AN ANALYSIS OF THE JOB MARKET FOR BIOMEDICAL COMPUTER SCIENTISTS

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ABSTRACT

Biomedical Information and Computer Science is an academic area that has received much interest recently. A number of training programs have been developed around the country. This paper is an examination of the potential market for biomedical information and computer scientists.

It is possible to identify a number of organizations that may potentially employ biomedical computer scientists. Included in such a list are medical schools, hospitals above a certain size, software houses, health maintenance organizations (HMO's), health-testing centers, biomedical instrument manufacturers, professional standards review organizations (PSRO's), insurance carriers, service bureaus, and academic institutions training biomedical computer scientists. An estimate of the current market is based on a summation of the various potential sub-markets. Growth statistics are determined or estimated for each market area to project future needs.

A description of the nature of each potential market area is used to indicate the type of training that will best prepare a student for the various job markets. It is suggested that a combination of biology, electrical engineering and computer science will be essential for some positions while extensive training in the development of large data bases along with a biological science background will be required to meet other job descriptions.

INTRODUCTION

The potential market for graduates from any academic training program should be of interest to the sponsors of that program. Recently, Shires (1973) reported the results of a survey of 123 medical schools in Canada and the United States. Of the respondents, 81 per cent indicated a need immediately or within two years for medical students to have an increased exposure to computer applications in clinical medicine. Several biomedical information and computer science (BICS) programs have been inaugurated that will provide teachers to meet the medical school needs. Unfortunately, 123 medical schools is a rather small market to absorb the graduates of several BICS programs that propose to place on the job market a number of graduates with BS, MS, and PhD levels of training. This study is an examination of the total potential market for graduates with interdisciplinary training in biology and information and computer science.

Figure 1 shows a Venn diagram that illustrates the several disciplines that interact with biology and medicine to form interdisciplinary regions. The diagram leads one to suspect that more than one program may be needed to meet several different application needs. The region labeled "BICS" interfaces four different parent disciplines that appear to be polarized either in the direction of engineering or information science. Table I is a list of types of medical computer applications that will potentially use graduates of BICS programs. These fall into three broad categories that are called (1) business data processing, (2) data-base management, and (3) automated medical instrumentation. These form the general categories that constitute a potential job market.

The business data-processing applications in the biomedical market can probably be handled by persons with little or no special biomedical training. That is, in fact, what has happened so far when business type data processing was incorporated within the hospital setting. The basic business data processing techniques have been carried over into the hospital business office. It is not anticipated that this picture will change much. Typically, persons to fill these positions have been, and will continue to be trained on-the-job as far as special requirements of the medical environment are concerned. During the late 1960's this particular market experienced an explosive growth. McCarn and Moriarty (1971) report that in 1970 over 1300 computers were in use in the U.S. health-care industry. The majority of these were installed in hospitals for business data-processing applications.

Special interdisciplinary training is required primarily in the other two categories: medical data-base management and automated medical instrumentation. Medical data-base specialists require advanced training due to the uniquely medical relationships that must be incorporated into the structure of data bases that are maintained for medical purposes. Even those that strive to develop "data independence", relational databases, etc. are currently unable to guarantee efficiency without and understanding of the expected use of the data.

Automated medical instrumentation incorporating computers requires even further depth in specialized education. A number of applications such as computerized intensive-care monitoring and computerized clinical laboratory automation require an understanding of electronic instrumentation and analog-to-digital conversion techniques. The best trained specialist in this type of environment will be both an engineer and computer scientist.

DEMAND ESTIMATION

Several trends are important in porjecting future needs for biomedical computer specialists. Figure 2 shows the trends in the number of hospitals, average daily census, and the number of outpatient visits per year in the United States (AHA, 1975). Of interest is that the data shows a relatively slow growth in the number of hospitals and the number of admissions to hospitals. Thus we would expect that future personnel demand will not be greatly increased by a growth in the number of institutions, but rather by new facilities and new capabilities being desired by the present institutions. On the other hand, a rapid growth is evident in the number of outpatient visits per year. This is part of an overall trend to increase the availability of ambulatory health care in contrast to institutionalized care. The total number of beds is tied to population growth while ambulatory care demand will reflect changing health-care technology, government support of comprehensive health care and health maintenance organizations (HMO's), and increased pressure to contain health-care costs. Computers have been found useful in the ambulatory care setting so it is likely that this rapidly growing segment of medicine will require significant support while the larger hospitals will over a period of time introduce computer automation first in such areas as clinical laboratories and later in medical records and hospital-wide information and communications systems.

HEALTH CARE IN 1984

The greatest impact on the health care job market will be a change in the over-all type of medical care provided in the United States. As with any effort to prognosticate the future, errors in time scale are readily possible. One can be quite secure in observing trends; however, the time scale or slope of a trend may be off by 100 per cent or so.

The most obvious trend in health care today is the growing cost of health services. Health services now amount to over $100 billion annually or close to ten per cent of the Gross National Product (Chester, 1972).About 50 per cent of that cost is paid by the federal government, therefore the government will wield an ever-increasing force in determining what and how health-care services shall be provided. Government efforts appear to be directed toward the establishment of a system providing so-called "comprehensive health care." Such a system will probably build on a hierarchy of central and satellite facilities based on the Kaiser model (Garfield, 1975). Federal forces seem to be moving with ever increasing momentum toward the establishment of a nationwide network of Prepaid Group Practices (PGP's) or Health Maintenance Organizations (HMO's).

Our prediction on the future manpower requirement for biomedical information and computer scientists is, therefore, based on the assumption that the number of hospitals with over 300 beds will increase slightly. Small hospitals with under 300 beds will become satellite facilities to the central hospitals and will handle much of the ambulatory care along with Automated Multiphasic Health Testing (AMHT). Based on this model, the small hospital in its present form will cease to exist to a large extent and for prediction purposes a network of AMHT's will service the nation's entire population and regulate the patient flow to various facilities. 2000 AMHT's can screen the entire present population once every two years. The 3000 or so independent clinical laboratories will either become part of, associated with, or absorb the health testing facilities, so that clinical laboratories will cease to exist as an entity requiring computer support. In addition, we would expect that the nation's health insurance carriers such as Blue Cross, Blue Shield, etc. would either become HMO's or would be absorbed by HMO's. Thus insurance carriers will cease to exist as users of BICS manpower and will be replaced by about 200 HMO's patterned on the Kaiser-Permanente system supporting about one million enrollees each. Table II shows this projected rearrangement of manpower requirements with a projected staffing of each facility type by persons with advanced biomedical computer science training. We predict a manpower need for 1984 of over 12000 persons with this special training. 1984 is a convenient target date but the time scale could be somewhat longer depending on the rate at which government forces move. Many persons think that this ultimate pattern of health-care delivery is inevitable, however.

Additional checks on the reasonableness of the above predictions have been made. Statistics are available on the current manpower utilized in the health-care industry (HEW, 1974). Figure 3 shows past trends in manpower utilization of automatic data processing and bioengineering personnel according to estimates by the Data Processing Management Association (DPMA) and the Alliance for Engineering in Medicine and Biology (AEMB). These data were linearly extrapolated <u>after</u> developing the estimates shown in Table II and the 1984 projection correlates embarassingly well.

As a second check on the plausibility of the projections shown in Table II and Figure 3, one can estimate the cost of the personnel based on present salary scales. If one assumes that PhD's will receive an annual salary of about $25,000 while specialists with BS and MS degrees will average $15,000 per year, the total specialist manpower cost is about $200 million in 1976 dollars. The present cost of health care is about $100 billion so a specialist manpower cost of only 0.2 per cent is within reason. In addition, there are predictions that the computer hardware market for health care will reach $1 billion before 1980 (Williams, 1975) so it is not unreasonable to expect that specialist manpower costing $200 million will be required to support health-related computers. This cost estimate is, of course, based on 1976 dollars and one must assume that salaries and costs will rise proportionately in the future. Since health-care costs are almost 70 per cent labor, such an assumption is reasonable.

COMPETITION FOR JOBS

Schwartz and Long (1975) have studied the Biomedical Engineering programs in the United States and project an annual graduating class at all levels of over 1000 bioengineers. Since most of these will have significant training in computer science, it is likely that bioengineers will be competing for many of the same positions open to biomedical computer scientists. It is also likely that many of the positions (especially in clinical laboratories and health-testing facilities) will require engineering and/or electronics training.

CONCLUSIONS

1. We have projected a demand for 8000 new BICS specialists for a total of over 12000 biomedical computer scientists by 1984. This amounts to a requirement for about 750 per year based on a need evenly spread over the years between 1973 and 1984.

2. A significant portion of the potential demand will require training in electrical engineering due to computer interfaces with sophisticated instrumentation. A computer scientist without engineering training will be at a competitive disadvantage in some positions.

3. Bioengineers that are expected to be graduating in predicted numbers of about 1000 per year will be competing for many of the same positions.

4. It is likely that biomedical computer scientists will be matched most appropriately to positions with computer systems supporting large medical data bases that will be needed to establish a nation-wide comprehensive health-care system.

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TABLE I

TYPES OF MEDICAL COMPUTER APPLICATIONS

A. Data Processing Applications
   1. Hospital Business Office
   2. Physicians' Billing Service
   3. Insurance Carrier Claims processing
B. Data-base Management Systems
   1. Automated Medical Records Systems
   2. Radiology and Pathology Reporting
   3. Medical Education Applications
   4. Total Hospital Computer Systems
   5. Professional Standards Review
   6. Utilization Review
   7. Health Maintanence Organization Support
   8. Pharmaceutical Research
   9. Epidemiological Research
C. Automated Medical Instrumentation
   1. Physiological Monitoring
      a. Catheterization Laboratories
      b. Intensive-care Monitoring
   2. Automated Health Testing Laboratories
   3. Clinical Laboratory Systems
      a. Hospital Laboratories
      b. Commercial Laboratories
   4. Medical Research Laboratories

TABLE II

PROJECTED BICS STAFFING REQUIREMENTS

Facility	Number		Staff/Facility		1984 Total	
	Current	1984	Senior	Junior	PhD's	BS & MS
Hospitals over 300 beds	1300	1500	1	3	1500	4500
Hospitals under 300 beds	6000	0*	-	-	-	-
Medical Schools	114	125	4	4	500	500
PSRO's (one computer/state)	52	52	1	1	52	52
Blue Cross/Blue Shield	52	0**	-	-	-	-
Other Insurance carriers	100	0**	-	-	-	-
HMO's	few	200	1	2	200	400
Multiphasic Health Testing	few	4000*	0	1	-	4000
State and Federal Agencies	100	200	1	2	200	400
Independent Clinical Labs.	3000	0*	-	-	-	-
			Total Staffing		2452	9852
			Grand Total BICS		12304	

* Hospitals under 300 beds will become satellite facilities to central hospitals. AMHT's will be installed within these satellite facilities. Independent clinical laboratories will all become part of AMHT's.

**Insurance carriers will all become or be replaced by HMO's/

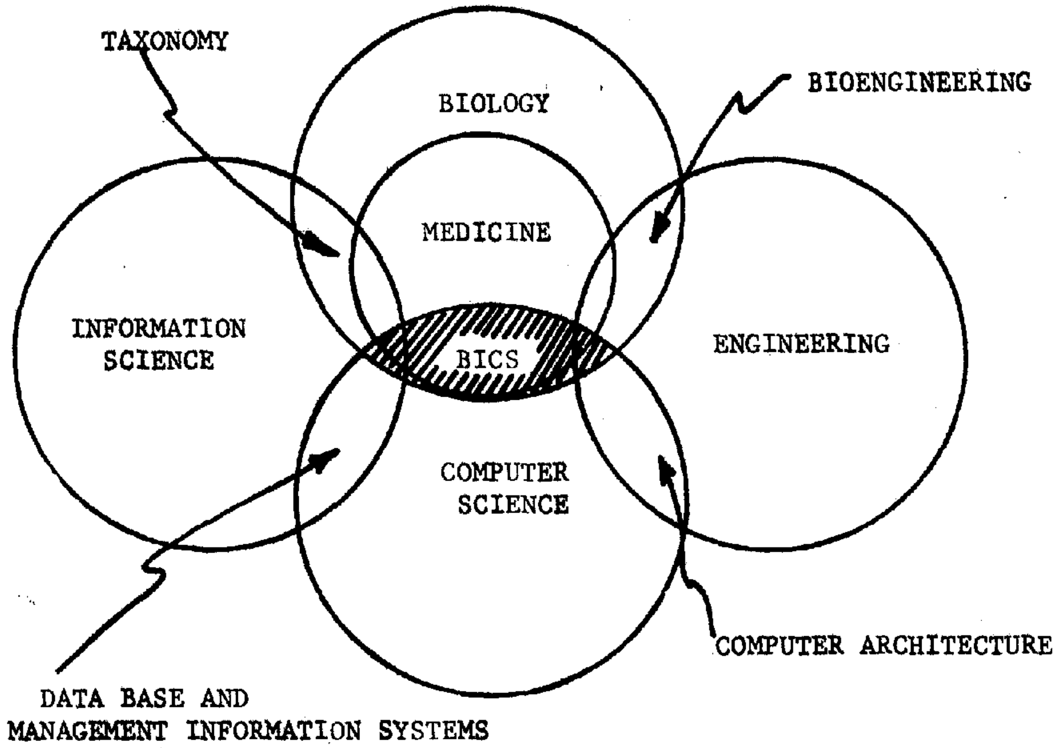

Figure 1. Domain of Biomedical Information and Computer Science

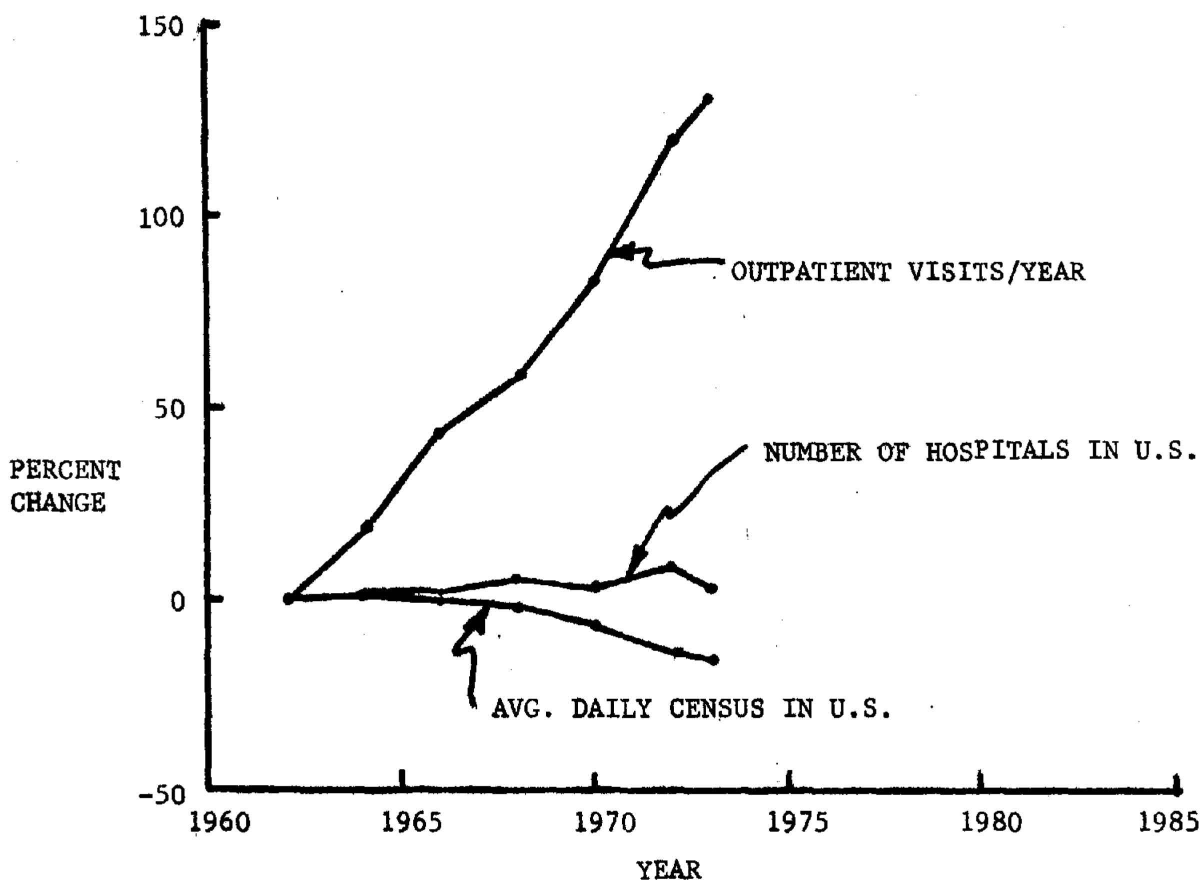

Figure 2. Trends in Hospital Statistics in the U.S.

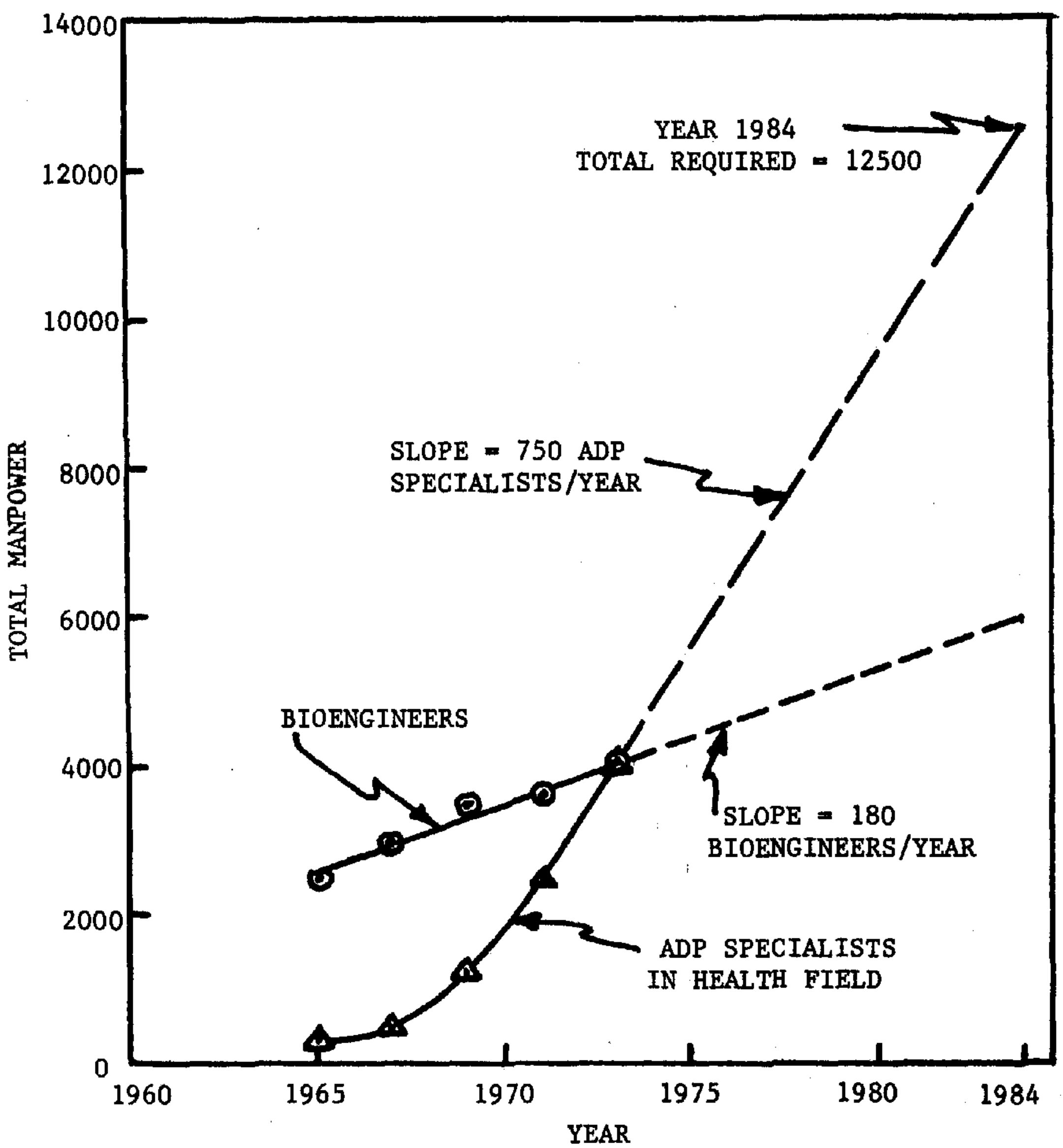

Figure 3. Manpower Requirements in Bioengineering and Biomedical Computer Specialists Projected to the Year 1984.