formed respiratory therapy procedures and because it has been one of the more controversial ones. Evidence is presented that suggests that in some instances IPPB may be substituted for by alternate treatment modalities. Respiratory therapy practices in the intensive care unit, though an important area of involvement for respiratory therapy personnel, are mentioned only briefly.

The fifth part of this case study presents the results of a survey we conducted of current respiratory therapy practices by hospitals in the Washington, D. C., Standard Metropolitan Statistical Area (SMSA) during 1979. Particular emphasis was placed on data concerning the use of IPPB and other modalities which can potentially be substituted for IPPB. We were able to obtain data on how often these different treatments were being delivered in the hospitals located in the Washington, D. C., SMSA, and were also able to discern a significant change in the pattern of usage over the past several years.

Using the information we collected about the time needed to deliver different types of respiratory therapies, the wages paid to respiratory personnel, and the cost of equipment, in the sixth part of this study, we estimate the relative cost of delivering specific types of treatments. We then compare differences in the relative costs of treatments that can be substituted for one another. Finally, we compare the estimated relative costs to the actual charges for hospitals in our survey.

Our analysis presented below supports the conclusion that for some medical indications, alternative treatment modalities, when compared to IPPB, could be delivered at a lower relative cost. Data on efficacy or effectiveness were not collected in our survey. However, our review of the medical literature suggests the comparability of the medical outcomes for some treatments. The implications of the results of our analysis, along with their limitations, are discussed in the concluding section of this study.

RESPIRATORY THERAPY: A DEFINITION

In general, the term respiratory therapy refers to the medical treatment of a diseased lung. It encompasses all nonsurgical efforts directed at maintaining, improving, or restoring lung function. However, in actual use, the term refers only to those therapeutic interventions carried out by trained respiratory care personnel in accordance with a physician's order. A recent definition of respiratory therapy is the followings

> Respiratory therapy is an allied health specialty employed with medical direction in the treatment, management, control, diagnostic evaluation, and care of patients with deficiencies and abnormalities of the cardiopulmonary system. Respiratory therapy shall mean the therapeutic use of the following: medical gases and administration apparatus, environmental control systems, humidification, aerosol, medications, ventilatory support, bronchopulmonary drainage, pulmonary rehabilitation, cardiopulmonary resuscitation, and airway management.

Therapeutic respiratory therapy interventions, as noted above, can be grouped into four major categories: 1) oxygen therapy, 2) aerosol therapy, 3) physical therapy, and 4) mechanical aids to lung inflation. The various modalities are defined in greater detail below. Individually or in varying combination, these methods of therapy are being used to treat almost any kind of respiratory problem. They may be used in the general medical and surgical wards, or used in the intensive care unit, where they have been refined into sophisticated and coordinated life support measures. Their use is especially common in patients undergoing surgery involving the chest or upper abdomen and in patients with chronic obstructive bronchial tube diseases, such as emphysema, chronic bronchitis, asthma, and bronchiectasis. Such diseases constituted the sixth leading cause of death in the United States in the 1970's ("16).

'This definition was approved in 1969 by the Board of Directors of the American Association of Inhalation Therapists (renamed the American Association for Respiratory Therapy in 1972) (8).

THE ORGANIZATION AND DELIVERY OF RESPIRATORY THERAPY SERVICES

Most U.S. hospitals have developed an organized respiratory therapy department staffed by highly trained and usually certified paramedical personnel. The activities of the paramedical staff are closely supervised by a physician, who serves as the department's medical director. The growth of autonomous respiratory therapy departments within U.S. hospitals, in terms both of total number and size of individual departments, has been substantial and rapid over the past two decades.[6] This growth may be attributed to a number of different factors, including the following:

- advances in engineering design since 1950 which have brought about the development of new, highly sophisticated mechanical devices useful in the support of lung function, e.g., mechanical ventilators (breathing machines) (37);
- increases in the number of patients with acute and chronic respiratory disease, who require respiratory care (22);
- the need to assure quality control of respiratory care services rendered, by means of effective supervision and ongoing education of workers in the field; and
- the overall increase in third-party reimbursement in the hospital sector, especially by medicare and medicaid.

Respiratory therapy departments may be staffed by personnel of varying levels of formal training (10). A respiratory therapist is usually a graduate of a 2-year hospital or community college program granting an associate degree, which has been approved by the American Medical Association and which is designed to qualify him or her for the registry examination given by the National Board of Respiratory Therapy. By passing that examination, an individual becomes a registered respiratory therapist (R.R.T.). A respiratory therapy technician completes a l-year hospital-based program combining a curriculum of basic respiratory sciences and supervised clinical experience. By passing the technician certification examination, the individual becomes a certified respiratory therapy technician (C.R.T.T.). Other personnel employed by respiratory therapy departments include aides, who are trained on the job, and individuals with nursing credentials (R.N. or L.P.N. certification).

Despite the distinct differences in formal training among these various types of personnel, the generic term respiratory therapist is often used to refer to any individual involved in the provision of technical respiratory care. The emergence of a formal educational apparatus with mechanisms for achieving professional credentials is fairly recent, and partly because of that, there is considerable blurring of professional role identities. Individuals with limited formal training often possess many years of practical experience which allow them to assume roles at a higher level of responsibility than their formal training would suggest.[7]

[6]By *1976*, virtually all large private, nonprofit hospitals (100 beds or more) had developed respiratory therapy departments (31).

[7]The recent report of the American Association of Respiratory Therapists concerning job descriptions and salary levels served amply to illustrate this confusion *(6).*

AN ASSESSMENT OF RESPIRATORY THERAPY SERVICES

The services offered by respiratory therapy departments can be conveniently grouped into four major categories: 1) oxygen therapy, 2) aerosol therapy, 3) physical therapy, and 4) mechanical aids to lung inflation. Each of these is briefly discussed below. Statements about the efficacy of specific interventions are made on the basis of the current medical literature. Since IPPB has been chosen as the major area of interest in this case study, more attention is directed to that than to any of the other interventions.

Oxygen Therapy

The administration of therapeutic gases is one of the more important functions of respiratory therapy. The primary function of the lung is to exchange gas between the atmosphere and the blood (i.e, to take in oxygen and eliminate carbon dioxide (CO_2), the waste product of cell metabolism). Many of the diseases that affect the lung can impair its gas exchange capability, resulting in a fall in the oxygen content of the blood.[8] Whether a patient needs supplemental oxygen to restore blood oxygen levels to normal can usually be ascertained by measuring the gas pressures in a sample of the patient's blood. If oxygen levels are too low, oxygen is administered to the patient and its supply adjusted by titrating (adjusting) the delivered oxygen concentration. In most instances, the indications for delivery of supplemental oxygen are well established, and there is currently no real controversy concerning when it should be used. A variety of simple devices to deliver varying concentrations of oxygen to a patient are available.

Oxygen therapy is one of the oldest of all respiratory therapy modalities, and its effectiveness was established quite early in the treatment of a wide variety of lung diseases (10). Nevertheless, it is possible to identify some serious problems relating to the misuse of oxygen. One problem is that supplemental oxygen is sometimes administered without documentation that the patient has inadequate oxygen in his or her blood. This course of action would be appropriate only under special circumstances (e. g., in an emergency or in the postoperative recovery room). Another problem is that sometimes the patient receiving oxygen is not adequately monitored with respect to the achievement of the desired therapeutic objective (i. e., correction of the oxygen-deficient state). Sometimes the patient will be given too much oxygen, exposing him or her to potential toxic effects of an overdose of this drug (for indeed, oxygen should be regarded as a drug). Occasionally, a patient is given supplemental oxygen solely because it makes him or her "feel better. " The issue of psychological benefits v. more objective therapeutic improvements derived from a specific treatment modality is difficult to assess when discussing the "scientific" efficacy of a therapy.

Quite apart from the issues surrounding the misuse of oxygen therapy, it should be noted that additional scientific studies are needed to define more accurately the short- and long-term toxic effects of oxygen when given to patients in higher concentrations than we normally breathe (26).

Aerosol Therapy

An aerosol is a suspension of very fine particles of a liquid or solid in a gas (e.g., the fog seen on a damp morning is a suspension of water droplets in the air). As such, an aerosol can be breathed into the respiratory tract, where the particles may be deposited and retained. Therapeutic aerosols consist of either water droplets or fine particles of medication added to the inspired air for deposition onto the surface of the lung. Humidity (aerosol of water) and other aerosols are used to achieve four general objectives (10):

- humidification of the respiratory tract,
- "wetting" of respiratory tract secretions (mucus) so that they can be coughed up more easily,
- delivery of bronchodilator drugs which dilate the breathing tubes, and
- administration of antibiotics to treat bronchial infections.

Several mechanical devices, which are known as nebulizers, are available to generate an aerosol (i. e., put the particles of water or drug into suspension). These range from a very simple device which depends on a jet of air to create small particles from a liquid to complicated electronic machines, called ultrasonic nebulizers, which create particles by vibrating

'Lung dysfunction results not only from primary lung disease, but also as a byproduct of diseases of other organs. Some degree of lung dysfunction is seen in most hospitalized patients. Thus, oxygen therapy is used by a high percentage of patients who are admitted to a hospital. The need for standardization and coordination of equipment used in oxygen therapy originally led to the development of respiratory therapy departments. Respiratory therapists have usual] y been assigned the role of sampling arterial blood to assess its gas contents, then reportin g these results to the medical team caring for the patient so that appropriate modifications can be made in the amount of oxygen being given to a patient.

the liquid medium.[9] The aerosol that is generated can be inhaled by the patient without mechanical assistance, or it can be forced into the patient's lungs under pressure by a pressurized delivery device such as an IPPB machine. A patient requires instruction by a respiratory therapist in the use of both nebulizers and pressurized delivery devices. Prior to each treatment, the therapist must add the fluid or medication which is to be nebulized to the device. In general, the more complicated the nebulizer used, the greater the degree of supervision required by a respiratory therapist while the patient is using the device. Special circumstances (e.g., a weak or uncooperative patient) may necessitate close supervision by a therapist of every treatment.

There are currently many controversies relating to the clinical use of aerosol therapy. The indications are not always clear cut, and the effectiveness of a treatment in any given patient has not been satisfactorily defined by scientific studies (26). Also controversial are the choice of type of nebulizer and the need for an IPPB. Many issues remain unresolved, e.g., whether an expensive ultrasonic nebulizer is any more effective than a simple aerosol generator, and whether an IPPB machine is necessary to deliver an aerosol to patients who are breathing on their own (33).

Physical Therapy

Physical therapy for patients with lung disease has two basic objectives:

- to facilitate the removal of secretions from the lungs, and
- to improve the efficiency of breathing.

Among the physical measures employed are: 1) percussion (clapping) and vibration of the thorax, 2) postural draining (positioning the patient so that secretions will drain toward the mouth under the influence of gravity), and 3) breathing exercises to teach a patient how to use his or her respiratory muscles more efficiently.

Although these procedures enjoy widespread acceptance throughout the United States and the world—indeed, many hospitals have established autonomous chest physiotherapy departments—there is a dearth of well-controlled scientific evidence to support their effectiveness. In many instances, a spontaneous cough could yield the same amount of expectorated sputum as the bronchial drainage procedures employed by the chest physiotherapist (9). For example, although chest physiotherapy is often routinely ordered for patients with uncomplicated pneumonia, these patients are usually quite capable of coughing themselves and can effectively clear excess secretions from their respiratory tracts. Few scientific studies have adequately demonstrated that chest physiotherapy aids patients in the recovery from lung diseases (24). Many additional well-planned and well-controlled studies will be necessary to answer the many questions in this area.

Mechanical Aids to Lung Inflation

Mechanical aids to lung inflation are those interventions used to support the ventilator function of the respiratory system, This function—bulk movement of air from the environment through the breathing tubes to the gas- exchange membrane deep in the lungs—is normally accomplished by the bellows-like action of the muscles of respiration acting upon the lungs. A variety of mechanical ventilators which are capable of pumping air into the lungs have been developed. Most of them are electrically powered and generate positive pressure which forces air into the lungs at rhythmic intervals.

If a patient's breathing has totally ceased owing to suppression of brain activity (e. g., following *an* overdose of sleeping pills), mechanical ventilator support is necessary to sustain the patient's life. Mechanical ventilator support may be similarly useful for patients with paralysis of the respiratory muscles, chest wall injury, and acute and potentially reversible lung disease, such as extensive pneumonia or smoke inhalation, Its effectiveness in these instances is well-accepted. Life support of a critically ill patient requires a coordinated team

[9]For more detailed description of the technical aspects of the various types of nebulizers, the reader should consult one of the standard textbooks of respiratory care, e.g., that by Egan (10).

effort involving a physician, nurse, respiratory therapist, and other paramedical personnel. The patient is best monitored in an intensive care unit where equipment and resources can be concentrated and made readily available. Most respiratory therapy departments are intimately involved in the delivery of critical care, and involvement in this area constitutes one of their major activities. The most highly trained and experienced therapists work in this area.

Some people have advocated the use of mechanical breathing machines for purposes other than life support of critically ill patients. One of these, mentioned in the discussion of aerosol therapy above, is the use of an IPPB machine to facilitate delivery of an aerosol into a patient's lungs. The acronym "IPPB" has now become virtually synonymous with this use and is only rarely used to refer to long-term continuous mechanical ventilator support. Thus, "IPPB treatment" refers to the use of a pressurized ventilator to deliver a gas with humidity and/or other aerosols to a spontaneously breathing patient for periods of 10 to 20 minutes each, usually several times a day (1).

IPPB treatments have been one of the more controversial areas in the respiratory field. Therefore, a more detailed discussion of the proposed indications for and the arguments concerning the efficacy of IPPB is presented below.

IPPB therapy has been based on the principal assumption that the mechanical breathing machine will deliver a larger breath than the patient is able to take spontaneously with less physical effort from the patient (17). Several objectives for the use of IPPB have been developed. These include (1):

- improving the delivery of aerosol medications to those patients who are unable to take a deep breath or whose pattern of breathing is not regular;
- improving the overall level of breathing where it is inadequate to meet the body's metabolic requirements (i. e., when not all the CO_z is being excreted by the patient's lungs);
- improving cough and expectoration of respiratory tract secretions (effective cough is dependent on a deep inspiration prior to the cough itself); and
- preventing collapse of lung segments in patients who cannot take deep breaths (e.g., in the postoperative patients whose respirations are hindered by residual anesthetic agents, drugs or medications, and pain).

Although these indications for the use of IPPB are widely accepted, very few scientific data have been collected to support its efficacy (38). Moreover, IPPB therapy was introduced and became widespread before its scientific validity had been rigorously tested.

In 1974, the available information about IPPB, as well as all other respiratory therapy modalities, was reviewed at the Conference on the Scientific Basis of Respiratory Therapy, held at Sugarloaf, Pa. That 1974 conference was a benchmark consensus conference sponsored by the National Institutes of Health (NIH). Although it focused on an assessment of the efficacy of respiratory therapy in the treatment of patients with stable chronic obstructive lung disease, it also considered the overall use of respiratory therapy. Conferees judged the majority of studies of clinical effectiveness of IPPB published up until that time to be inadequate investigations, often not well designed from a scientific or statistical standpoint (9), They also recommended additional scientific studies that would attempt to determine whether IPPB has more than transient effects in any group of patients (29).

Since 1974, there have been a number of editorials and papers, many highly emotional, restating the IPPB controversy, but offering very little new information (14,16,25). The total number of investigations published every year on the subject of IPPB has actually declined (27). An attempt to draw conclusions from the available studies of IPPB is difficult, because many of the studies were not well-designed. Many do not use comparable patient populations or methods of delivering IPPB (e.g., studies attempting to compare IPPB with alternative treatment modalities often use different endpoints or outcomes as indicators of successful results).

For delivery of aerosol medications, IPPB has been compared to a number of other delivery modes. In seven of eight studies published since 1953, a simple nebulization device was found to be just as effective as an IPPB machine in delivering an aerosol medication (12,13,15,21,23, 30,36); the eighth report found IPPB to be better (34). Given this apparent similarity of efficacy between devices, considerations other than efficacy might be used to dictate the choice of treatment modality.

The evidence yielded by studies on the effectiveness of IPPB for improving the overall level of ventilation (5,11,19,20,35) is difficult to assess because of problems with the study designs. A review of the various studies suggests that any improvement in ventilation brought about by IPPB treatment is usually transient, being essentially limited to the duration of the treatment. One study found that the same level of intermittent improvement in breathing could be achieved if the patient were required to voluntarily hyperventilate for several minutes (33). At many hospitals, a routine of delivering four approximately 20-minute treatments per day has evolved. There is no satisfactory evidence to show that improving a patient's breathing for 1 hour each day will have any significant overall effect on that patient's clinical course. Few, if any, data exist on the issue of long-term benefits (26).

A third accepted indication for IPPB use is in the prevention of lung collapse, especially in the postoperative period when the patient may not be able to take deep breaths. However, the majority of studies fail to show measurable benefit from this use of IPPB (3,4,32). For improving lung inflation, IPPB has been compared in other studies to two other mechanical devices: 1) blow bottles (which require the patient to move water from one bottle to another by generating high pressures in the system when the patient blows into it), and 2) the incentive spirometer (which requires the patient to generate a negative pressure in the system by deep inspiration, thus raising a plastic ball in the vacuum created). Both of these other devices have been claimed to be more effective than IPPB in preventing postoperative lung collapse. One study found a complication rate of 30 percent in patients receiving IPPB, 15 percent in patients using the incentive spirometer, and 8 percent in those using blow bottles (18). These results certainly raise doubts about the continued exclusive use of IPPB in the prevention of lung collapse,

Significant unanswered questions about the efficacy of IPPB remain, and the need for more scientific studies is great. Despite the overall dearth of information, however, the evidence we have reviewed suggests that IPPB may be no more effective than various other treatment modalities in achieving specific therapeutic goals. In delivering a therapeutic aerosol to a patient, an IPPB machine seems to be no more effective than an ultrasonic nebulizer or a simple aerosol generator. In preventing postoperative lung collapse, IPPB would appear to be no more effective than the simply designed incentive spirometer.

A second Conference on the Scientific Basis of Respiratory Therapy, sponsored by the National Heart, Lung, and Blood Institute of NIH, was held in Atlanta, Ga., on November 14-16, 1979. The conference program was limited to a discussion of in-hospital, nonintensive care respiratory therapy. Intensive care respiratory therapy was specifically excluded. Because of the highly specialized equipment and techniques employed in a total life support setting, intensive care respiratory therapy was regarded as worthy of being the topic of a separate conference.

Conferees at the 1979 conference discussed a broad array of topics under the same four general categories which have been used in this case study: oxygen therapy, aerosol therapy, physical therapy, and mechanical aids to lung inflation. Their reports sought to define what was known and what was not known, and to recommend what additional studies should be undertaken. A brief overview of the 1979 Atlanta conference proceedings, which will be published in their entirety, is presented below.

In 1979, many issues highlighted by the 1974 Sugarloaf conference on respiratory therapy, still remained unresolved. A recurring theme throughout the 1979 conference was that the lack of proof of a procedure's efficacy does not equate with no efficacy at all. Most procedures have been empirically derived. Many have a long history of use in the realm of folk medicine, with at least subjective benefit derived by the patient being treated. The application of rigid scientific analysis to study the mechanism of action and measurement of objective outcome achieved by these procedures has come to the forefront only within the past several decades. Whether a procedure which is at least not harmful to the patient, and possibly quite beneficial, should be withheld pending the final outcome of scientific studies which may take many years to complete to anyone's satisfaction remains to be answered.

The major issues regarding oxygen therapy in 1979 were basically the same issues discussed in 1974: misuse of the drug, effective monitoring of its therapeutic success, and a need for better understanding of its toxicities. Conferees noted that the efficacy of the drug in relieving acute hypoxemia (oxygen deficiency) is beyond dispute. However, with regard to chest physiotherapy measures, conferees noted, a great deal of fundamental information concerning their effectiveness is lacking. There is a need to define more precisely what the various techniques are and to define standards for them (e. g., standards concerning the performance of chest vibration).

In the discussion of aerosol therapy, conferees directed their attention to the lack of information about what constitutes an adequate aerosol for penetration of the lung. The size of the aerosol particle created may be of some importance. There is little information available on the mechanism of action of aerosols at the cellular level and the effects aerosols bring about. Additionally, it is not clear which parameters can or should be measured to assess whether an aerosol has had any effect. Until such knowledge has been accumulated, conferees suggested, no definitive conclusions can be drawn about the choice of the device used to generate an aerosol.

The final topic of discussion at the 1979 conference was mechanical aids to lung inflation. Once again, the lack of basic information about both the theory and practice pertaining to this type of respiratory care was noted. To establish the comparative efficacy of the various aids—IPPB v. incentive spirometry v. deep breathing-—conferees recommended additional studies with standardized endpoints and precise definition of terms. They felt that the potential benefits of such aids must be established before meaningful cost-benefit studies could be undertaken.

Any attempt to draw overall conclusions about whether respiratory therapy itself is efficacious is faced by formidable obstacles. Too many pieces of scientific evidence are unavailable at this time. Conferees suggested that continued research in this area is clearly warranted.

Data we collected on the utilization of selected respiratory therapy modalities among the hospitals in Washington, D. C., SMSA in 1979 are presented in the next part of this case study. The subsequent part contains our estimates of the relative costs of delivering an aerosol medication by three different devices: an IPPB machine, an ultrasonic nebulizer, and a simple aerosol generator, Also compared are the relative costs of using an IPPB v. an incentive spirometer to improve lung inflation.

A SURVEY OF HOSPITAL-BASED RESPIRATORY THERAPY IN THE WASHINGTON, D. C., SMSA

Survey Methods and Procedures

In order to estimate the relative costs of IPPB and those treatment modalities which are potential substitutes, it was necessary for us to develop a new data base including the utilization of different treatment modalities, their relative cost, and the personnel employed by different sizes and types of hospitals. This information is not currently available for multiple hospitals on a systematic basis.[10] We selected as our geographic survey area the Washington, D. C., SMSA. This SMSA has a population of over 3 million (making it the seventh largest SMSA in the United States), and it includes a total of 56 hospitals.

Using the 1978 guide issue of the American Hospital Association, we located each hospital in the Washington, D. C., SMSA and recorded data on hospital ownership, control, size (in terms of number of beds), yearly admissions, and occupancy rates. We then designed and pretested a questionnaire on seven sample hospitals. In the pretest, data were collected via phone interviews with the technical directors (chief therapists) of respiratory therapy units.

After the pretest, the questionnaire was revised and mailed to the technical or medical director of the respiratory therapy department at each of the 56 hospitals in the Washington, D. C., SMSA. Of the 56 hospitals in the survey universe, 43 provided some type of respiratory therapy. These 43 hospitals were contacted between July and September of 1979. For the overall utilization data on respiratory therapy in these hospitals, the response rate was about 60 percent. For some specific data items, the response rate may have been lower.[12]

Of the 43 hospitals that provide respiratory therapy in the Washington, D. C., SMSA, 75 percent are private (60 percent private nonprofit, 15 percent private for-profit) and 25 percent are governmental (15 percent non-Federal governmental and 10 percent Federal). Approximately 31 percent have some type of teaching affiliation. Twenty-seven percent of the 43 hospitals surveyed have up to 150 beds, 15 percent have 151 to 250 beds, 32 percent have 251 to 450 beds, and 26 percent have more than 450 beds.[13]

In order to provide some time-trend data on the utilization of four major treatment modalities used in delivering respiratory therapy, we also conducted a special survey of five teaching hospitals in the Washington, D. C., SMSA. These hospitals provided data from their records for the 1976-79 period on the following four modalities: 1) IPPB, 2) ultrasonic nebulization, 3) simple aerosol, and 4) incentive spirometry. These hospitals were large (averaging over 600 beds) and all had some teaching affiliation.

Survey Results: Hospital Utilization of Respiratory Therapy

The results of the survey of Washington, D. C., SMSA hospitals shown in table 1 indicate that 44 patients per 100 hospital admissions per month received some type of respiratory therapy. On the average, for all reporting hospitals, 723 respiratory therapy treatments were delivered per 100 hospital admissions. Governmental hospitals (Federal and non-Federal) delivered less than one-fourth the average number of respiratory treatments per 100 admissions for all reporting hospitals. A qualitative judgment of the appropriateness of these different utilization rates is not possible without data on the case mix and health status of the patient population treated. In part, the differences may reflect factors such as lack of equipment or the quantity and training of the staff.

At private for-profit hospitals, IPPB was delivered to 12 patients per 100 admissions, about twice the average rate for all hospitals in the sample. For all hospitals in the sample, an average of 60 IPPB treatments were delivered per 100 patient admissions. Private for-profit hospitals, at 190 IPPB treatments per 100 patient admissions, were significantly above the

[10] To our knowledge, our data are the only systematically collected data on the cost, charges utilization, and personnel used in hospital-bad respiratory therapy departments.

[11] Using "t and chi-square tests on the average size of the hospital and ownership of reporting and nonreporting hospitals we find no systematic bias.

[12] A statistical test 01 the representativeness of each specific data item was not feasible within the framework of our data collection

[13] Further details on the hospitals in the Washington, D.C., SMSA are available in the guide issues published yearly by the American Hospital Association.

[14] The five hospitals were George Washington University Hospital, Holy Cross Hospital, Veterans Administration Hospital, Fairfax Hospital, and Washington Hospital Center.

[15] This compares to an estimate of between 25 and 30 patients per 100 admissions in the early 1970's (2).

Table I.— Utilization of Respiratory Therapy by Hospital Ownership, 1979[a] (per 100 admissions per month)

	Governmental		Private		
	Federal	Non-Federal	Nonprofit	For-profit	All hospitals
Total patients treated with respiratory therapy	46 N = 4	55[b] N = 2	41 – N = 4	 N = 1	44 N = 11
Total respiratory therapy treatments	153 N = 4	180[b] N = 2	830 N = 17	—[c] N = l	723 N = 24
IPPB patients	3 N = 3	3[b] N = 2	7 N = 19	12 N = 5	6 N = 29
IPPB treatments	11 N = 4	27[b] N = 2	79 N = 24	190 N = 7	60 N = 37
Incentive spirometry patients	12 N = 3	12[b] N = 2	12 N = 19	7 N = 5	11 N = 29
Chest physical therapy treatments	63 N = 3	32[b] N = 2	130 N = 15	130 N = 5	66 N = 25

N = number of responding hospitals
[a]Based on hospitals in the Washington, D.C., SMSA
[b]Because of the small number of observations in these categories, these data should be used with caution
[c]Insufficient observations

mean, followed by private nonprofits, at 79 treatments per 100, ” The number of IPPB treatments delivered per 100 admissions at Federal and non-Federal Government hospitals was below the average for all hospitals in the sample. Combining the data on the patients treated with IPPB **and** the number of IPPB treatments, we estimate that, on average, 10 IPPB treatments are given to each patient receiving IPPB.[17]

Incentive spirometry was used by about 11 patients per 100 patient admissions, except at private for-profit hospitals, where the figure was 7 per 100 patient admissions. The number of chest physical therapy treatments averaged about 66 per 100 admissions, although Federal and non-Federal Government hospitals had a far lower utilization rate than private for-profit and nonprofit hospitals.

Although the data in table 1 suggest differences between for-profit hospitals’ and other hospitals’ patterns of usage of respiratory treatment modalities, the reasons for these differences are unclear.[18] Many of the for-profit hospitals in the Washington, D. C., SMSA are small, do not have teaching affiliations, and lack the equipment and staff necessary to deliver respiratory therapy. For-profit hospitals may have a somewhat different patient mix, and the physicians ordering respiratory therapy treatments in these institutions may not have the benefit of consultation with lung specialists.[19] Moreover, the indication for employing a specific respiratory modality is rarely documented in the medical records. Respiratory therapy departments at these and other hospitals do not document why specific treatments are given.

Table 2 shows the data we collected on the utilization of respiratory therapy by hospitals of different bed-size categories. It is interesting to observe that hospitals with more than 450 beds delivered about 25 IPPB treatments per 100 patient admissions, as compared to the average of 60 per 100 admissions for all hospitals in the sample. Moreover, the percentage of patients receiving IPPB treatments is inversely related to hospital bed-size.[20] Compared to the other hospitals in the sample, hospitals with 150 to 250 beds have more patients per 100 admissions receiving incentive spirometry (30 per 100 admissions), and less production of chest physical therapy treatments.[21]

[16]In 1973, one study estimated the number of IPPB treatments to be 236 per 100 patient admissions per month for 123 reporting hospitals (2).
[17]Usually, this would mean four treatments a day for 2 ½ days,
[18]We are grateful to Louise Russell of The Brookings Institution for suggesting this point.
[19]Moreover, some hospitals contract out to private firms for respiratory services. This arrangement may also alter the pattern of respiratory treatments performed.
[20]The smallest hospital had more than 330 beds and the largest had 848 beds in 1979.
[21]Again, it should be noted that without data on the severity of illness of the mix of patients treated in hospitals of different sizes, normative judgments concerning the appropriateness of the treatment are not possible.

Table 2.—Utilization of Respiratory Therapy by Hospital Bed-Size, 1979[a] (per 100 admissions per month)

	Up to 150 "beds	150 to 250 beds	250 to 450 beds	>450 beds	All hospitals
Total patients treated with respiratory therapy	18b N = 2	18b N = 2	52b N = 3	42 N = 4	44 N = 11
Total respiratory therapy treatments	720 N = 5	842 N = 5	710 N = 7	760 N = 6	723 N = 23
IPPB patients	13 N = 6	12 N = 6	6 N = 7	6 N = 8	6 N = 27
IPPB treatments	105 N = 10	105 N = 7	111 N = 12	25 N = 8	60 N = 37
Incentive spirometry patients	15 N = 10	30 N = 5	9 N = 9	10 N = 5	12 N = 29
Chest physical therapy treatments	43 N = 5	27 N = 6	54 N = 9	107 N = 5	66 N = 25

N = Number of responding hospitals
[a]Based on hospitals In the Washington DC SMSA
[b]because of the small number of observations In these categories, these data should **be used With Caution**

In order to make observations concerning any recent changes in the utilization of respiratory therapy modalities, especially IPPB, we selected a sample of five teaching hospitals from the universe of 43 hospitals in the Washington, D. C., SMSA that delivered respiratory therapy services in 1979. These five teaching hospitals are large, with an average bed-size of 626 beds, and have an occupancy rate of about 82 percent.

Table 3 shows trends from 1976 to 1979 in the utilization by these five hospitals of four respiratory treatment modalities: 1) IPPB, 2) ultrasonic nebulizer, 3) simple aerosol, and 4) incentive spirometry. Of considerable interest is the dramatic reduction in the number of IPPB treat-

Table 3.—Trends in the Utilization of Four Respiratory Therapy Treatment Modalities, 1976"79[a]

	1976[b]	1977[b]	1978[bc]	1979[c]
***IPPB* treatment**				
Total IPPB treatments	121,772	111,990	50,698	36,418[d]
IPPBs/ 100 admissions per month	108	100	45	33d
IPPBs/bed	38.89	36.92	16.72	12.o1[d]
Ultrasonic nebulizer treatment				
Total ultrasonic treatments	8,847	8,501.5	2,350.5	2,976[d]
Ultrasonics/100 admissions per month[e]	13	9	3	3d
Ultrasonics/bede	3.65	3.66	1.01	1.29[d]
Simple aerosol treatment				
Total simple aerosol treatments	32,337	47,715	91,088	131 ,066[d]
Simple aerosols/100 admissions per month	29	43	81	117d
Simple aerosols/bed,	10.33	15.73	30.03	43.21[d]
Incentive spirometry treatment				
Total incentive spirometry treatments	—	8,543[f]	13,240[f]	**16,1 38[f]**
Spirometry treatments/100 admissions per month[g]	—	18	27	**33**
Spirometry treatments/bed	–	8.48	13.25	**16.03**
Incentive spirometry patients	—	—	7,656[h]	**7,792[h]**
incentive'spirometry patients/100 admissions per month	—	·	0.12	0.12
Incentive spirometry patients/bed	—	—	2.69	3.75

[a]Based on data from the followtng hospltals in **the Washington D c SMSA** George Washington Unlversity Hospital, Holy Cross Hospital, Veterans Admlnlstratlon Hospital Fairfax Hospital and Washington Hospital Center

	1976	1977	1978	1979
Average bed size	6262	6066	6066	6066
Average admissions/bed	358	3692	3692	3692
Occupancy rate	8274	8352	8352	8352
Census of hospital beds	2.539	2,498	2,498	2,498

We are assuming that the figures for 1978 and 1979 were the same as those for 1977

[b]Full year statistlc

[c]We are assuming the number of beds and admissions remains constantat 1977 levels

[d]1979 figures were estimated by doubling the first 6 months statistics

[e]Ultrasonic fiqures are compiled from four hospitals

[f]Two hospitals supplied this Stat istic

[g]For two hospitals reporting spirometry, admissions = 48,746 and beds -1,007, and for three hospitals reporting spirometry admissions = **63,259** and beds = 2,076

[h]Three hospitals supplied this Stat istic

ments per 100 admissions and per hospital bed over the 1976-79 period. During that period, the number of IPPB treatments per 100 admissions declined about 70 percent (from 108 IPPB treatments in 1976 to an estimated 33 treatments in 1979). The number of ultrasonic treatments per 100 admissions declined about 75 percent (from about 13 ultrasonic treatments in 1976 to 3 treatments in 1979). The number of simple aerosol treatments per 100 admissions in these hospitals increased from 1976 to 1979 over 300 percent (from 29 treatments to 117), and the number of incentive spirometry treatments per 100 admissions increased from 1977 to 1979 over 200 percent (from 18 treatments in 1977 to 33 treatments in 1979).[22] [23]

[22] The per bed comparisons are quite similar.

[23] Data demonstrating a similar dramatic decline in the frequency of use of IPPB in selected hospitals were presented at the Atlanta Conference on the Scientific Basis of Respiratory Therapy in November 1979. A survey from a 1,000-bed New York City Hospital revealed a rapid decline since 1973. The Massachusetts General Hospital witnessed marked decrease in use of IPPB since 1974. Similar results have been observed at four unidentified Midwest hospitals, Dr. Steven Ayers, professor and chairman of the Department of Medicine of St. Louis University, speaking on the magnitude of use and cost of in-house respiratory care, said that a national decline of approximately 70 percent had occurred in the use of IPPB. (It should be recalled that the Sugarloaf Conference on the Scientific Basis of Respiratory Therapy took place in 1974.)

ESTIMATES OF THE RELATIVE COSTS OF RESPIRATORY TREATMENT MODALITIES

The significant decrease in the utilization of IPPB and ultrasonic treatments and the increase in utilization of simple aerosol and incentive spirometry treatments in five major teaching hospitals in the Washington, D. C., SMSA may represent important new trends in respiratory therapy. One important reason for these trends is that for some therapeutic indications these different treatment modalities may well be substitutes for one another.[24] In delivering a medication to a patient, a simple aerosol device has been found to be as effective as an IPPB machine (25). It seems quite likely that other substitutions among treatment modalities exist, but documentation is currently limited.

Using data from our Washington, D. C., SMSA hospital survey, we estimated differences in the relative cost of producing the following respiratory treatment modalities: 1) IPPB, 2) ultrasonic nebulization, 3) simple aerosol. and 4) incentive spirometry.[25] It was assumed *for our calculations that the effectiveness of these four treatment modalities is equivalent,* It was also *assumed* that the amount of physician time required for each modality is equal, because the physician's role is to select the appropriate treatment modality. For each of the four modalities, the actual delivery of treatment to the patient is the responsibility of different types and levels of respiratory personnel. The delivery usually involves the time of a "therapist" and the use of the needed equipment .[26]

In order to estimate relative costs, we first examined the types of personnel involved and the amount of time required to deliver each of the treatment modalities. As shown in table 4, for three of the four modalities, about 70 percent of the responding hospitals in our Washington, D. C., SMSA survey reported that either a respiratory technician or therapist delivered the treatment. For incentive spirometry, nearly 50 percent of the hospitals use either a therapist or technician, and about 23 percent use a therapist or a nurse. These data suggest that some hospitals use these different types of personnel somewhat interchangeably. For our relative cost estimates, it was *assumed* that there are no significant differences in the respiratory therapy personnel used for the four treatment modalities under consideration, Table 5 shows the modal amount of personnel time necessary to deliver

[24] See Burton, et al. (8) for a discussion of some of these modalities.

[25] The relative cost estimates include resource costs that differ among treatment modalities, e.g., equipment and respiratory therapy personnel time. Thus, costs common to each treatment modality, such as overhead and the physician's time used in ordering the treatments, are not included.

[26] We are assuming that the hospital overhead allocated does not differ significantly for different equipment.

four types of respiratory therapy treatments.[27] It is clear that IPPB treatments require the greatest amount of personnel time. For purposes of our cost estimates, delivery time for each modality was *assumed* to be at the higher end of the interval reported in table 5. The followup treatment time was *assumed* to be identical to the initial setup and treatment time.[28] Since respiratory personnel appear to be used somewhat interchangeably by a significant number of hospitals in our survey, an average wage paid of $12,000 per year was used for our calculations.[29]

Table 4.—Personnel Used To Deliver Various Respiratory Therapy Treatments[a]

	Frequency of response	Percentage of respondents
IPPB treatment		
Technician or therapist	31	72.1%
Therapist,	5	11.6
Technician	4	9.3
Therapist or nurse	3	7.0
Ultrasonic nebulizer administration of a drug		
Technician or therapist	29	69.0
Therapist.	6	11.9
Technician	5	11.9
Therapist or nurse	2	4.8
Simple aerosol generator administration of a drug		
Technician or therapist	29	69.0
Therapist.	5	11.9
Technician	5	11,9
Therapist or nurse	2	4.8
Incentive spirometry treatment		
Technician or therapist	21	48.8
Chest physical therapist	1	2.3
Any nurse	3	7.0
Therapist,	4	9.3
Technician	3	7.0
Therapist or nurse	10	23.3

[a]Based on hospitals in the Washington, D C, SMSA
[b]Because of missing observations, totals may not equal 100 percent

Table 5.—Modal Time Required by a Respiratory Therapist or Technician To Deliver Various Respiratory Therapy Treatments[a]

Treatment modality	Modal time in minutes
IPPB treatment	20-25
Ultrasonic nebulization of a medication	15-20
Aerosol medication treatment delivered by a simple aerosol generator	15
Instruction to patient for incentive spirometer	10-15

[a]Based on hospitals in the Washington D c SMSA

We combined the cost of personnel time with the cost of equipment to estimate the cost differentials between these four different treatment modalities. First, we examined the personnel and equipment costs for delivery of medication or improving inflation of the lungs with an IPPB machine. The various types of IPPB machines currently sell for about $600 and have an expected life of 15 years. However, to be liberal in our estimates, we depreciated the IPPB equipment costs in 7 years using a straight-line depreciation method. This produced a yearly cost of about $85 per year, or about $0.14 per treatment.[30] There is also a one-time charge of about $2.35 for disposable tubing to connect the patient to the machine. The machine is usually powered by compressed air or oxygen, for which we added a generous allowance of $1.00 per treatment. The personnel costs for IPPB are about $2.90 for 25 minutes of personnel time. The estimated cost for initial setup and treatment with IPPB, therefore, is about $6.40.[31] A followup treatment would cost $4.05, because it would include only the personnel, machine, and the electricity costs.

For the delivery of medication with an ultrasonic nebulizer, we estimate the following costs. A nebulizer which currently costs $580 is assumed to depreciate over the same time span as the IPPB machine. There also is a one-time charge for each of the following disposable

[27]The modal time was used instead of the mean, because the data were not normally distributed.
[28]In many instances, followup treatment will require less time. Hence, the cost estimates of followup treatments may have an upward bias.
[29]This wage figure is reported by the Bureau of Labor Statistics, *Industry Wage Survey*, Washington, D. C., SMSA, September 1978(7). The cost of fringe benefits would add about 20 percent to these estimates. Obviously, as the mix of personnel changes or differs between hospitals, costs will also change in a corresponding manner,

[30]We used 25 treatments per week, which we calculated from the survey data.
[31]Recall that this estimate is not the full cost of respiratory therapy, because overhead costs and the cost of physician's time are omitted Since the omitted costs are similar for the four treatment methods, they do not affect the differences in costs,

items: an ultrasonic cup, $2.00; tubing, $0.70; mask, $0.60; and electricity costs, $1.00.[32] The personnel costs for 20 minutes are about $200. This produces a total cost of about $6.30 for an initial setup and treatment. The followup treatment in most instances involves only the personnel, machine, and electricity costs, which amount to $3.14.

Next, we estimate the personnel and equipment costs of delivering a medication by a simple aerosol generator. The equipment cost for simple aerosol is $3.50, and the cost of 15 minutes of personnel time is $1.50, making the total cost for the initial setup and treatment about $5.00. For each followup treatment that requires only personnel,[33] the cost would be only $1.50.

The costs for incentive spirometry to improve lung inflation include the cost of the spirometer itself, $8.60, and the cost of personnel time needed to instruct and supervise the patient in the spirometer's use. This instruction and supervision takes an average of 15 minutes, at a personnel cost of approximately $1.50. This produces an initial treatment cost of $10.10. The cost of a followup treatment is only $1.50, assuming that personnel time is still required but the same instrument is used. (Recall that these relative cost estimates, as well as the others presented, do not include the cost of the physician's time or overhead since these costs are common to all the treatment modalities.)

The relative cost estimates shown in table 6 suggest that for initial treatment, incentive spirometry has the highest relative cost, and simple aerosol has the lowest. The relative costs of the IPPB machine and the ultrasonic nebulizer fall between these. Comparing the calculated relative costs for initial treatment to hospital charges for initial treatment shows the largest difference between costs and charges for IPPB;[34] the next largest difference is for the ultrasonic nebulizer.

Respiratory therapy patients usually require multiple treatments, and the relative cost estimates in table 6 suggest that for a followup treatment, IPPB and the ultrasonic nebulizer have the highest relative costs. The largest difference between the relative cost estimates and hospital charges for a followup treatment is for the simple aerosol; the next largest difference is for the IPPB machine. For a followup treatment, hospital charges are the highest for the IPPB machine.

It is interesting to view these findings in the light of recent trends in the utilization of different respiratory treatment modalities. As noted in the previous part of this case study, at five major teaching hospitals in the Washington, D. C., SMSA, the use of the IPPB machine and the ultrasonic nebulizer is declining, while the use of the incentive spirometer and the sim-

[32] The $1 cost of electricity is only a very rough estimate.
[33] This is the case if the aerosol generator is reused.

[34] These costs do not include the cost of physician's time or hospital overhead costs.

Table 6.—Estimates of Relative Costs and Charges for Four Respiratory Therapy Treatment Modalities[a,b]

	costs		Charges		Difference between costs and charges	
Treatment modality	Initial treatment	Followup treatment	Initial treatment	Followup treatment	Initial treatment	Followup treatment
IPPB	$6.40	$ 4.04	$10.90	$8.90	$4.50	$4.86
Ultrasonic nebulizer	6.44	3.14	10.70	6.60	4.26	3.60
Simple aerosol	5.00	1.50	8.70	6.90	3.70	5.40
Incentive spirometry	10.10	1.50	13.10	6.10	3.00	4.60

[a] Costs include only wages paid to nonphysician personnel and equipment related costs and do not Include the cost of physician's time or hospital overhead costs The latter are assumed to be equal for the four treatments considered
[b] Charges are mean values reported from our survey of the hospitals m the Washington, D C , SMSA