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Epidemiology and Health Services Administration: Future Relationships in Practice and Education

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IN 1862, A RATHER INTENSE GENTLEWOMAN, Miss Florence Nightingale, in directing her considerable energies to the importance of gathering information on the quality of hospital care, suggested that hospitals adopt her uniform classification of diseases and operations, thus assuring the practice that a standard set of statistics would be gathered on each hospitalized patient. Among the elements of her proposed data set were: diagnosis; operation (if any); complications; age; sex; occupation; date of admission to hospital; and date of discharge or death.

> With fixed data, arrived at on these principles, we can readily obtain the proportionate mortality, not only of the whole hospital, but of every ward of it, and also the proportionate mortality and duration of cases for each age, sex, and disease.
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> These methods, if generally used, would enable us to ascertain the mortality in different hospitals, as well as from different diseases and injuries at the same time and at different ages, the relative frequency of different diseases and injuries among the classes which enter hospitals in different countries, and in different districts in the same country. They would enable us to ascertain how much of each year of life is wasted by illness,—what diseases and ages press most heavily on the resources of particular hospitals.

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> The laws which regulate diseased action would become better known, the results of particular methods of treatment, as well as of special operations, would be better ascertained than they are at present. As regards their sanitary conditions, hospitals might be compared with hospitals and wards with wards. The whole question of hospital economics as influenced by diets, medicines, comforts, could be brought under examination and discussion.
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> They would show subscribers [hospital board members] how their money was being spent, what amount of good was really being done with it, or whether the money was not doing mischief rather than good. They would enable us, besides, to ascertain the influences of the hospital . . . upon the general course of operations and diseases passing through its wards; and the truth thus ascertained would enable us to save life and suffering, and to improve the treatment and management of the sick and poor. (Nightingale, 1863)

What Miss Nightingale was attempting to do was to transfer her evaluative model from the Scutari Hospital in Turkey to those hospitals treating the civilian population in London. She was able, with mortality statistics in the former instance, to assess what her biographer, E. T. Cook, refers to as the "most complete experiment ever made in army hygiene" (Cook, 1914: 315) with a few dramatic figures:

> We had [she pointed out] during the first seven months of the Crimean campaign a mortality among the troops at the rate of sixty percent per annum in disease alone, a rate of mortality which exceeds that of the great plague in London. We had during the last six months of the war a mortality among our sick not much more than among our healthy guards at home, and a mortality among our troops in the last five months, two-thirds only of what it is among our troops at home. (Cook, 1914: 314).

She ran into immediate difficulties, however, in her attempts to compare mortality measurements across hospitals in London. In a letter to William Farr, dated 1857, she states: "There are some differences between hospitals which, however, can be explained by some taking in worse cases than others" (Cope, 1958: 98). It was just this problem that she hoped to address with her standard classification of diseases, which was based on Farr's tables of mortality and formally presented to the International Statistical Congress in the summer of 1860.

Although Miss Nightingale was able to gain some temporary acceptance of her "forms," as she called them, from a few London hospitals, including St. Thomas's and St. Bartholomew's (Cook, 1914: 431), her work and the conceptual model behind it died within her lifetime. Some mention of it appears in the literature. For example, although Burdett mentioned Miss Nightingale only as a nurse, he used her approach to demonstrate that cottage hospitals had a lower death rate for amputation than did larger London hospitals (Burdett, 1880). Greenwood made several slighting remarks about her methodology, but admitted that, had Miss Nightingale's plan been adopted, "much might have been learned which we still do not know," and blamed the fact that it was not accepted on the lack of enthusiasm that all clinicians have toward "doing sums." He pointed out: "Now [1947], there is good reason to believe that hospital statistics will really be utilized scientifically on a nationwide scale not quite a century after Miss Nightingale made the suggestion" (Greenwood, 1948: 99–100).

A more recent expression of Greenwood's estimation, albeit in an economic frame, appears in a paper presented by the King Edward's Fund: "Only if such information is available, will it be possible to establish the cost effectiveness of particular units of activity, to cost alternative strategies for achieving outcomes, and to reexamine priorities for expenditures" (King Edward's Hospital Fund for London, 1973: 22). Miss Nightingale wrote of this need for recording data in 1860; Greenwood's book was published in 1948; and by 1978 no one as yet has realized any of Miss Nightingale's objectives.

Despite the very real problem that hospitalized patients are not a random sample of the total population, and that they do not (with possible exceptions, such as newborn deliveries in Connecticut) represent a complete sample of the population affected by any condition, it is maintained that much can be learned from a nation- or area-wide analysis of hospital statistics. Systematic data on the cost, quality, and utilization of this most expensive medical resource are essential to the analysis of the contribution of the hospital to the general well-being of the population through its effect on intervention in selected diseases.

The uniqueness of Miss Nightingale's message is that her writings explicitly and clearly address four aspects of health planning and management as specific objectives:

1. The determination of the quality of care delivered to individual patients can and should be aggregated properly (by diagnosis) to obtain measurements of performance for various patient subsets in a single institution as well as within the institution over time.
2. The analytic frame should be extended to the level of inter-institutional comparisons and specific treatment evaluation across institutions.
3. An attempt should be made to relate hospital morbidity to specific populations served by the hospitals.
4. Assessment of the quality of care should be linked with utilization of hospital resources and the costs of treatment, both in a cost-effective manner and in a cost-benefit analysis, to determine whether hospitals have saved lives and suffering and improved the treatment and management of the sick and poor.

Epidemiology and Health Services Administration

What Miss Nightingale did not have at hand were statistics that combined the medical records with some estimate of resources consumed, in order to link the cost and outcome of treating patients. Nor did she possess the ability to relate the incidence of hospitalization to a defined population. The first step in such an approach is the creation of a system to close the diagnosis-resource use link. The second, once this system is adopted by a sufficient number of hospitals within a defined catchment area, is to relate these statistics to the population of those same areas.

This paper concentrates on the first aspect of the problem and, therefore, deals with the cost, quality, and cost-effective side of the equation, leaving the cost-benefit effect of the hospital on the general health of the community for a later application. Although epidemiologists would be expected to be interested primarily in the second phase, there is need for the application of their skills in the first phase as well. Even cost-effective measurements are important to populations. Lack of cost effectiveness results in a waste of resources which, given a finite limit to such resources, means that some other program may not obtain enough money or manpower to make a more beneficial contribution to the health of the community.

Education in Epidemiology and Management

Of prime importance is that the current generation of health planners and administrators be trained to accept the epidemiological approach as an analytic framework within which problems can be defined and solutions fashioned. It follows, then, that the evaluation of both plans and results must be subjected to rigorous testing by the specific application of epidemiological standards. The relationship between epidemiology and the planning and management of health institutions and programs is held to be the unique characteristic of health services administration—that which separates it from the generic fields of organization and management.

The principal thesis of this paper is that planning, management, and evaluation, without quality control, cost analysis, or the measurement of the effect of medical intervention on the natural history of diseases and the incidence and prevalence of that disease, lack both epidemiological rigor and practical relevance. If health services planning, management, and evaluation are not so examined, all three will deteriorate into a political process as unrelated to their avowed purposes as a Miss Universe popularity contest. In carrying this out several fundamental problems must be addressed. First is the development, validation, and application of a practical, medically meaningful, descriptive and analytical model that is statistically stable. The model must also present alternative uses for resources in a fashion that enables community and administrative decisions to be based on realistic health assessments of the region.

The main impediment in the teaching of epidemiology to health services administrators (and to the eventual inclusion of epidemiological concepts in management) is its seeming irrelevance. Despite attempts to demonstrate its application to planning and monitoring health services at various levels, epidemiology seems far from the administrator's quest for the ultimate indicator, the fiscal "bottom line." In some ways, this attitude reflects a discomfort on the part of health services administrators—although this may seem a paradox—with any aspect of medical science. Whether this discomfort is the result of a guild-directed exclusion on the part of physicians or merely the inability of administrators to grasp the complexity of medical practice is beside the point. The basic problem is that the administrator's bottom line is seen as "cost," and he or she has few ways to measure precisely the effect of medical practice on the cost of delivering medical care. It is not surprising, then, that the administrator or planner has failed to utilize any part of medical science to help in understanding that relationship. Until a model or theory is developed that explicates the interdependence of selected medical and administrative services, it will be impossible to manage or plan health services in a manner acceptable to both medical and administrative practitioners.

The key to operational rapprochement is contained in the phrase, "medically meaningful," since the model must be understood by physicians and reflect both validated medical practice patterns and the probable prevalence of the health problem in the community. The development and teaching of such a model requires much more medical and epidemiological input than have the previous geographic, money flow, or political management approaches. This new blend of planning, management, and medical and epidemiological skills will be required and must be developed for the immediate future.

A second problem facing an integrated approach will be the derivation of a control model sensitive enough to monitor the operational aspects of the system and to detect changes in the diagnostic mix patterns that might reflect changes in the natural history of a disease. For example, the model should be able to detect the unexplained decrease in the incidence of perforated duodenal ulcers in one hospitalized population (Greco and Cahow, 1974). "Control" is used here in the statistical sense of comparability, not in the regulatory sense (although, indeed, these statistical control techniques may later serve as a basis for regulation of the individual institution or a set of institutions within a region or state).

Control or surveillance, in the meaning stated above, is based on a body of theory developed in industrial quality control. There it is assumed that the level of resources consumed by each production process is determined by a set of underlying causes related to the characteristics of the product. Furthermore, this cause system is fundamentally stable insofar as the costs of producing the product do not fluctuate widely. Changes in the behavior of such statistics can be detected and used to signal changes in the underlying cause system.

To apply these concepts to hospitals, where the products are the treatment of patients with similar conditions, and the cause system is the way physicians treat patients with these conditions, a complete understanding of the resources consumed in these treatment processes must be mastered. It is, therefore, necessary to associate output statistics with meaningful definitions of the treatment process.

In a hospital setting, such an approach to cost control would be the classification of patients into groups according to their consumption of resources, assuring that the patients are clustered into medically meaningful classes, such as diagnosis, complication, specific surgical procedures, age, and sex. If resource expenditures identified by such classification were shown to be stable, then rational budgets might be constructed. They would be based on the expected number of patients in each class and on the anticipated resources consumed by each class. As the budget period advanced, deviations from the expected levels of resource consumption could be identified and explained on the basis of: 1) differences in the number of cases actually treated; 2) differences in the treatment process; 3) differences in the price of these resources; or 4) interactive differences in all three. In this way, *control over expenditures* for inpatient care could be attained. A potential for *quality control* is also inherent in this approach, since one is dealing with medical treatment *processes* as well as *outcomes*. An extension of the model enables one to compare diagnostic and treatment processes in terms other than cost, *i.e.*, adherence to accepted criteria of quality of care.

Lest one sees herein a plea for another hyphenated epidemiology, such as fiscal-epidemiology or administrative-epidemiology, to join the list of hyphenated terms that includes social-epidemiology or non-infectious-epidemiology, let us dispel that idea. What is considered here is the increased importance of a body of knowledge to the basic understanding of a set of problems. These problems may be stated in financial terms or in terms of the consumption of other kinds of resources. In either event, they must be viewed in terms of a defined population; thus, the basic constructs of the epidemiological method are present, *i.e.*, population and health states.

Epidemiology may be defined operationally as the study of events that affect the health of populations. The underlying approach of applied epidemiology is to determine the relationship between cause (the event) and effect (changes in the health of the population). The method entails a careful delineation of the life history of the event and a meticulous definition of the population at risk, in order that any causality may be validly tested or inferred.

The objectives of applied epidemiology are usually the prevention, containment, or eradication of the events resulting in a negative change in a population's health. To choose from among competing sub-objectives, and between prevention, containment, and eradication, many positive and negative factors must be estimated. One of the positive factors must be the trade-off between the monetary costs of the program and the savings to the population from that program. More attention, therefore, must be paid to the specific effect of intervention on the health of the population, but this is in no way a redefinition of the science as it is described in *Epidemiology as a Fundamental Science* (White and Henderson, 1976: 235) or as it is applied by Cochrane (1973). Indeed, it was pointed out in *Higher Education for Public Health* that

> Recently, epidemiology has been recognized to be crucial to the planning and evaluation of medical care and other health programs because of the contribution it can make to the development of methods for program surveillance in such terms as who is being reached with what kinds of services, with what kind of quality, and with what outcomes. (Milbank Memorial Fund Commission, 1976: 62)

This paper, echoing Florence Nightingale, would add "at what cost."

The AUTOGRP Model

An approach to the determination of "who is being reached with what kinds of hospital services" is the Automatic Grouping (AUTOGRP) model,[1] through the classification of groups of patients with similar medical conditions who utilize similar resources during a single hospital inpatient stay. We will review one type of analysis using this approach to illustrate the questions that will arise where the particular skill sets and concepts of epidemiology may contribute to the generation of answers. In addition, these same data, in a more mature stage of development, may be used for epidemiological studies of various kinds.

Ideally, such a categorization of patients should respond to four different characteristics: 1) the number of categories must be

[1] An interactive computer program that classifies patients by resource use.

manageable; 2) they must make medical sense; 3) they must be relevant to the parameters under discussion (*i.e.*, cost or resource utilization); and 4) they must be statistically stable (*i.e.*, correspond to the characteristics of those frequency distributions for which reasonable measures of central tendencies can be estimated and, more important, where aberrant behavior from these distributions can be identified). Further elaboration of these characteristics and the application of the AUTOGRP logic to one diagnostic set is contained in the Appendix of this paper.

The Medicare Study

To test whether some of Miss Nightingale's objectives could be achieved by the AUTOGRP approach, the hospitalization experience of a specific subgroup (persons eligible for Medicare) of the total population within a limited geographic area (Connecticut) was examined for the fiscal year 1971–72. Medicare patient data, the Medicare Analysis of Days of Care (MADOC) tapes, for 34 Connecticut hospitals[2] were grouped into the Diagnosis Related Groups (DRGs) as in the Appendix, but were extended in order to "cost" each group, as well as to determine the length of hospital stay. The MADOC tapes contain the discharge abstracts and the itemized bills of 20% of the Medicare patients.

Because of the specific age groupings of Medicare patients, many of the 383 DRGs (for example, those involved with maternity and newborn care) used in classifying the total patient population contain no values. The Medicare hospital population can be described by 198 DRGs. The diagnosis used in malignant neoplasm of the prostate (see Appendix) is well represented among Medicare patients. When "costs" are derived from the patients' bills, through cost analysis and the establishment of ratios of costs to charges for each of the categories on the itemized bill, one can examine the costs and kinds of resources consumed in the treatment of these different groups as well.

Table 1 presents these data on our illustrative groups with a total of 308 patients. Although the data were drawn from an older

[2]One hospital, that of the University of Connecticut, was not included since it was in the process of opening and, consequently, treated only a few Medicare patients during this period.

TABLE 1
Costs Per Patient Treated for Cancer of the Prostate:
34 Connecticut Hospitals

Cost Item (in dollars)	All Patients & All Treatments	Type of Treatment Received by Patients: No Surgery	Cystoscopy & Orchidectomy	Transurethral Resection: Age <78 (Yrs)	Transurethral Resection: Age 78+ (Yrs)	Suprapubic and Perineal Prostatectomy
Total Cost	**$1246.45**	**$1054.71**	**$957.60**	**$1468.02**	**$1664.85**	**$2447.50**
Room cost	744.78	730.99	542.37	822.32	944.33	1217.20
Total ancillary cost	501.67	323.72	415.23	645.70	720.51	1230.30
Intensive care unit	16.18	1.33	3.21	28.57	42.41	65.00
Operating room	107.97	15.99	113.81	176.50	186.90	291.70
Drugs	57.94	52.63	32.74	73.95	72.69	131.20
Laboratory	126.59	113.89	97.41	141.77	148.28	268.00
Radiology	86.74	85.84	83.06	92.00	91.23	114.10
Supplies	48.64	36.15	28.79	63.50	70.85	165.70
Other	57.60	17.90	56.20	69.41	98.15	194.60
No. of patients	**308**	**106**	**80**	**62**	**48**	**12**
Hosp. stay (days)	**11.78**	**11.37**	**8.44**	**13.04**	**15.82**	**19.10**
Death rate (%)	**8.44**	**19.81**	**1.25**	**0.00**	**6.25**	**8.33**

Source: Adapted from Youngsoo Shin, M.D. *Cost Variation Among Hospital and Product "Heterogeneity."* Doctoral Dissertation, May, 1977. New Haven, Conn: Yale University School of Medicine, Department of Epidemiology and Public Health. Data based on a 20% sample of all Medicare patients discharged from 34 short-term general hospitals in Connecticut during 1971–72.

segment of the population and from 34 hospitals, the lengths of stay were markedly similar in each treatment category to those of a more extensive data set only from Yale-New Haven Hospital appearing in the Appendix. The DRG specific death rates are quite different among the treatment groups, suggesting evidence of the validity of these designations as well as the sensitivity of a possible quality indicator. The resources used in treating the patients differ both in their value and in the mix of ancillary services used during hospitalization. The limited sample size, due to the fact that the data represent only one-fifth of the hospital experience of this over-65 population, precludes inter-hospital comparisons of individual DRGs on the utilization of resources, the cost of treatment, and the one quality indicator of DRG specific death rates.

It was possible to compare each hospital's total performance over all DRGs with the average performance of all hospitals, however, and thus arrive at an institutional performance index for each hospital on these three parameters. These indices are expressions of the hospital's actual death rate, length of stay, or cost divided by the expected values derived from the analysis of the data from all hospitals. Since both the actual and expected values are aggregated from the lengths of stay, cost, and death rates of each DRG, the indices are corrected for differences in diagnostic mix. There were marked differences among hospitals in all three indices.

Although application of the findings is not yet indicated, due to the limitations of the data base, the range of these indices indicates the future promise of the analytic approach. The aggregated average experience for all hospitals was set at 1.000 for each of the three parameters. The diagnosis-related death rate index across the 34 hospitals varied from a high of 1.426 to a low of 0.660. When the experience in diagnosis-related length of stay was reviewed, the index varied from 1.186 to 0.880. Total costs per case corrected for diagnostic mix varied from 0.789 to 1.202. In other words, when these data are corrected for the mix of Medicare patients, the death rate was 76.6% higher in one hospital than in another; these patients stayed 30.6% longer in one hospital than in another, and it cost 41.3% more to treat these patients in one hospital when compared to another.

These variations indicate that the 34 hospitals studied (all accredited by the Joint Commission on Accreditation of Hospitals) exhibit substantial differences in the effectiveness with which they deliver care to their communities. The implications of these differences on the health and economics of these communities are certainly important areas of future studies for epidemiologists and health services administrators.

Future Research Applications

The ability to: 1) consider a hospital's performance in terms of the kinds of patients it treats; and 2) compare this performance with that of other hospitals, having corrected for differences between them due to diagnostic mix, implies that a whole range of problems can now be examined. We can now solve Miss Nightingale's problem of comparing hospitals, even though some take in "worse cases than others." This approach then permits the balance of her objectives of determining the cost effectiveness and benefit of hospital services to be studied with some rigor.

One such application at the individual hospital level would be to evaluate that institution's actual performance with that of a projected cost and quality budget. The hospital is assumed to be a multiproduct firm, processing some 383 diagnosis-related "products," each of which will require certain sets of resources and will result in an anticipated number of "improved" discharges. The AUTOGRP technique permits the institution to project the probable outcomes of cost, days, and mortality based on its historic DRG treatment data. This, then, becomes a "product" budget. At the close of the budget year, the actual and projected values can be compared. Differences in all three areas can then be identified and examined. In the cost area, the data can be subjected to variance analysis by each DRG to determine how much of these differences between actual and projected costs was due to volume changes, *i.e.*, more or fewer patients being treated than had been anticipated. It may be that these cost differences were due to real differences in the cost of treating all cases in that DRG, or due to an interaction between volume and case cost. A comparison of actual and projected deaths and lengths of stay would more likely reflect differences in the way patients were being treated rather than changes in the relative volume of cases.

One such comparison (Fetter, 1977) has recently been completed for a two-year period at a major teaching hospital. Although inferences must be limited by time and site constraints, some of the findings are of considerable interest. Since planners and epidemiologists would be primarily interested in differences in the volume of cases, and would be particularly concerned with unit cost differences when they are of a magnitude that might indicate changes in the ways such diseases are being treated, these two aspects of the data are considered. The important characteristic of volume is its relative stability across DRGs over two years. For example, in 256 groups, or 5% of all groups, patients treated reflected a plus or minus volume change of less than 10 patients. More than 85% of the DRGs fell between a positive or negative volume change of less than 20.

The significant findings about costs is the relative sensitivity of total institutional costs to the number of cases treated within a few selected DRGs. Patients within 12 DRGs with case costs above $5000 numbered 1144 out of 35,739 patients treated (3.2%); they accounted for 20% of the total hospital expenditures incurred in the second year.

Extremely high volume changes were noted in several DRGs, for example, in internal injuries among patients over the age of 41, while unit cost charges were high enough in several selected cardiac surgery procedures to make one suspect new methods are being employed in the diagnosis and/or treatment of these cases.

We do not know how to interpret all of these findings, although for some, the reasons are fairly obvious. For example, of the 16 DRGs with an absolute volume change of 50 or more patients, half of them related to birth or infancy. Most of these changes were in the direction of being under expected volume, except caesarians, which were over the anticipated load.

Two extensions of the DRG approach are now under development. The first is the development of an ambulatory care application. This is of major importance since examination of the inpatient experience suggests that there is a substantial shift in the locus of treatment for some of the DRGs from inpatient to outpatient sites of various types. The bulk of outpatient services is not, however, so diagnosis-bound as suggested by the experience previously related in the inpatient setting. The logic of the approach is similar, however (*i.e.*, the application of AUTOGRP in the classification of patients into groups using similar resources—in this case the resource of physicians' time and the use of less complex ancillary services). Preliminary studies have already indicated that one of the most costly services a prepaid group practice can deliver to its subscribers is the annual physical examination. In a prepaid practice, a cost-benefit analysis of such practices is then central to the financial viability of the plan.

The next developmental step in adapting the DRG approach is the extension of this methodology into program and community planning. When one examines the existing methodologies, particularly in the latter case, one is struck by the overly simplistic and arbitrary view of the conceptual base required for valid planning. The projection of DRGs into community planning is, in some ways, a more direct application of its basic logic than the ambulatory effort in that it is a problem of proper aggregation of meaningful service statistics with a clear identification of the population at risk.

Implications in the Curriculum for Health Services Administrators

It is in posing questions about these volume and cost differences over time, in exploring the possible reasons for these findings, and in applying the DRG model to ambulatory care and planning that epidemiological theory will find a vehicle for presentation to students in health services administration. Epidemiology will no longer be considered merely a fascinating, though irrelevant, mental exercise in medical detection, nor will the epidemiologist be considered a person in charge of infections. Linking the prevalence of hospitalized disease to the planning and budgeting process at the institutional level not only mandates the teaching of epidemiology to health services administrators, but enables them to use routinely some of the complex approaches to planning suggested by, among others, Luck, Luckman, Smith et al. (1971), thus permitting health institutions to become more responsive to the needs of the population in their service areas.

Since the linkage between populations, the prevalence of treated disease, the medical aspects of that treatment, and the resources consumed by it is an approach used to solve multiple health services problems, the systems model describing these interrelationships appears in many parts of the curriculum. It is first mentioned in the public health "core" along with basic epidemiology. The logic of the approach and specific analytic techniques employing the model are introduced in a specific series of sessions within a quantitative analysis course. Specific aspects of these interrelationships appear in courses in institutional administration, health planning, utilization and quality review, and financial management. Several cases are now under development to illustrate the application of this analytical approach to various management and public policy problems in health services administration. This teaching approach does not envision, then, an expansion of existing basic epidemiology courses; instead, the above content will be in lieu of such an option. Many will feel that one cannot teach the "new" without teaching more of the "old." That remains to be proven. We feel that basic epidemiology, its logic and techniques, can be taught within this framework as well as by descriptions of disease incidence and prevalence in the Faeroe Islands or urban slums.

If these developmental objectives are achieved and used in the educational preparation of present and future health services administrators, we believe the application will follow. Then, we have a reasonable chance of carrying out Miss Nightingale's objectives and, as White and Henderson stated (1976, ix), moving one identifiable step toward realizing " . . . the potential contribution of quantitative approaches to the problems of allocating finite resources with the objective of improving the public's health."

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Appendix:

AUTOGRP Model: Application to Yale-New Haven Hospital Data Set

The AUTOGRP analysis of hospital case mix attempts to classify that mix into DRGs that satisfy the following criteria: 1) the number of categories must be manageable; 2) they must make medical sense; 3) they must be relevant to those areas under discussion, such as cost or resource utilization; and 4) they must be statistically stable.

The manageability of the number of such indicators of mix, when committed to some kind of medically rational categorization based upon diagnosis, can be difficult since there are 3622 diagnoses coded in the "Classification of Diseases and Injuries" section in the HICDA-2 (*Hospital Adaptation of the International Classification of Diseases Adapted for Use in the United States,* 2nd edition). If certain other patient characteristics are to be considered, such as the presence of selected medical procedures or complications and age of patient, an unmanageable number of categories will result. The inapplicability of this model in the designation of a diagnostic mix of the individual institution is obvious. In many hospitals there would be so many categories in some of these groups with zero or small number values that any kind of measurement for a comparative or monitoring model based on this large number of categories simply would not prove valuable over a single year's experience.

Medical rationality is a constraint to assure that the diagnostic definitions are related to the types and kinds of clinical specialty areas within which each group is treated. It makes little difference that patients undergoing dilatation and curettage (D&C), full mouth extractions, tonsillectomies and adenoidectomies (T&A), and possibly hemorrhoidectomies stay in the hospital for approximately the same length of time and utilize about the same kinds and amounts of hospital resources, such as laboratory, operating room, and recovery room time. Physicians cannot group these diagnoses in any meaningful way, since four entirely different surgical specialties are involved in the treatment of such patients.

Since this model is primarily concerned with the kinds and types of resources used in the treatment of these different mixes of patients and the cost of these resources, any classification of the total number of patients treated by the hospital must certainly use as its dependent variable some measure of this resource use. Research at Yale indicates that the most sensitive of these resource uses is length of stay. The entire spectrum of diagnoses is first analyzed by different patterns in these lengths of stay. Further testing on other resource use parameters, such as costs of radiology tests, laboratory tests, or operating room time, can then be approached rather than used as the primary dependent variable. Previous research indicates that there is a very close relationship between the length of stay and the dollar value of these resources utilized per day in hospital once a meaningful classification on clinical attributes has been attained.

It is in the statistical definition of the Diagnosis Related Groups that the AUTOGRP model differs from other approaches aimed at defining diagnostic mix and the cost and quality implications of that mix (Mills, Fetter, Riedel et al., 1976). The data base for such a definition is the combined medical abstract and the patient's bill (Fetter, Thompson, and Mills, 1976). The abstract can be a PAS (Professional Activities Service), HUP (Hospital Utilization Program), or specially designed form that includes coded diagnoses, operative procedures, and selected non-medical characteristics. The patient's bill, in many acceptable formats, contains the details of resource use by types and quantity of services received by the patients.

The logic of this approach is to decrease the variance in the distribution of resources by partitioning the patients into groups depending solely (within the constraints of medical practice patterns) on the history of the resources used in treating these patients. To illustrate this process, the analysis of one diagnostic set from Yale-New Haven Hospital, carcinoma of the prostate, is presented. This diagnosis is one of the initial categories used that spans the entire ICDA (*International Classification of Diseases Adapted for Use in the United States*) or HICDA. The partitioning was based on three years of data, including some 80% of patients discharged with this primary diagnosis during the three-year period.

The first treatment of the data identifies and sets aside those 14 patients who died during their stay. These patients and the 4.9% death rate are discussed in the body of this paper where they are considered in the derivation of DRG-specific death rates, the first quality measurement.

The 273 remaining cases are then examined using AUTOGRP, and appear at the top of Fig. A-1 with an average length of stay of 14.29 days and a standard deviation of 10.2 days. The AUTOGRP program reported that the largest reduction of that variation would occur if the total cases were partitioned on whether or not surgery was performed during the hospital stay. The first branch on Fig. A-1 demonstrates the two frequency distributions then obtained. The 61 non-surgery (NS) patients had a significantly shorter hospital stay of 11.62 days (SD of 7.9 days) than the 212 patients who received surgery, with an average length of stay (ALOS) of

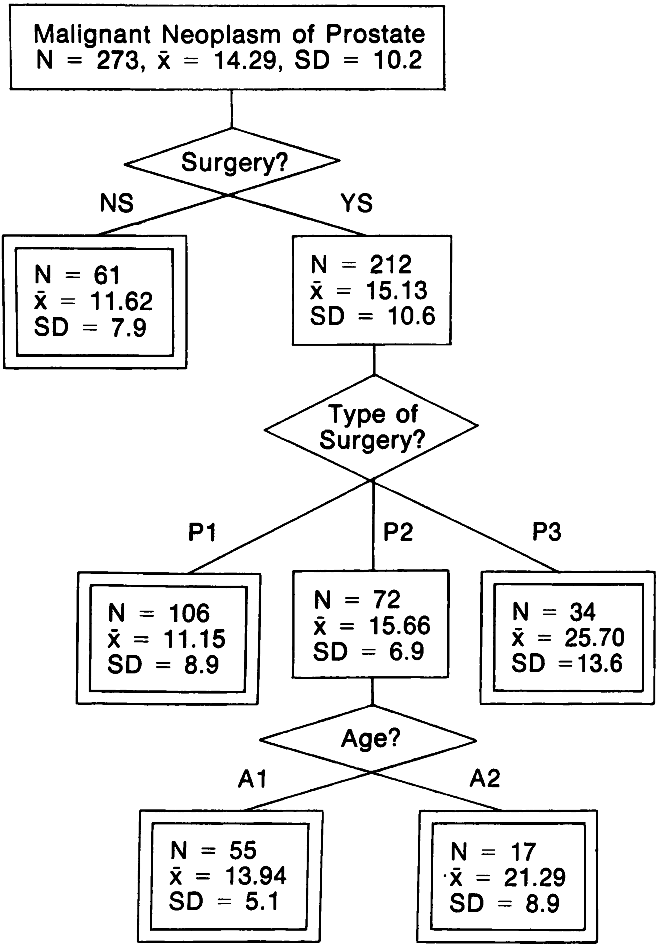
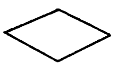


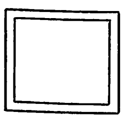
FIG. A-1. Generation of Five Diagnosis-Related Groups Utilizing AUTOGRP Method from Patients with Malignant Neoplasm of Prostate.

15.13 days (SD of 10.6 days). The non-surgical group was examined further, but little was found in either specific medical complications or the age breakdown of these patients which would significantly reduce the variance in length of stay. Consequently, these patients were categorized as a terminal group, one of 383 such groups describing a hospital's output.

The surgical group (see second branch in Fig. A-1) did, however, break down into three sub-categories depending upon the type of surgery. Patients who underwent cystoscopies and orchidectomies used, on the average, 11.15 days of hospital care, while the transurethral prostatectomy patients stayed

1. Unit = length of Stay
2. Data Base = Patients with malignant neoplasm of prostate (ICDA8 Code: 185) discharged from Yale-New Haven Hospital during the years of 1972, 1973, and 1974
3.  : Initial or Intermediate Groups

    : Selected Variable in AUTOGRP Process

    : Terminal Diagnosis Related Groups
4. NS = Absence of Surgery

   YS = Presence of Surgery

   P1 = Cystoscopy, Orchidectomy, or Biopsy of Male Genital Organs

   P2 = Transurethral Prostatectomy

   P3 = Suprapubic Prostatectomy or Other Prostatectomy

   A1 = Age 77 yrs and Below

   A2 = Age 78 yrs and Above

FIG. A-1. (*Continued*). Explanation of abbreviations and symbols to the diagram at left.

15.66 days in the hospital; and the average length of stay for suprapubic and perineal prostatectomy patients was 25.70 days. The first and third of these groups were also selected as terminal designations, while there were indications that the age of the patients affected the lengths of stay of the transurethral prostatectomy patients. The last split reveals the vastly different lengths of stay between the two age groups, specified by AUTOGRP as being less than 78 years of age (ALOS of 13.94 days) and 78 years and above (ALOS of 21.29 days). In both instances, the standard deviation has also decreased, and these two categories are labeled as two more terminal groups.

To review this process from the one initial group, malignant neoplasm of the prostate, five terminal groups are derived depending on their hospital utilization.

Table A-1 is more than a repetition of the grouping process. The values of ALOS and the SDs of the length of stay distributions are different from those obtained in the grouping process because of the identification of "outliers" based on the 0.80 probability level of the Camp-Meidel two-tailed test (Camp, 1922).

TABLE A-1

Length of Stay Statistics for the Five Diagnosis-Related Groups Generated from Patients with Malignant Neoplasm of Prostate Excluding Outliers and Deaths

Diagnostic Code	No. of Pts	Length of Stay		Outlier*		Deaths	
		Mean Days	SD	No.	%	No.	%
No surgery	56	10.16	6.1	5	8.2	8	11.6
Cystoscopy and orchidectomy	100	9.61	5.5	6	5.7	2	1.9
Transurethral prostatectomy:†							
Age 77 yrs and below	55	13.58	4.4	1	1.8	0	0.0
Age 78 yrs and above	16	21.29	8.9	0	0.0	1	5.9
Suprapubic or perineal prostatectomy	31	22.65	8.7	3	8.8	3	8.1
Total	258	—	—	15	5.5	14	4.9

* Calculation of per cent of outliers was based on the total number of patients excluding deaths.

† This finding may be somewhat misleading due to the fact that the diagnostic information is obtained from a discharge abstract. Whitmore points out that Stage "A" prostatic cancer is "clinically inapparent, found incidentally at autopsy or during examination of clinically removed prostatic tissue" (Whitmore, W. F. 1973. The Natural History of Prostatic Cancer. *Cancer* 32(5): 1104–1122). Prout derives an estimate from the literature that 10% of all surgical specimens removed for benign prostate hyperplasis will have histological evidence of carcinoma present (Prout, G. R. 1973. Diagnosis and Staging of Prostatic Cancer. *Cancer* 32(5): 1096–1103).

Source: Discharge abstracts, Yale-New Haven Hospital (1972–1974).

Outliers exist in any DRG for some of the following reasons:

1. A deviation from the usual pattern of care for this kind of case has occurred.
2. A variable or variables necessary to the identification of the treatment process employed in this case is not available in the record.
3. There are insufficient cases of this type in one's experience to allow for the identification of a unique DRG.
4. There may be an error in the record of variables which describe this case.

These outliers may also be used as a sampling frame for quality monitoring when each of these cases is reviewed by a medical care evaluation and utilization review committee.

Table 1 in the body of this paper shows the extension and application of this same grouping process to a different population of patients, and includes cost data as well as lengths of stay.

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