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The Impact of Medical Technology on Medicare Costs

There is no gathering the rose without being pricked by the thorn.

Bidpai

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INTRODUCTION

Changes in the kinds of medical technologies[1] available and changes in the patterns of use of technologies already available continually influence health care and Medicare costs—at times moderating cost increases and at times exacerbating them. As noted in the previous chapter, various factors affect the adoption and use of medical technology. This chapter examines the patterns of medical technology use experienced by the Medicare population compared to the general population. Its primary purpose, however, is to explore the nature and size of medical technolo~yrs contribution to health care and Medicare cost s .

How medical technology contributes to health care and Medicare costs is a question that can be addressed either from an aggregate perspective or from the standpoint of particular technologies or classes of technology.

The question from the aggregate perspective is whether changes in medical technology use as a whole have raised or reduced health care or Medicare costs and, if so, by how much. This perspective is useful, because it puts technology's relationship to costs into a policy perspective. Changes in the use of medical technology reflect changes in the behavior of medical decision makers. Quantitative estimates of technology's aggregate contribution to health care costs, therefore, reflect the importance of changes in medical decisions, which can be presumed to be influenced by policy, relative to changes in other, less controllable factors such as population growth or general wage and price inflation.

The aggregate approach is limited, however, because it ignores the patient benefits associated with cost increases or decreases, it does not take into account the underlying reasons for changes in medical decisions or practices, and i t does not show that cost-saving or cost-raising changes in technology are not scattered evenly across illnesses. In short, it offers no way of knowing whether any particular technology-related rate of change in health care or Medicare costs is too high or too low.

Analyzing how specific technologies or classes of technology affect health care or Medicare costs can be more enlightening, particularly when the information that results is combined with data on efficacy and patterns of adoption and use. Analyses of the cost implications for Medicare of seven specific medical technologies are provided in this chapter.

[1]As noted in ch. 1, OTA defines medical technology as "the drugs, devices, and surgical and medical procedures used in medical care, and the organizational and supportive systems within which such care is provided." The term "medical services" is often used interchangeably with "medical technology" in this report.

MEDICARE BENEFICIARIES' USE OF MEDICAL TECHNOLOGY

By definition, Medicare enrollees are either aged or disabled. Furthermore, they are disproportionately high users of health care services in general and of medical technology in particular (126). Although a high proportion of health care expenditures for the elderly is for nursing homes and other long-term care services, it is important to recognize that the elderly are high users of services provided in hospitals, where medical technology is concentrated. Age-specific hospital discharge rates for selected years from 1973 to 1982 are shown in table .5. Not only has the number

Table 5.—Discharges From and Days of Care in Short-Stay Non"Federal Inpatient Hospitals by Patient Age, Selected Years From 1973 to 1982

Age	Discharges per 1,000 population							Average annual percent change	Percent change 1973 to 1982
	1973	1975	1978	1979	1980	1981	1982		
<15	70.8	71,5	68.8	70.8	71,8	7 2 . 9	71:2	0.1%	0-.6 0/0
15-44	154.4	155.4	155,1	151.8	151.3	148.7	145.0	–0.6	–6.0
45-64 ., ...	182.3	194.7	193,1	192.4	196,0	195.3	195.5	0.7	7.2
› 65	341.8	359.3	381.9	361.5	405.2	396.5	398.8	1.5	16.7
All ages	154.0	158,8	159,8	156.9	161,9	160.2	167.9	0.9	9.0

Age	Days of care per 1,000 population				Percent change 1973 to 1980
	1973	1978	1979	1980	
< 15	321.9	304.8	314.7	316.4	– 1.7%
15-44	878.5	824.7	817.8	793.1	– 9.7
45-64	1,661.0	1,638.7	1,604.3	1,607.0	– 1.0
≥ 65	4,136.4	4,183.8	4,182.5	4,327.5	4.6
All ages	1,192.3	1,165.4	1,158.2	1,163.0	– 2.5

Data sources:

1. 1973 and 1978 data, U.S. Department of Health and Human Services, National Center for Health Statistics, *Health—United States, 1980,* DHHS publication No. (PHS) 81-1232 (Hyattsville, Md.: DHHS, December 1980).
2. 1975 and 1980 data, U.S. Department of Health and Human Services, National Center for Health Statistics, *Health—United States, 1982,* DHHS publication No. (PHS) 83-1232 (Hyattsville, Md.: DHHS, December 1982).
3. 1979 and 1981 discharge data, U.S. Department of Health and Human Services, National Center for Health Statistics, *Health—United States, 1983,* DHHS publication No. (PHS) 84-1232 (Hyattsville, Md.: DHHS, December 1983).
4. 1979 days of care data, U.S. Department of Health and Human Services, National Center for Health Statistics, *Health—United States, 1981,* DHHS publication No. (PHS) 82-1232 (Hyattsville, Md.: DHHS, December 1981).
5. 1982 discharge data, U.S. Department of Health and Human Services, National Center for Health Statistics, "1982 Summary: National Hospital Discharge Survey," No. 95, DHHS publication No. (PHS) 84-1250 (Hyattsville, Md.: DHHS, Dec. 27, 1983).

SOURCE: Office of Technology Assessment

of discharges per 1,000 population increased dramatically for the elderly population, but in the period from 1977 to 1982, the number increased more rapidly for the elderly than for other segments of the population, Furthermore, once in the hospital, elderly people experience longer lengths of stay than do younger people.[2] It is interesting to note, however, that the covered clays of care for the Medicare population increased only **4.6** percent between 1973 and 1980.

[2]The longer lengths of stay experienced by the elderly are due in part to the use of the hospital as a substitute for nursing homes. "Backed-up" hospital patients awaiting nursing home placement have been estimated to account for 10 percent of the annual occupancy of some hospitals (371) and in 1980 cost Medicare $1.5 billion in hospital expenditures (371).

In the hospital, elderly patients use many medical technologies more frequently than the rest of the population. Table 6 presents age-specific data on surgical operations in short-stay hospitals between 1973 and 1980. In 1980, the rate of surgery among the elderly was 61 percent higher than the rate in the population as a whole. Furthermore, from ***1973*** to 1980, it increased by 37 percent, while the rate for the population as a whole increased only 22 percent (.5).

Intensive care units (ICUs) typically represent the confluence of medical technology and intensive nursing care in a complex system of care for the critically ill. In 1980, about 18 percent of Medicare hospital stays involved intensive or coronary

Table 6.–Operative Procedures in Short-Stay Hospitals by Patient Age, 1973-80 (rate per 1,000 population)

Age	1973	1974	1975	1976	1977	1978	1979	1980
<15	41.9	42.2	40.5	41.0	41,0	37.6	37.2	36.0
15-44	96.4	99.8	101.5	99.5	104.7	100,6	125.7	121.3
45-64	113.2	117.3	123.3	122.5	124.6	119.0	121.3	122.8
>65	140.7	145.9	154.8	154.9	165.9	172.2	183.4	193.2
All ages[a]	89.5	92.9	95.4	95.4	99.7	97.0	110.5	109,9

aBeCaUSe of rounding, the sum of procedures for all ages may not total

SOURCE: I N Haug and R Seeger (eds), Socio-Economic Factbook *for* Surgery 1982, Surgical Practice Department, American College of Surgery, 1982 care units (161). The available evidence seems to indicate that the representation of the elderly is the same or only slightly greater in ICUs than it is in the hospital as a whole (354). Thus, while the elderly are likely to require more intensive care than other segments of the general population, once in the hospital they appear to be placed in ICUs no more often than the nonelderly population (3.54). Once in an ICU, however, elderly patients generally receive more interventions than other patients (57). According to Knaus, the key factor influencing the use of resources once a patient is in an ICU is acute and chronic health status, not age in and of itself (190). Elderly patients in ICUs are simply sicker than other ICU patients.

The more frequent and intensive use of specific medical technologies by elderly patients translates into a greater representation of the elderly among high-cost patients within the hospital. Thus, for example, a 1976 study of almost 27,000 patients in three short-term hospitals found that ***23.8*** percent of the patients were over **65** years of age, but 41 percent of the high-cost patients' were over 65 (437). Furthermore, the National Medical Care Expenditures Survey conducted in 1977 found that the mean charge per hospital admission was $2,198 for patients 65 or older compared to $1,251 for the nonelclerly population, a difference of $947 (395). The difference reflects not only the greater use of specific medical technologies by the elderly but also the longer inpatient stays generally experienced by the elderly ***(10.3*** days per admission compared to 7.1 days in the general population in 1977) (39.5). In 1977, the average daily rate for a semiprivate room was approximately $91 (180).

'High-cost patients were defined in the study as patients whose total charges fell in the upper 20 percent of charges for patients in the hospital.

Thus, of the $947 extra charge per stay, about **$503 can be** attributed to the extra use of ancillary technologies by the elderly and the rest to the longer length of stay.

The general pattern of high use of medical technology by the elderly extends beyond the hospital to ambulatory care settings as well. As shown in table 7, the rate of ambulatory visits to physicians for diagnostic services is higher among elderly persons than among other segments of the population. Interestingly, however, the rate of X-ray testing in patients who do visit a physician for diagnostic reasons is not higher in the elderly. The elderly are also relatively high users of prescription drugs, despite the fact that Medicare does not pay for outpatient prescription drugs. In 1977, about 75 percent of the population 65 or older had at least one prescription compared to 58 percent of the general population (398). Furthermore, during the decade preceding that year, the intensity of use of prescriptions by Medicare Part B beneficiaries had increased (147). Finally, the use of medical equipment and supplies outside of hospitals and nursing homes was more than twice as frequent in the elderly as in the general population (397).

It is hardly startling that elderly people use more health care services and medical technologies in the aggregate and use them more intensively than the rest of the population. The importance of this fact lies in its implications for the Medicare program. Changes in types of medical technologies available or the patterns and conditions of the use of such technologies are likely in the aggregate to have strong effects on the costs of the Medicare program precisely because of the intensity with which Medicare enrollees use technology. The next section attempts to explore the extent of that impact.

MEDICAL TECHNOLOGY'S AGGREGATE IMPACT ON MEDICARE COSTS

In order to investigate the aggregate contribution of changes in medical technology (i. e., changes in the kinds of technologies available and in the ways in which technologies are used in the practice of medicine) to Medicare costs, one must first examine the impact of technology on over-

Table 7.–Use of Ambulatory Physician Visits With Specified Diagnostic Services by Age, 1977

		Annual number of visits per 1,000 population			Percent of persons with at least one visit		
Age	Total population (in thousands)	Visits with any diagnostic services	Visits with X-ray	Visits with laboratory tests	Visits with any diagnostic service	Visits with X-rays	Visits with laboratory tests
<6 years	18,216	746	119	528	39.1	7.9	30.9
6 to 18 years.	50,647	652	204	355	34.1	12.7	21.7
19 to 24 years	22,299	1,211	231	654	46.9	13.4	26.5
25 to 54 years.	78,472	1,327	262	565	51.5	16.0	24.4
55 to 64 years.	20,180	1,614	307	673	55.4	18.1	27.0
>65 years	28,284	1,881	254	971	56.0	15.9	34.0
All ages	212,098	1,189	236	574	46.6	14.4	25.8

SOURCE: L. F Rossiter and C M Horgan, "Unequal Financial Incentives for Diagnostic and Preventive Health Care, " paper prepared for 109th Annual Meeting of the American Public Health Association, Medical Care Section, Los Angeles, Caif., November 1981 all health care expenditures. There are several methods for measuring technology's contribution to health care costs. The most common method is the "intensity of care" approach.

The "Intensity of Care" Approach to Measuring Technology's Contribution to Health Costs

The intensity of care approach involves dividing a change in total expenditures for health care[4] into its constituent parts:

- population or enrollment changes,
- overall wage and price inflation,
- wage and price inflation in medical care in excess of general inflation, and
- changes in "service intensity."

Changes in technology use are included in the latter two measures, although these measures also reflect other factors.

Service intensity refers to the quantity of inputs that go into producing a given unit of health care. Such inputs include labor, supplies, materials, and equipment. Labor intensity refers to the quantity of personnel used to produce a unit of health care. Nordabor intensity refers to the quantity of materials and supplies as well as the capital plant and equipment used in producing the unit of health care.

Although changes in service intensity have been labeled the "technology factor" (132), service intensity is not synonymous with medical technology use, To understand both the usefulness and limitations of estimates of changes in service intensity, it is helpful to consider how measures of intensity are related to the changes in medical technology whose effects are desirable to identify.

One way to relate service intensity to the use of technology is to examine how hypothetical changes in medical technology would be likely to alter the operations, and thus costs, of health care institutions. The introduction of a new device in a hospital, for example, often involves both capital (nonlabor) and some operating (both labor and nonlabor) costs for its application and maintenance. If the device is more sophisticated than the average technology in the hospital, it may require more highly trained technicians, thus driving up the average wages of hospital personnel. But the services provided by the device might substitute for other services, thereby reducing labor and nonlabor costs in other areas. Or the new device may have negligible effects on hospital operations and simply be a product improvement, with a concomitant increase in product price.[5] Finally, a new device may draw into the hospital patients who would otherwise not be hospitalized, thereby increasing admissions and the routine (labor and nonlabor) costs associated with a hospital stay as well as the costs of the service itself. Of course, these admissions might reduce the costs of other sectors of health care, such as ambulatory care or drugs.

These observations suggest that the effects of changes in medical technology on health care costs must be traced through the changes' specific effects on hospital costs and other components of health care costs. Changes in hospital costs due to technological change are reflected in two measures:

- service intensity, or the quantity of inputs per admission and the frequency of hospital admissions; and
- the technical sophistication of inputs as reflected in changes in the input prices (or wages) relative to general price level changes.

Thus, changes in technology affect service intensity, but they also affect another component of hospital cost.

Each of these components of hospital cost is also affected by forces unrelated to technology. For example, both the quantity of labor used in the hospital and the average wage paid to hospital personnel may be driven up because hospitals have inadequate incentives to be efficient or because the hospital work force has been recently unionized (131). The price and quantity of medical equipment, materials, and supplies might also

[4] This approach may also be used for one or more of the major components of health care costs.

[5] A new fully programmable cardiac pacemaker, for example, would be more expensive than more traditional pacemakers, but it would have little effect on the hospital's costs of pacemaker insertion; the full effect on hospital cost would be the increased price of the pacemaker reflecting its enhanced capabilities.

increase relative to general inflation because of inadequate incentives for efficiency in the hospital sector: Finally, hospital admissions are altered by changes in the incidence of illness and the general aging of the population, among other things. Thus, the components of hospital cost likely to be affected by changes in medical technology are also likely to be influenced by other factors.

It appears, then, that the separation of health care cost increases into their components provides at best an oblique view of the contribution of changes in medical technology use to costs. The aforementioned caveats having been noted, the evidence on the components of hospital and health care cost (or expenditure) inflation is presented below,

Several analysts have divided changes in *hospital costs* into their constituent parts, including service intensity (3,117, 126,419,430). Waldman (419) estimated that increases in service intensity (i.e., labor, supplies, and equipment) accounted for about one-half of the annual change in the daily cost of hospital care between 1951 and 1970. Studies of increases in hospital costs per day through the mid-1970's found similar results (3, 116). Feldstein and Taylor (117), for example, found that slightly less than one-half of the rise in average daily hospital costs between 1955 and 1975 was due to an increase in the intensity of services delivered per day. Altman and Wallack (3) found that roughly one-third to one-half of the annual increase in daily hospital costs between 1971 and 1976 was the combined result of an increase in the intensity of services and an increase in the price of hospital inputs relative to general wage and price inflation.

Freeland and Schendler's recent analysis of the 283-percent increase in national expenditures for hospital care over the period 1971 to 1981 found that 59 percent of the increase could be explained by overall inflation in the economy and growth in the U.S. population (126). The remaining 41 percent of the increase in national expenditures for hospital care was due to three technology-related factors:

- increased hospital admissions per capita (8.6 percent);
- increased intensity, or input use, per admission (20.8 percent); and
- increased hospital input prices in excess of general inflation (11.7 percent).

From 1971 to 1981, these three factors raised national expenditures for hospital care about 157 percent.

Table 8 presents data on hospital cost increases for the period 1977 to 1982. OTA estimates that increases in service intensity (labor and nonlabor imputs) per capita accounted for 24 percent of the 93-percent increase **in per capita hospital costs during the most recent 5-year period.** A small part of this effect is due to the higher admission rate (a 5-year increase of 2.1 percent), but the overwhelming part of the intensity increase is due to higher intensity per hospital admission.

The results of the aforementioned analyses are summarized and compared in table 9. The estimated growth in the intensity of hospital inputs clearly depends on the time period studied and the denominator unit. However, all five analyses support the conclusion that **the intensity of hospitals' services has contributed substantially to the growth in hospital costs over the past 20 years.**

When the components of growth of total personal health care expenditures in the United States are considered, increasing intensity of care appears to be a less important source of expenditure inflation than it is for the hospital sector alone. Table 10 shows estimated growth in real per capita personal health care expenditures between 1977 and 1982 (when population growth and general price inflation, as measured by the Consumer Price Index, are taken into account). The combined effect of increasing intensity and increasing health care prices in excess of the Consumer Price Index is a relatively small proportion (about 16 percent) of the increase in per capita personal health care expenditures during the 5-year period. Nevertheless, these two technology-related components of cost together increased real per capita health care expenditures at an average annual rate of 2.8 percent during the period.

It is possible to account for the components of Medicare cost increases over an appropriate time

Table 8.– Decomposition of Hospital Costs, 1977-82

	1977	1982	Difference 1982 – 1977	Percent change 1977-1982	Average annual percent change
1. Total hospital costs (millions) ... ., . .	$51,647	$104,876	$53,229	103,1 '70	15.2%
2. Total U.S. population (thousands)	219,760	231,534	11,774	5	1,1
3. Total adjusted hospital admissions (thousands)	39,012	41.947	2,935	8	1.5
4. Total full time equivalent employees (thousands) ., ., ...	2,573	3,306	733	29	5,1
5. Consumer Price Index (1977= 100)	100	159.3	NA[b]	NA	NA
Service intensity per adjusted admission:					
6. Hospital costs per adjusted admission . .	$1,324	**$2,500**	$1,176	89	13,6
7, Nonlabor costs per adjusted admission . . .	$563	**$941**	$378	92	13,9
8. Nonlabor inputs per adjusted admission (7/5)	$563	**$591**	$28	21	3.8
9. Labor costs per adjusted admission ., ...	$761	**$1,421**	$660	87	13.3
10. Index of hospital labor costs per full time equivalent employee (1977 = 100) . .	100	156	NA	NA	NA
11, Labor inputs per adjusted admission (9/10) .,	$761	$910	$149	19	3.6
12. Change in labor and nonlabor inputs per adjusted admission (8+ 11) ., ..., ...	NA	NA	177	NA	NA
Service intensify per capita:					
13. Hospital costs per 1,000 population . . .	$235	$453	$218	93	14.0
14 Nonlabor costs per 1,000 population ., . .	$100	$196	$96	95	14.3
15 Nonlabor inputs per 1,000 population (14:5) . .	$100	$123	$23	23	4.2
16. Labor costs per 1,000 population . . . . . .,	$135	$257	$122	92	14.0
17, Labor inputs per 1,000 population (16 / 10) . .	$135	$164	$29	21	4.1
18, Change in labor and nonlabor inputs per capita (15+17) ., ..., ...	NA	NA	52	NA	NA

aAdjusted admissions include outpatient visits, which are weighted in equivalent units
bNA—Not applicable
Data sources
1 Most data derived from American Hospital Association *Hospital Statistics* table 6, 1978 and 1983 editions
2 Population data from U S Department of Commerce *U S Statistical Abstract*
3 Consumer Price Index found in U S Department of Health and Human Services National Center for Health Statistics *Health—United States 1982* DHHS publication No (PHS) 83 1232 (Hyattsville Md DHHS December 1982]

SOURCE Office of Technology Assessment

Table 9.—Summary of Studies of Hospital Cost Inflation

	Source and study period covered				
	Waldman 1951-70	Feldsteln 1955-75	Altman & Wallack 1971-76	Freeland & Schendler 1971-81	OTA 1977-82
Hospital cost per patient day:					
Annual average percent change	8.6% per year	1 20/0 per year	17.1 %per year	—	—
Proportion due to service intensity	50 %	480/o	30.6 to 50.5%	—	—
Hospital cost per admission:					
Annual average percent change .,	—	—	—	1 3% per year	13.2$ per year
Proportion due to service intensity	—	—	—	20,8 %	15 0/0
Hospital cost per capita:					
Annual average percent change	—	—	—	—	14.0% per year
Proportion due to service intensity	—	—	—	—	24%

Data sources
1 S Waldman, "The Effect of Changing Technology on Hospital Costs," *Research and Statistics Note*, Social Security Administration, Office of Research and Statistics, DHEW publication No. (SSA) 72-11701, Feb. 28, 1972.
2 M. S. Feldstein, *Hospital Costs and Health Insurance* (Cambridge, Mass.: Harvard University Press, 1981).
3 S. H. Altman and S. S. Wallack, "Technology on Trial—Is It the Culprit Behind Rising Health Costs? The Case For and Against," in *Medical Technology: The Culprit Behind Health Care Costs*, proceedings of the 1977 Sun Valley Forum on National Health, DHEW publication No. (PHS) 79-3216, 1979.
4 M. S. Freeland and C. E. Schendler, "National Health Expenditure Growth in the 1980's: An Aging Population, New Technologies, and Increasing Competition," *Health Care Financing Review* 4(3):1-58, March 1983.

SOURCE Office of Technology Assessment

Table 10.—Increase in Personal Health Care Expenditures,[a] 1977-82

	1977	1978	Percent change	1979	Percent change	1980	Percent change	1981	Percent change	1982	Percent change	Average annual percent change 1977-82
1. Total personal health care expenditures (billions)	$148.7	$166.7	12.1 0/0	$188.9	13.30/0	$219.4	16.1 '/0	$255.0	16.2%	$286.9	12.50/o	14.0"/0
2. U.S. population (millions)	220	222	0.9	225	1.4	227	0.9	229	0.9	22	1.3	1.1
3. Personal health care expenditures per capita	$657.9	$750.9	11.1	$839.6	11.8	$996.5	15.1	$1,113.5	15.2	$1,236.6	11.0	12.8
4. Consumer Price Index	100.0	107.6	7.6	119.9	11.4	136.1	13.5	150.0	10.2	159.3	6.2	9.8
5. Medical care index (1977=100) (12-month period ending September)	100.0	108.5	8.5	118.3	9.1	131.0	10.7	146.1	11.5	162.2	11.0	10.2
6. Real personal health care expenditures per capita (3 / 4)	$675.9	$697.9	3.3	$700.3	0.3	$710.1	1.4	$742.3	4.5	$776.3	4.6	2.8
7. Real health inputs per capita (service intensity (3 ÷ 5)	$675.9	$692.1	2.4	$709.7	2.5	$737.8	3.9	$762.1	3.2	$762.4	0.1	2.4

[a]Personal health care expenditures are national health care expenditures minus administrative costs.

Data sources:

1. Total health care expenditure data for 1977 to 1981. U.S. Department of Health and Human Services, National Center for Health Statistics, *Health—United States, 1982*, DHHS publication No. (PHS) 83-1232 (Hyattsville, Md.: DHHS, December 1982).
2. 1982 health care expenditure data, U.S. Department of Health and Human Services, Health Care Financing Administration, Statistical Information Services, personal communication, Sept. 1, 1983.
3. U.S. population, U.S. Department of Commerce, *U.S. Statistical Abstract*.
4. Medical care price index, U.S. Department of Health and Human Services, Health Care Financing Administration, *Health Care Financing Trends*, DHHS publication No. 03091, winter 1981.
5. 1981 and 1982 medical care index data, U.S. Department of Commerce, Bureau of Labor Statistics, personal communication, Sept. 1, 1983.

SOURCE: Office of Technology Assessment.

interval, but the interpretation of the estimates is more clouded than it is for general health care costs. Changes in program eligibility, such as the inclusion of disabled people in ***1972,*** or in covered benefits, such as the expansion of home health care benefits in 1980, can lead to dramatic changes in measured service intensity that have little to do with changes in medical technology but instead represent a shift in the burden of payment for services already available and used. Changes in per capita service intensity do indicate how much more or less of health care services Medicare is paying for now than at some earlier date. Table 11 provides per capita estimates for ***1977*** and ***1982.***

The data presented in table 11 indicate that most of the 107-percent increase in Medicare expenditures per enrollee between 1977 and 1982 is due to general price inflation. But 25 percent of the increase in Medicare expenditures per enrollee from 1977 to 1982 is due to Medicare's payment for **more services per enrollee, and another** 3 percent is due to the increased prices of medical services **in excess of general price inflation.** [b] **Thus, nearly 30 percent of the increase in Medicare costs per enrollee from *1977* to** 1982 can be attributed to two technology-related components of costs.

[b]The percent due to medical price inflation may be overstated, and the service intensity percentage correspondingly understated, because the amount Medicare actually pays for *services* (i.e., the effective price) probably lies somewhat below stated prices,

Table 11.—Real Medicare Expenditures per Enrollee, 1977 and 1982

	1977	1982
1. Medicare expenditures per enrollee	$927.54	$1,925.40
2. Consumer Price Index (1977=100)	100.00	159.30
3. Medical care price index (1977=100)	100,00	162.40
4. Real Medicare expenditures per enrollee (1 ÷ 2)	$927.54	$1,208.66
5. Real Medicare inputs per enrollee (1 ÷ 3)	$927,54	$1,185.59

Data sources
U S Department of Health and Human Services Health Care Financing Administration, *The Medicare and Medicaid Databook, 1981*, HCFA publication No 03156 (Baltimore, Md HCFA, April 1982) U S Department of Health and Human Services, Health *Care Financing* Administration, Office of Statistical Information, personal communication, Sept 1, 19&3, U S Department of Commerce, Bureau of Labor Statistics, personal communication, Sept 1, 1983

SOURCE Office of Technology Assessment

Other Estimates of Technology's Contribution to Health Care Costs

The service intensity approach has its limitations as a way of estimating technology's contribution to health care costs. A few analysts have used different approaches and data bases to look at the question.

Redisch (267), for example, analyzed cost and operating data for a sample of about 1,500 hospitals and found that approximately 40 percent of the rise in operating costs per admission resulted from the increased use of eight types of ancillary services, all of which must be ordered by the physician. (The services were pathology, nuclear medicine, anesthesiology, pharmacy, laboratory, diagnostic X-ray, therapeutic X-ray, and blood bank.) Whether the increased use of ancillary technologies in the hospital has corresponded to reductions in the cost of other kinds of health care, however, is unknown.

Several analysts have used a "residual approach" to measure the impact of technological change on hospital or health care expenditures. In this approach, expenditures over time are regressed on a number of variables influencing supply or demand for health care services. [7] The unexplained residual of changes over time is then assumed to measure the effect of technological change.

In a study of hospital costs from 1962 to 1968, Davis (82) found that 38 percent of the total annual increase in hospital cost per admission was unexplained by variables reflecting supply and demand conditions. This residual translates into a 2-percent annual increase in hospital expenses per admission attributed to technological change.

Other analysts have used the residual approach to estimate the impact of technological change on total health care costs (130,231). In one study, which covered the period 1930 to 1975, Mushkin and colleagues (231) estimated that technological change *reduced* total health care expenditures at

[7]In the regression process, each variable receives a weight that represents the relative degree to which that variable explains or contributes to the change in expenditure. Some percent of the change cannot be explained by the variables. This percent is called the residual.

an annual rate of 0.5 percent. In a similar study, which covered the period ***1947*** to 1967, however, Fuchs (130) found that technological change raked expenditures at an annual rate of 0.6 percent.

The difference in the findings of these two studies could, as Mushkin claimed, be due to differences in the periods studied or the variables chosen for study. Altman and Wallack (3) have pointed out significant limitations of the approach used in both studies. One limitation is the sensitivity of any residual estimate to the variables chosen for inclusion. In Altman and Wallack's words, "even relatively small errors in specification [of the variables chosen] or in the statistics used to estimate the model can lead to the conclusion that technology has had a positive impact on rising health care costs when the true result is negative, or vice versa" (3). An even more important limitation of the approach is the narrow interpretation of technological change embodied in the residual. A major portion of the increased use of medical technology may well be attributed to demand-related factors such as the growth of third-party payment or personal income over the periods of study. Since these variables were included as variables in the regressions, the contribution to health care costs of changes in medical technology is underestimated. In short, the residual approach gives too narrow a view of just how changes in the quantity, quality, kinds, and settings of use of medical technology have influenced health care costs.

Another useful approach to looking at technology's impact on health care costs is to focus on a specific illness and to document the array of medical practices and procedures used to treat the condition at two different times. The costs of treating the illness using the practices current in each time period can be estimated, and the difference in these costs can be considered the effect of technological change on the cost of illness, However, it should be noted that this approach does not account for changes in the rates of use of treatments. Furthermore, only a few conditions can be studied because of the high cost of this kind of analysis. Trends detected in studies of a few illnesses certainly do not represent all illnesses and may not even represent the most important ones.

Scitovsky and McCall (298) took this approach to explain the net increase from 1964 to 1971 in the average cost of treatment for eight conditions: otitis media, forearm fracture, appendicitis, maternity care, breast cancer, pneumonia, duodenal ulcer, and myocardial infarction. In almost every instance, there were both cost-raising and cost-saving changes in treatment. However, the authors noted that the costs of treatment of conditions requiring hospitalization rose at a considerably faster rate than those of conditions treated on an ambulatory basis. Among the factors leading to higher costs were shifts to more expensive drugs, increases in the number of laboratory tests per case, and the use of more miscellaneous inpatient and outpatient services. The most dramatic cost increases occurred in the treatment of myocardial infarction, traceable principally to the increased use of ICUs during the time period. [a] The increase in the cost of treating this condition was greater than the decrease in the costs of five other illnesses combined. Of course, the net effect on health care costs would depend on the relative frequency of the various conditions in the population.

Conclusions From the Aggregate Studies

Although none of the approaches to measuring technology's aggregate contributions to health care cost is entirely satisfactory, **taken as a whole, the available evidence leads to the conclusion that U.S. health care costs have increased in part because more is being done for patients today than ever before.** More and better trained personnel, more procedures, more medicines, and more and higher priced equipment, materials, and supplies are being used in the delivery of health care to Medicare patients and to the Nation as a whole. And, the trend toward "more" is not abating. The intensity of service use continues to increase.

Despite the net increase in service intensity, the evidence also demonstrates the variation in tech-

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'For more information, see the forthcoming case study in OTA's Health Technology Case Study Series entitled *Intensive Care Units (ICUs): Costs, Outcomes, and Decisionmaking (354),* prepared by Robert A, Berenson, M.D.

nology's effects on costs. In the **past 5 years, the hospital sector appears to have experienced relatively** greater increases in intensity than has the health care sector as a whole. And, as Scitovsky and McCall's (298) research illustrates, cost-raising and cost-saving changes in technology are not scattered evenly across illnesses. **The real cost of treating some illnesses has declined as a result of technological change, while that of others** has increased dramatically. Thus, summary statements about technology's net influence on health care *or* Medicare costs mask the rich assortment of ways in which changes in medical technology **shape the health care** system **and** its costs.

SELECTED MEDICAL TECHNOLOGIES AND MEDICARE COSTS

To highlight the extent to which the costs of the Medicare program are altered by new technologies, this section describes seven technologies first introduced in the 1960's or 1970's and examines their actual and potential impact on Medicare costs. The seven technologies are:

- coronary artery bypass graft surgery,
- the drug cimetidine,
- therapeutic apheresis,
- pneumococcal vaccine,
- intensive care units,
- parenteral nutrition therapy, and
- kidney dialysis.

All seven of the technologies have clear patient benefits—in some cases, they are even life saving—but for all of them, there are uncertainties about the most appropriate indications for use. Five of the technologies have raised or could raise Medicare's costs, in some cases significantly. Two have saved or could save Medicare costs. Above all else, these seven technologies illustrate how exposed the Medicare program is to changes in medical technology that are largely beyond its control. In the face of new technologies that offer both patient benefits and higher costs, the challenge for Medicare may be how to encourage the use of those that are most cost effective.

Coronary Artery Bypass Graft Surgery

Coronary or arteriosclerotic heart disease, often caused by narrowing and blocking of the arteries that supply blood to the heart, is the number one cause of death in the United States. In 1982, heart disease was responsible for approximately 500,000 deaths (408). Furthermore, in 1968, this disease was the most frequent condition diagnosed for patients at the time of discharge from hospitals in this country (198).

Coronary artery bypass graft surgery (CABG), a procedure in which a graft is used to bypass a constricted portion of the coronary artery and thus to improve oxygen supply to the heart muscle, has become the primary surgical approach to treatment of coronary artery disease (53). Since coming into practice in the early 1970's, the procedure has diffused quite rapidly: approximately 25,000 operations were performed in the United States in 1973; at least 70,000 in 1977; 86,000 in 1979; 100,000 in 1980 (266); and 170,000 in 1982 (87,341). The rate of CABG in the United States has been estimated to be from 4 to 10 times as high as that of the United Kingdom, although the incidence of coronary artery disease is similar in the two countries (266,297),

Data from a 15-institution registry of patients undergoing evaluation for suspected coronary artery disease during the period from 1974 to 1979 reveal that 10 percent of such patients were ***65*** years of age or older (186). About 15.2 percent of the bypass procedures performed in Maryland in 1980 were on patients 65 or older (68). However, 1982 data from the National Hospital Discharge Survey suggests that almost 30 percent of all such procedures were performed on those ***65*** years of age or older ***(87).***

Almost all evaluations of CABG have shown that the surgery is more effective than medical management in relieving angina pectoris (a condition characterized by severe chest pain). After surgery, angina is lessened in 80 to 90 percent and totally relieved in ***60*** to 70 percent of patients. The available data can be interpreted as suggesting that surgery is far more effective than medical manage-

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ment in improving that aspect of quality of life (266). Two clinical evaluations have demonstrated the life-extending properties of CABG in patients with coronary artery disease involving three vessels or the left main coronary artery, but the life-extending properties of the procedure are more uncertain when only one or two arteries are involved and when left ventricular function is severely restricted ***(422).*** Recently, the results of a clinical trial covering 15 medical centers revealed that CABG has not been shown to extend life in patients with mild or no chest pain and should probably be delayed until chest pain increases. The trial included patients under ***65*** years of age who did not have narrowed left main coronary arteries and who had mild or moderate chest pain, or those who had had at least one heart attack already but no chest pain. The investigators found no difference in mortality between medical and surgical management. Patients with surgery had greater relief from chest pain and better exercise tolerance, but the surgical group was hospitalized more often. Perhaps most telling, chest pain gradually worsened in both groups, and since a second operation is more hazardous than the first, the investigators concluded that "there is no penalty for waiting. " The investigators estimate that about 25,000 of the 170,000 CABG procedures performed in 1982 would be contraindicated by these findings (192),

CABG itself is costly, estimated at approximately $15,000 to $20,000 in 1981, including hospital and surgical fees (422). But, the surgery also saves part of the costs of medical management of coronary artery disease and avoids the cost of treating heart attacks that are prevented by the surgery. When these savings in medical costs are taken into account, the net costs associated with CABG surgery range from $10,000 to $19,000, depending on the presenting condition of the patient (422).

If the age distribution of bypass surgery patients in the United States follows that reported by the National Hospital Discharge Survey, then approximately 50,000 procedures were performed on Medicare's aged population in 1982. This would imply that the procedure cost the Medicare program and its beneficiaries approximately $500 million to ***$950*** million in that year.[9] At this cost, Medicare buys for some elderly patients substantial benefits in the form of improved quality and extra years of life. For a substantial minority (estimated at 15 percent or ***7,500*** procedures), the procedure may offer little in the way of improvement. Thus, an estimated ***$75*** million to $142 million of the 1982 expenditures by or on behalf of Medicare patients for CABG surgery may have been unnecessary. Even disregarding these potentially excess costs, CABG has had a substantial impact on annual Medicare costs.

Cimetidine

Peptic ulcer disease is a relatively common illness with important ramifications for Medicare. In ***1976,*** about ***620,000*** hospital discharges in the United States were for peptic ulcer, representing a rate of about 175 per 100,000 people (432). Furthermore, over 25 percent of the hospital stays for peptic ulcer involved surgery (433). The incidence of peptic ulcer disease increases with age (119). In 1978, fully 40 percent of hospital days of care for ulcer disease were for those 65 years or older (see table 12). In addition, the rate of ulcer-related surgery was twice as high for the elderly as for the general population (see table 13). In 1975, the total direct and indirect costs of ulcer disease in the United States were roughly estimated to be in the neighborhood of $2 billion (121).

In August 1977, a new drug was approved for use in the United States for the short-term treatment of duodenal ulcers. ***[10]*** This drug, known as cimetidine, acts by blocking stimulation of gastric acid secretion. Clinical evidence has demonstrated that cimetidine promotes healing of ulcers compared to placebo (121).

Several analysts have investigated cimetidine's impact on the use of health services. Studies in the United States and abroad have documented

[9] Although not all of the costs of an individual surgery occur during the year in which the procedure is performed, the estimate is reasonably accurate for the Medicare population as a whole,

[10] In 1976, duodenal ulcers accounted for approximately one-half of all hospitalized peptic ulcer cases in the United States. Gastric and unspecified ulcers accounted for the other half.

Table 12.— Days of Care for Ulcer Disease for Patients Discharged From Short-Stay Hospitals, 1977-79 (per 100,000 population)

	1977		1978		1979	
ICDA code	All ages	› 65 years	All ages	>65 years	All ages	>65 years
531 —Stomach ulcer	524.6	2,119.5	484.1	2,186.0	412.3	1,773,3
532—Duodenal ulcer	751,3	2,554.1	636.9	2,220.2	559.7	1,955.5
533—Peptic ulcer	294,4	940.4	263.9	871.4	248.4	708.5
534—Gastrojejunal ulcer	30.5	140,5	37.3	90,3	30.7	105,3

Data sources
U S Department of Health and Human Services, National Center for Health Statistics, "Detailed Diagnosis and Surgical Procedures for Patients Discharged From Short Stay Hospitals United States " for years 1977 1978 and 1979 (Hyattsville, Md DHHS)

SOURCE Off Ice of Technology Assessment

Table 13.—Operations for Ulcer Disease for Patients Discharged From Short-Stay Hospitals, 1977-79 (per 100,000 population)

	1977		1978		1979	
ICDA procedure	All ages	z 65 years	'All ages	>65 years	All ages	› 65 years
46,2—Partial gastrectomy ., ...	24.1	77.7	18.5	37.7	4.0	8.1
46.8—Vagotomy.	21.5	46,9	13,6	26.2	1.8	8.1

Data sources
U S Department of Health and Human Services National Center for Health Statistics, "Detailed Dtagnosis and Surgical Procedures for Patients Discharqed From Short Stay Hospitals United States, " for years 1977 1978, and 1979 (Hyattsvllle Md DHHS)

SOURCE Off Ice of Technology Assessment

reductions in duodenal ulcer surgery rates immediately following the introduction of cimetidine in 1977. Fineberg and Pearlman (122) estimated that in 1978 the number of surgeries in the United States was 21,000 to 31,000 less than would have been predicted from the trend prior to 1977. In 1979 and 1980, the number of procedures was below the expected rate (but there was no statistical significance) (122,312). Thus, cimetidine may delay surgery to a greater extent than it replaces it.[11]

The introduction of cimetidine coincided with a dramatic decrease in the rate of hospitalization for peptic ulcer disease in young adults (15 to 44 years old). There was only a modest decrease in the rate for all patients in the United States between 1977 and 1978 (432). This fact suggests that the elderly population may not have experienced a substantial reduction in hospitalization as a result of the drug's availability.

A recent analysis reported on the impact of cimetidine on the costs of ulcer disease in Rhode Island (272), Although this study was limited by the available data, the researchers had access to hospital charges for patients undergoing ulcer surgery. Ulcer surgery rates declined in Rhode Island after the introduction of cimetidine, and a proportion of this decline was ascribed to cimetidine's availability. The authors estimated that this reduction in surgery meant statewide savings in medical care of between $185,000 and $450,000, depending on the extent to which it can be assumed that a reduction in surgery keeps ulcer patients out of the hospital.

The evidence on the economic evaluation of cimetidine reviewed above highlights the impact that a single drug can have on the patterns of hospital and medical care. It also demonstrates the difficulty of determining whether these changes in patterns of use save health care or Medicare costs without the passage of enough time to monitor such changes. Today, physicians prescribe cimetidine for a variety of indications that are not among those approved by the Food and Drug Administration, including prevention of gastrointes-

[11] It is important to note that the expected surgery rate in the absence of the cimetidine was calculated on the basis of a declining linear time trend It is questionable whether such a trend would normally continue as rates of surgery decline to low levels One might expect surgery rates to level off at some point in time

tinal bleeding in hospitalized patients (63,290). The economic impact of cimetidine in these areas has not been investigated, yet it could surpass the effects of cimetidine in treating ulcer disease.

Therapeutic Apheresis[12]

Therapeutic apheresis is not a new procedure, but the extent of its use has grown rapidly during the past 5 years. It is a procedure in which a patient's plasma or blood cellular parts or both are separated and then removed from the blood and most often replaced by substitute plasma or a related physiological solution. It is believed that abnormal or harmful substances or cells are thereby removed, leading to a cure or arrest of disease. At present, apheresis is primarily accepted as an acute therapy in a small group of relatively obscure diseases, and the number of patients undergoing treatment is approximately 20,000 (183). Results reported in the scientific literature have been dramatic, and apheresis is being used to treat an increasing number of medical conditions. Skepticism over the validity of such claims along with the high costs of apheresis, however, have touched off recent controversies over this procedure's use.

From 1977 through 1980, procedure volume increased more than 700 percent, from around 5,000 to over 40,000 procedures per year. In the late 1970's, the rate of growth far outpaced the estimates. For example, the now defunct National Center for Health Care Technology originally estimated its use in 1979 at "hundreds of procedures. It turned out to be around 16,000. A lot of people were doing it but not reporting it" (95).

The costs of apheresis have become a particularly volatile issue. Each treatment costs between ***$400*** and $1,200. Furthermore, each patient requires a number of treatments, usually varying between 5 and 15. (Sometimes as many as 30 treatments are needed initially, but the number tapers off with time,) Estimates of current national expenditures on apheresis therapy range from $3.2 million to $240 million. If apheresis therapy is extended in the future to the wider array of diseases to which it has been only experimentally applied thus far, total national treatment costs could range from $650 million to over $7 billion per year (349).

In 1981, the Health Care Financing Administration (HCFA) issued the first national instructions on the coverage of apheresis under Medicare. Only a small group of relatively rare diseases were listed as acceptable indications for the procedure. These included: myasthenia gravis; leukemia; and macroglobulinemia and hyperglobulinemias, including multiple myeloma (382). In 1983, a few additional uses were added to the list, including thrombotic thrombocytopenic purpura as a last resort treatment; life-threatening rheumatoid vasculitis; life--threatening forms of Goodpasture's syndrome, when the patient has not responded to more conventional forms of therapy; and glomerulonephritis, when the patient has not responded to more conventional forms of therapy (74). Moreover, Medicare coverage of apheresis has been limited only to procedures performed in the hospital inpatient or outpatient setting.

The ultimate cost of therapeutic apheresis to the Medicare program will depend on whether coverage is extended to new indications and on the distribution of the affected diseases in the elderly population. By far the largest potential cost will arise if therapeutic apheresis is used for those who suffer from rheumatoid arthritis, which afflicts an estimated 5 million to 7 million people in the United States. Most observers believe that apheresis would be used on patients who have failed to respond to traditional forms of therapy. At present, the consensus of professional opinion is that apheresis for treatment of rheumatoid arthritis is an experimental therapy (349). Clinical evaluation of the use of this procedure in rheumatoid arthritis has been limited, but one controlled study found no statistically significant differences between the short-term response of patients receiving apheresis together with drug therapy and the response of patients receiving drug therapy alone (287).

Pneumococcal Vaccine

An estimated 10 to ***35*** percent of all cases of pneumonia are bacterial infections caused by pneumococci (358). There are over 80 known

[12] This section is based on a case study prepared for this project by OTA, entitled *The Safety, Efficacy, and Cost Effectiveness of Therapeutic Apheresis* (349).

serotypes of pneumococcal bacteria (293), but a much smaller number is responsible for the majority of pneumococcal pneumonias in the world.

Vaccines for various combinations of pneumococcal serotypes have been produced at different points in time since the turn of the century, but in 1978, a vaccine offering protection against 14 serotypes of pneumococcal bacteria responsible for about 70 to 85 percent of pneumococcal infections was introduced into commercial production (18). At the time of the vaccine's introduction, immunizations were specifically excluded as Medicare benefits by Section 1862 of the Social Security Act.

The ultimate potential for the pneumococcal vaccine is uncertain because of a lack of knowledge about the incidence of pneumococcal pneumonia in various population groups, the distribution of pneumococcal serotypes in these pneumonias, and the effectiveness of the vaccine in various patient groups, particularly high-risk groups (18,168). It is unknown, for example, whether a reduction in pneumococcal infections of the 14 types contained in the vaccine will be met with a concomitant increase in the incidence of other types of pneumococcal pneumonia, especially in high-risk patients (31). Since estimates of economic costs must rely on estimates of these rates, they are themselves subject to a great deal of uncertainty.

In 1979, noting these data and methodological problems, OTA performed a cost-effectiveness analysis of a pneumococcal vaccination program (358). OTA's analysis compared the net societal medical care costs and health effects (measured in terms of quality-adjusted life-years) that would result from vaccination. Under the base case set of assumptions, vaccination would increase net medical care costs[13] for vaccinees in all age groups, but would also yield health benefits that could not be obtained through treatment. Furthermore, vaccination of the elderly (those ***65*** years of age and older) was relatively cost effective in comparison to many existing health programs.

Working largely with data provided by OTA, the Congressional Budget Office analyzed the likely impact of covering the pneumococcal vaccine as a Medicare benefit on Medicare expenditures (331). That study found that a vaccine benefit would be cost saving to Medicare after 3 to 5 years, depending on the assumptions made about vaccination rates, levels of reimbursement for vaccination, and the inclusion of medical costs arising from increased life spans.

Partly as a result of these analyses, Congress amended the Social Security Act to allow Medicare coverage of pneumococcal vaccination. At present, it appears that vaccination rates in the Medicare population are low, and estimates of Medicare cost impacts are not available (305).[14]

Intensive Care Units

The ICU is an example of a technology which has proliferated widely despite the absence of studies of efficacy or cost effectiveness. Because of the difficulty of separating the intensity of care from the setting in which it is provided, it is difficult to know whether intensive care would be as effective if provided on the general hospital floor as in the physically and administratively separate ICU. For many medical problems, however, treatment in an ICU has become the standard method of treatment.

A recent National Institutes of Health sponsored consensus panel concluded that it is impossible to generalize about whether ICU care improves outcome for the varied ICU patient population. The panel agreed that ICU intervention is unequivocally lifesaving for some conditions, particularly where there is an acute, reversible problem, such as drug overdose or major trauma. It was less certain about the effectiveness of ICU care in other conditions, particularly in the presence of a severe, debilitating chronic illness, such as cancer or cirrhosis of the liver (409).

Despite the uncertainty about the indications for ICU care, almost 80 percent of short-term gen-

[13] OTA's analysis included the discounted value of future medical care costs arising from increased life expectancy among vaccinees

[14] For more information, see OTA's forthcoming technical memorandum *Update on Federal Activities Regarding the Use of Pneumococcal Vaccine,* OTA-TM-H-23 (Washington, D C.: U S. Government Printing Office, May 1984).

eral hospitals have at least one ICU (354). Large hospitals are likely to have two or more ICUs, organized along specialty lines. Overall, 5.9 percent of total hospital beds in non-Federal, short-term community hospitals in 1982 were beds in adult intensive and coronary care units (9). In 1980, 7 percent of hospital Medicare charges were for intensive and coronary care units (161). This figure understates the full costs of ICU care because it does not include the ancillary charges for patients. In any case, it is a representation of charges instead of costs, which may be higher. It is estimated that the costs of adult intensive and coronary care unit care represent over 15 percent of total hospital inpatient costs, or $4,742.5 million in 1982 (354). Inclusion of the other types of specialized ICUs, such as neonatal and burn care units, would bring the percentage up to about 20 percent of total hospital costs, or almost 1 percent of the Nation's gross national product.

According to 1979 Medicare data, 18 percent of Medicare discharges included a stay in intensive or coronary care units (160). From reports from individual hospitals, it appears that the representation of the elderly Medicare population in ICUs is about the same as in the hospital as a whole (354). Age alone does not appear to be a significant factor limiting use of ICUs in the United States. It is noteworthy that in other countries, ICU patients have a significantly lower mean age (354).

The literature on the outcomes of ICU care has demonstrated consistently the inverse relationship between the cost of ICU care and the likelihood of survival. The sickest ICU patients, many of whom do not survive their hospital stay, consume a disproportionately high share of ICU costs, Under Medicare's cost-based hospital reimbursement system, the high-cost patients were not particularly burdensome financially to the hospital. However, under Medicare's recently initiated prospective payment system for inpatient hospital care, many of these long-stay, high-cost ICU patients will become financial losers to the hospital ***(354).***

Total Parenteral Nutrition

Total parenteral nutrition (TPN) refers to the intake of nutrients directly into the bloodstream, circumventing the digestive tract (14). Its primary use is in eliminating malnutrition in patients who cannot adequately digest food or whose nutritional needs are elevated because of disease or injury. To receive TPN, a patient must have his or her nutritional needs assessed by a doctor or dietician and must have a catheter implanted in a large vein.

Clinically, a patient must be on TPN for a variety of reasons, most commonly inflammatory bowel disease (e.g., Crohn's disease), ischemic bowel infarction, and cancer-related problems, including damage due to radiation therapy (158). Indications for the use of TPN have been the subject of considerable discussion in the medical profession in the last 5 years. Some physicians advocate the use of TPN to bolster patients before surgery and to improve cancer patients' tolerance to therapy. Others suggest that TPN has little influence on the outcome in these cases and may actually promote tumor growth (139,181).

Before the late 1960's, prolonged maintenance of patients with digestive dysfunction was not possible. The development of TPN came about through advances made in four areas: improved knowledge of human nutritional needs, improved surgical procedures, improved catheter composition and design, and improved infusion control devices. The development of volumetric infusion pumps, especially the cassette-type electronic pump introduced in 1974, was the watershed for safe and reliable infusion that made overnight parenteral feeding practical.

TPN can be delivered either in the hospital or in the home. Before 1979, all home TPN patients were treated as hospital outpatients. In that year, a private firm, Home Health Care of America, entered the market, offering a package of supplies and services (189). Today there are some 30 to 40 commercial home TPN providers, several of which are owned by firms that manufacture solutions and supplies ***(37).***

In either setting, hospital or home, TPN is an expensive long-term therapy. A study at the Cleveland Clinic found that costs to the hospital for home TPN were about one-fourth of TPN costs in the hospital, but even in the home, the average per-patient first-year costs were estimated at ***$21,465*** (in ***1978*** dollars) ***(421).*** The most important factor in cost was the quantity of disposable supplies, including nutritional solutions, which accounted for almost ***90*** percent of the total cost. Other studies have estimated costs of a typical home TPN patient to be about $40,000 to $45,000 per year (158,189,301).

Medicare coverage of TPN delivered to hospital inpatients has never been at issue. TPN provided in a hospital setting has been covered as a Part A hospital benefit since the technology was developed. In 1977, HCFA began to cover home TPN on the advice of the Public Health Service. At that time, HCFA did not anticipate home TPN as a major expense; it was expected that only about 10 patients per year would need home coverage and that most of these patients would not live long ***(56).*** Because intravenous nutrients are classified as drugs and are therefore not individually reimbursable under Medicare's Part B, HCFA declared the whole home TPN system a prosthetic device, and therefore subject to Part B coverage. In ***1981,*** HCFA tightened the requirements for **home** TPN, listing seven diagnoses for which it was appropriate. Other indications can be approved on a case-by-case basis {62,184).

All persons eligible for Medicare and participating in the Part B program are covered for **home** TPN supplies. Persons younger than ***65*** and not otherwise eligible can receive Medicare coverage if their need for home TPN renders them unable to work, but over half of home patients consider themselves fully functional once they receive the needed nutrition ***(241),*** TPN covered under Part B is reimbursed on the basis of reasonable charges, but because there have been relatively few home TPN patients, it has been difficult to establish charge screens. As with other Part B services, TPN at home is subject to the deductible and coinsurance provisions of Medicare.

The use of home TPN has undergone tremendous growth in recent years, much of which was stimulated by the increase in coverage by Medicare and other insurers. For example, a registry maintained by the New York Academy of Medicine reported a 103-percent increase in the number of patients on home TPN between 1979 and 1981 (241). It has been estimated that about 200 TPN patients were discharged to the home in 1978 (301), while estimates for 1983 are around 4,000 home patients (37). It is unknown to what extent this increase represents a substitution of home TPN for inpatient nutrition services and to what extent it represents a net increase in the number of patients receiving TPN.

The home parenteral nutrition registry estimates that about 22 percent of patients receiving home TPN in 1979 were Medicare enrollees (241). If the cost estimate of $40,000 per year for TPN in the home is accepted, and if it is assumed that 22 percent of the 4,000 patients on home TPN are Medicare beneficiaries, then Medicare currently pays in the neighborhood of $28 million per year for home TPN. 15 A lack of data precludes estimation of the total cost to Medicare of providing TPN in the hospital, but it is likely to be greater than that for home TPN.

Although over $28 million in annual Medicare expenditures for a technology that extends life is small in relation to total Medicare expenditures ($52.2 billion in 1982), this case illustrates the extent to which the impact on Medicare cost of a new technology can be grossly underestimated at the time coverage is introduced.

Hemodialysis for Chronic Renal Failure

Hemodialysis represents the classic case of a lifesaving technology whose development dramatically affected the costs of Medicare. Although hemodialysis has been available since 1945 for temporary treatment of acute and reversible renal failure, its application to patients with end-stage renal disease (ESRD) was first made possible in 1960, when Quinton and Scribner developed a subcutaneous arteriovenous shunt (a plastic tube connected to an artery and a vein in the arm or

[15](0,22 x 4,000 x $40,000 x 0.80).

leg) (271). Without the shunt, filtering the blood as often as necessary was not possible on a long-term basis because the blood vessels would collapse. In the early 1960's, hemodialysis became accepted as a life-extending therapy for victims of chronic kidney failure.

The cost of hemodialysis for ESRD varies with the setting in which treatment is provided. One study estimated that the costs of dialysis in 1980 were approximately $25,000 per patient year for in-center treatment and $13,000 per patient year for home treatment after the first year (279).

Because of the high costs and the obvious life-extending properties of both hemodialysis and its

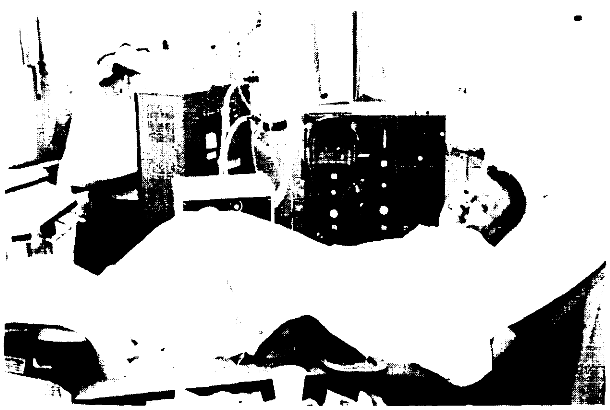

Photo credit: National Kidney Foundation, Washington, D.C

Hemodialysis is a lifesaving medical technology that has affected the costs of the Medicare program

competitor, kidney transplantation, a debate began in the mid-1960's over who should be responsible for paying for treatments of patients with ESRD. The debate culminated in 1972 with the passage of the Social Security Amendments (Public Law 92-603), which extended Medicare coverage of treatment for ESRD to over 90 percent of the ESRD population. Factors that led to the congressional decision to pay for ESRD treatment included a recognition that the alternative to life sustainment by dialysis or kidney transplantation was death, that ESRD treatment was very expensive, and that there occurred 7,000 to **10,000** uremic deaths **a** year because of the limited availability of dialysis facilities.

In 1972, 40 patients per million population were receiving long-term hemodialysis treatment in the United States, almost entirely under the auspices of nonprofit organizations. The number now exceeds 200 per million population (a fivefold increase) and is one of the highest in the world (96,269).

The cost of Medicare's ESRD program grew from $250 million in 1974 to an estimated $1.8 billion in 1982 (378), greatly exceeding original congressional estimates of the potential costs (279). In 1979, benefit payments for ESRD exceeded 5 percent of total Medicare expenditures and were fully 10 percent of expenditures from the Supplemental Medical Insurance fund of Medicare, although renal patients constitute only 0,2 percent of the Medicare population (38,279).

CONCLUSIONS

The evidence presented in this chapter was intended to illuminate how changes in medical technology alter the cost of the Medicare program. **Although its aggregate impact on Medicare costs cannot be estimated precisely, medical technology has clearly added to the costs of the Medicare program and to health care costs as a whole. Today, Medicare is buying more services for its beneficiaries than ever before, and the pressure to adopt new beneficial but cost-raising technologies continues. Despite this conclusion, the increase in the provision of services to Medicare beneficiaries and inflation in the price of medical care represent less than a third of the 107-percent increase in Medicare expenditures per capita from** 1977 to 1982. Increases in enrollment and general price inflation account for the bulk of Medicare expenditure inflation.

The descriptions of the seven new medical technologies provided in this chapter highlight the difficulty of predicting at the outset how technological change in medicine is likely to affect Medicare costs in the future. New technologies are and will continue to be developed regardless of Medicare's policies. Some of them substantially prolong life or improve its quality for Medicare beneficiaries. Application of new technologies to the Medicare population can have large and unanticipated **impacts on Medicare expenditures.** But the cases demonstrate quite clearly that the extent **of impact on Medicare program expenditures depends on whether Medicare chooses to cover a technology, and if it chooses to, to influence the conditions under which it is used.**

It is important to note that changes in service intensity are measures of the incremental effects, not the cumulative effects, of technology on total Medicare costs. It is not just at the margin that there is an opportunity to reduce Medicare costs by altering the patterns of technology adoption and use; **there are many opportunities to save costs by altering longstanding patterns of use of medical technology. It might be desirable to have the new cost-raising but life-extending technologies widely adopted and used and the** use of many existing ineffective technologies substantially reduced. The issue for the remainder of this report is how Medicare policy can be structured to bring about the most cost-effective use of both new and existing medical technologies.

Part Two