Research Support
University of Michigan Business School

October 1998

MANAGEMENT OF HEALTHCARE TECHNOLOGY LITERATURE (1979-97): A MULTI-DIMENSIONAL INTROSPECTION

WORKING PAPER #98020

BY
ASHOK KUMAR
GRAND VALLEY STATE UNIVERSITY
AND
JAIDEEP MOTWANI
GRAND VALLEY STATE UNIVERISITY

Management of Healthcare Technology Literature (1979-97): A Multi-Dimensional Introspection

ABSTRACT

This work takes an introspective look at the trends, patterns, and directions taken by the researchers in the field of management of healthcare technology (MHT) during the period 1979-97. A total of 333 publications are classified in six distinct categories. The major findings of this study include: (1) A very substantial number (55%) of researchers employed the "incremental" or ripple strategy as a primary strategy of research. (2) 69.7% of all publications were untested theory papers. While 38.1%of the publications claimed application status only 26% were found rooted in the real world. (3) Improvement in cost performance was the most pursued objective – 31.5% of the publications. (4) 28.5% of the publications used application and evaluation of information systems as the dominant MHT application setting. (5) Process, technology, and equipment was the preferred choice of operations strategy reflected in 33.9% articles. Lastly, (6) 45.6% of all publications led the hospital system category by choosing fiscal management as their research area.

Furthermore, given that more than half the papers (56.1%) were published in the last four years of this nineteen-year study, we project that MHT is and will remain a vital and vibrant field for researchers and practitioners looking for ways to economize cost, improve quality, and enhance customization and speed through adroit management of healthcare technologies. Finally, our analysis supported the fact that vertical and virtual integration of care providers will continue using the technology management as its primary vehicle as projected by MHT experts.

We hope that the findings of this work will provide useful insights into the anatomy of MHT publications and motivate further research on where the field is going and what course corrections are needed, if any, beyond those that have been proposed here.

Management of Healthcare Technology Literature (1979-97): A Multi-Dimensional Introspection

INTRODUCTION

In order for a field or discipline to enjoy continued vitality and relevance, experts should periodically engage in a systematic process of meta-research (research on research) to assess where research in the field has been, where it is heading, and what, if any, should academics and practitioners do to change the course warranted by the assessment process (Reisman 1994). More specifically, there is a clear need for conducting this kind of research in the field of Management of Healthcare Technology (MHT) Reisman (1996). This then is the motivation and the intent of the study presented here. We have, gathered, performed content analysis, collated and statistically analyzed MHT research publications over the years (1979-97). The results provide a perspective on MHT research as the data are dissected in several different ways. We employ six different classification schemes. These have been derived, borrowed, or adapted from existing literature dealing with meta research in general and MHT in particular. Lastly, we present findings with respect to the current status of MHT research and what it portends for the future.

BACKGROUND AND LITERATURE REVIEW

The technological landscape of the healthcare industry has been changing continuously over the last three decades. The changes have been particularly hectic since the early eighties. Several compelling factors have affected this change (Woolhandler and Himmelstein 1991, Jacobson, Schleyer, Smith 1992, Simpson 1995, and Smith 1996). First, there is an immense pressure from the general public to provide customized, high quality care that renders salutary

results virtually instantly, and at the lowest possible cost. The care providers recognize the inherent conflicting nature of these four objectives (customization, quality, agility or speed, and cost). Generally one can only be improved at the expense of the other. Moreover, limited critical resources must be traded off in order to accomplish any one objective over the other. However, experience in other industries, e.g., electronic and automotive, has demonstrated that with adroit use and management of technological innovations, it is possible to attain all of the four objectives concomitantly (Hayes and Schmenner 1978, Swamidass 1986, Hayes and Pisano 1996). Thus, pursuing technological solutions to respond to the public pressure makes good strategic sense. Second, there has been significant pressure from regulatory bodies, such as the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) to employ technology management techniques in order to obtain accreditation status. (Woolhandler and Himmelstein 1991). Finally, there is a pressure from federal Medicare/Medicaid administrators to economize on cost of care without impairing the quality, speed, or exhaustiveness of service. The impact of the last factor cannot be overstated since the Medicare/Medicaid expenditures represent one-seventh of the U.S. economy. While these pressures have provided a perpetual strategic incentive for the providers to innovate, develop, and manage technologies, there have been two defining moments in the chronology of healthcare delivery systems that have triggered a serious momentum in this direction. First, the enactment of the Medicare Act (1983) during Reagan administration (Nelson 1993, Longo, Sohn, and Shortell 1996) drastically changed the payment modalities to care providers. The Prospective Payment System (PPS) set forth in this act required classification of each patient into one of the 468 Diagnosis Related Groups (DRGs), and the payment to the provider was strictly based on the DRG classification. Prior to PPS, the

hospitals were paid on a cost plus basis, e.g., the full cost of each admission/discharge regardless of the cost or quality of care actually realized. Thus, the inception of PPS created the prospects of significant revenue losses for providers, but, more importantly, it required significantly greater accountability to document diagnostic and treatment decisions on their part. Thus, PPS rewarded those providers that were cost-efficient and detail conscious and penalized those that were not (Averill and Kalison 1986, Butters and Eom 1992, Kettlehut 1992). As a result, PPS set off two trails of inevitable actions – all providers began to look for increasingly cost-efficient methods of treatment and quick and cheap ways for gathering and analyzing diagnostics related information. Needless to say, each of these trails provided enormous motivation for developing technological solutions, specifically directed towards development of cost-effective diagnostic tools, equipment, and information technology. The net effect of this increased technological activity was that MHT research, which had largely lay dormant up to that time, took off with a momentum of its own.

For approximately a decade since the enactment of PPS, MHT researchers registered a steadily increasing trend of publication as the technological activity in the industry increased to address the PPS issues and the other aforementioned pressures. Specifically since 1985, the role of information technology (IT) has expanded to serve greater strategic pursuits of healthcare providers. These pursuits include improving financial planning, using more accurate cost accounting methods, enhancing efficiency and productivity, and identifying opportunities for enhanced profitability and revenues. Furthermore, IT was innovatively used for tracking discrete services used in production/operations, global sourcing, nurse scheduling/nursing management, facility location, equipment purchasing, managed care contracts, operational assistance to

healthcare supervisors, emergency service vehicle deployment, blood distribution, and central information scanning of case information (Butters and Eom 1992).

In our view, the other defining moment came, during 1993-94 with the Clinton health plan. As everyone knows, that plan never passed the muster of the U.S. Congress. Nevertheless, it created a specter of scrutiny and accountability as never before and sent the industry scrambling into introspection. The political will to reduce healthcare costs without sacrificing quality caused the inflation rate of healthcare costs to register lower than ever and showed that technology can be the key to an institution's survival. In this context, Ginn (1990)'s findings are worth noting: "Changes in the reimbursement policies, the emergence of new technologies, changing consumer expectations, and new sources of competition made the environment for hospitals progressively more turbulent in the later period and provided an opportune setting to evaluate strategic change. Results showed that a significant number of hospitals did change strategy as the environment changed and in the anticipated direction."

Since 1994, the rate of MHT publications has multiplied several fold. The last four years (1994-97) alone accounted for 56% of total publications during its 19-year (1979-97) life span. We conjecture that the evolution of knowledge-based (expert/decision support) systems assisting physicians in maintaining diagnostics and treatment case related data in desired structures played a vital role in this technological fillip. Furthermore, the onset of information super highway technologies in the late eighties/early nineties and an explosion in cyberspace/ internet technologies that allowed inexpensive information acquisition and transition also played critical roles in the spurt of technological publications registered since 1994. This is evidenced in

numerous success stories published in the context of LAN, WAN and other network technologies.

Despite the spurt in MHT research, the fields of technology management and that of healthcare management have largely remained isolated modules of investigation. To be sure, there has been some effort to integrate these two areas (Geisler and Heller 1996, 1998). The specific foci were informatics and Telemedicine in healthcare (Auslander 1992, Greener and Shortliffe 1990, Mantas 1992, Rubenstein et al. 1994, Tan 1997), use and implementation of computers in healthcare (Pierskalla and Woods 1988, Modai and Valevski 1993), technology assessment and implementation issues in healthcare (Kirsesuk et al. 1994, Kotch et al. 1993, Law et al. 1995), and OR/MS applications in healthcare delivery systems (Fries 1976, Fries 1979, Pierskalla and Wilson 1989).

Shortell (1985) is among the early works exploring healthcare organizations' performance related issues. He identified ten characteristics of high performing healthcare organizations. Even though the use or the management of technology was not identified as a characteristic per se, most of the characteristics pointed towards a propensity for technological usage. Such characteristics included, "stretch themselves, take risks, exhibit transforming leadership, bias for action, and manage ambiguity and uncertainty".

Structural changes in the industry marked the late seventies and early eighties. These changes generally involved the horizontal integration of healthcare institutions within the local markets and their consolidation at the national and regional levels. However, more recently the movement has been towards vertically diversified and virtually integrated delivery systems.

Virtual integration research typical addressed the benefits and strategic advantages of information exchange (e.g., through internet) to obtain greater systemic or clinical efficiencies. (Conrad and Dowling 1990, Robinson 1994, Conrad and Shortell 1996, Shortell and Hull 1996, Walston, Kimberly, and Burns 1996, Luke and Bugn 1996). Both of these integration types were compelled by the strategic need to deliver more cost-effective care by eliminating redundancies, shortening cycle times and having more reliable outcome data (Shortell 1988, Manus 1995, Conrad and Shortell 1996). The realizations of integrations, of course, occurred as the technological advancements promised to precisely address these very needs.

According to Shortell (1995), the integrated healthcare systems have the capacity to deliver low-cost, high quality care with shorter recovery/care times. Evidence on the performance of integrated health systems is only beginning to emerge. Specifically, the Health Systems Integration Study (Shortell, Gillies, and Anderson 1994, Shortell et al. 1996) found that more integrated systems performed better financially relative to their competitors. Some of the other findings of this study are:

(1) Greater physician-system integration was related significantly to higher inpatient productivity and to higher levels of clinical integration.

(2) Greater perceived clinical integration has led to greater system net revenue and to higher inpatient productivity.

(3) Additional features that characterize successful integration of healthcare systems – vertical or virtual – include: a capacity for creativity and curiosity; an ability to manage change; the willingness to make tough decisions and address unknowable problems; an ability to

differentiate and integrate themselves simultaneously; and the capacity to redefine and manage a new value chain for delivering health services.

DATA COLLECTION

The data retrieval process involved searching the usual and customary library databases such as ABI/Inform, Business Periodicals Index (BPI), Math Science and World Cat. Both mainframe-based and CD-ROM versions of these databases by UMI/data courier were searched for the period covering January 1979 through December 1997. This step provided access to articles from over 900 different journals worldwide. By using descriptors such as: Management and healthcare and technology; management and hospitals and technology; healthcare and technology; management and medical technology; information and technology and healthcare; strategic planning and healthcare; systems and healthcare; and healthcare and providers and technology; we were able to retrieve more than 800 abstracts. The authors carefully reviewed each abstract before making a decision regarding its inclusion in the study. Furthermore, short or inconsequential articles (press release, commercial nature) comprising fewer than three pages were deleted from the candidate set. This yielded a candidate set of 378 articles. In several instances, when the abstract was not clear, the original article was obtained and read for the purpose of the initial screening. The authors then obtained a copy of all 378 articles. Any references included in these articles but not previously identified were also considered for inclusion in our census. This increased the number of candidate articles to 402. Each article in this set was screened carefully by both authors with a view to ascertain its relevance to this study. This process discarded a number of articles yielding a final valid candidate set of 333 articles published in 47 journals. Table A1 (in the appendix) alphabetically lists the name of the journals

and provides the yearly number of publications in each of these journals for the period of the study (1979-97).

Each of the articles identified in the above search was carefully reviewed and separately classified by both authors into six different categories described in the next section. Notes were then compared. There was agreement in 85-90% in all categories. Differences of judgment were resolved via discussion and compromise. This rather high degree of agreement between the authors' judgments is not altogether surprising since the authors have participated in several meta-research studies involving similar classifications (Reisman et al. 1997a, b, c).

CLASSIFICATION METHODLOGY

Each of 333 articles in the candidate set was classified under six different schema as explained below. While this is, by no means, an exhaustive set of classifications, we believe that it adequately maps the progress and captures essential strategic and structural changes that have occurred during the 1979 to 1997 period within the MHT field.

Research Strategies

RESEARCH STRATEGY	DEFINITION
Ripple	An extension of previous theoretical or applied type of research in a given discipline or subdiscipline.
Embedding	The development of a more generalized formulation or a more global theory by embedding several known models or theories.
Bridging	The bridging of known models or of known theories resulting in the growth of the contributing and/or some initially unrelated field of knowledge.

Transfer of Technology	The use of what is known in one discipline to model problem domains falling in some other, perhaps even in a disparate, discipline.
Creative Application	The application directly, not by analogy, of a known methodology to a problem or a research questions that were not previously so addressed.
Structuring	The process of organization and documentation of the organizational phenomena in the form of models.
Statistical Modeling	Models arising from the analyses performed on empirically obtained data. These models arise from statistical manipulations such as regression or cluster analysis rather than from logical derivations based on various assumptions.

The above comprehensive seven-category classification for the types of research strategies normally employed in the Operations Research/Management Science (OR/MS) literature was developed by Reisman (1988a), and applied by Reisman & Kirschnick (1995). We found the same framework appropriate for classifying the research literature in MHT as well. The seven strategies are also graphically depicted in Figure 1.

Application/Theory Content Rating Scale

A second classification scheme for classifying articles based on their application/theory content was also adapted from Reisman and Kirschnick (1994). Under this scheme, articles were classified into two broad categories – application and theory – and then fine-tuned into subcategories depending on the application/theory content as explained later.

The papers classified as theory were formal constructs and theoretical in nature. While such papers might be motivated by real-world problems and offered a variety of potential applications,

they essentially failed to demonstrate specific real world applications. Each theory paper was further classified as pure theory, theory using synthetic data, meta research or philosophy/history.

Application papers either modeled the real world or described specific real world applications. Such papers were further classified on a five-point scale described below, or, like their theory counterparts, were classified into meta research or philosophy/history category.

CATEGORY	DEFINITION
A1	A figment of the modeler's imagination, a result of logico-deductive reasoning.
A2	A figment of the modeler's imagination that uses synthetic data.
A3	A grounding in the real world.
A4	A grounding in the real world with real world data and a demonstrate application that made a difference.
A5	Either category 3 or 4 above with the additional use of synthetic data to test sensitivity, conduct an error analysis, and/or explore behavior boundaries.

Classification Based on Health Care Technology Application Settings

The third set of classifications facilitates study of the trends and patterns pertaining to the specific settings represented by these articles. The settings included: Clinical, administration, materials management planning and technology, research, education, programmed instruction, medical records, application & evaluation of information systems, and others (Badawy 1989, Geisler and Heller 1996, Reisman 1996).

Objectives Pursued

The fourth set of classifications was based on the objectives pursued in each article. These objectives were determined in two ways: First a base set of objectives consisting of cost, quality, flexibility, and agility was drawn from manufacturing parlance as essential dimensions of competition in manufacturing and service. However, additional objectives were included as it became clear that this set of objectives was inadequate. Several articles were identified that were dedicated to developing strategic planning constructs and information/expert systems, thus not falling within the narrow purview of any one dimension or priority.

Choice of Operations Strategy

The captions for this set of classifications were adapted from (Giffi et al. 1990). This required breaking down articles into three main categories – structural, infrastructural and integrated. The structural choices of strategy included "brick and mortar" decisions such as facility design and location; technology and process; degree of vertical integration; and types of material transport system. The infrastructural choices included the "soft" aspects of operations decision making such as quality management; human resource policy and staffing; performance management; organizational structure and design; and process planning and control mechanisms. Lastly, the integration decisions were concerned with the vital "linkages" including relationships, communication mechanisms, and strategies for learning (Roth, Johnson, and Short 1996). As a practical matter two modifications were incorporated in the original Giffi's model. First, most integration related articles under study did not fall clearly into an external or internal integration category. Indeed, most such articles aimed at bringing about both internal and external

integration, i.e., they aimed at improving the provider system from within as well as from its environment (physicians, insurance, etc.). Hence, we combined the two categories into a single "integration" category. Second, many articles were basically informational in nature and did not support a structural strategic choice. These articles were simply classified under a new category called "information" within the structural category.

Type of Hospital Decision System

This classification involved categorizing articles based on decisions relevant to medical technology in hospitals introduced by Greer 1985. The three decisions are medical, fiscal-management, strategic-institutional. The medical decisions are considered the domain of medical doctors who make decisions in regards to the technology they will use in diagnosing and treating the patients (Greer 1985). The fiscal management decisions are concerned with knowing the bottom line of hospital actions emanating from using a specific technology or equipment, usually measured in dollars. The strategic/institutional decision systems concern technologies important for the hospital's strategic development. These decisions depend more on the visions of the future rather than those currently measurable (Greer 1985, Heller 1992).

CONSISTENCY AND VALIDATION ISSUES

To check on the issue of consistency of the above subjective classifications we took a random sample of 30 articles and asked two professionals to classify these articles, (six classifications for each for a total of 180 classifications) independently of each other and of the

authors of this paper. One of the outside classifiers had much experience in this process[1] albeit with a broader OR/MS literature, the other had no experience[2]

The results are as follows: Cheng's results were identical to ours on 174 out of the 180 classifications. In the remaining classifications discussion led to further agreement in 3 cases. Zubair Mohamed, on the other hand, showed agreement on 164 of the 180 classifications. In this case, the further discussions led to total agreement in 15 more instances. Based on the high degree of agreement, we concluded that the consistency of our classifications was excellent. The issue of validity of the research instruments the (six-classification schema) used was also considered. The first two schema were borrowed directly from seminal papers (Reisman and Kirschnick 1994, 1995) and have been repeatedly used in other articles published in refereed journals (e.g., Reisman et al. 1997a,b). Three other schema, namely, the objectives pursued, application settings, and hospital decision systems were borrowed from an authoritative text (Geisler and Heller 1996). The classification pertaining to the strategy choices was developed by the authors based on several other industries' (automotive and electronic) competitive criteria.

The results were found to be consistent with most projections made by experts. Overall, it can be claimed that these classifications were well founded. For a rigorous discussion of the

---

[1] Dr. Chun Hung Cheng is a Lecturer in the Department of Systems Engineering and Management at the Chinese University of Hong Kong, Shatin, Hong Kong.

[2] Dr. Zubair Mohammed is an Associate Professor of Operations Management at Western Kentucky University, Bowling Green, KY 42101, USA.

validation issue involved here, readers are also invited to read (Reisman et al. 1997b) which encountered similar validation questions.

INVESTIGATION AND ANALYSIS

In this section, we identify certain trends, patterns, and other salient observations pertaining to healthcare technology management journals and the six sets of classifications just described.

Healthcare Technology Management Journals

Table 1 provides a ranked list of the top ten journals publishing in the area of healthcare technology management. *Computers in Healthcare* journal, which was renamed as *Health Management Technology* journal in 1994, accounted for 132 out of the 333 articles, or 39.6% of the publications in our set. Clearly this journal has rendered a yeoman service to the cause of research in healthcare technology management field. The other significant journals that published more than 5% of articles in the field are *Healthcare Financial Management* (63 or 18.9% articles) and *Healthcare Forum* (23 or 6.9% articles). It is noteworthy that the top technology and innovation management journals as identified in Chung et al. (1998) are conspicuous by their absence on the list shown in Table A1.

Trend in Total Publications

Some observations with regard to the trend of the total number of MHT papers published are worth a note. The most salient observation is the exponential growth of publications (see Total Papers trend in Figure 2). For instance, the last four years of this study (1994-97) have registered

a total of 187 (56%) publications, which exceeds 146 (44%) publications published in the previous 14 years of this study. Indeed, the last two years of this study (104papers) account for almost one-third of the total publications. We believe that it will not be an overstatement to say that the vitality of this field is growing in leaps and bounds.

Types of Research Strategy

First, each of the 333 articles was classified into one of the seven research strategies used by the authors. In some cases, a secondary strategy was also identified when the article used more than one strategy. The results of our classification are placed in Table 2 and trends are shown in Figure 2.

The Ripple or "incremental" strategy was found to be the dominant research strategy employed by MHT researchers. A total of 183 articles out of 333, or 55.0%, used Ripple as the primary strategy of research. In addition, 16 articles or 4.8% used Ripple as a secondary strategy of research. Ripple was thus an overwhelmingly popular strategy used by MHT researchers. The next most common primary strategy used was Creative Application, which was used in 49 or 14.7 % of the articles. Transfer of Technology was a close third, accounting for 42 or 12.6% of articles. Finally, 33 articles or 9.9% used Bridging as their primary research strategy.

Application/Theory Content Rating Scale

The salient findings of theory/application classifications are placed in Table 3 and Figure 3. Prior to the study, the authors had postulated that almost all papers in the MHT area will belong to the application category. That postulate was repudiated by the factual data. A majority of papers,

206 out of 333, i.e., 61.9%, were primarily theory papers. Furthermore, within the 206 theory papers, 177 or 85.9% papers belonged to pure theory category. On its own, pure theory category accounted for 53.2% of the total papers surveyed. In the application (primary) category, 87 out of 127, or 68.5%, papers were classified in category 3, 4, or 5. These articles clearly represented research work based on an actual operating system. In an overall ratio, 26% of the total articles (87/333) fell into the 3-4-5 classification and had a genuine real-world grounding. This ratio, we are pleased to report, compares favorably with the other studies in the OR/MS areas mentioned previously.

Furthermore, there were 26 papers (7.8%) in category 1 and 2 that essentially described possible applications but failed to provide a real world grounding of such projections. Combined with the 206 theory papers, these articles represent a total of 232 papers or 69.7% of articles that would constitute what Ormerod and Kiossis (1996) termed "untested theory" papers. This percentage is lower compared to the other parallel studies in OR/MS areas and, if one can argue in favor of application-oriented research, healthcare technology management research can be said to be on the right track, albeit relatively. Finally, the fact that there are only 18 (5.4%) articles in application category 5, may suggest that the researchers in MHT area are exploring and reporting new applications, but are not conducting necessary sensitivity analyses using real world or synthetic data.

Application Settings

The data pertaining to application settings in healthcare technology is presented in Table 4 while trends are presented in Figure 4. Application and evaluation of information systems was clearly

the dominant setting used by researchers accounting for 28.5% or 95 papers. Administration was the second most used setting accounting for 21.3% or 71 papers. There was a near tie in the next two dominant settings - clinical, and medical records (improving or enriching the data base to provide better service) - each accounting for about 17.5 % of the papers. Furthermore, each of these four settings showed a significantly improving trend in terms of number of articles that addressed these settings. Indeed, application & evaluation, administration, clinical, and medical records settings respectively registered 53.7%, 47.9%, 59.3% and 56.9% of the total articles in the last four years compared to the publications in first 15 years!

Period	Application & Evaluation of IS	Administration	Clinical	Medical Records
1979-93	44 (46.3%)	37 (52.1%)	24 (40.7%)	25 (43.1%)
1994-97	51 (53.7%)	34 (47.9%)	35 (59.3%)	33 (56.9%)
Total	95	71	59	58

Objectives Pursued

Table 5 and Figure 5, show the distribution of MHT publications over the period 1979-97 classified according to the objectives accomplished. The most common objective pursued by MHT researchers was to make systems more cost-effective. A total of 105 articles (31.5%) primarily had cost-performance improvement as their core objective and another 27 (8.1%) had the same as a secondary objectives. In all, 39.6% articles addressed the cost issue as a primary or secondary goal of their research. Interestingly, 63 or 60% of the total cost-oriented articles were published in the last four years of this study, underscoring the need for cost-effectiveness in the

delivery of heath care. Strategic planning was the second most dominant objective of MHT research. It registered 87 or 26.1% of total articles. Improvement in quality of service was the third most pursued objective. While 57 or 17.1% articles set quality improvement as their primary objective, another 23 or 6.9% set quality improvement as their secondary goal. In all, 80 articles, or 24.0%, had improvement of healthcare service as their primary or secondary goal. Once again the quantity of articles seeking quality of care as their goal gained much momentum in the last four years, accounting for more than half of the articles in that category. The fourth most popular objective pursued by MHT authors within this study was development of DSS/ES/MIS. There were 53 papers or 15.9% in this category. .A point to note here is a natural comparison that readers may invoke between this category and the application/evaluation category of Table 4. (In this context it is noteworthy that the later category includes a larger set wherein evaluation of existing DSS/ES/MIS is also included.) As one would suspect most of these articles invoked the Creative Application category of Table 2.

The remaining two dimensions of competitiveness – agility and flexibility – were objectives of research pursued with relatively lesser frequency. Respectively, only 6.3% and 3.0% of the articles observed these as a primary objective of their research. Another 31 articles (15 with agility objective and 16 with flexibility as objective), i.e., 9.3% used agility or flexibility as their secondary objective.

All in all, we believe that these observations are consistent with the projections/ observations made by several researchers (Manus 1995, Ginn 1990, Rhea 1986, Veal 1994).

Choice of Operations Strategy

MHT researchers preferred the PTE (process, technology and equipment) choice of operations strategy within the systems classification over all the other choices. In all, 33.9% or 113 papers were published under the PTE choice (Table 6). The next choice operations strategy was information, which was indeed a non-strategic choice. These papers accounted for 74 or 22.2% of total articles. The next choice strategy within this classification was adaptive mechanism, which accounted for 46 papers or 13.8% articles. Clearly the high ranking of this choice signifies the interest among the providers to install modified or improved mechanisms of administration or technology. The third ranked choice in this classification was integration which included both internal (e.g., within the hospitals) and external (with the environment – e.g., physicians, customers, suppliers) integrations. This category included 44 or 13.2% MHT articles. Furthermore, as with the other classifications, we saw a burst of research publications in the final four years of study in this classification as well. In most prominent categories, approximately half the publications came in the last four years.

Hospital Decision Systems

Not surprisingly, most articles under this classification fell under fiscal-management category. A total of 45.6% or 152 articles were motivated by financial/cost considerations (see table 7, Figure 6). According to Ginn (1986) and others, PPS and the market dynamics dictated the activities of providers, during the eighties. This timeframe recorded a major dedication of effort to view hospital units and sub units (e.g., radiology) as cost centers/profit centers. This trend not only continued, but actually accelerated during the nineties when the customer (including

government) attention focused on cost even more strongly. The strategic/institutional category accounted for 109 or 32.7% articles and the medical category accounted for 72 or 21.6% articles. Once again, these observations are consistent with expectations.

INTERPRETATION/EXPLANATION OF FINDINGS

In this section, we provide further interpretation of the statistical findings of the previous section.

Trend of Publications

First, with respect to the finding that there was a significant spurt in MHT publications between 1994-97, it is worth repeating that this occurred due to a renewed national focus on Medicare costs in 1993. Just as the first burst in MHT research in mid-eighties can be associated with the prospective payment system that took effect during the Reagan administration, the burst in 1994 was a result of the prospect of a closer scrutiny of industry practices and the spawning and use of new healthcare technologies.

Research Strategy Used

In terms of the research strategies used, we noted earlier on that the Ripple strategy was used by a majority of researchers. The reason for this is that a large number of articles under study were either specific case studies that used minor variations of existing systems or were computer application enhancements built upon existing information systems/databases/ computer applications. For instance, a publication dealing with the use of Magnetic Resistance Imaging (MRI) in the first instance would constitute a Creative Application strategy but subsequent research that focused on the use of MRI were classified as Ripple.

There are three further observations that deserve a note. First, we did not find any article in the surveyed MHT literature that used statistical modeling as a primary strategy. Second, to the extent the dominance of ripple as a primary research vehicle is concerned, the MHT field has displayed a trend that is consistent with some OR/MS sub-areas. For instance, the percentage of papers using ripple as primary research strategy in Flowshop Scheduling, Cellular Manufacturing, and Game Theory is 71.8%, 56.6% and 47.9% respectively (Reisman et al. 1997c). Third, we found that a significantly higher proportion of articles employed structuring in this study compared to the other studies just mentioned. This was because a number of articles were devoted to generating a cross referencing lists of technologies, suppliers, or providers' capabilities, and networks which we found to be appropriately classified as a structuring effort in this area.

Application/Theory Content Rating Scale

However, as the table below shows, there is a proportionally higher increase in real-world Application papers (categories 3, 4, 5) than in Untested Theory papers (Theory + Application categories 1, 2). Whereas the real-world application papers accounted for 59.8% of all papers since 1994, which is a 19.6% increase over the percentage of application papers published up to 1994. On the other hand, the untested theory papers accounted for 56.1% of the total papers, which is a 12.2% increase. Looked at another way, the real-world application papers account for 28.6% of the articles since 1994, an increase of 3.1% from the period 1979-93. It can be concluded that MHT research has shown a trend of increasing real-world application content. – a welcome trend.

Period	Real-world Application (3, 4, 5)	Untested Theory (Theory + Application 1, 2)	Total[c]
1979-93	35 (40.2%)[a][25.5%][b]	102 (43.9%)[74.5%]	137
1994-97	52 (59.8%)[28.6%]	130 (56.1%)[71.4%]	182
Total	87	232	319

[a] Represents percentage of column total
[b] Represents percentage of row total
[c] Does not include Application papers classified in Meta Research and Philosophy/History

Although it may be a bit premature and statistically not entirely defensible, the authors believe that this trend underscores the health and vitality of MHT in years to come. Indeed, the application papers in the last four years exceed all application papers published during the all the previous years of the study (70 out of 127, i.e., 55.1%). The application-content findings are not only counterintuitive; they are intriguing and gratifying. Also, noteworthy is the fact that there were only 28 papers in meta-research or philosophy/ history category among theory and application papers surveyed in this study. We hope that more meta-research will be conducted in these categories in due time as the MHT field gains maturity.

In the application settings classifications (Table 4), the dominance of Application and Evaluation of information systems (28.5% or 95 papers) was expected since the pressure to improve service while maintaining accountability of the providers'/physicians' decisions can be best be addressed through meticulous information capturing and processing or knowledge-base/decision support/expert systems. Furthermore, the complexity and multiplicity of decisions involved requires a holistic/systemic approach to the issues, and knowledge-base/decision support/expert systems are ideal vehicles for effective decision-making under such conditions.

The next most popular setting in this area is Administration. Indeed, Information Systems and Administration settings combined account for about half of all the articles published in MHT. Furthermore, publications in these two settings have also registered a significant increase in the last four years (1994-97) of the study. This trend is exactly on the mark with respect to the projections made by Geisler and Heller (1998). They state, ". . . the trend of continuing adoptions of [administrative] innovations in medical information technologies is picking up pace and evolving into several diverse areas such as home care and telemedicine(p. 178). This trend is also consistent with what Geisler and Heller (1998, p. 178-9) call "Trend B" in healthcare delivery environment. Specifically, a part of Trend B stipulates that the structural changes in information technology have primarily occurred from "little, if any, automation in administration," to "initial applications of information technology in administrative functions". The surge of MHT research activity in this direction was expected as the use of computers allows them to add to their competitiveness via efficient management of finance, accounting, human resources (e.g., in assignments, schedules, and personnel), facilities, inventories, customer relations, patient records, and other information (Geisler and Heller 1998). Indeed, although not explicitly mentioned in any of the publications studied, it is precisely these functions that are performed most efficiently and effectively through the use of knowledge-based/expert systems. As will be further shown, the remaining projections in Geisler and Heller (1998) have also been substantially validated by our study.

Objectives Pursued

The most common objective pursued by MHT researchers is to make systems more cost-effective. This comes as no surprise since the cost of healthcare is the first and foremost criterion

of competition. According to Geisler and Heller (1998), "as the medical disciplines and healthcare professionals are forced by external pressures to get involved with organizational and economic issues of medical care (such as cost containment and managed care), medical technology becomes the crucial link between medicine and business." Indeed, the structural changes necessitated by cost containment pressures constituted the very basis for the wholesale rise of managed care institutions. The preeminence of the cost-effectiveness objective in MHT research is simply indicative of the fact that the healthcare industry, like many others, had to respond quickly and summarily to a number of external environmental changes such as the changing economic conditions, general awareness of the economic/financial weight of the healthcare system, free market ideology, role of government, demographics, and the industry's structural conditions (Geisler and Heller 1998, p. 184-5). Similar projections are made by many other experts (Manus 1995, Ginn 1990, Rhea 1986, Veal 1994) and confirmed by our study.

The second dominant objective of MHT research was strategic planning which accounted for 26.1% of the total articles. This finding is unique in that it contrasts the observations made by some healthcare experts in the context of strategic planning/management. For instance, Geisler and Heller (1998) write: "As an area of specific application for strategic management researchers, healthcare and healthcare delivery organizations – and in particular their medical technology processes – did not receive adequate interest in exploring how they are managed strategically. The difference in our finding and the observation made by Geisler and Heller (1998) may, however, lie in how the term is defined. We have defined the term strategic planning somewhat loosely – papers that did not fall under any other objectives (cost/quality/ flexibility/agility/ES-DSS) were also included under strategic planning so long as they contained

an element of system improvement. These papers may not be classified typically as strategy papers. With this caveat in mind, we believe that researchers are beginning to show greater interest in the area of strategic planning as it relates to healthcare and healthcare delivery organizations.

Improvement in quality of service was the third most pursued objective. Once again the articles that sought quality as their goal picked up substantial publication momentum during the last four years as they accounted for more than half the articles in that category.

Choice of Operations Strategy

MHT researchers preferred the PTE (process, technology and equipment) choice of operations strategy (113 papers or 33.9%) within the systems classification over all the other choices (Table 6). This is simply indicative of the fact that specific processes/technologies/procedures were increasingly being incorporated in the management and organization of healthcare systems. Given the pressure to reduce cost, and speed up recovery/care without impairing quality, the dominance of this strategy is consistent with expectations, since an adroit use of technology can best allow these conflicting objectives to be attained simultaneously. The next two choices of operations strategy – adaptive mechanism (46 papers or 13.8%) and integration (44 papers or 13.2%) which included both internal (e.g., within the hospitals) and external integration (with the environment – e.g., physicians, customers, suppliers) deserves further interpretation. The usage of the term integration here is in a narrow or elemental sense, that is, if a publication addressed a process, procedure or technology that would impact upon its internal or external functioning, it was considered an integration article. The finer guidelines for an article to be classified under

integration were borrowed from Geisler and Heller (1996, p. 197). To the extent these guidelines contained the elements that led to the broad types of integrations, the trend presented here are reflective of all types of integrations (Conrad and Dowling 1990, Robinson 1994, Conrad and Shortell 1996, Shortell and Hull 1996, Walston, Kimberly, and Burns 1996, Luke and Bugn 1996). Therefore, it can be concluded that MHT research publications have captured the trend in integration as it is occurring in the healthcare industry.

It should be noted that many of the articles classified under PTE, adaptive mechanism, and organizational structure and design were also integration articles but were placed in the above categories due to the preeminence in the article's content. Viewed in this context, articles that fell within the integration category will be the largest single category of articles, consistent with the projections. The low proportion (3%) of articles seeking quality as a primary objective was surprising. This perhaps can be explained by the fact that many articles seeking to improve quality as a strategic goal, were doing so through process, technology, or equipment, and were therefore classified under PTE. The same applies to several other categories, such as adaptive mechanism, external/integral integration, performance and rewards, and organizational structure and design.

Furthermore, as with the other classifications, we saw a burst of research publications in the final four years of study in this classification as well. In most prominent categories, approximately half the publications came in the last four years.

Hospital Decision Systems

Based on the discussion thus far, the dominance of fiscal-management among hospital decision systems is only to be expected. The fiscal issues such as life-cycle cost of facilities, cash and flow, cost of staffing, bottom line of operating expenses and the like became the very bases for designing and implementing hospital systems. Just as PPS and market dynamics dictated activities of providers during the eighties (Ginn 1986), resulting in a major dedication of effort to viewing hospital units and sub-units (e.g., radiology) as cost-centers/profit-centers, the trend not only continued but actually accelerated during the nineties when the customer (including government) attention focused on cost even more strongly.

SUMMARY AND CONCLUSIONS

The main objective of this study was to investigate the trends and directions taken by MHT research using a number of different schema/criteria. We classified the literature according to each of six specific schema:

1. Healthcare technology settings
2. Objectives pursued
3. Types of research strategy used
4. Application/ Theory content
5. Choice of operations strategy, and
6. Types of hospitals' decision systems.

The salient findings in these classifications were:

a. As many as 55% of the researchers employed "incremental" or ripple as their primary strategy of research.

b. Untested theory papers accounted for 69.7% of all publications.

c. Application and evaluation of information system was the theme of 28.5% papers

d. Improvement in cost performance was pursued as an objective by a total of 31.5% (39.6% if the papers using this category as secondary were included) of the publications

e. Process, Technology, and Equipment was the primary choice of operations strategy in 33.9% of articles, and

f. Fiscal-management was the leading hospital function in MHT publications.

The use of Ripple as dominant research strategy in MHT comes as no surprise; this is consistent with the trends established in previous studies undertaken by the authors (Reisman et al. 1997a, b, and c) in several OR/MS subdisciplines. However, the field of MHT performed significantly better (with the singular exception of game theory) in terms of the percentage of application papers published when compared with the above studies. We believe, and hope, that with the increasing use of clinical and administrative technologies and with projected trends towards greater degree of integration among the physicians and providers' networks through internet linkages, and proliferation of telemedicine and healthcare (Geisler and Heller 1998), the application content of MHT research will grow even faster than witnessed thus far. There is, however a disturbing though not an unexpected note. As can be seen from Figure 2, the rate of increase of papers using the Ripple strategy of research outpaces all the other strategies over the years. Though this is expected to happen as the field matures and the academic community

jumps on the band wagon let us hope that MHT does not suffer the same "devolutionary" or "inbreeding" consequences that were found to be the case in OR/MS (Reisman and Kirschnick 1994).

In terms of the objectives pursued by researchers, the spurt in publication activity at this point is largely confined to cost improvement. Further maturity will no doubt entail expansion of this focus to enhancing flexibility and agility in healthcare service. Drawing a parallel with other industries, specifically automotive, we believe that customization and speed will be the competitive battlegrounds during this period even as providers struggle to improve cost and quality performance of their service. This means that the field will give rise to progressively increasing expert/ knowledge-based systems that will enhance administrative and clinical efficiencies to provide an exhaustive vehicles for system-based financial decisions.

A singularly distinct upward trend was noticed in the research that chose integration as a primary objective. Among the external integrations, a significant upward trend was noticed specifically in two dimensions – vertical and virtual. Vertical integration research typically underscored the improved competitiveness available through the enhancement of the efficiency, better coordination of care across the board, better quality of value chain activities, and facility of one-stop shopping. Virtual integration research typically addressed the benefits and strategic advantages of information exchange (e.g., through internet) to obtain greater systemic or clinical efficiencies. The typical advantages underlying such integrations were consistent with Geisler and Heller (1998) – networking efficiencies, centralized clinical systems, and administrative innovations such as centralized patient records systems. The study did not find any significant

upward trend in horizontal integration – mergers leading to benefits of economies of scale were not reported in any noticeable number in the research.

Our results were equally telling in terms of the spurt in research activities in internal integration. Such research typically brought out the strategic benefits of incorporating new technologies, processes and procedures. (including information systems, data bases, patient record systems, and of course, hardware technologies).

What are the limitations of this work? Well, like any other study of this type, we may be limited in terms of the number of classifications explored. Yet, we believe that the six different sets of classifications presented here give a fairly exhaustive perspective of where the field is currently. From this we can better speculate as to where it is headed. Also, our data sources were limited. We have limited ourselves to academic/professional journal articles only; conference proceedings and doctoral dissertations were excluded as we assumed that high quality research will eventually see the daylight in academic/professional journals. Finally, many international journals were not included in our review since our focus was on the U.S. healthcare industry and the data sources were also limited in this respect.

Perhaps, the most salient observation worth the note here was the significant spurt in publication beginning in the year 1994. More than half the articles (187 out of 333 or 56.1%) were published in last four years compared to 43.9% in previous fifteen years. This gain in currency of healthcare could well have been triggered by the political climate that surfaced in 1993-94 when healthcare expenditure invited a major debate across the country. This observation also explains

the fact that the bulk of the effort was directed towards cost effectiveness and strategic planning on the part of the providers.

In terms of the future projections of MHT research, we believe that the current trends will continue in several respects, while they will change in others. First, we think that the increasing trend in application oriented research with a firm grounding in real-world would continue, indeed, may well pick up some acceleration as the providers gain more experience in handling technologies and the researchers begin to report such experiences. Second, the trend for cost cutting will continue, but taking a cue from other industries, we believe that healthcare technologies will be increasingly employed to obtain the competitive advantages in quality, customization, and speed. Naturally, the publications would shift gears in those areas. Third, the spurt currently observed in integration papers would not only continue, but pick up acceleration. The innovations in technology to obtain sustained competitive advantages will necessitate structural changes in the providers' systems, creating new avenues and needs for integration. Fourth, we believe that the fiscal management as the key vehicle for medical decisions will change in the wake of other attractive competitive priorities such as quality, customization, and speed. Finally, the need to attain varied and mutually contradictory objectives (price, quality, speed, and flexibility) will necessitate development of new knowledge-based softwares that yield optimal decisions in the face of numerous performance variables having complex trade-offs.

Also, the future researchers should be able to identify needed or under-represented research by using the six different classification schema of this paper and the numbers of papers published in each category over the years. (Reisman, 1988b). This can be done by seeking out those (joint) subsets of data presented in Tables 2 through 7 that have the lowest populations (papers

published). To do this exactly will of course require having the full database in hand. The authors are indeed willing to share their database with any one wishing to use it productively.

Irrespective of the issues and debate about the underlying dynamics of evolution of MHT, there is little question that the field has picked up significant acceleration in terms of activity as reflected by the number of publications. As indicated before, this underscores, in our view, the vitality and vibrancy of the field of MHT. This certainly is a welcome trend for a discipline that concerns and has a potential impact on one-seventh of the U.S. economy and more importantly, on the health status of this nation.

To conclude, in this paper, we analyzed the bulk of the recent MHT literature so as to reflect on what the field of MHT has been doing over the last 19 years, where it might be headed, and what directions might be appropriate for researchers and practitioners in the future.

REFERENCES

Auslander, G.K. 1992. "The Role of Computerized Information Systems in Quality Assurance in Hospital Social Work Department," Social Work in Healthcare, 18(1): 71.

Averill, R. and M. Kalison. 1986. "Present and Future: Predictions for the Healthcare Industry," Health Financial Management, March, 50-54.

Badawy, M. 1989. MOT: On Benchmarking a Discipline. The National Academy of Management, TIM Division Newsletter.

Bronzino, J. 1992. Management of Medical Technology. Butterworth-Heinemann, Boston.

Butters, S. and S. Eom. 1992. "Decision Support Systems in the Healthcare Industry," Journal of Systems Management, 43(6): 28-31.

Chun, C., Kumar, A., Motwani, J., Reisman, A. and M. Madan. 1998. "A Citation Analysis of the Technology and Innovation Management Journals," IEEE Transactions on Engineering Management, Forthcoming.

Conrad, D. and S., Shortell 1996. "Integrated Health Systems: Promise and Performance, Frontiers of Health Services Management, 13(1): 3-40.

Conrad, D., and W. Dowling. 1990. "Vertical Integration in Health Services: Theory and Managerial Implications," Health Care Management Review, 15(4): 9-22.

Fries, B. 1976. "Bibliography of Operations Research in Health Care Systems," Operations Research, 24: 801-814.

Fries, B. 1979. "Bibliography of Operations Research in Health Care Systems: An Update," Operations Research, 27(2): 408-419.

Geisler, E. and I. Heller. 1996. Managing Technology in Health Care, Kluwer Academic Publishers, Norwell, MA.

Geisler, E. and I. Heller. 1998. Management of Medical Technology: Theory, Practice and Cases, Kluwer Academic Publishers, Norwell, MA.

Giffi, V., Roth, A., and G. Seal (1990). Competing in World-Class Manufacturing: America's 21st Century Challenge," Richard D. Irwin, Inc., Homewood, IL.

Ginn, G. 1990. "Strategic Change in Hospitals: An Examination of the Response of the Acute Care Hospital to the Turbulent Environment of the 1980s," Health Services Research, 25(4): 565-591.

Greener, R., and E. Shortliffe. 1990. "Medical Infomatics: An Emerging Academic Discipline and Institutional Priority," Journal of the American Medical Association, 263(8): 1114-1120.

Greer, A. 1995. "Adoption of Medical Technology: The Hospital's Three Decision Systems," International Journal of Technology Assessment in Health Care, 1: 669-680.

Hayes, R. and R. Schmenner. 1978. "How Should You Organize Manufacturing?" Harvard Business Review, January-February, 107-108.

Hayes, R. and G. Pisano. 1996. "Manufacturing Strategy: At the Intersection of Two Paradigm Shifts," Production and Operations Management, 5(1): 25-41.

Heller, O. 1992. "The New Role of Chief Technology Officer in US Hospitals," International Journal of Technology Management, 7(6): 455-461.

Jacobsen, T., Schleyer, R., and R. Smith. 1992. "Better Planning Needed to Strengthen Patient-Care Systems," Computers in Healthcare, 13(10): 20-26.

Kettlelhut, M. 1992. "Strategic Requirements for IS in the Turbulent Healthcare Environment," Journal of Systems Management, 43(5): 6-9, 18.

Kiresuk, T.J., A. Smith and J. Cardillo. 1994. "Good Attainment Scaling: Applications, Theory and Measurement," Lawrence Erlbaum Associates, Publishers, Hillsdale, NJ.

Kotch, J., J. Veney, A. Kaluzny et al. 1994. "Performance-Based Management in Local Health Departments: Measuring the Success of Implementation," Journal of Medical Systems, 17(5): 317-325.

Law, K., H. Ip, and S. Chan. 1995. "An Investigation of a Cost-Effective Solution for Multimedia Medical Information Management," Information and Management, 28(6): 361-376.

Longo, D., Sohn, M. and S. Shortell. 1996. "The Etiology and Determinants of Hospital Closure," Journal of Health Care Finance, 22(3): 34-48.

Luke, R. and J. Begun. 1996. "Permeating Organization Boundaries: The Challenge of Integration in Healthcare," Frontiers of Health Services Management, 13(1): 46-49.

Mantas, J. 1992. "The Application of Advanced Information Technology in Medicine and Health Care: A European Approach," International Journal of Technology Management, 7(6): 560-571.

Manus, P. 1995. "Stephen M. Shortell, PhD: The Future of Integrated Systems," Healthcare Financial Management, 49(1): 24-29.

Modai, I., and A. Valevski. 1993. "Computerized Patient Information System in a Psychiatric Unit: Five Year Experience," Journal of Medical Systems, 17(5): 309-316.

Nelson, I. 1993. "Leading Change: The 90's Healthcare Challenge," Computers in Healthcare, 14(7): 30-33.

Pierskalla, W.P. and D. Wilson. 1989. "Review of Operations Research Improvement in Patient Care Delivery Systems," Unpublished Report of a Study Supported by a Grant #14200 from the Robert Wood Johnson Foundation.

Pierskalla, W.P. and D. Woods. 1988. "Computers in Hospital Management and Improvements in Patient Care: New Trends in United States," Journal of Medical Systems, 12(6): 411-428.

Reisman A. 1988a. "On Alternative Strategies for Doing Research in the Management and Social Sciences," IEEE Transactions on Engineering Management, 35(4): 215- 220.

Reisman, A. 1988b. "Finding Researchable Topics Via a Taxonomy of a Field of Knowledge" Operations Research Letters, 7(6): 295-301

Reisman A. 1996. "Management Technologies for Managing the Health Care Sector Technologies," in E. Geisler and O. Heller (Eds.), Managing Technology in Health Care, Kluwer Academic Publishers, Norwell, MA.

Reisman, A. 1994. "Technology Management: A Brief Review of the Last 40 Years and Some Thoughts on Its Future," IEEE Transactions on Engineering Management, 41(4): 342-346.

Reisman, A., A. Kumar, J. Motwani, and C.H. Cheng. 1997a. "Cellular Manufacturing: A Stastical Review of the Literature, 1965-1995," Operations Research, 45(4): 508-520.

Reisman, A., A. Kumar, and J. Motwani. 1997b. "Flow Shop Scheduling; A Statistical Review of the Literature, 1952-1995," IEEE Transactions on Engineering Management, 44(3): 316-329.

Reisman, A., A. Kumar, and J. Motwani. 1997c. "A Statistical Comparison of Research Strategies Pursued within Three OR/MS Subdisciplines and in OR/MS As a Whole," Working Paper.

Reisman, A., and F. Kirschnick. 1994. "The Devolution of OR/MS: Implications From a Statistical Content Analysis of Three Flagship Journals," Operations Research, 42(4): 577-588.

Reisman, A., and F. Kirschnick. 1995. "Research Strategies Used by OR/MS Workers As Shown by an Analysis of Papers in Flagship Journals," Operations Research, 43(5): 731-740.

Rhea, J. 1986. Long-term Improvement in Cost and Quality Within Hospitals," Hospitals & Health Services Administration, 31(4): 64-73.

Robinson, J. 1994. "The Changing Boundaries of the American Hospital," The Milbank Quarterly, 72(2); 259-275.

Roth, A., Johnson, S., and N. Short. 1996. 'Strategic Deployment of Technology in Hospitals: Evidence for Reengineering," in E. Geisler and O.Heller (Eds.), Managing Technology in Health Care, Kluwer Academic Publishers, Norwell, MA.

Rubenstein, A.H., E. Geisler, et al. 1994. "Factors Influencing the Adoption of Clinical Information Technologies in Health Care Organizations," Proceedings of the Fourth International Conference on Management of Technology, February 27-March 4, Miami, FL, 1248-1259.

Shortell, 1988. "The Evolution of Hospital Systems; Unfulfilled Promises and Self-fulfilling Prophesies," Medical Care Review, 45(2): 177-214.

Shortell, S. 1985. "High-Performing Healthcare Organizations," Hospital & Health Services Administration, July/August, 7-35.

Shortell, S. and K. Hull. 1996. "The New Organization of Health Care-Managed Care/Integrated Health Systems," in Strategic Choices for a Changing Healthcare System, edited by S. Altman and U. Reinhardt, Chicago: Health Administration Press.

Simpson, R. 1995. "Trends in Health Care Computing According to CIOs" Nursing Management, 26(8): 20-21.

Smith, L. 1996. "Preparing for Healthcare in the Next Century," Health Management Technology, 17(10); 15-18+.

Swamidass, P. 1986. "Manufacturing Strategy: Its Assessment and Practice." Journal of Operations Management, August, 471-484.

Tan, M. 1997. "Turning in for Treatment: Telemedicine Brings Opportunities and Risks," Risk Management, 44(4): 46-52.

Veal, T.1994. "High-tech Ways to Reduce Insurance Claims Overpayments," Compensation & Benefits Management, 10(4): 19-23.

Walston, S. J. Kimberly, and L. Burns. 1996. "Owned Vertical Integration and Health Care: Promise and Performance," Health Care Management Review, 21(1): 83-92.

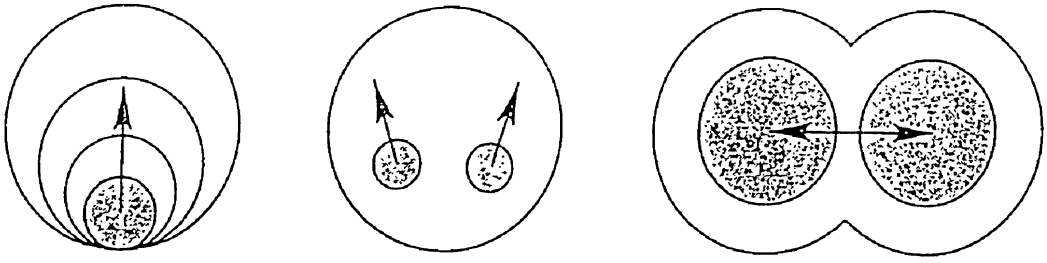
Woolhandler, S. and D.U. Himmelstein. 1991. "The Deteriorating Administrative Efficiency of the U.S. Health Care System." New England Journal of Medicine, 324: 1253-1258.

Table 1: List of Top Ten MHT Journals Based on Total Number of Publications (1979-97)*

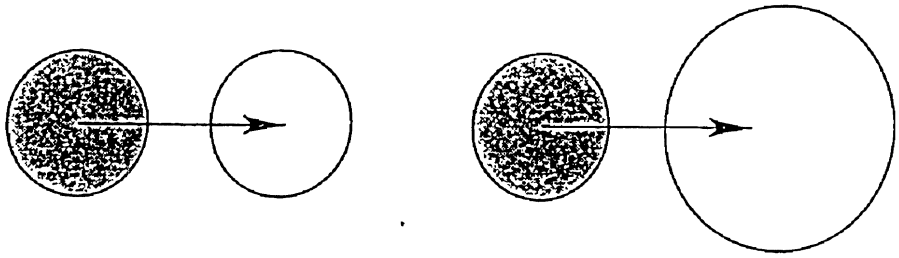
Journal Name	Rank	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	Total
Health Management Technology**	1																21	23	25	17	86
Healthcare Financial Management	2	1			1	5	3	2	2	3	3	3	2	4	3	5	7	4	8	7	63
Computers in Healthcare**	1							3	6	3	2	4	1	6	9	12					46
Healthcare Forum	3							1	1	2	1	2	1	4	2	1	1	1	3	3	23
Modern Healthcare	4							1				2		1		2	2	2	3	2	15
Frontier of Health Services Management	5									1	1	1	2	1	1	1	1	1	2	2	14
Healthcare Executive	6													4	1		2	1	1	1	10
Managed Healthcare	7																1	1	2	5	9
Nursing Management	8														2	4	1	1		1	9
Hospital & Health Services Administration	9							2								1				2	5
Medical Marketing & Media	10																1	1		2	4

* Total of forty-seven journals were identified for data collection.

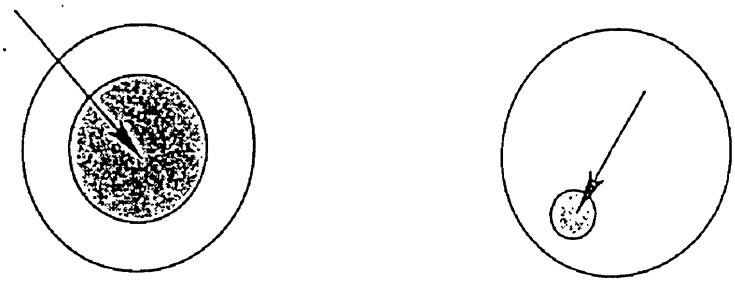
** Computers in Healthcare was published as Health Management Technology Journal after 1994



(1) The ripple process (2) The embedding process (3) The bridging process



(4) The transfer of technology process (5) The creative application process



(6) The structuring process (7) The statistical modeling process

Figure 1: The seven categories of research processes.
The shaded areas represent available knowledge based on past research.
The unshaded areas represent new knowledge encompassed by the new research.

Table 2: Classification of MHT Papers Based on Research Strategy Used

Year	Total No. of Papers	Ripple		Embedding		Bridging		Trans. of Tech.		Creative Applic.		Structuring		Stat. Modeling	
		P*	S**	P	S	P	S	P	S	P	S	P	S	P	S
1979	1							1							
1980	0														
1981	0														
1982	1	1													
1983	5	1				2		2							
1984	5	3	1			1				1	1				
1985	9	5	1			1	2	1		2	2				
1986	9	4	2			2	1	2	1	1					
1987	9	5	2		1	1		1	1	2			1		
1988	8	5				1		1		1					
1989	13	9	2	1			1	1	2	1		1			
1990	10	8	1	1				1							
1991	20	15		1		1		2		1					
1992	28	18	1	1		3		3		2	1	1			
1993	28	18		1		1		3	1	4		1			
1994	43	27	3			4	1	3		5	1	4	1		
1995	40	22	1	1		4		5	1	4		4	1		
1996	51	20	1	4		8	1	9	1	9		1			
1997	53	22	1	2		4		7	2	16	2	2			
Total No. of Papers in Each Classification (P or S)	333 (P only)	183	16	12	1	33	6	42	9	49	7	14	3	0	0
% of Total Papers in Each Classification	100.0 (P only)	55.0	4.8	3.6	0.3	9.9	1.8	12.6	2.7	14.7	2.1	4.2	0.9	0.0	0.0
Total No. of Classifications Under Each Strategy (P+S)	375 (P+S)	199		13		39		51		56		17		0	
% of Classification Under Each Strategy (P+S)	100 (P+S)	53.1		3.5		10.4		13.6		14.9		4.5		0.0	

*P = Primary Strategy **S = Secondary Strategy

Figure 2: Trends of Research Strategies Used in MHT Papers (1979-97)

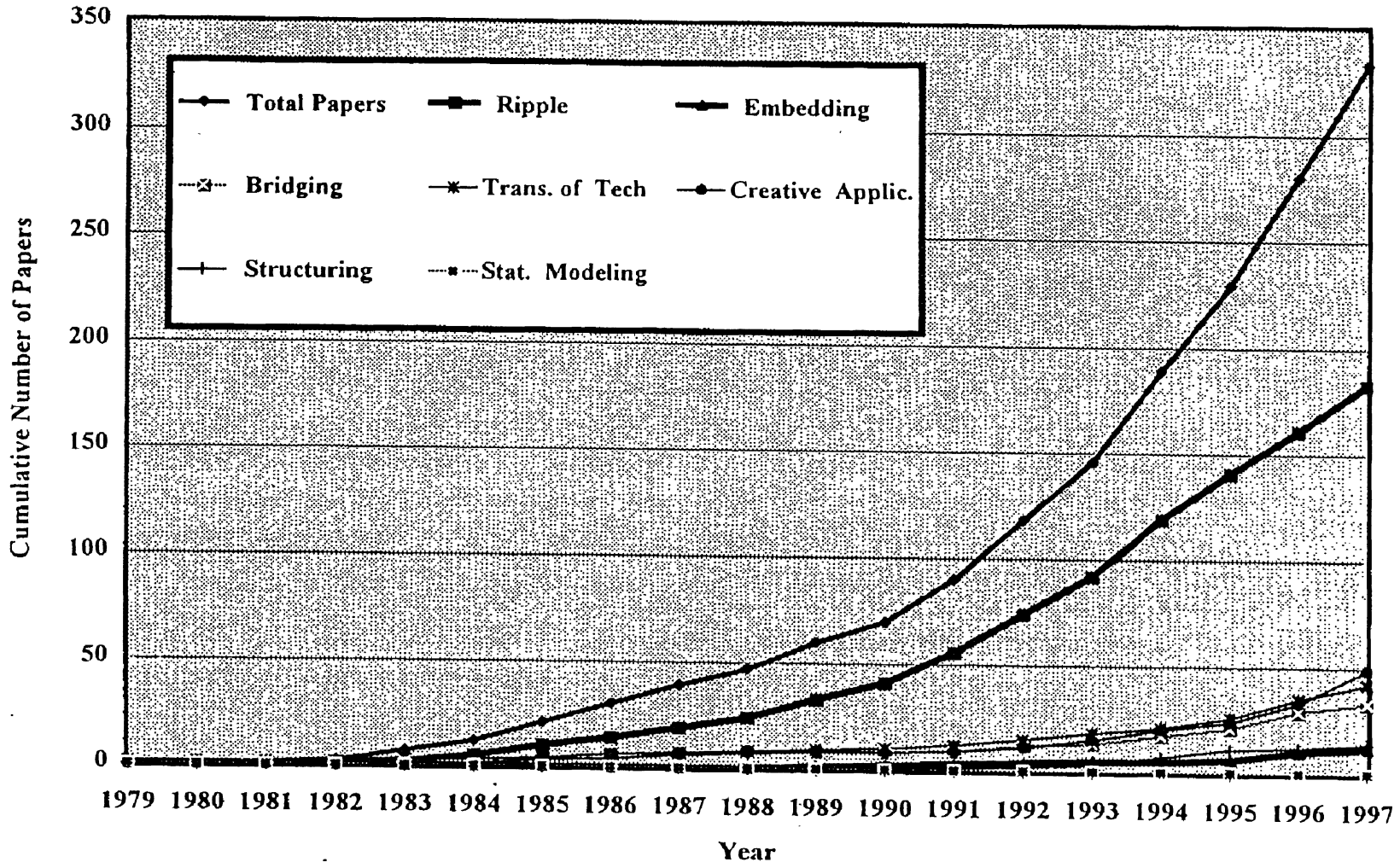


Table 3: Classification of MHT Papers Based on Application/Theory Content

Year	Total No. of Papers	Applications									Theory							
		Category					Meta Research		Philosophy/ History		Pure		Synthetic Data		Meta Research		Philosophy/ History	
		1	2	3	4	5	P*	S**	P	S	P	S	P	S	P	S	P	S
1979	1		1															
1980	0																	
1981	0																	
1982	1						1											
1983	5	1		1	3													
1984	5		2		1		1						1					
1985	9		3	1	1						4							
1986	9				4		1	1	1		2		1					
1987	9	1		1	3						3		1					
1988	8				1		1				5				1			
1989	13		1	1	2						8		1					
1990	10			1					1		7		1					
1991	20	2	1	2	1		2				11		1					
1992	28	1				1	1				20	1	2		2	1	1	
1993	28			2	5	4					16		1					
1994	43		1	5	6	5	1				21				3	1	1	
1995	40	2	3	4	3	2	3	1			20	1	2			1	1	
1996	51		3	3	3	2	1				35		2		2	1		
1997	53	2	2	5	10	4					25		2		3			
Total No. of Papers in Each Classification (P or S)	333 (P Only)	9	17	26	43	18	12	2	2	0	177	2	15	0	11	4	3	0
Percentage of Total No. of Papers in Each Classification (Based on 333 Papers)	100% (P Only)	2.7	5.1	7.8	12.9	5.4	3.6	0.6	0.6	0.0	53.2	0.6	4.5	0.0	3.3	1.2	0.9	0.0
Total No. of Classifications Under Each Strategy (P+S)	341 (P+S)	113					14		2		179		15		15		3	
Percentage of Classifications in Each Category (Based on 341 Papers)	100% (P+S)	33.1					4.1		0.6		52.5		4.4		4.4		0.9	
Percentage of Classifications in Application/ Theory Categories (Based on 333 Papers)	100% (P Only)	38.1									61.9							

*P = Primary, **S = Secondary

Figure 3: Trends of Application/Theory Content in MHT Papers (1979-97)

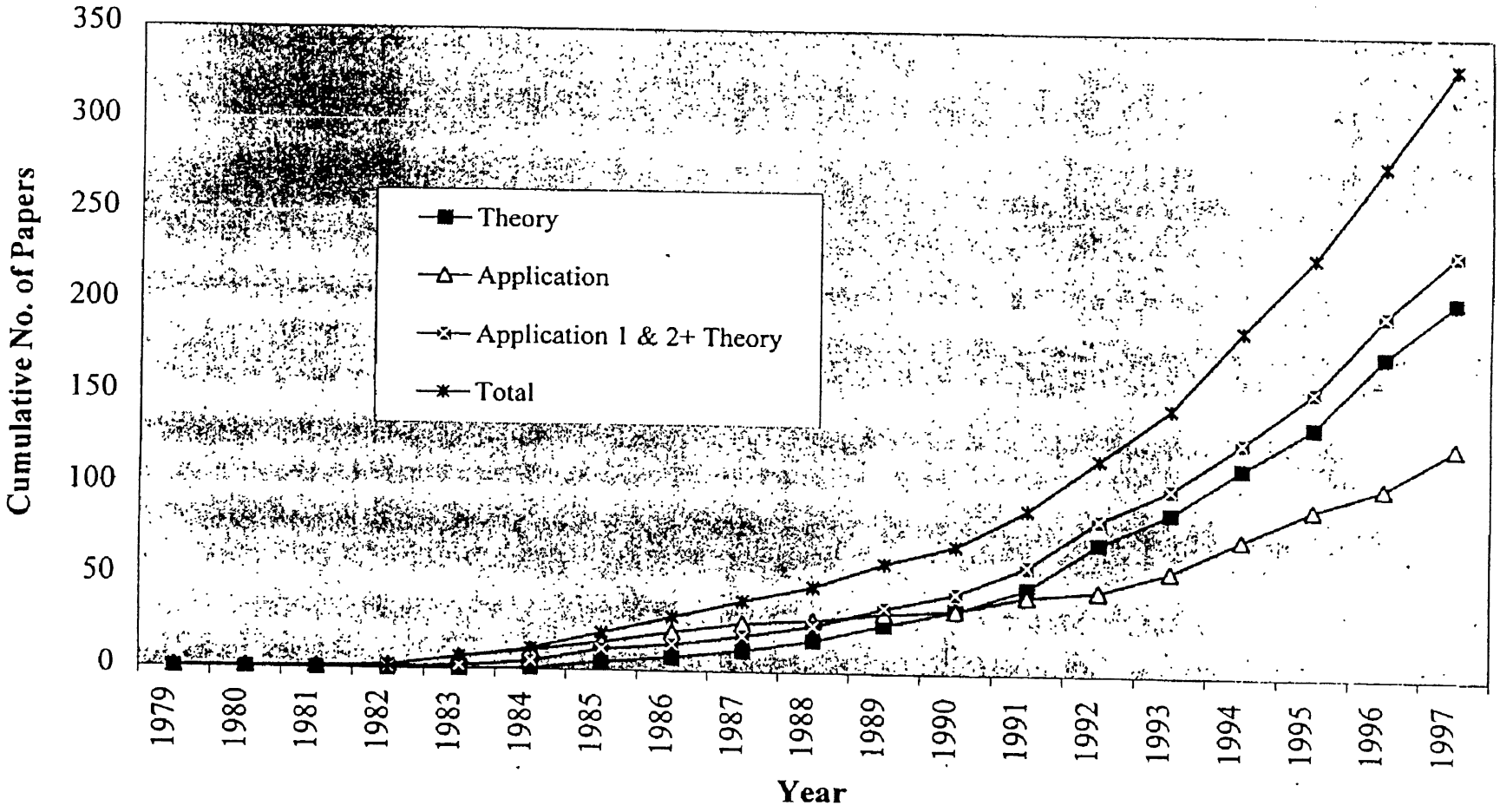


Figure 4: Trends in MHT Publications Based on Application Settings (1979-97)

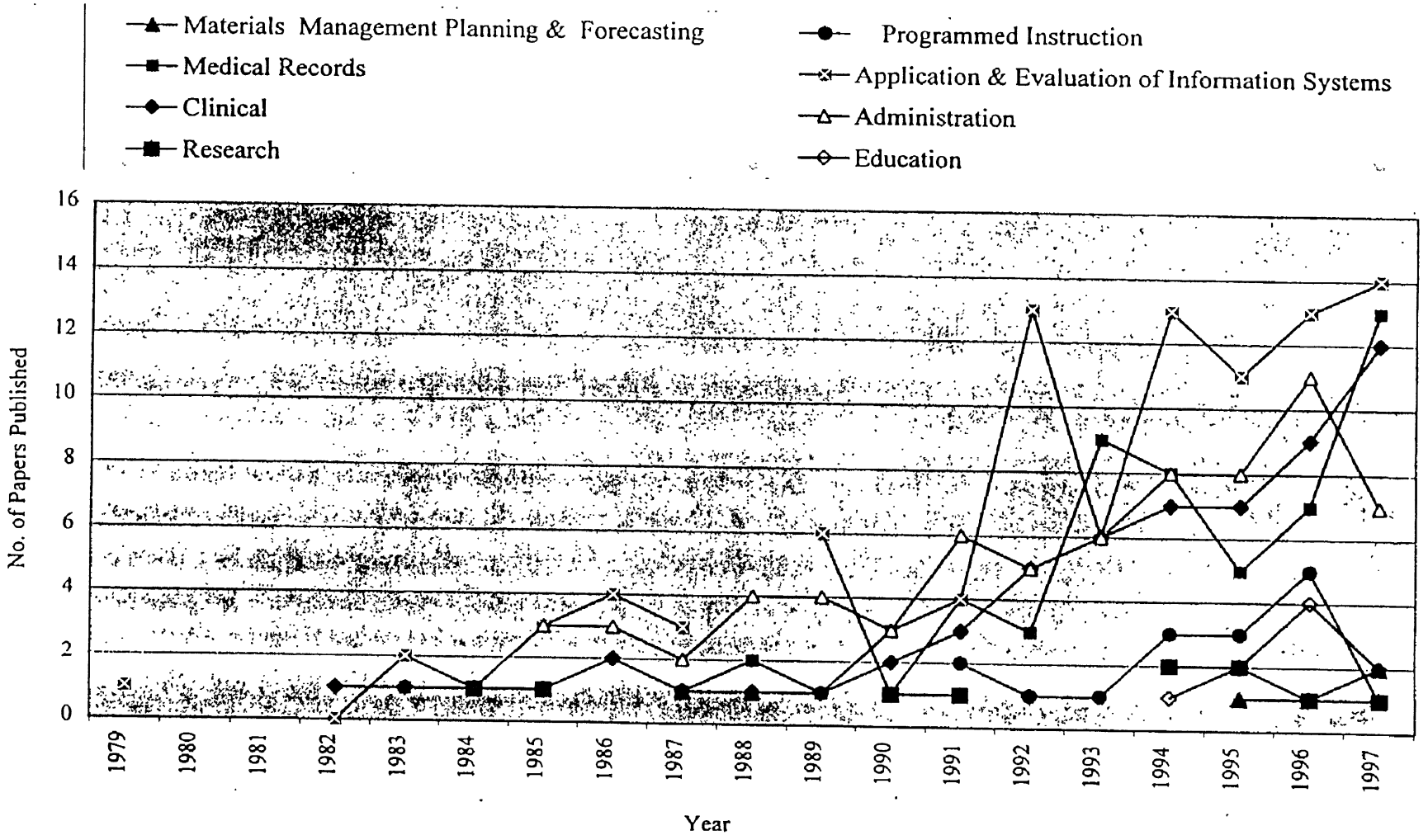


Table 5: Classification of MHT Papers Based on Objectives Pursued

Year	Total Number of Papers	Improvement in								Strategic Planning		Development of DSS/ES/MIS	
		Cost Performance		Quality of Service		Agility		Flexibility					
		P*	S**	P	S	P	S	P	S	P	S	P	S
1979	1											1	
1980	0												
1981	0												
1982	1									1			
1983	5	1		1					1	2		1	
1984	5	3				1	2		1			1	
1985	9	3	1	1		1	1		2	2		2	
1986	9	1	3	1	1				2	5		2	2
1987	9	3	1	2	1	1	1		2	2	1	1	
1988	8	3			2		2			2		3	
1989	13	2	2		2					5		6	
1990	10	5	1	1	1			2	1	1		1	
1991	20	6	3	6	2	1	2		2	5	2	2	
1992	28	7	4	4	2	2	2		2	11	2	4	
1993	28	8	2	2	4	3	2			10		5	
1994	43	16	3	7	3	2				11	2	7	
1995	40	12	2	9	2	3	1	2		6	4	8	1
1996	51	15	4	15	1	3	2	3	1	10		5	1
1997	53	20	1	8	2	4		3	2	14		4	1
Total	333	105	27	57	23	21	15	10	16	87	11	53	5
Percent	100.0	31.5	8.1	17.1	6.9	6.3	4.5	3.0	4.8	26.1	3.3	15.9	1.5

*P = Primary, ** S = Secondary

Figure 5: Trends of Objectives Pursued in MHT Publications (1979-97)

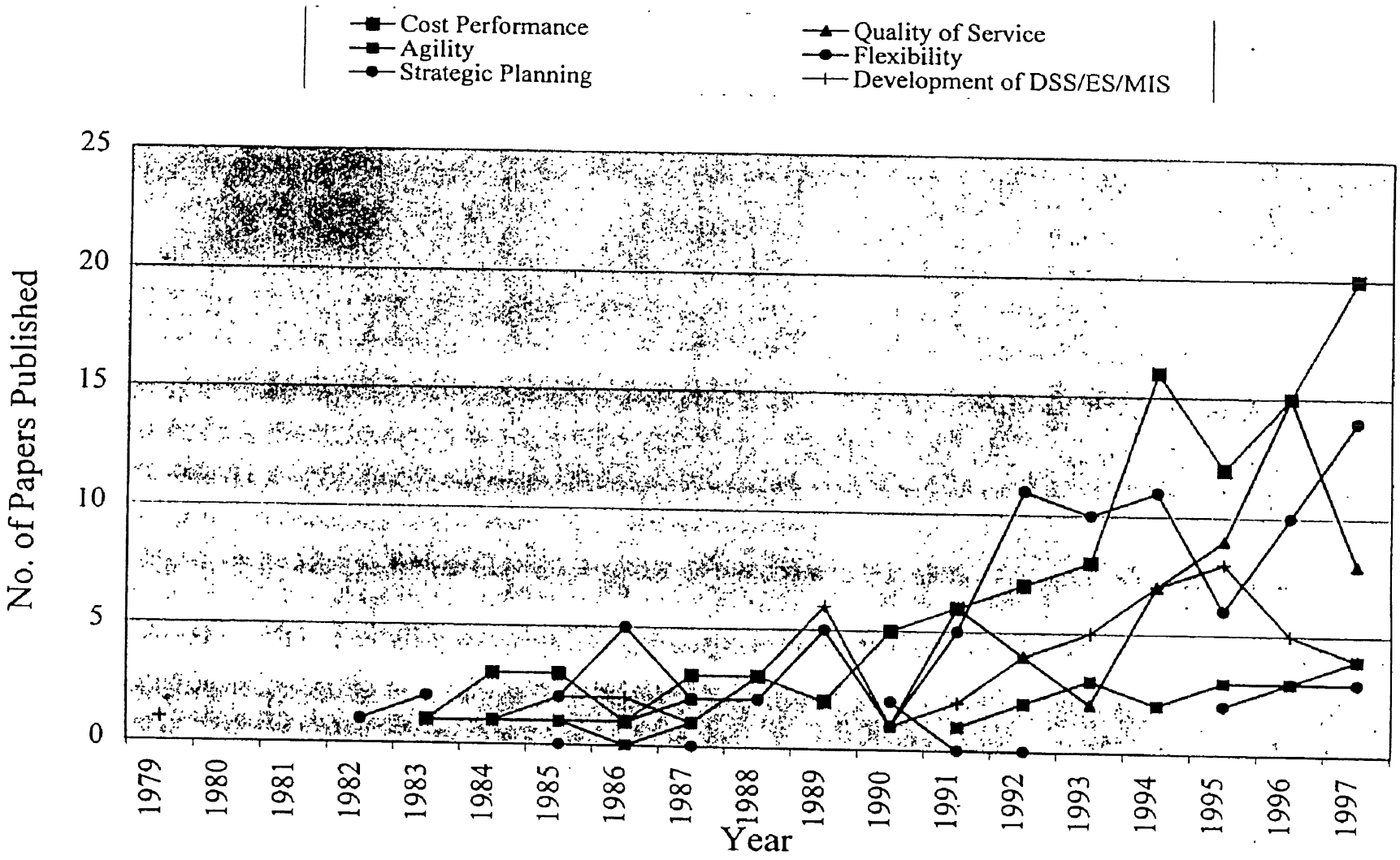


Table 6: Classification of MHT Papers Based on Choice of Operations Strategy

		Systems					Infrastructural						Integration	
Year	Total No. of Papers	Facilities & Logistics	Capacity	Process, Tech & Equt.	Vertical Integration	Material	Information	Human Resources	Quality	PPC	Performance & Rewards	Orgn. Str., & Design	Internal and/ or External	Adaptive Mechanisms
1979	1												1	
1980	0													
1981	0													
1982	1													1
1983	5	1								1	1			2
1984	5	1		2								1		1
1985	9			4								3	1	1
1986	9			5	1							1		2
1987	9			7									2	
1988	8			5								1	2	
1989	13			4			2			1	2		4	
1990	10			2		1	5						2	
1991	20			6	1		3	1	5			1	3	
1992	28			6			10					1	4	7
1993	28			11			6					3	3	5
1994	43			13			15		1			2	5	7
1995	40	1		16	1	1	9	3	1			2	4	2
1996	51			17		1	10	1	3	1		3	6	9
1997	53	1		15	1		14	1				5	7	9
Total	333	4	0	113	4	3	74	6	10	3	3	23	44	46
Percent	100.0	1.2	0.0	33.9	1.2	0.9	22.2	1.8	3.0	0.9	0.9	6.9	13.2	13.8

Figure 6: Trends of MHT Papers Based on Hospital Decision System (1979-97)

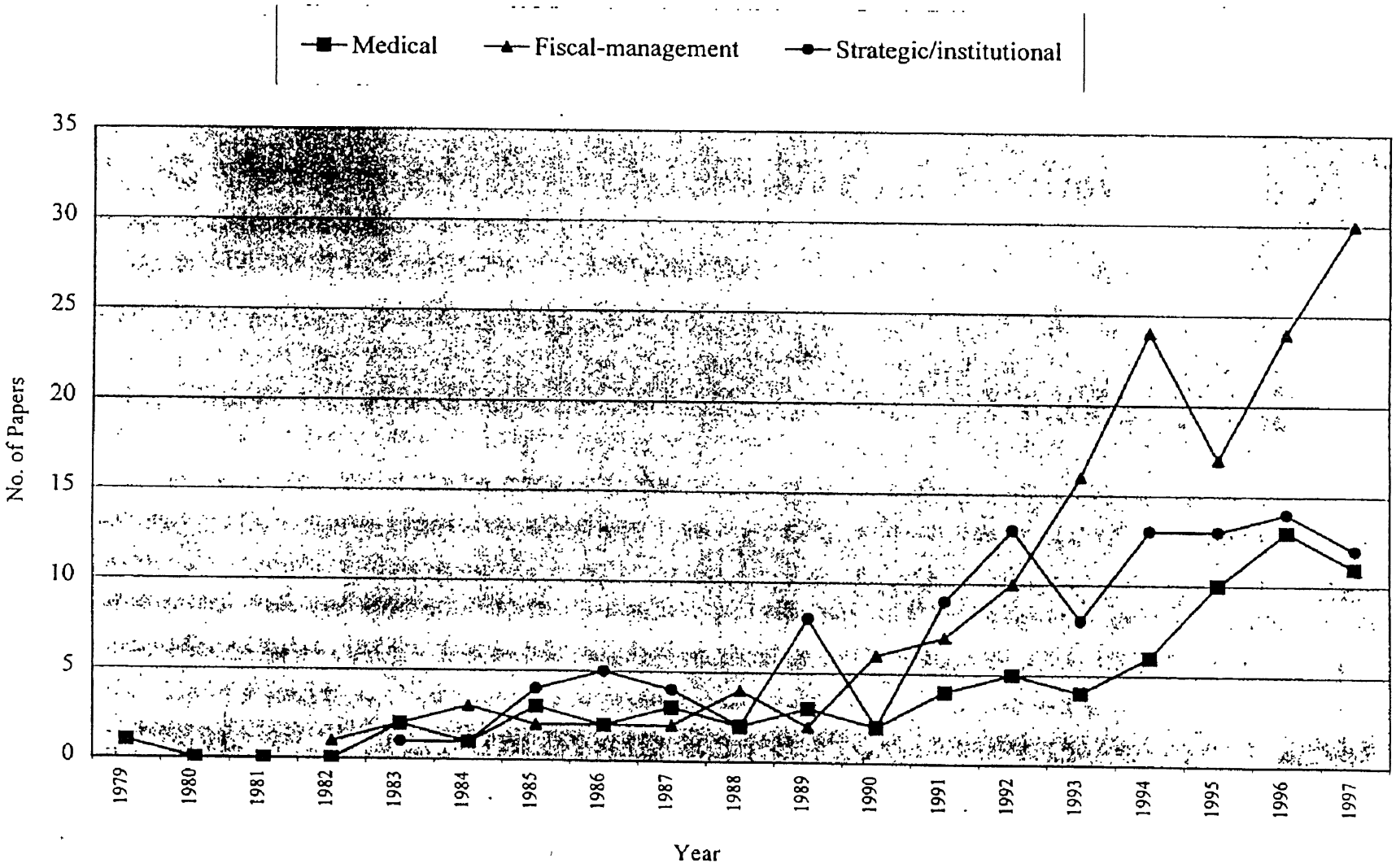


Table 7: Classification of MHT Papers Based on Type of Hospital Decision System

Year	Total No. of Papers	Medical	Fiscal-management	Strategic/institutional
1979	1	1		
1980	0			
1981	0			
1982	1		1	
1983	5	2	2	1
1984	5	1	3	1
1985	9	3	2	4
1986	9	2	2	5
1987	9	3	2	4
1988	8	2	4	2
1989	13	3	2	8
1990	10	2	6	2
1991	20	4	7	9
1992	28	5	10	13
1993	28	4	16	8
1994	43	6	24	13
1995	40	10	17	13
1996	51	13	24	14
1997	53	11	30	12
Total	333	72	152	109
Percent	100	21.6	45.6	32.7

Table A1: List of MHT Journals (1979-97)[a]

Journal Name	Rank	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	Total	Percent
Business & Health	23																			1	1	0.3
Chief Information Officer Journal	24															1					1	0.3
Compensation & Benefits Management	12												1				2				3	0.9
Computer and Communications Decisions	25									1											1	0.3
Computer Reseller News	26																1				1	0.3
Computers in Healthcare**	3							3	6	3	2	4	1	6	9	12					46	13.8
Computerworld	14																1			1	2	0.6
European Journal of Operational Research	27											1									1	0.3
Facilities Design & Management	28																			1	1	0.3
Financial World	29						1														1	0.3
Food Management	30																			1	1	0.3
Frontier of Health Services Management	6									1	1	1	2	1	1	1	1	1	2	2	14	4.2
Health Care Supervisor	31																		1		1	0.3
Health Management Technology**	1																21	23	25	17	86	25.8
Health Services Research	32												1								1	0.3
Healthcare Executive	7													4	1		2	1	1	1	10	3.0
Healthcare Financial Management	2	1			1	5	3	2	2	3	3	3	2	4	3	5	7	4	8	7	63	18.9
Healthcare Forum	4							1	1	2	1	2	1	4	2	1	1	1	3	3	23	6.9
Hospital & Health Services Administration	19							2								1				2	5	1.5
Hospital Financial Management	33														1						1	0.3
Hospital Material Management Quarterly	34						1														1	0.3
Hospitals	15														2						2	0.6
Hospitals & Health Networks	35																	1			1	0.3
I/S Analyzer Case Studies	16																	2			2	0.6
IEEE Transaction on Engineering Managem	36														1						1	0.3
Information & Management	37														1						1	0.3
Information Strategy: The Executive's Jour	38															1					1	0.3
Informationweek	39																		1		1	0.3
Insurance & Technology	13														1				1	1	3	0.9
International Journal of Technology Manage	40																			1	1	0.3
Journal of Database Management	41																		1		1	0.3
Journal of Systems Management	17														2						2	0.6
Managed Healthcare	8																1	1	2	5	9	2.7
Management Accounting	42																		1		1	0.3
Management Review	18														1				1		2	0.6
Medical Marketing & Media	11																1	1		2	4	1.2
Modern Healthcare	5							1				2		1		2	2	2	3	2	15	4.5
Modern Office Technology	43												1								1	0.3
National Real Estate Investor	44																1				1	0.3
Nursing Management	9														2	4	1	1		1	9	2.7
Research Technology Management	45																			1	1	0.3
Reseller Management	19																			2	2	0.6
Risk Management	46																			1	1	0.3
Sloan Management Review	20														1					1	2	0.6
Software Magazine	21												1							1	2	0.6
Systems Management	22																1	1			2	0.6
Training	47																	1			1	0.3
Total No. of Papers		1	0	0	1	5	5	9	9	9	8	13	10	20	25	28	43	40	51	53	330	100
Percentage of Papers		0.3	0	0	0.3	1.5	1.5	2.7	2.7	2.7	2.4	3.9	3	6	8.4	8.4	13	12	15	16	100	
Year		79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	Total	

** Computers in Healthcare was published as Health Management Technology Journal after 1994