

Description of the Device and Its Market

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TECHNOLOGY OF WHEELCHAIRS

Wheelchairs fall into four broad categories: 1) general-purpose manual wheelchairs, 2) power wheelchairs, 3) manual sports wheelchairs, and 4) power alternatives—other motorized vehicles not shaped like a chair. In this study, the term “wheelchairs” refers to all four types of equipment.

Manual wheelchairs, the most commonly used kind, may be propelled by the user’s hands or feet or pushed by another person. They are usually built in a traditional chair shape with two sets of wheels rather than legs. One set, usually located in the rear, consists of large bicycle-type wheels, and the other set is of small casters, usually 5 or 8 inches in diameter.

Power wheelchairs are usually battery powered, with a power supply of 12, 24, or, more recently, 36 volts. Batteries make power chairs much heavier than manual ones (e.g., 180 pounds for the motorized Power Rolls® IV described in ch. 6). Motorized wheelchairs are generally controlled by a hand-operated joystick, which regulates direction and speed. Some control mechanisms, however, are operated by breath, chin or head position, or other nonmanual means.

Manual sports wheelchairs are lightweight and are designed to shift the center of gravity to achieve greater mobility and stability than is possible with general-purpose manual or power wheelchairs. Some chairs are designed for specific sports, such as basketball or racing; others are for general sports use. Features associated with sports wheelchairs may include larger propelling wheels than on general-purpose manual wheelchairs, small handrims, sloping propelling wheels, more durable and efficient bearings and hubs, movable axle positions, and steerable casters. Some of these features are also available as options on nonsports chairs as well.

Power alternatives, which function like motorized chairs but do not look like typical wheelchairs, offer a variety of advantages over power wheelchairs. Most of these models have three wheels and resemble golf carts or motor scooters; some allow travel over terrain that typical wheelchairs do not, such as shallow water or sand and other soft, uneven surfaces. Smaller power alternatives permit greater mobility through narrow doors and aisles. Other models have swivel seats to allow closer approaches to desks and work surfaces. In addition to the physical advantages, power alternatives may provide a psychological advantage because they do not evoke the stereotypical image of a helpless, confined person often associated with standard wheelchairs. They usually require, however, that the user can hold his or her trunk upright with minimal support.

Wheelchairs are available in a variety of sizes to accommodate infants as well as large or tall adults. Some children’s models can accommodate growth by changing the legrests and upholstery. Seat heights can be varied to place children at eye or table level with their peers. Such variations in seat height can be helpful for people of all ages who need to use their feet for propulsion. An alternative to foot propulsion and steering is the one-arm-drive device on which different handrims on one wheel control both large wheels independently.

Most wheelchairs have small wheels in casters in the front and large wheels in the rear—a design which makes the chair stable and easy to get in and out of. Some wheelchairs are designed with the large wheels in front and the casters in back. Although less stable, these indoor chairs may make maneuvering over door thresholds easier.

Special features can be added to most chairs to meet the individual’s needs. Armrests may be ei-

ther fixed, to provide support, or detachable, to allow side transfers (movement in or out of the wheelchairs accomplished by sliding sideways). They may be designed to allow close approach to tables and desks or to increase the seat width. Legrests are available in a range of styles to allow close approach to a table or to make it easier to fold the chair, elevate a leg, or facilitate transfers. Many manual wheelchairs are lightweight and fold for transport in a car. Optional safety features

include: heel and toe loops, rear and front anti-tipping devices, hill-climbing adaptations that prevent back-sliding, and easy-to-grip handrims.

Recent or expected design innovations include: voice-controlled motorized wheelchairs; stair-climbing chairs that have tanklike belts rather than wheels; and lighter weight, more durable chairs.

SAFETY AND EFFECTIVENESS

To date, there are no comparative studies of the safety and effectiveness of different wheelchairs. The only information is from case reports and impressions by those involved with wheelchairs—primarily consumers and therapists—and the results of evaluative testing on specific wheelchairs by the Veterans Administration Prosthetics Center.

In general, people with greater mobility are able to use a wider variety of wheelchairs more safely and effectively than those with more serious dis-

abilities. One important factor in predicting safe use of wheelchairs is the person's trunk stability and control; without this, an individual may have difficulty sitting in the chair without special body support and operating a wheelchair or its locks when bending or reaching is required. Accessory supports, such as pommels and straps, are available for those people who have problems with trunk instability. However, these do not improve the effectiveness of the wheelchair if the person needs to lean or bend to operate any part of it.

USERS, PURCHASERS, AND PRESCRIBERS OF WHEELCHAIRS

In its 1982 report, *Technology and Handicapped People*, the Office of Technology Assessment (OTA) reported that there were about 9 million Americans with lower extremities missing, paralyzed, or impaired (36). Of those people, approximately 1,168,000 (one American in 200) used wheelchairs. Users in 1977 included 650,000 non-institutionalized persons (33) and an additional 518,000 residents of nursing homes. The number of nursing home users is expected to grow to 584,800 by 1985, an annual growth rate of 1.5 percent (25).

The number of wheelchairs in use exceeds the number of users. People dependent on wheelchairs often have more than one chair, either for different uses, such as sports, or, especially, for times when one is being repaired. A 1982 survey by the Paralyzed Veterans of America found that 72 per-

cent of the respondents had more than one wheelchair (16). This percentage may be greater than that for the overall population of users, because most of the respondents obtained their wheelchairs from the Veterans Administration (VA), which typically supplies people with two wheelchairs, whereas other agencies generally supply only one.

The type of wheelchair bought often depends most on the physical therapist and the dealer. A physician's prescription is generally required for third-party reimbursement for a wheelchair, its accessories, or its special features, but physicians are frequently unaware of which special features and accessories are available and appropriate for the patient. The therapist usually makes these decisions based on the user's medical, personal, and environmental needs. (Most insurance companies,

however, will pay only for those accessories that are medically necessary.)

The therapist or dealer is also usually the one to measure the user to determine the wheelchair size needed. Measurements determine the optimal height of the seat from the floor, the height of the backrest, the length of the armrests and legrests, and the width and depth of the seat. Dealers who have floor models may ask the purchaser to sit in the chairs to determine which is most comfortable, but accurate measurements are the best guarantee of a proper fit. An improper fit can cause back problems and pressure sores and can make safe operation of the wheelchair difficult.

The prescription may or may not specify the wheelchair brand. If it does not, the therapist or dealer makes the decision. Most dealers carry only a few of the larger brands of wheelchairs. The decision to carry a specific brand or model is based partly on past service and product quality and partly on the amount of profit. If dealers buy a high volume of wheelchairs from the manufacturer, they usually receive a discount off the wholesale price. At any given time, dealers may have in stock only the models on which they were given the best price. In addition, lower priced products carry a greater percentage markup. Most manual wheelchairs have a 40-percent markup

COSTS

Purchase Costs

General-purpose manual wheelchairs are the least expensive type. List prices of general-purpose manual wheelchairs recorded in the ABLEDATA System generally ranged from \$400 to \$900. Most power wheelchairs cost between \$2,000 and \$3,000, and power alternatives cost from \$950 to \$3,000. Sports wheelchairs vary in price from \$800 for a racing model to \$1,200 for a general sports model, significantly more than most general-purpose manual chairs (37).

One major purchaser, the VA, paid an average of \$336 for a manual wheelchair and \$2,216 for a power wheelchair in fiscal year 1982 (40). Costs vary with the type of chair bought. The VA

over dealer's wholesale price, and motorized wheelchairs a 30-percent markup.

Most users do not special order a wheelchair model not in stock at the dealer or manufacturer. Those who are purchasing their first chairs often are not aware of the options. Even those who are purchasing replacement wheelchairs may be aware only of the chairs that they have had in the past.

The dealer's comments may be the only evaluation the user ever hears, which makes the dealer's personal recommendation and training very important. Most dealers' recommendations are based on a combination of what wheelchair they believe is best for the user, plus the reimbursement and profit that they will receive on different wheelchairs. Proper recommendations require training in fitting techniques and knowledge about the consequences of different impairments.

Sales of wheelchairs are expected to increase as a result of current efforts to control rising hospital costs. Because of decreasing lengths of stay in hospitals, more patients may need to buy *or* rent wheelchairs for use at home. Patients at home obviously require their own wheelchairs, whereas hospitalized patients can share chairs (4).

Outpatient Clinic in Boston bought chairs primarily for use outside rather than inside the facility. There, the average manual wheelchair cost \$579 (41).

In addition to the manufacturer's base purchase price, there may be significant customization costs. These costs vary according to what is required. The customization needed may be as simple as adding a swing-away legrest or as complex as adding an entire life-support system complete with respirator and intravenous drip bottle holder.

Maintenance and Repair Costs

Maintenance of a wheelchair is a substantial component of the cost of wheelchair use. Data

from the VA Outpatient Clinic in Boston indicate the magnitude of maintenance costs. During fiscal years 1981 through 1983, it performed or authorized an average of 380 wheelchair repairs per year on all chairs in use. During that same time, it purchased an average of 137 wheelchairs per year (114 manual or sports and 23 electric) (41).

In this study, the authors assumed that the overall life expectancy of a VA wheelchair (manual and power combined) is 3.5 years, the midpoint of the generally reported lifetime (2 to 5 years) and a reasonable estimate according to the VA prosthetics official contacted. The rates of chairs purchased and repaired were stable over the fiscal years studied. The average lifetime of 3.5 years per wheelchair was used to calculate that each wheelchair received 0.8 repairs (380 ÷ [3.5 x 137]) per year. At an average 1982 direct cost of \$190 per repair (\$140 for parts and purchased services, and \$50 for technician salary and fringe benefits), each chair required at least \$150 in repairs during a single year, or \$525 over its lifetime (undiscounted). This almost equals the average purchase price of a manual wheelchair.

Although these VA repair data are not divided into manual and power chair costs, the actual repair costs were probably lower for manual wheelchairs and higher for power wheelchairs. These costs do not include repairs paid by sources other than the VA or the VA's indirect costs (administration, building upkeep, equipment, etc.), which together could double the aggregate repair cost. For example, according to a survey by the Paralyzed Veterans of America, the VA performed only 42 percent of repairs on respondents' chairs (16). (It was not reported, however, whether all respondents were eligible for repairs by the VA.)

Medsger (17), using data from the Berkeley Center for Independent Living, found that power wheelchairs required an average of \$900 of maintenance a year. If the average life of a power wheelchair is 4 years, the \$3,600 lifetime cost of maintenance (4 x \$900, undiscounted) is 1.6 times its purchase price, a relationship similar to the VA pattern. A 1982 survey by the Paralyzed Veterans of America showing six or more repairs per year reported by the top category (16 percent of respondents) (16) also underscores the frequency of repairs.

Total annualized cost conveniently combines initial purchase plus maintenance into an expression of the annual overall costs of wheelchair use. This measure converts the capital cost of initial purchase of a wheelchair into an annualized capital cost. To effect this conversion, first the cumulative present value (CPV) factor over the expected life of the wheelchair is needed. (This is also termed the "present value of an annuity.") The CPV factor is based on the lifetime of the wheelchair and the discount rate, an interest rate that measures the time value of money invested in the initial wheelchair purchase.

For illustration, using the discount rate of 10 percent per year recommended for some Government cost-benefit analyses (39), the CPV factors for 3 to 4 years are:¹

<i>Lifetime (years)</i>	<i>CPV</i>
3.02487
3.52,828*
4.0	3.170

*Interpolatd

Annualized capital cost is obtained by dividing the initial purchase price by the CPV. Total annualized cost, then, is annualized capital cost plus average maintenance costs. To apply these methods to the direct cost data from the VA Outpatient Clinic (mostly manual wheelchairs), the life expectancy was set at 3.5 years, as described previously, and, therefore, for all chairs:

$$\begin{aligned} \text{Annualized capital cost} &= \frac{\text{initial purchase price}}{\text{CPV}} \\ &= \frac{\$579}{2.828} \\ &= \$205 \end{aligned}$$

and

$$\begin{aligned} \text{Total annualized cost} &= \text{capital} + \text{maintenance} \\ &= \$205 + \$150 \\ &= \$355 \text{ per year.} \end{aligned}$$

¹If r is the discount rate (as a decimal), and n is the expected lifetime (as a whole number), then:

$$\text{CPV} = \frac{1}{1+r} + \frac{1}{(1+r)^2} + \dots + \frac{1}{(1+r)^n}$$

For example, for a discount rate of 10 percent and 3 years (r = 0.10 and n = 3), we have:

$$\text{CPV} = \frac{1}{1.1} + \frac{1}{(1.1)^2} + \frac{1}{(1.1)^3} = 2.487$$

This figure is 73 percent more than the annualized capital cost alone. If the initial cost of the power wheelchairs analyzed by Medsger was \$2,216 (the national VA average for power chairs [40]), then for power chairs:

$$\begin{aligned} \text{Annualized capital cost} &= \frac{\$2,216}{3.170} \\ &= \$699 \end{aligned}$$

and

$$\begin{aligned} \text{Total annualized cost} &= \$699 + \$900 = \$1,599 \\ \text{or 129 percent more than the capital component alone.} \end{aligned}$$

This annualizing procedure is equivalent to amortizing a mortgage or a capital asset over its expected lifetime. The annualized capital cost is slightly higher than the amount that would be obtained by straight line depreciation. Depreciation computes the money needed each year to replace a capital asset; annualized capital cost also includes foregone interest on the money tied up in a wheelchair that could have been invested.

This technique provides a way of comparing different models to determine which is lower in total annualized cost. To illustrate, hypothetical repair profiles were developed for an "inexpensive" and a "medium-priced" wheelchair (table 1). On the assumptions that each would have an expected life of 3.5 years and that repairs for the inexpensive chair would be more frequent, the total annualized cost of the inexpensive chair (\$338) would actually be higher than that for the medium-priced chair (\$309) because of higher annual maintenance and repair costs. In this illustration, the greater initial investment would pay off.

To place the repair record of wheelchairs in perspective, the lifetime frequency of major repairs

was estimated for several other types of durable medical equipment (table 2). Wheelchairs ranked second highest, which underscored users' concern.

Table 1.—illustrative Comparison of Total Annualized Costs of an "Inexpensive" v. a "Medium-Priced" Wheelchair

	Inexpensive wheelchair	Medium-priced wheelchair
Given data:		
Initial purchase cost (new)	\$320 ^a	\$590 ^b
Expected lifetime (years)	3.5	3.5
Average annual maintenance and repair costs ^c	\$225	\$100
Calculated results:		
Cumulative present value factor	2828	2.828
Annualized capital cost	\$113	\$209
Total annualized cost	\$338	\$309

^aCost for an inexpensive, all-purpose wheelchair

^bCost for a manual wheelchair with anti-flutter sealed bearing and flutter adjust system Magnesium wheels added for \$50

^cBoth models assumed to require annual replacement of tires, biannual replacement of seat upholstery, and miscellaneous repairs and adjustments The inexpensive model is also assumed to require replacement of axle, casters, and spokes

SOURCE Initial purchase costs are from Invacare pricelist Repair costs are hypothetical

Table 2.—Comparative Lifetime Repair Data of Selected Medical Equipment^a

Item	Number of repairs	Number of items supplied	Repairs per item
Braces, all	36	228	0.16
Eyeglasses	176	7,542	0.02
Home dialysis equipment	11	5	2.2
Artificial legs, all	604	137	4.4
Wheelchairs, all	383	128	3.0

^aNumber of repairs and items are for fiscal year 1982 at the VA Outpatient Clinic. Repairs per item would equal lifetime number of repairs in steady state (numbers of repairs, items supplied, and items in use were constant)

SOURCE Derived from U. S. Veterans Administration, *AMIS Report for VA Outpatient Clinic for Fiscal Year 1982*, Boston VA Outpatient Clinic, Boston, MA, 1982

PRIVATE PAYMENT SOURCES

An estimated 90 to 95 percent of all wheelchair purchases are at least partially funded by third parties (Government or private insurers); only 5 percent are paid totally by the user (19). Over half of wheelchair purchases are at least partially paid

for by Government sources including Medicaid, Medicare, and the VA. In particular, in 1976, 11 percent were reportedly paid for by the VA (17). (See ch. 3 for a fuller discussion of the Government's role as a purchaser of wheelchairs.)

Private Insurance

To illustrate private insurance coverage for wheelchairs, the authors contacted Blue Cross of Massachusetts, the largest private insurer in the Commonwealth of Massachusetts. Insurance coverage for rental or purchase of wheelchairs depends on whether the policy covers durable medical equipment. If it does, reimbursement is usually for 80 percent of the reasonable charge, using a formula similar to that used by Medicare. Only those wheelchairs and accessories that are prescribed by a physician are covered (11).

Blue Cross of Massachusetts, for example, will pay for rental of a wheelchair up to the allowable reimbursement for purchase of a similar wheelchair. Repairs of rented chairs are covered as part of the rental agreement. Blue Cross will not pay, however, for repairs of purchased wheelchairs. A Blue Cross benefits representative usually decides whether a wheelchair should be purchased or rented.

Blue Cross pays for the least costly wheelchair that meets the user's physical needs. For a new, more costly model of a wheelchair to be covered, it must have a unique feature of medical benefit not available on a less costly model. Depending

on the policy, purchase of electric wheelchairs was covered in 1983 for up to \$2,711; power alternatives are covered up to \$2,700.

New products are reviewed for coverage by Blue Cross of Massachusetts by its Medical Review Board. The Physicians Advisory Panel may be consulted in cases where the medical benefits of a new product to an individual subscriber are unclear.

Health Maintenance Organizations

The Harvard Community Health Plan, which serves over 100,000 members throughout the Boston area, was studied as an example of a health maintenance organization. The Health Plan will pay in full both rental and purchase costs for medically necessary wheelchairs for members. The user's physician must complete a form documenting the need. The particular wheelchair and features needed may be decided on by the physician, physical therapist, or nurse practitioner. The Benefits Coordinator then reviews the need and recommends rental or purchase based on the expected length of use. Wheelchair rentals are reviewed monthly to verify continuing need.

SIZE OF THE MARKET

Aggregate annual sales of wheelchairs in the United States, including imports and exports, were estimated to reach \$107.5 million in 1983, measured by shipments from the manufacturers. This is an annual increase of 11.7 percent over the 1980 figure of \$77.2 million (25).

A market study done by Invacare Corp. estimated the total market to be \$126 million in 1982 (valued at cost to dealers and other major purchasers). Thirty percent, or \$37.7 million, was attributed to the home care market. (Home care wheelchairs tend to be manual, fairly standard models, for people with limited mobility.) Another 30 percent was attributed to institutions, including hospitals, nursing homes, and rehabil-

itation centers. (Institutional wheelchairs are also standard, manual chairs, used almost exclusively for transport within the institution.) The remaining 40 percent (\$50 million) was attributed to rehabilitative care, for active and short-term users who are neither homebound nor institutionalized. (Rehabilitative chairs may be from any of the four basic categories and cover a wide range of customization and cost.)

Invacare's estimate of the total number of units sold in 1982 was tentative, ranging from 250,000 to 364,000. Market share estimates in terms of numbers of chairs showed 38 percent for home care, 35 percent for institutional care, and 27 percent for rehabilitative care. On a price-per-unit

basis, home care chairs are least expensive, and rehabilitative wheelchairs are most expensive (see table 3).

Based on an estimate of 338,000 wheelchairs bought in 1982, another breakdown shows about 125,000 rental chairs, 125,000 institutional chairs, 55,000 manual chairs for active users, 15,000 power wheelchairs, and 18,000 depot chairs for the VA (see ch. 3) (3).

MARKET STRUCTURE

Reviews of product descriptions in the National Rehabilitation Information Center's computer bank, ABLEDATA, identified 53 manufacturers of wheelchairs. However, the market appears to be reasonably concentrated, for one-quarter of the manufacturers accounted for 71 percent of the products (see table 4). This measure uses the number of different model lines of wheelchairs or power alternatives listed for each manufacturer in ABLEDATA as a proxy for a manufacturer's size. Seven manufacturers are located outside of the United States, and six are outside of North America; of these, two have U.S.-based distributors. This concentration should cause the market to behave as an oligopoly.¹

¹Oligopoly refers to a situation in which there are a limited number of sellers of a product. Competition in price and design may be limited not by any explicit agreements, but by the knowledge that an action by one firm will prompt a reaction by the others.

Table 3.—Market Size and Shares of Wheelchair Uses

	Units ^a	Dollars ^b	Price/ unit ^c
Total	330,000-360,000	\$1257 million	\$349-\$381
Home care	380/i	30%	279-305
Institutions	35%	30%	299-326
Rehabilitative	280/c	40%	508-554

^aThe range given is based on the range in total number of units sold. All figures are rounded to the nearest dollar.
^bNumber of wheelchairs of all types sold based on Central estimates.

SOURCE: Market study by Invacare/Elyria OH 1983

The large manufacturers gain oligopoly power from their distribution patterns. National distributorships enable consumers to find knowledgeable local dealers and obtain repairs and replacement parts quickly. In wheelchairs, as with other equipment, service can be a major factor in choice of brand.

Prior to 1978, Everest & Jennings, Inc. (E&J) acted virtually as a large single seller, controlling 90 percent of the prescription wheelchair market (17). In 1978, settlement of an antitrust suit brought against E&J by the U.S. Department of Justice imposed some limits on E&J's market power. At the same time, E&J relocated its headquarters and plant. The combined effect of these two events caused E&J severe difficulty in meeting its orders on time. As a result, smaller companies were able to gain a greater share of the market, increasing competition and stimulating innova-

Table 4.—Concentration of Manufacturers of Wheelchair Products^a

Rank group for size of manufacturer	Number of products listed for a manufacturer	Number of manufacturers	Cumulative number of products	Cumulative percent of products	Cumulative number of manufacturers	Cumulative percent of manufacturers
1	32	1	3	18.20/o	1	1.9 %/0
2	15	1	47	26.7	2	3.8
3	14	2	75	42.6	4	7.5
4	9	1	84	47.7	5	9.4
5	8	2	100	56.8	7	13.2
6	6	1	106	60.2	8	15.1
7	5	1	111	63.1	9	17.0
8	4	2	119	67.6	11	20.7
9	3	2	125	71.0	13	24.5
10	2	11	147	83.5	24	45.3
11	1	29	176	100.0	53	100.0

^aManufacturers ranked from the one with the most products (32) to the least (1) in ABLE DATA (see app. A)

SOURCE: Derived from U S Department of Education National Institute of Handicapped Research, National Rehabilitation Information Center ABLEDATA System, 1983

tion. Since 1978, E&J's sales have declined slightly in absolute terms, but markedly when adjusted for inflation. In 1983, Invacare Corp. overtook E&J in the quantity of wheelchairs sold, although E&J remained first in dollar volume of wheelchair sales. Invacare and E&J combined sales accounted for 70 percent of wheelchair sales dollars in 1983 (1).

Prior to 1978, wheelchair imports were almost nonexistent, but the antitrust suit the Department of Justice settled against E&J in that year lifted the import restrictions E&J had imposed on its foreign subsidiaries. Nevertheless, imports remain a tiny part of the wheelchairs sold in the United States. This is evidenced by the lack of a category number under the Tariff Status of the United

States for wheelchair imports. The director of wheelchair marketing at Invacare estimated imports to account for 1 percent of 1983 gross sales measured in dollars (\$1.3 million) and more than 1 percent measured in units sold. In his opinion, this share is rising due to the recent wave of imports from countries with "preferred developing country" status (23). Products made in these countries can be imported duty-free and are significantly less costly than U.S.-made wheelchair: of similar quality.

Wheelchair exports from the United States are large enough to merit their own classification (Schedule B, No. 7270120). Exports of wheelchairs and wheelchair parts in 1982 were \$9.6 million (34).

PRIVATE RESEARCH AND DEVELOPMENT INITIATIVES

Most wheelchair manufacturers do their own research and development (R&D), calling it crucial to the success of their companies. R&D reportedly focuses on improving current wheelchair design, rather than on developing completely new products. For instance, those companies whose major products are lightweight wheelchairs are interested in developing even lighter weight products (see ch. 5).

Only one manufacturer surveyed referred to work on process innovations (new manufacturing techniques) rather than product innovations, but the lack of response about process innovation probably resulted from the slant of the questions toward product innovation.