefully examined to insure that there were no items that repeatedly caused problems for the respondents. Several items were simplified or clarified and the amount of demographic data requested was reduced. Reliability of the computed individual innovativeness was calculated for the first eight items on the survey. A Chronbach Alpha of .73 was calculated with no large difference by deleting any of the items.

The results of the pilot study were examined to determine if the final survey would be able to test the hypotheses they were intended to test. Seventy-eight percent (25/32) of the pilot study respondents were using computers for one or more of the tested uses and a plot of the cumulative time of adoption versus year formed an "S" shaped curve. The mean number of hospitals using computers for low level uses (13.2, 52.8%) was higher than the mean number of hospitals using computers for high level uses (6.2, 24.8%). There was a positive, significant correlation between the predicted innovativeness of the directors and both the adoption time of computers and the level of adoption of innovative services. There was also a larger number of hospital pharmacies with at least one innovative service than there were hospital pharmacies with computers.

The results of the pilot study confirmed that the instument could be used with minor changes since the response rate was acceptable and the hypotheses that required testing could be tested with information taken from the instrument.

Participants

Directors of hospital pharmacies were randomly selected from the American Hospital Associations 1982 Guide. Hospitals with highly specialized care that would not have a normal pharmacy service were excluded. The categories of hospitals excluded were Tuberculosis hospitals, Psychiatric hospitals, and Convalescent centers. Hospitals with less than one hundred beds were excluded since their manpower and workload were not considered to be sufficient to efficiently use computer assistance.

Data Collection

Data were collected using a mail survey instrument

(Appendix A includes the survey and all correspondence). The instrument was prepared and printed at the University of Arizona. Mailing was done from the University using envelopes addressed to the Director of Pharmacy for each hospital. To increase response, multiple mailings and reminder cards were used. The first survey was mailed to the entire sample on August 16, 1983 with a cover letter. A reminder post card was mailed thirteen days later on August 29, 1983. A second survey was mailed to all non-responders under a separate cover letter on September 7, 1983. A final reminder post card was mailed on September 19, 1983.

Validity

Face validity was ascertained prior to the pilot test by submitting the survey instrument for review by graduate students and faculty at the College of Pharmacy, University of Arizona.

Assumptions

It was assumed that the surveys were completed by the directors of the pharmacies at the hospitals to which the surveys were addressed. It was also assumed that the number of innovative services reported at a hospital pharmacy would be a reflection of the innovativeness of the director of that pharmacy.

Survey Design

The survey was designed to measure the extent of computer use in each hospital. The literature was carefully reviewed to identify each conceivable use for computers in hospital pharmacy. Each identified use was included in question thirteen as well as four different sizes of computers. These four sizes of computers were described and included in the chart to insure that the directors completing the surveys would not hesitate to check a use for a computer simply because they felt their application was not significant.

Question fourteen asked for both the month and year that computers were first used. Time of adoption was calculated as the year computers were first used plus the month divided by twelve. As an example, a pharmacy that reported the first use of computers in June of 1980 had an adoption time of 80 plus 6/12 or 80.5.

The questions on computer uses were intentionally placed towards the end of the instrument. Questions on innovative pharmacy services were placed first to gain the participants interest and start them off completing items with familiar subjects and terminology.

The relative innovativeness of each hospital pharmacy was determined by adding the number of innovative services that pharmacy currently offered. Innovativeness was also determined using a Guttman Scaling technique that separated the sample into five different categories. Both methods were used in data analysis. Guttman Scaling is discussed at the end of Chapter Four.

Several variables required some computing for data analysis. Those variable computations are described briefly below and in more detail in Appendix B.The predicted individual innovativeness was calculated for each director using his responses to the cosmopoliteness, change agent contact, educational level, and experience questions, plus demographic data. Cosmopoliteness was calculated as a sum of the answers to questions nine, ten and eleven. Change agent (salesmen) contact was equal to the response to question twelve. Experience was a sum of years as a pharmacist, years worked for present employer, years worked in the present position, and number of subordinates. For each of the variables that required computation there was a wide range of possible responses. As can be seen from examining the survey, respondents were given only five categories to choose from in questions such as "meetings attended in the last year". In those questions, the maximum value for an answer would be five. In other questions, such as the number of subordinates, the responses ranged from zero to over one hundred. To rectify the great differences between the responses limited to five categories and those with continuous response possibilities, the continuous variables were divided by their individual means, that reduced their large values down to values between zero and five.

Response Bias

All hospitals in the selected sample were considered in analysis of response bias. Information was obtained from the American Hospital Association Guide (1982) used to select the sample to determine the hospital size in beds, percent occupancy, annual expenditure, and number of employees. From those published figures the number of beds occupied, expenditure per bed, and expenditure per employee were calculated. All of these variables were compared to insure that the means were not significantly different for responders and non-responders, indicating some response bias.

Limitation

This study was limited by the possibility of self-report bias from the respondents and the limited choice of answers available to choose from on most of the survey items. The population for this study was limited as described in the participants portion of this chapter. No attempt was made to determine the truthfulness of the respondents answers.

Statistical Analysis

Statistical analysis was performed to test each hypothesis. Hypothesis I was tested by comparing the observed rate of adoption of computers for each year reported with the expected rate of adoption for that year as calculated by the formula widely accepted in innovation literature (Russell, 1977, Olshavsky, 1980). Similarity of these two groups of data and their cumulative plots were ascertained using a Chi-square "Goodness of Fit" test.

Hypothesis II was tested by computing the mean number of uses reported for computers at low levels and comparing that to the mean number of uses of computers at higher levels and using a Student t-test to determine if a significant difference existed between the two means.

Hypotheses three and four were tested by computing the correlation coefficients for predicted innovativeness with adoption time of computer technology and innovative services. Since the data for both of these tests were not continous in nature, non-parametric correlations were used. Both Spearman's R_s and Kendall's tau were calculated in every case, but it was felt that tau was more representative of the true correlation due to the large number of ties to be expected with so many cases grouped into a few categories.

CHAPTER 4

RESULTS

The response rate was 83.2%; 417 out of the 501 surveys mailed were returned. All surveys were complete after eight that were missing demographic data were returned to the respondents with an explanation letter for completion. Four additional surveys were received, but not included in analysis since they arrived after the fifty two day cutoff date of October 7, 1983.

Response Bias

An analysis was performed to detect possible response bias. First, hospitals were grouped by size as shown in Table 1. The percent of hospitals in each group were examined for the total population, selected sample, and responding hospitals. The data for the total population and the selected sample were taken from the American Hospital Association's Guide (1982). A Chi square test was calculated to determine if the percent frequency of each size hospital in the selected sample and responding group were significantly different from the percent frequency for the total population. The Chi square was not significant, meaning that no difference was found between the sample and the population on bed size category. Second, for all hospitals not responding, the means for beds, percent occupied, annual expenditure, and number of employees were calculated from data in the American Hospital Association's Guide (1982). Non-responders were compared with those hospitals that responded. Also, annual expenditure per bed and annual expenditure per employee were computed. The responders were compared with non-responders for all seven of the variables listed above. The results of the Student t-tests are shown in Table 2.

The calculated values for the t-test were not significant at the .05 level for all pairs of variables except number of employees at the hospital. Although the means for almost all the reported and calculated variables were lower for non-responders than responders, the t-test results indicated that the means were within sampling error range with ninety five percent confidence in all cases except number of employees in the hospital.

Instrument Reliability

The reliability for predicted innovativeness and level of adoption of innovative services was determined by computing Cronbach's alpha reliability coefficients. The reliability coefficient for predicted innovativeness for the six variables was .79. The reliability would have

Table 1. Percent of hospitals in each category of bed size for the entire population, selected sample and survey responders.

Hospital Bed Size	Population	Sample	Responders
100-199	44.6%	45.3%	46.1%
200-299	22.8%	23.9%	22.3%
300-399	13.6%	13.6%	13.7%
400-499	8.5%	8.4%	9.0%
Over 500	10.5%	8.8%	8.9%
	100.0%	100.0%	100.0%

Population with Sample: X^2 = 0.331, df=4, Not Significant

Pop with Responders: X^2 = 0.171, df=4, Not Significant

Sample with Responders: X^2 = 0.151, df=4, Not Significant

Table 2. Student t-test for significance in difference of means between responders and non-responders for beds, percent occupancy, annual expenditure, number of employees, beds occupied, expenditure per bed, and expenditure per employee.

	Responders (N=417)		Non-Responders (N=84)		
	Mean	S.D.	Mean	S.D.	t
Number of Beds	275.8	187.5	246.2	125.3	1.79
Percent Occupancy	75.0	12.6	73.7	14.8	0.79
Annual Expenditure	24,031	23,778	20,624	18,751	1.45
Numberof Employees	1189	188.6	830	1136	2.32*
Beds Occupied	213	160	188	114	1.75
Expenditure Per Bed	109	52	103	48	1.05
Expenditure Per Employee	26.6	9.9	27.2	10.5	0.47

* $p < .05$

Note: An F test was performed to determine if the pooled variance or separate variance estimates were appropriate to use. For expenditure per bed and expenditure per employee the F was not significant at the .05 level so the pooled variance estimate was used. For all others the F was significant at the .05 level so the separate variance estimates were used.

increased slightly if either the number of professional meetings attended or change agent contact were deleted from computation of predicted innovativeness. Neither item, however, was omitted. The reliability coefficient for level of adoption of innovative services for the eight services that were used to compute that variable was .80. The reliability would have increased slightly if Unit Dose, Generic Substitution, or Mobile Satellites were deleted from computation of level of adoption of innovative services. None of those items, however, were omitted.

Demographic Information

Responses to instrument questions about the individual responders and their institutions are summarized in this section.

The age of respondents ranged from twenty four to sixty five years with a mean of 40.9 years. A summary of age of respondents in groups is shown in Table 3.

The education of respondents is shown in Table 4. All respondents had an entry level degree in pharmacy and fifteen had both a B.S. in pharmacy and a Pharm D.

Years worked as a pharmacist, with the present employer and at the present position are summarized in Table 5. Table 6 summarizes the number of subordinates working for the responding directors.

Table 3. Age of respondents in groups

Age	Number	Percent
Under 30	30	8%
30 thru 39	179	43%
40 thru 49	121	29%
50 thru 59	69	16%
Over 60	16	4%
Total	417	100%

Table 4. Educational degrees of respondents by percent of individuals responding to survey

Educational Degree	Number	Percent of Total Responding
Bachelors Degree	391	93.8
Masters Degree	58	13.9
Ph. D.	2	0.5
Pharm D	41	9.8
One Other Degree	44	10.6
Two Other Degrees	4	1.0
Completed Residency	53	12.7

Total Respondents = 417
Note: The number and percent columns do not add up to the correct totals because many respondents reported more than one degree.

Table 5. Respondent's years worked as a pharmacist, for the present employer and in the present position

Employment Years	<5	5-9	10-14	15-19	20-24	>25
As a Pharmacist	83	53	84	67	55	75
	20%	13%	20%	16%	13%	18%
(Mean=17.3,S.D.=10.4)						
With Present Employer	146	71	79	51	49	21
	35%	17%	19%	12%	12%	5%
(Mean=11.2,S.D.=10.4)						
At Present Position	204	58	54	42	46	13
	49%	14%	13%	10%	11%	3%
(Mean=8.9,S.D.=10.2)						

Total Respondents = 417

Table 6. Number of subordinates reported working for respondents by groups

	<9	10-19	20-29	30-39	40-49	50-99	>100
Number of	179	104	63	21	17	25	8
Subordinates	43%	25%	15%	5%	4%	6%	2%

Total Respondents = 417
Mean=21.4 S.D.=22.1 Minimum=0 Maximum=189

A summary of percent occupancy by category is shown in Table 7, revealing a slight skewness for non-response towards the hospitals with a lower occupancy rate.

The number of employees at each hospital is reported in Table 8 for both the entire sample and responders. This table shows a slight skewness towards non-response for hospitals with fewer employees.

Annual expenditure, as reported in the American Hospital Association's Guide, is shown in Table 9 showing a slight skewness towards non-response for hospitals that have lower annual expenditures.

Table 7. Percent occupancy for total sample and responders

	TOTAL SAMPLE		RESPONDERS	
Percent Occupancy	Number Hospitals	Percent	Number Hospitals	Percent
Under 49%	16	3%	12	3%
50 to 59%	29	6%	24	6%
60 to 69%	92	18%	76	18%
70 to 79%	168	33%	141	33%
80 to 89%	163	33%	137	33%
over 90%	33	7%	27	7%
	501	100%	417	100%

X^2 = 0.0365, not significant

Table 8. Number of hospitals in each group by number of employees for total sample and responders

	Total Sample		Responders	
Number of employees	Number	Percent	Number	Percent
Under 500	187	37%	152	37%
500 to 999	169	34%	139	33%
1000 to 1499	72	14%	60	14%
1500 to 1999	29	6%	26	6%
2000 to 2499	15	3%	13	3%
Over 2500	29	6%	27	7%
Totals	501	100%	417	100%

X^2 = 0.137, not significant

Table 9. Annual expenditure of hospitals in millions of dollars for total sample and for responders

	Total Sample		Responders	
Millions of Dollars	Number	Percent	Number	Percent
Under $10	138	28%	111	27%
$10 to $19	146	29%	119	29%
$20 to $29	90	18%	76	18%
$30 to $39	53	11%	50	12%
$40 to $49	31	6%	25	6%
$50 to $99	37	7%	30	7%
Over $100	6	1%	6	1%
	501	100%	417	100%

X^2 = 0.272, not significant

Survey Responses for Innovativeness

Responses to items used to predict a director's cosmopoliteness are summarized in this section. Table 10 summarizes responses to survey questions on the number of outside contacts per month that respondents had with pharmacists outside of the institution at which they worked, how many journal articles they read per month, how many change agents (salesmen) they had contact with each month, and how many professional meetings they attended in the previous year.

Innovative Services

Table 11 summarizes the innovative services provided by each pharmacy as reported by the director. For each service the director chose one of five responses: 1) Not provided; 2) Implemented under previous director and currently provided; 3) Programmed for implementation within the next twelve months; 4) Implemented under my direction but no longer provided; 5) Implemented under my direction and currently provided. The number of responses for each innovation and the percent of the total are displayed for each service.

Table 10. Responses to questions on outside contacts per month, journal articles read per month, change agent contacts per month, and professional meetings attended last year.

Survey Question	None	1-5	6-10	11-15	16-20	>20
	Frequency Reported					
Contacts per month with pharmacists outside of respondents institution	3	126	110	85	35	58
	1%	30%	26%	20%	9%	14%
Journal articles read per month	3	78	137	82	45	72
	1%	19%	33%	20%	11%	17%
Change agent contacts per month	6	50	119	103	70	69
	1%	12%	28%	25%	17%	17%
Professional meetings attended last year	13	143	114	68	37	42
	3%	34%	28%	16%	9%	10%

Table 11. Services provided by responding hospital pharmacies

Service	Not Provided	Implemeted Previous Director	Implemeted Current Director	But Stopped	Programmed in future
Unit Dose	42 10%	114 27%	230 55%	0	31 8%
Generic Substitution	15 4%	167 40%	222 53%	0	13 3%
Mobile Satellite	337 81%	9 2%	35 8%	4 1%	32 8%
Fixed Satellite	330 79%	16 4%	50 12%	4 1%	17 4%
Intravenous Admixture Service	30 7%	111 27%	225 54%	4 1%	47 11%
24 hour Pharmacy Service	263 63%	51 12%	86 21%	0	18 4%
Kinetic Consultations	295 71%	11 2%	98 24%	2 1%	11 2%
Patient Monitoring	241 58%	25 6%	122 29%	4 1%	25 6%

Table 12 summarizes the reported uses for computers in the 308 hospitals that reported using computers in the pharmacy. For each potential use of a computer the number of pharmacies that actually reported that use is shown in the "Any Comp" column. The number of respondents who had a computer but were not using it for that specific use are shown in the first column labelled "none". The other four columns show what size computer was being employed for each specific use. In all cases, the actual number reported as well as the percent of the total of 308 are shown.

Table 13 shows the adoption of computers by hospital pharmacies. A positive response for any computer use was interpreted to mean that computers had been adopted by that pharmacy. The year of adoption was obtained directly from the survey. The cumulative percent adopted was based on 406 complete cases since eleven cases were missing some data on computer uses (usually year adopted).

Table 12. Number and percent of hospitals reporting each use for computers, including the size computer

	None	Memory Typewriter	Micro Computer	Mini Computer	Larger Computer
Type Letters	295 71%	90 22%	9 2%	7 2%	16 4%
Prescription Labels	264 64%	60 14%	9 2%	9 2%	75 18%
Admixture Labels	160 38%	116 28%	26 6%	23 6%	92 22%
Narcotic Inventory	355 85%	2 <1%	4 1%	9 2%	47 11%
Other Drug Inventory	345 83%	3 1%	4 1%	9 2%	56 13%
IV Patient Profiles	309 74%	8 2%	9 2%	17 4%	74 18%
Unit Dose Labels	257 62%	54 13%	17 4%	15 4%	74 18%
Unit Dose Profiles	321 77%	2 <1%	2 <1%	14 3%	78 19%
Unit Dose Fill Lists	323 78%	0	2 <1%	12 3%	80 19%
Patient Lists	238 57%	0	1 <1%	15 4%	163 39%
Patient Billing	195 47%	1 <1%	9 2%	12 3%	200 48%
Utilization Review	327 78%	5 1%	4 1%	15 4%	66 16%
Formulary Production	304 73%	7 2%	11 3%	14 3%	81 19%

Note: Rows do not always add to total sample, see note on page 74. Definitions for computer sizes on page 110.

Table 12. Continued

	None	Memory Typewriter	Micro Computer	Mini Computer	Larger Computer
Clinical Pharmacy	350 84%	0	42 10%	9 2%	16 4%
Research	393 94%	1 <1%	8 2%	2 <1%	13 3%
Summary Reports	308 74%	3 1%	6 1%	14 3%	86 21%
Predicting Future	371 89%	0	11 3%	4 1%	31 7%

Note: Many rows do not add up to 417 (total responses) or 100% since a pharmacy may be using more than one type of computer to perform the same function. For example, typing letters can be done with a memory typewriter or any larger size computer available.

Table 13. Adoption of computers by hospital pharmacy. Number adopted each year, cumulative number adopted by the end of each year, and cumulative percent are shown.

Year	Number	Cumulative Number	Cumulative Percent
1963	1	1	0.2%
1964	0	1	0.2%
1965	0	1	0.2%
1966	0	1	0.2%
1967	2	3	0.7%
1968	3	6	1.5%
1969	0	6	1.5%
1970	5	11	2.7%
1971	7	18	4.4%
1972	8	26	6.4%
1973	7	33	8.1%
1974	5	38	9.4%
1975	17	55	13.6%
1976	15	70	17.3%
1977	20	90	22.2%
1978	29	119	29.4%
1979	30	149	36.8%
1980	37	186	45.9%
1981	42	228	56.3%
1982	44	272	67.2%
1983	36	308	76.0%

Percents based on 406 complete cases. Total sample was 417 cases, 11 cases were missing data.

Hypothesis Testing

The instrument was designed to collect data that would test the hypotheses stated in Chapter 3. All null hypotheses were evaluated for rejection at the .05 significance level.

Hypothesis I

The first hypothesis stated that there would be no difference between the shape of the curve for the adoption of computers by hospital pharmacy and the shape of the curve reported in numerous previous diffusion studies. In order to test this hypothesis the data on time of adoption was collected and is summarized in Table 13. This data was plotted as Cumulative Percent Adopted versus Time in Figure 1.

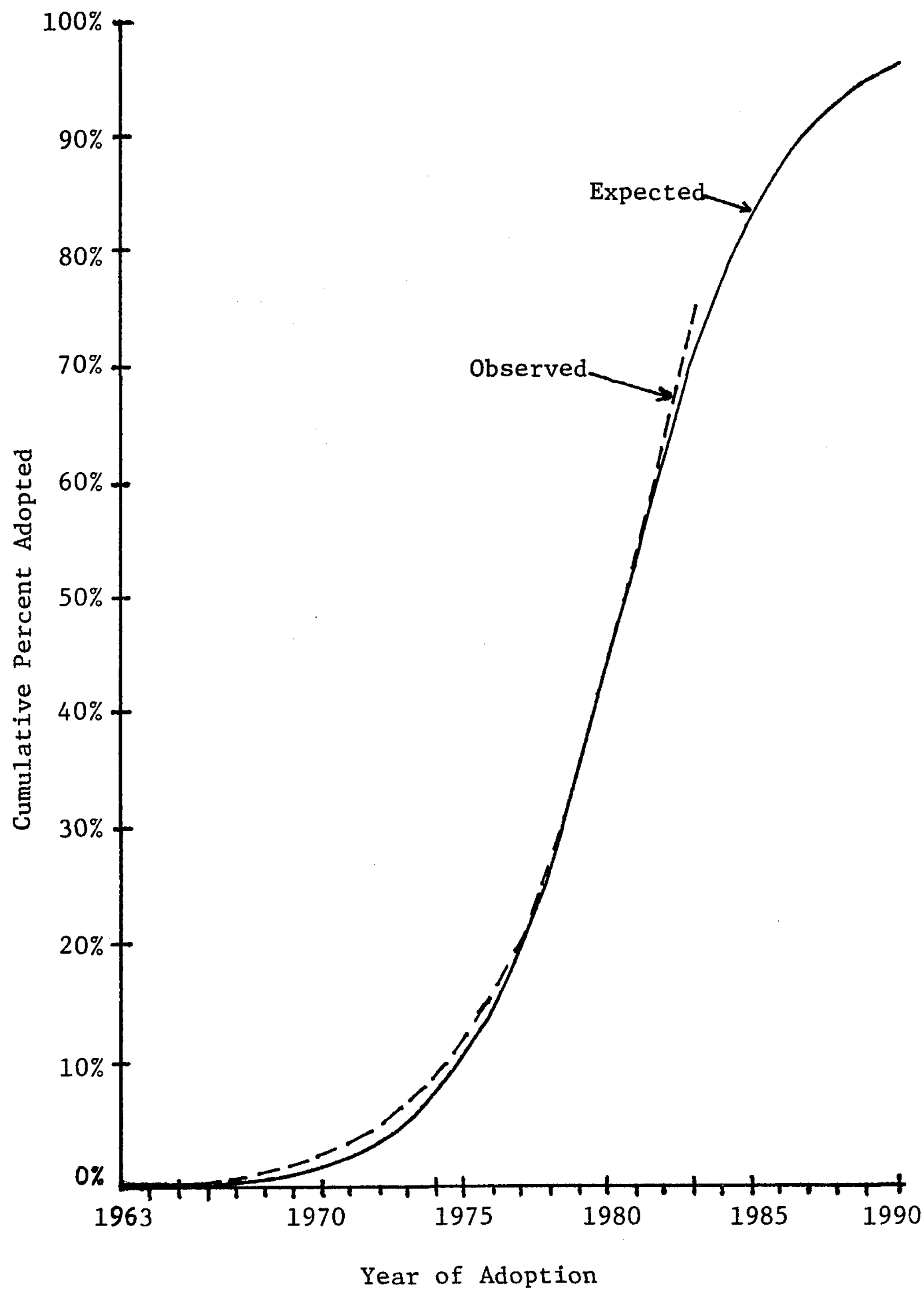
The model that this adoption data and curve were compared with is the well accepted formula shown below.

$$P = \frac{K}{1 + e^{-(a + b\,t)}}$$

P = Percent Adopted
K = Ceiling Value (100% assumed)
a = constant of integration (-.369)
(positions curve on scale)
b = rate of growth coefficient
(6.75)

In order to use this formula the value for the two coefficients "a" and "b" were first determined by plotting the natural logarithm of one hundred minus the percent adopted divided by the percent adopted versus time of adoption. This plot yielded an essentially straight line

Figure 1. Cumulative percent of hospital pharmacies that have adopted computers versus time



whose "y" intercept was the value of "a" and a slope whose value was "b". To determine the expected value for cumulative percent adopted for each year the ceiling value was assumed to be one hundred percent since Russell (1979) had shown that there is no difference between assuming complete adoption of an innovation and a lesser number like ninety percent in this type of calculation. The observed and expected values for percent adoption of computers are shown in Table 14.

The expected values for percent adopted for the years 1984 through 1990 were shown to illustrate the tapering off that occurs as adoption approaches completion or one hundred percent.

In order to test the hypothesis a Chi-square "goodness of fit" test was performed on the observed and expected percents of adoption. The chi-square calculated was 3.4 with twenty degrees of freedom. This value is less than the critical value required to reject the hypothesis, therefore the hypothesis is not rejected. A look at the plot of the observed percent and expected percent also show that adoption of computers has in fact closely followed the expected shape for an adoption curve.

Table 14. Adoption of computers. The number of computers adopted each year along with the cumulative percent observed and expected are shown.

Year	Observed Cumulative Number	Expected Cumulative Number	Observed Cumulative Percent	Expected Cumulative Percent
1963	1	0.7	0.2%	0.17%
1964	1	1.0	0.2%	0.24%
1965	1	1.4	0.2%	0.35%
1966	1	2.1	0.2%	0.51%
1967	3	3.0	0.7%	0.74%
1968	6	4.3	1.5%	1.06%
1969	6	6.2	1.5%	1.53%
1970	11	8.8	2.7%	2.20%
1971	18	13.0	4.4%	3.2%
1972	26	18.2	6.4%	4.5%
1973	33	25.9	8.1%	6.4%
1974	38	36.0	9.4%	8.9%
1975	55	50.2	13.6%	12.4%
1976	70	68.9	17.3%	17.0%
1977	90	92.8	22.2%	22.9%
1978	119	121.5	29.4%	30.0%
1979	149	155.1	36.8%	38.3%
1980	186	191.6	45.9%	47.3%
1981	228	228.8	56.3%	56.5%
1982	272	264.1	67.2%	65.2%
1983	308	296.1	76.0%	73.1%

Table 14. Continued

Year	Observed Cumulative Number	Expected Cumulative Number	Observed Cumulative Percent	Expected Cumulative Percent
1984		323		79.7%
1985		344		85.0%
1986		361		89.1%
1987		373		92.2%
1988		383		94.5%
1989		389		96.1%
1990		394		97.3%

X^2 = 7.88, not significant

Hypothesis II

The second hypothesis was that there would be no difference between the number of hospital pharmacies using computers at low levels and at high levels. To test this hypothesis, uses of computers were divided into low level uses and higher level uses. Low level uses were those uses that would normally be repetetive in nature, not requiring a lot of decision-making. The list of possible uses of computers in question thirteen of the survey instrument were arranged so that the first eleven were low level and the last six were higher level.

Table 15 shows the means and standard deviations for the number of hospitals using computers at each of the lower and higher level uses. A Student t-test was done to determine if there was a significant difference between those two means ($t = 2.69$, $df = 15$, $p < .05$). The null hypothesis was rejected since the mean number of hospitals using computers at low levels is significantly higher than the mean number of hospitals using computers at higher levels.

Table 15. Means and standard deviations for levels of computer usage

	Mean	S.D.
Low Computer Uses	138.6	62.1
Higher Computer Uses	64.8	35.6

Hypothesis III

The third hypothesis was that no correlation exists between a director of pharmacy's predicted innovativeness and his adoption time of computer technology.

This hypothesis was tested by computing the predicted innovativeness of the director as described in Chapter Three and correlating that predicted innovativeness with the adoption time for computers. The correlation coefficients were .0059 for Kendall's tau and .0071 for Spearman's R_s. Neither correlation was significant at the .05 level, therefore the third hypothesis can not be rejected.

Further analysis was done to determine if there were significant correlations within the components that measured predicted innovativeness (as shown in Appendix B) and between those components and adoption time of computer technology. Those correlations are shown in Table 16 as Spearman correlation coefficients.

Hypothesis IV

The fourth hypothesis was that there would be no significant correlation between a director of pharmacy's predicted innovativeness and his level of adoption of innovative services. The director's predicted innovativeness and level of adoption of innovative services were both calculated and correlation coefficients calculated. The correlation coefficients were .236 for

Table 16. Spearman correlation coefficients for the components that made up predicted innovativeness with predicted innovativeness and with adoption time for computers

Component	Predicted Innovativeness	Adoption Time
Cosmopoliteness	.61	.02
Outside Contacts	.45	.02
Journals Read	.44	.01
Outside Meetings	.45	.09
Change Agent Contact	.31	.11*
Education Level	.58	.03
Experience	.52	.26*
Years as a Pharmacist	.38	.16*
Years for Present Employer	.32	.20*
Years in Present Position	.32	.16*
Number of Subordinates	.46	.27*

* $p<.05$

Kendall's tau and .3372 for Spearman's R_s. Both of these correlation coefficients were significant at the .05 level, therefore the fourth null hypothesis was rejected.

Hypothesis V

The fifth hypothesis was that there is no difference between the number of innovative services offered by hospital pharmacies with low and high levels of computer adoption. To test this hypothesis, all hospitals that reported using computers were divided into two groups. The first group were those hospitals who reported using computers at less than the median number of uses. The second group were those hospitals who reported using computers at greater than the median number of uses. The mean number of innovative services offered was then computed for each group and a Student t-test was done to determine if there was a significant difference between those two means ($t=1.14$, $df=258$, $p>.05$). Table 17 shows the means and standard deviations for the number of innovative services offered by hospital pharmacies with low and high levels of computer adoption. The null hypothesis was not rejected since the mean number of innovative services offered by hospitals with low levels of computer adoption was not significantly different than the mean number of innovative services offered by hospitals with high levels of computer adoption.

The total number of uses reported for computers at each hospital was significantly correlated with the total number of innovative services offered by that hospital (Spearmans $R_s = .19$, $p < .05$). The placement of each hospital into a low or high computer adoption group was also significantly correlated (Spearmans $R_s = .14$, $p < .05$) with the number of innovative services offered by each hospital.

Table 17. Means and standard deviations for the number of innovative services offered by hospital pharmacies with low and high levels of computer adoption.

	Mean	S.D.
Low Computer Uses	4.57	3.89
High Computer Uses	4.12	2.97

$t=1.14$, $df=258$, $p>.05$

Guttman Scaling

A Guttman Scaling technique was used to rank each hospital pharmacy on its level of innovativeness and level of computer usage. Guttman Scales require items to be unidimensional, dichotomous variables classified as a yes or no attribute, and cumulative, step number one a prerequisite to step number two. To effectively be used in this study, then, the innovative services being ranked would have to have only a single dimension; a hospital would have been judged to either have a service or not have a service. That was a possibility since both plans to implement a service in the future and implementing a service and then stopping it could have been coded as not having that service. The real problem with Guttman Scaling for this study was the cumulative requirement. The innovative services and uses for computers were not in all cases highly enough related to each other so that in order for a director to implement service number two or computer use number two he would have already had to implement service or use number one. That problem did not make the construction of a Guttman Scale impossible, it just made the usefullness of the Guttman Scale very questionable.

In spite of the shortcoming discussed above, a Guttman Scale was constructed. In trying to find the best scale all the innovative services and adoption of computers were used as possible discriminators. The items that made the best scales, their scale values, and the number of cases in each scale level are shown in Tables 18 and 19.

These Guttman Scales had sufficiently high coefficients of reproducibility and scalability to be useful. Correlation coefficients were calculated for the same variables as were used in testing hypotheses three and four. The results indicated no change in accepting or rejecting the hypotheses using the Guttman Scale values instead of the predicted innovativeness scores and level of computer use scores.

Table 18. Guttman scaling for innovative services

Scale Value	Service	Number	Percent	Cum Percent
4	Pharmacokinetic Consultations	75	18%	100%
3	Patient Monitoring	92	22%	82%
2	IV Admixture Service	179	43%	60%
1	Generic Substitution	62	15%	17%
0	Passed None	9	2%	2%

Coefficient of Reproducibility = .92

Coefficient of Scalability = .65

Table 19. Guttman scaling for computer use levels

Scale Value	Computer Use	Number	Percent	Cum Percent
7	Type Correspondence	6	1%	100%
6	Narcotic Inventory	22	5%	99%
5	Drug Utilization Review	27	7%	94%
4	Summary Reports	39	10%	87%
3	IV Profiles	40	10%	77%
2	Unit Dose Labels	71	17%	60%
1	IV Labels	81	19%	50%
0	None	131	31%	31%

Coefficient of Reproducibility = .90

Coefficient of Scalability = .55

Multiple Regression

As shown in the Guttman Scales above and in previous tables, there was considerable variance between survey respondents in their 1) levels of computer use, 2) time of computer adoption, 3) predicted innovativeness, and 4) level of adoption of innovative services. Multiple regression was performed to determine the amount of variance accounted for in each of those dependent variables by personal characteristics of the individual directors, survey responses, and characteristics of the respondent's hospitals. Table 20 shows the results of those multiple regressions, and the amount of variance accounted for by each independent variable that was significant. Factor analysis was used to determine the independent variables which were most appropriate to use without using variables that were highly correlated with each other. The independent variables used were sex, age, experience of the director, education level of the director, survey responses that comprised cosmopoliteness, time of computer adoption, number of innovations adopted, the number of beds, and the percent of beds occupied in the hospital. All of those independent variables were used in the regressions, but Table 20 only reports those that accounted for a significant amount of variance.

Table 20. Multiple regression on computer use level, time of computer adoption, level of innovation adoption, and individual innovativeness

Dependent Variable	Independent Variable	B	Simple R	F	R^2
Computer Use Level (Guttman Scale)	Time of Adoption	.003	.53	162	.28*
	Number of Beds	.001	.23	8.7	.01*
	Innovation Level (Guttman Scale)	.06	.22	5.7	.01*
	Percent Occupied	.008	.10	2.0	.01
				Total	.31
Time of Computer Adoption	Number of Beds	3.6	.20	18.5	.08*
	Level of Innovation (Guttman Scale)	2.3	.20	15.2	.05*
	Age of Director	-5.5	-.14	10.7	.03*
	Education of Director	10.7	.02	0.6	.01
				Total	.17
Level of Adoption of Innovations (Guttman Scale)	Experience of Director	0.3	.26	21.6	.07*
	Time of Computer Adoption	0.6	.22	14.6	.05*
	Cosmopoliteness	0.4	.13	6.1	.02*
	Age of Director	-0.2	-.09	1.7	.01*
	Number of Beds	0.2	.03	0.6	.01
	Percent Occupied	0.2	.02	0.3	.01
				Total	.17
Predicted Innovativeness	Sex of Director	22.0	.80	747	.42*
	Age of Director	0.7	.44	97	.19*
	Number of Beds	0.1	.11	9	.03*

* $p<.05$

Note: The following variables were used as an independent variable in each regression, unless they were the dependent variable: sex, age, experience of the director, education level of the director, cosmopoliteness, time of computer adoption, Guttman Scale for level of adoption of innovations, Guttman Scale for level of adoption of computers, number of beds, percent of beds occupied.

CHAPTER 5

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

This study used a mail survey to determine the diffusion of computer use in hospital pharmacies throughout the United States. This chapter summarizes the results of that survey, draws some conclusions about those results, and makes some recommendations for the use of computers, future studies, and education.

Discussion

Response Rate

When planning a mail survey there is usually some concern for the response rate involved in designing the instrument. A low response rate could seriously affect the results of the survey and cause considerable concern about non-response bias. This survey was designed with the intent of securing a high response rate by capturing the attention of the recipients with a topic that had a current high level of interest and by keeping the instrument short and easy to complete. Three follow-up mailings in a short period of time also proved to be effective in reminding the recipients to complete the surveys. The final response rate of 83.2%

was better than had been predicted by response to the pilot study.

Response Bias

The high response rate left less than 17% of the sample to consider for non-response bias. Unless that small portion of the sample was very different from those that responded to the survey the non-response bias would not be expected to be significant. The analysis in Chapter Four indicated that the sample was in fact randomly selected from the total population. That analysis also indicated that there was no significant difference between the responders and non-responders in several descriptive characteristics. Although there can not be a guarantee that a non-response bias does not exist, only the fact that smaller hospitals tended towards non-response suggests some differences for this sample.

Reliability

In order to minimize the errors possible in measurement, the reliability or consistency of an instrument must be ensured. The Cronbach's alpha reliability coefficient measures the internal consistency among items within a group. The two variables that were computed in this study were predicted innovativeness and level of adoption of innovative services. They both had coefficients of about .80, indicating that there would be relatively little fluctuation in response to measurement error.

Validity

For this study only content validity was considered. The extent to which this instrument was representative of the area of content that it was intended to measure was determined in two ways. First, graduate students and faculty at the College of Pharmacy, University of Arizona determined that there was adequate face validity by examining the instrument prior to use. Second, review of the literature showed that other researchers considered the same services (Stolar,1983) and uses of computers (Burleson, 1982) to be innovative in hospital pharmacy.

Innovative Services

The instrument measured what innovative services were provided by each responding hospital. These services were considered by experts in the field to be beneficial in general and desirable in many cases (Stolar, 1983). While a service like a satellite pharmacy may be a solution to a distribution problem at one facility it may be just the opposite at another. Likewise, setting up a unit dose distribution system at some facilities has been prevented by obstacles such as fiscal problems, declining community population, and low hospital census levels. The results support the contention that unit dose has been implemented in most hospitals since only ten percent of the responding hospitals did not currently have unit dose and seventy percent of those planned on implementing unit dose within the next year. In other cases services have been implemented to solve a specific problem earlier than normal. An example would be a large facility with distribution problems that opened satellites and realized savings by doing so. The roughly eighty percent of hospitals that did not report having satellites may not have a specific need for them and may have some other plan to provide pharmacy expertise on the patient wards. Some other innovations are less facility specific. Generic substitution really does not cost anything and in fact should save money and make dispensing medication easier in the pharmacy. Only four percent of the responding hospitals did not have generic substitution and seventy five percent of those had plans to inplement substitution in the next year. Preparation of the intravenous additives in the pharmacy is of benefit to everyone and raises the quality of health care in general. Only seven percent of the responders indicated that they did not prepare the IV's at the time of the survey and all of those had plans to implement that service within the next year. The newer and more clinical services like kinetic consultations and patient monitoring had much lower adoption rates of 29% and 42% respectively. Those lower levels of adoption are indicators of newer ideas that are not universally accepted or have not yet been adopted due to fiscal problems or a need for specially trained personnel.

Computer Diffusion

A previous survey had indicated that computers had not diffused into hospital pharmacies very widely (Stolar, 1983). The Stolar surveys had inquired about very limited uses for computers in hospital pharmacies and reported that only 35% of the responding hospital pharmacies were using computers. This study attempted to identify any possible use for a computer in hospital pharmacy and determine what percent of the sample was using a computer in any manner. The outcome was that 76% of the responding hospital pharmacies were using computers for at least one function. The large discrepancy between the percent reported by the Stolar survey and this survey is due to the difference in the sensitivity of the instruments and to a lesser extent the later time during which this survey took place.

Uses for Computers

Some functions in the practice of hospital pharmacy were shown in the literature review to be able to be performed by computers better than some other functions. An obvious example is in the preparation of intravenous admixtures. Ninety-three precent of the responding hospitals reported providing IV admixture services. That service requires an especially large amount of label typing since one patient will frequently require four separate doses per day, and it is not unusual for a single patient to require more than ten labels per day. Each dose requires a detailed label with the patient's name and location, physician's name, date and time prepared, name and strength of drug, name and volume of vehicle, administration time and date, expiration time and date, and any special instructions such as refrigeration or light sensitivity requirements. Typing these labels is very time consuming and they must be accurate. Each label for a single patient and drug differs from the others for the same patient and drug only in the dates and times for preparation, administration and expiration. Using a computer to prepare the IV labels saves a great deal of time since all of the repetitive information need only be entered once, then the dates and times can be quickly changed for each different label. The computer usually can produce other useful documents such as administration records and patient profiles without further effort from the person who input the original order.

Typing labels for IV solutions is clearly a beneficial application for computers that can save time and improve accuracy. Implementation can be as cheap and simple as purchasing a memory typewriter. This application is also the most widely diffused application reported in this survey with 62% of the responding pharmacies using some type computer to prepare the IV labels.

Patient billing and patient census lists were the two next most popular uses for computers reported in this survey (53% and 43% respectively). Those two functions are directly connected to the accounting departments in most hospitals. Lopez (1982) reported that the basic accounting functions in hospitals received the earliest emphasis for implementing computers. The ability to do patient billing and census lists by the accounting departments is a direct outcome from the early computerization of accounting functions in the hospital.

The most recent survey of hospital pharmacy services (Stolar, 1983) reported that 45% of the responding hospitals had at least a partial unit dose drug distribution system. That type of distribution system has many benefits and advantages, but also requires a lot of clerical type record keeping and labelling. The computer has obvious advantages in unit dose: saving time, improving accuracy in labelling doses, and providing patient profiles and administration records. Respondents to this survey reported 38% used a computer to prepare unit dose labels, 23% to provide unit dose profiles, and 22% to provide unit dose fill lists.

That means that almost half of the responding pharmacies were doing those functions manually. The unit dose application for computers may be the one area that is the most under-used as indicated by the results of this survey.

Diffusion of Computers

As pointed out in Chapter 4, computers have diffused in hospital pharmacy similarly to the diffusion of technology in other areas. It is only logical that any new technology that was beneficial would have a low rate of diffusion early after its initial trials. That rate would logically increase with time as the early adopters told their associates about the innovation and its benefits. The rate of diffusion would reach its maximum at around 50% adoption when most of a population had some knowledge of the innovation. After that point, the number of potential adopters would begin decreasing as smaller and smaller percentages of the population remained to adopt an innovation. As adoption approaches completion, usually somewhere between 80% to 100% for cost effective and beneficial innovations, the rate of adoption would decrease considerably. As shown in both Figure 1 and Table 14 in Chapter 4, diffusion of computers in hospital pharmacy has closely followed the predicted curve.

Level of Computer Usage

The applications for computers in hospital pharmacy that were most easily understood, most cost effective, and easiest to implement were the applications that were adopted first. As discussed above, IV additive, unit dose, and billing applications were implemented to the greatest extent. Those applications are all at the lower or transaction processing level. Higher level uses would be those that were used to control lower level uses, summarize events at the lower level, or manage other functions. For purposes of this study those higer level uses were utilization review, formulary production, clinical pharmacy, research, summary reports, and predicting future events. Those six applications averaged only 18% adoption by responding pharmacies. The higher level uses were more difficult to understand, more difficult to implement, and probably did not have an obvious advantage of solving a problem in the day to day operation of managing a hospital pharmacy.

Predicting Innovativeness

This study attempted to predict the relative innovativeness of responding directors of hospital pharmacies. The predicted innovativeness did not correlate well with the adoption time of computers or the extent of adoption of innovative services. Several reasons for the lack of ability to predict innovativeness exist. The first is that the instrument may not have had sufficient sensitivity. Review of the literature showed that a person's attitude towards innovation may be an important factor in predicting his innovativeness (Rogers, 1983). The instrument used did not attempt to take any attitude factors into account in predicting innovativeness. Second, the population sampled was directors of hospital pharmacies. Although that population is composed of individuals with many differences, they also have many similarities. Their basic education is similar in that they are all college graduates, all have a degree in the same major field, and are all involved in the same profession. The instrument was not sensitive enough to measure the small differences in those individual's characteristics relative to predicted innovativeness.

Adoption of Innovative Services Versus Computers

One of the most important concepts in the diffusion of innovations is that of relative advantage (Rogers, 1983). An innovation that can benefit an adopter the most is expected to be the first adopted. Another important concept is the ease of communication of an innovation within a social system (Rogers, 1983). New ideas that were developed within the profession of pharmacy and had an obvious advantage were expected to be most widely diffused. The innovation that was found to be most widely diffused in this study was generic substitution. Ninety six percent of the responding hospitals reported having generic substitution approved. That innovation was developed by hospital pharmacy, had obvious advantages, and was easily understood and communicated throughout the profession. The same statements could be made about unit dose and intravenous additive services whose adoption rates are 90% and 96% respectively. Computer technology on the other hand was developed outside pharmacy, the advantages were not easy to see or did not exist early in computer growth, and communication about computers in the profession was not rapid.

Multiple Regression

Previous studies had reported varying levels of success in accounting for the percent of variance in the diffusion of innovations(R^2=.25 to .80). The studies that most consistently characterized adopters of innovations were those that measured personality variables such as intelligence, rationality, and a favorable attitude toward change (Rogers, 1983). This study was unable to measure those types of variables and had less than optimal success in accounting for significant amounts of variance using easily obtained characteristics of the individual responders and the hospitals where they worked.

Conclusions

There are functions in hospital pharmacy that have been demonstrated in the literature to be definitely appropriate for computers. This study has shown that for those functions computers have been adopted to a greater extent than in the functions where there is not a clear advantage.

This study has shown that the diffusion of computers in hospital pharmacy is greater than previously reported in the literature (Stolar, 1983). All seventeen uses for computers identified in the literature had a significant number of hospitals that reported using computers for those applications. The size of computers in use for those applications varied from the smallest to the largest size in almost every case.

The adoption of computers by hospital pharmacy has followed quite closely the expected curve for adoption of an innovation described in other studies.

Predicting the innovativeness of directors of hospital pharmacies is not easy. For this reason, correlations between predicted innovativeness and time of adoption of computers and level of adoption of innovative services were not high.

Recommendations

Several applications for computers have been shown to be beneficial. Specifically, for intravenous additives, unit dose, patient billing, and census lists, computers are fast, efficient, accurate and cost-effective. It is recommended that hospital pharmacies adopt computers for those applications as soon as possible. Waiting for the hospital to either obtain a computer of sufficient size to be able to add these pharmacy functions or waiting for a data processing department in the hospital to get time or room to add on these services is not recommended. Instead, purchase or other arrangements to obtain a mini computer and the necessary software to perform these functions is highly recommended. Caution should be used in selecting the hardware and software. Advice from experts, experienced in the specific applications being considered, and with no interest in selling a specific product, is highly recommended.

Education about computers in hospital pharmacy is an area where much work needs to be accomplished. Colleges of pharmacy should consider adding basic computer literacy to some part of their curriculum. Continuing education programs should provide the same type of information to graduates who are in practice. Pharmacy journals should continue to educate their readers about computer applications that are cost-effective and beneficial.

Further research is recommended to develop more cost-effective uses for computers and to make those uses which are already developed more beneficial. Cost-effectiveness and cost-benefit studies would also be beneficial in more accurately identifying appropriate uses for computers. Further research in the diffusion of innovation could develop a more sensitive instrument for prediction of innovativeness of directors of pharmacies.

APPENDIX A

SURVEY INSTRUMENT AND CORRESPONDENCE

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

COLLEGE OF PHARMACY
DEPARTMENT OF PHARMACY PRACTICE

August 16, 1983

Dear Colleague;

Hospital pharmacy has undergone some major changes during the last two decades. New methods of drug distribution, new services available at many hospitals, and new types of equipment have all had a part in changes of our profession. The use of computers in hospital pharmacies is one of these changes that has attracted my particular interest.

As part of my graduate studies at the University of Arizona I am conducting a national survey of hospital pharmacy directors. The purpose of this survey is to determine how widely computers are used and what some of the more common uses of computers are in hospital pharmacies. The high cost of printing and postage makes it unreasonable to survey every hospital pharmacy. You have been randomly selected as part of the sample from the American Hospital Association Directory. Your participation is extremely important to ensure that this survey will be truly representative of the entire spectrum of hospital pharmacies in the United States.

The questionnaire is brief and pretests indicated that it could easily be completed in under 15 minutes. The number at the top of the first page is used for accounting purposes only so that reminders letters can be sent. The identity of all survey participants will be kept in the strictest confidence. Your consent to participate in this survey is voluntary and returning the survey form will indicate your willingness to participate. Your decision not to participate will, of course, incur no ill will.

Upon completion of the survey please return it by mail in the enclosed addressed envelope. If you have any questions concerning this survey you may call me at (602) 626-5730. I appreciate your time and effort and look forward to receiving your completed survey in the mail.

Sincerely,

William C Browning

William C. Browning, R.Ph.

INSTRUCTIONS

THIS SURVEY IS DESIGNED TO BE COMPLETED BY THE DIRECTOR OF THE PHARMACY AT THE HOSPITAL TO WHICH IT IS ADDRESSED. PLEASE MARK THE BOX FOR THE ONE MOST APPROPRIATE RESPONSE FOR EACH SERVICE WITHIN YOUR PHARMACY.

1. Unit Dose Service. This is defined as a distribution system in which almost all drugs (including injectables) are dispensed in single unit packages in an amount not exceeding a 24 hour supply of doses.

[ ] Not provided.
[ ] Implemented under previous director and currently provided.
[ ] Programmed for implementation within the next 12 months.
[ ] Implemented under my direction but no longer provided.
[ ] Implemented under my direction and currently provided.

2. Generic Substitution. Your pharmacists have the authroity to select the brand or supplier of drug dispensed for all medictaion orders and prescriptions unless a specific notation to the contrary by the prescriber is present.

[ ] Not provided.
[ ] Implemented under previous director and currently provided.
[ ] Programmed for implementation within the next 12 months.
[ ] Implemented under my direction but no longer provided.
[ ] Implemented under my direction and currently provided.

3. Mobile Satellite Pharmacy Services. The concept of this service is to provide a pharmacist with a mobile pharmacy cart to the patient-care areas of the hospital. Most of the unit dose drug distribution functions would be handled through the mobile satellite pharmacy rather than the central pharmcy.

[ ] not provided.
[ ] Implemented under previous director and currently provided.
[ ] Programmed for implementation within the next 12 months.
[ ] Implemented under my direction but no longer provided.
[ ] Implemented under my direction and currently provided.

4. Fixed Satellite Pharmacy. The concept of this service is to provide a small, fixed, satellite pharmacy or pharmacies close to or within the patient-care areas.

[ ] Not provided.
[ ] Implemented under previous director and currently provided.
[ ] Programmed for implementation within the next 12 months.
[ ] Implemented under my direction but no longer provided.
[ ] Implemented under my direction and currently provided.

5. Pharmacy-operated IV Admixture Program. The pharmacy prepares and distributes intravenous fluids with added medications.

[ ] Not provided.
[ ] Implemented under previous director and currently provided.
[ ] Programmed for implementation within the next 12 months.
[ ] Implemented under my direction but no longer provided.
[ ] Implemented under my direction and currently provided.

6. 24-Hour Pharmaceutical Services. This would mean that your pharmacy is open 24 hours a day, every day.

[ ] Not provided.
[ ] Implemented under previous director and currently provided.
[ ] Programmed for implementation within the next 12 months.
[ ] Implemented under my direction but no longer provided.
[ ] Implemented under my direction and currently provided.

7. Pharmacokinetic consultations. This would consist of, at a minimum, review of serum drug level values and verbal or written follow-up with the prescriber when necessary.

[ ] Not provided.
[ ] Implemented under previous director and currently provided.
[ ] Programmed for implementation within the next 12 months.
[ ] Implemented under my direction but no longer provided.
[ ] Implemented under my direction and currently provided.

8. Patient Monitoring. This involves monitoring the drug therapy of patients and should include, as a minimum, review of the patient's chart in conjunction with direct observation of the patient and a verbal or written follow-up with the prescriber when indicated.

[ ] Not provided.
[ ] Implemented under previous director and currently provided.
[ ] Programmed for implementation within the next 12 months.
[ ] Implemented under my direction but no longer provided.
[ ] Implemented under my direction and currently provided.

PLEASE ANSWER THE FOLLOWING QUESTIONS ABOUT YOURSELF AS DIRECTOR OF THE PHARMACY.

9. How many contacts per month do you have with other pharmacists outside of your institution. Contacts include telephone conversations, correspondence, and personal meetings.

[ ] none
[ ] 1 to 5 per month
[ ] 6 to 10 per month
[ ] 11 to 15 per month
[ ] 16 to 20 per month
[ ] over 20 per month

10. How many journal articles do you read per month? Include any journal articles relating to any aspect of your work.

[ ] none
[ ] 1 to 5 per month
[ ] 6 to 10 per month
[ ] 11 to 15 per month
[ ] 16 to 20 per month
[ ] over 20 per month

11. How many professional meetings have you attended in the last 12 months outside of your place of employment.

[ ] none
[ ] 1 to 3
[ ] 4 to 6
[ ] 7 to 9
[ ] 10 to 12
[ ] over 12

12. In an average month how many times do you meet with sales representatives of either equipment or drug manufacturers?

[ ] none
[ ] 1 to 5 times
[ ] 6 to 10 times
[ ] 11 to 15 times
[ ] 16 to 20 times
[ ] over 20 times

13. Computer Equipment in the Pharmacy. In the matrix on the following page mark the boxes for each use of a computer currently employed in the pharmacy.

Definitions:

Memory Typewriter: An electric typewriter that has internal memory of what has been typed and can print multiple copies of text material. Examples: IBM 7500, Olivetti ET-121, Facit 8000.

Micro Computer: A small, desktop, self contained computer with no external memory or communication with other computers. Cost is usually under $5,000. Examples are TRS-80, Apple, Kaypro, Compustar, Osborne.

Mini Computer: A desktop computer that has either a large internal memory (over 1 mega byte) or access to some external memory. Cost is usually under $10,000. An example is an IBM System 3.

Larger Computer System: A computer system large enough to handle most of the functions listed in the chart on the following page. This type computer is usually part of a large computer system with many departments in the hospital sharing its use. Examples are IBM mainframe computers, DEC 20, VAX 1170, Honeywell, etc.

Please mark an "X" in each box for which you are currently using a computer.

	Memory Typewriter	Micro Computer	Mini Computer	Larger Computer
Types Correspondence				
Types Prescription Labels				
Types IV Labels				
Narcotic Inventory				
Other Drug Inventory				
IV Patient Profiles				
Unit Dose Labels				
Unit Dose Profiles				
Unit Dose Fill Lists				
Patient Lists(census)				
Patient Billing				
Drug Utilization Review				
Automated Formulary Production				
Clinical Pharmacy (ie Kinetics)				
Research Purposes				
Summary Reports on Selected Drugs(review)				
Forecasting or Predicting Future				

14. When were computers first used in this pharmacy in any of the above uses? Answer with the month and year if possible.

Month __________ Year _________

NOTE: IT IS IMPORTANT THAT SOME ANSWER TO THE QUESTION ABOVE BE PROVIDED. IF THE DATE IS NOT KNOWN, PLEASE GIVE AN APPROXIMATE TIME THAT YOU THINK COMPUTERS WERE FIRST USED IN THE PHARMACY.

THIS IS THE LAST PAGE!!! PLEASE ANSWER THE FOLLOWING QUESTIONS ABOUT YOURSELF AND YOUR PHARMACY DEPARTMENT.

Your Age________.

Male_______ Female _____

Years worked as a pharmacist:__________

Years worked for present employer ________

Years worked in present position _________

Number of subordinates who work for you ________

Check degree(s) you have completed

___ BS

___ MS

___ PhD

___ Pharm D

___ Others, specify:_________________________.
_________________________.

Have you completed a residency program in pharmacy?

___ yes

___ no

I am sending this postcard to remind you to please complete the survey on pharmacy computer uses that was mailed ten days ago. If you have already returned the survey I thank you for your participation. Your response adds significantly to the success of this study. If for some reason you have put the survey aside, please take the time now to complete it. If you have any questions feel free to call me at (602) 626-5730.

Sincerely,

William C. Browning

William C. Browning
College of Pharmacy

APPENDIX B

COMPUTATION OF VARIABLES

Predicted Innovativeness

Predicted Innovativeness = Cosmopoliteness + Change Agent Contact + Education Level + Experience

Cosmopoliteness = (Responses to Question 9 + Question 10 + Question 11) - 3

Change Agent Contact = (Response to Question 12) - 1

Education Level = (Sum of number of degrees reported including a residency) X 3

Experience = (Years as a pharmacist / 15) + (Years worked for present employer / 10) + (Years worked in present position / 7) + (Number of subordinates / 21)

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