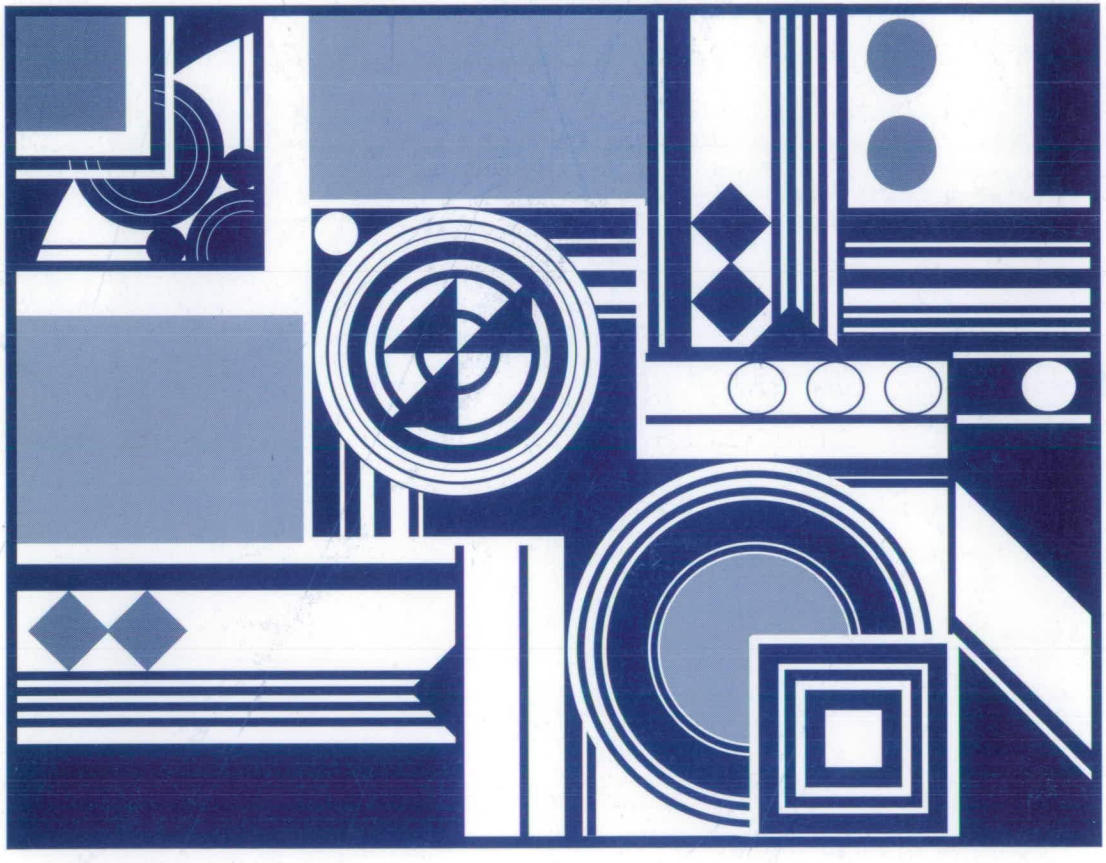
Technology Innovation for an Aging Society:

Blending Research, Public & Private Sectors



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TECHNOLOGY INNOVATION FOR AN AGING SOCIETY: BLENDING RESEARCH, PUBLIC AND PRIVATE SECTORS

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JAKE PAULS, C.P.E. researched building use and safety with the National Research Council of Canada from 1967 to 1987. From June 1987 to 1992, he extended this work as a Life Safety Specialist with Hughes Associates, Inc., located in the Washington-Baltimore corridor, to include consulting, research and technology transfer though model building codes and safety standards. Since 1992, he has operated an independent consulting service while intensifying activity with the Building Use and Safety Institute, an international not-for-profit network for information, research and advocacy. The focus of his work ranges from hazards in the home to infrequent but catastrophic events such as crowd incidents in large facilities for public assembly. His particular expertise is in bridging between ergonomics (human factors) in building safety and the development of related requirements in standards, codes and regulations.

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MARGARET WYLDE, Ph.D. is President of the ProMatura Group. Headquartered in Oxford, Mississippi, ProMatura supplies seniors housing, consumer research and product development services. Clients have included Buick, Sharp Electronics, Wal-Mart, The Del Webb Corporation and the American Association of Retired People. Dr. Wylde holds degrees in audiology and in 1990, earned a Faculty Associate Award in Geriatrics/Gerontology from the University of Mississippi Medical School. Her publications include *Building for a Lifetime* (1994), published by Taunton Press and *Enabling Products: A Sourcebook* 2 (1995) published by the National Kitchen and Bath Association. She is President of the National Association for Senior Living Industries and serves on the Board of Directors of LifeSpec Cabinet Systems, Inc., the American Society of Aging and the Business Forum on Aging. Her personal research has examined the relationship between the abilities of intended users and the design of automobiles, appliances, bathing systems, toilets, medication compliance devices, walkers, wheelchairs, assistive listening devices and complete living environments.

CHAPTER 1

INTRODUCTION: TECHNOLOGY, AGING AND DISABILITY IN CANADA

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ORIGIN OF THIS VOLUME

This volume originated with a workshop held in Vancouver immediately prior to the 1995 Annual Meeting of the Canadian Association on Gerontology. A group of individuals from the public policy, corporate and research sectors were invited to come together to explore issues relating to the development and market expansion of new technologies designed to enhance the health and quality of life of 'at risk' seniors. Among topics of concern were how to reconcile market imperatives with social and public policy agendas; how to effectively research and market technology to older persons; how to ensure consumer protection without destroying producers' incentives for innovation, and generally, how to increase the availability, affordability, and use of appropriately designed technology by and for the benefit of seniors. The workshop featured more than a dozen outstanding speakers from Canada, the United States and Europe. Eight of them accepted an invitation to expand their workshop remarks into formal written form — the chapters that follow this introduction are the result.

CHAPTER ORGANISATION AND CONTENT

Chapter 2, entitled *Bringing the Product from the Design Concept to the Marketplace* is written from the perspective of a technology developer. The author, Geoff Fernie, Director of the Centre for Studies in Aging at Sunnybrook Health Science Centre in Toronto, is a Mechanical Engineer with a doctorate in Bio-Medical Engineering. He begins the chapter by posing the question "Why do we need university/public sector involvement in the development of assistive products for seniors?" In answering the question, he cites American data on the proportion of non-institutionalized adults using some form of assistive technology which suggests a sizable market, especially

for mobility and hearing devices (among persons aged 75 and over, 35% have assistive devices). Still, he notes, the perception remains that the market for mobility devices is small. Given small profit margins, this perception has resulted in a dearth of private sector involvement in R & D around mobility products, particularly on the part of large companies. The remainder of the chapter describes the opportunity this provides for partnerships between university-based researchers and small companies. Dr. Fernie uses the experience of his own laboratory to illustrate potentials and pitfalls in the steps from concept development to introduction of a product into the marketplace. One key element of success he identifies is the bringing together of producers and end-users, early in the process; another relates to the timing of patent applications.

At the outset of Chapter 3, Margaret Wylde, a seniors' housing and consumer research supplier also underscores the importance of consumer input. The theme is reiterated in her discussion of market research methods. Dr. Wylde also recommends 'competitive analysis' — both direct and indirect — as part of the research process. The direct form requires an understanding of who else and what else is being produced that is similar to the product one wishes to develop. Indirect competitive analysis involves identifying all of the reasons that might preclude consumer's purchase of the product. A third theme in Dr. Wylde's chapter, similar to Fernie's advice to put people (or mannikins) in the drawings and prototypes of products one is asking prospective purchasers to consider, is the importance of evaluating products in realistic use settings. Many of us are not very good at visualizing how a carpet will look when installed in the dining room of a care facility from looking at a small square of it in the administrator's office. Many of us are equally disadvantaged when attempting to visualize how an assistive device will handle when the main information we have is a flat, peopleless photograph or artist's rendering. Dr. Wylde closes Chapter 3 with a list of questions market research should answer for the product developer, and with a helpful discussion on how to effectively market technology to older people.

In the Fernie and Wylde chapters, the focus is on assistive devices, defined in the 1988 U.S. Technology-Related Assistance for Individuals with Disabilities Act as: *"any item, piece of equipment, or product system, whether acquired commercially off the shelf or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities"*. In Chapters 4 and 5, attention turns to another type of technology — equipment used for falls prevention and for surveillance and movement monitoring of frail elders. In Chapter 4, in addition to the needs of the 'at risk' client, the needs of formal and informal caregivers are identified as a stimulus for technology development. In Chapter 5, the researcher is considered as one of the end-users.

Chapter 4 begins with a description of the nature and frequency of 'problem' behaviours encountered by persons caring for psychogeriatric patients in home and institutional settings. In setting the stage for a discussion of technology that will aid in patient management and improve both the caregiver's and the care receiver's quality of life, Gloria Gutman points out that traditionally in North America many of the

problem behaviours exhibited by psychogeriatric patients have been managed by the application of mechanical and/or chemical restraints. Tying people in beds and chairs or confining them with vests, belts and lap-trays is, however, no longer an acceptable practice. The theme of the chapter is how to create a safe, restraint-free environment. After a brief discussion of environmental design approaches (eg. camouflage doors to prevent unauthorized exiting), two broad groups of devices are described which are considered to be alternatives to restraints. The first group signal when an 'at risk' person is attempting to leave a bed or chair and the second group signal room or facility exiting.

In Chapter 5, the focus is on video-based technology as an aid to understanding and managing behaviour problems in long term care settings. Bettye Rose Connell begins the chapter by outlining the advantages of video-based observational data collection techniques over self-report, proxy and archival data to determine incident rates and the events surrounding them. She goes on to describe situations where application of video-based technology is particularly appropriate — for example, where there are questions about the frequency, duration, temporal and/or spatial correlates of specific problem behaviours (eg. falls; physical aggression) or when one wishes to ascertain where and when residents spend their time within a care facility environment (i.e. when the objective is to determine space-use patterns). Dr. Connell notes that persons captured on videotape may include residents, their visitors, and various levels of staff. Of particular interest, is her discussion of consent issues for video taping and for use of the data.

Research is also the focus in Chapter 6, but the emphasis is on measuring person-behaviour-environment fit rather than on understanding and managing problem behaviours and the approach is more theoretical than in previous chapters. In Chapter 6, Drs. Scott Danford and Edward Steinfeld briefly review the theoretical underpinnings of the 'transactional' perspective (Lewin's B=f(PE) equation, Nahemow and Lawton's Environmental Docility Hypothesis and Bandura's Reciprocal Determinism model). This serves as a prelude for detailed discussion of Danford's (1983) Dynamic Reciprocal Determinism model and its application to the home modification situation. As the authors note:

> *Home modifications for the elderly are interventions designed to achieve an appropriate and sustainable fit between person, behaviour and environment...The difficulty, of course, is knowing how to assess which home modifications to do and how much of them to do to achieve an appropriate and sustainable fit (p. 88).*

The remainder of the chapter describes the development and testing of a set of outcome measures, theoretically anchored by the Dynamic Reciprocal Determinism Model, that have been developed by the Center for Inclusive Design and Environmental Analysis at the State University of New York at Buffalo. They are designed to complement the Functional Independence Measure (Granger, Hamilton, Keith, Zielezny and Sherman, 1986), a tool used extensively by rehabilitation medicine

personnel. In the testing program, 24 mobility impaired individuals were rated, using the new outcome measures, as they simulated grooming, toileting and bathing in three full-scale simulated bathrooms. In these bathrooms five sets of design attributes typically addressed in accessibility standards were varied to provide a challenging, intermediate and supportive bathroom. In addition, the 24 subjects were scored as they interacted with 26 distinct door configurations.

'Environmental design as enabling technology' takes a different slant in Chapter 7. Here the focus is on stairs. Jake Pauls, a Life Safety Specialist, takes the reader through a series of changes that have been made to U.S. national model building codes (and that still need to be made to Canadian codes), in order to ensure maximum safety of stairs in private dwellings, the site of most fall-related injuries. To provide a context for the discussion, the chapter begins with a series of statistics showing that falls are the leading cause of non-fatal injuries in the U.S. and that after motor vehicle crashes, they are the second leading cause of fatal injuries. The relative risks and the lifetime costs of stair fall injuries compared with other injury-causing events are then presented. In the chapter a cogent argument is made for more stringent standards with respect to stairs (eg. improved riser-tread geometry, dimensional uniformity of steps, safer stair carpeting and stair railings and better stair visibility).

In Chapter 8, Satya Brink places the development and use of information and communication technology by seniors in the context of historical developments — specifically, the transition from the Industrial Age to the Information Age. She argues that Canada is well positioned to take advantage of the shift from a manufacturing to a knowledge based economy because it has a well developed electronic research capacity, a coast-to-coast fibre optics system, an emerging information technology industry and an increasingly computer literate population. The public sector needs, however, to play a more facilitative role than it has to date. One way of doing this with respect to fostering researcher-industry collaboration, is by increasing funding and/or tax incentives for conjoint R & D. Another way is to relax regulations and procedures that stifle innovation or place Canadian inventors at a disadvantage with respect to licensing, development contracts and patents. A third suggestion is for active public sector participation and promotion of technology development for older persons and persons with disabilities such as is occurring in Europe via the TIDE program (see chapter 9). Brink also talks about the potential of seniors to remain active, productive contributors to the information economy rather than being primarily passive consumers of goods and services. The telephone, television set and computer provide vehicles for this to happen. They also provide a vehicle whereby even the most physically frail can remain connected to their community.

In Chapter 9, Rosalyn Moran and Egidio Ballabio describe the European Union's Technology for the Integration of Disabled and Elderly People (TIDE) Program. Part of the Telematics Applications Program, the TIDE program supports the development of assistive devices with a particular focus on information, communication and control

technologies. It is clear from the background information provided that European Union countries are grappling with many of the same problems as Canada with respect to escalating demand for and costs of social and health care services. Like us, the direction cost containment has taken has been to reduce institutional beds and to place greater emphasis on community-based services. Also like us, the European Union has been faced with a dwindling supply of informal caregivers as more and more women have entered the paid labour force. Increased urbanization, geographic mobility of family members and emigration also have impacted the traditional way in which care has been provided in the home to elderly and disabled persons in Europe. As a means of ensuring that products, services and environments that meet the needs of the growing number of disabled persons, seniors and their caregivers, are available at reasonable cost, one tact that TIDE has taken has been to actively promote the principle of 'design for all'. At the same time, there is recognition of a need for specialized products and services. There are a number of lessons that Canada can learn from the TIDE program, now into its fourth five year plan. The successes as well as some of the difficulties are spelled out in Chapter 9.

DISABILITY AND AGING IN CANADA

Throughout the book, reference is made to a potentially large market for various types of 'design for all' and specialized technology among seniors — but how large is large? Moran and Ballabio, in Chapter 9, note that the majority of older people who require some support and assistance in everyday life may not define themselves as having a disability. To gain a better understanding of the numbers and characteristics of disabled persons in Canada, Statistics Canada included a question in the 1986 and 1991 Censuses of Population which asked respondents living in private households if they were limited in the kind or amount of activity they could undertake because of a mental or physical health problem or if they had a long-term disability or handicap. A post-censal survey, the Health and Activity Limitation Survey (HALS) was conducted among those answering in the affirmative (plus a sample answering no). Individuals in health care institutions were also sampled (in 1991 children in institutions were not included). Section A of the HALS included a set of questions designed to determine if respondents were limited in their performance of ADLs even when using aids such as glasses, a brace, etc. Section B ascertained what aids were used and needed by the respondent. Questions about medication consumption were also included. Section C asked about IADLs and the level of support needed by the respondent to continue to live independently. Remaining sections enquired about employment barriers, educational opportunities, problems with transportation, special environmental design features the respondent used or needed for entering, leaving and moving inside his/her residence, respondent's participation in physical and leisure activities, and about his/her economic situation. As background for the chapters that follow, some data from the 1991 HALS are presented below. These data are supplemented with information from the 1991 Survey of Ageing and Independence (SAI), a national

survey which focused on Canadians aged 45 and over living in private households. The SAI data have been disaggregated by both gender and age grouping (45-64, 65-74, 75-84 and 85+) in order to allow simultaneous comparison among and between males and females who currently are seniors and those who in the near future will become seniors. In both the HALS and the SAI, the World Health Organisation's (1980) definition of disability is used. According to this definition, a disability is:

> *...any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being (p. 143).*

DISABILITY RATES BY AGE

In 1991, 4,184,685 Canadians (15.5% of the population) reported some degree of disability (HALS, 1991). Disability clearly increases with age — 14% of adults aged 35-54 were reported to have a disability, compared with 27.1% in the 55-64 age group, 37.8% in the age group 65-74, 50.3 in the age group 75-84 and 72.3% among persons aged 85+ (see Table 1).

TABLE 1

Disability rates by age group, Canada, 1986 and 1991.

	DISABILITY RATE (%)	
	1991	**1986**
Total All Ages	15.5	13.2
Total 65+	46.3	45.5
0-14	7.0	5.2
15-34	8.0	5.7
35-54	14.0	11.7
55-64	27.1	26.1
65-74	37.8	36.7
75-84	50.3	53.6
85+	72.3	82.1

Source: HALS (1986 & 1991); Statistics Canada (1990), p.5, Table 2; Statistics Canada (1992a) Table 6, Statistics Canada (1992b).

RESIDENTIAL LOCATION OF ADULTS WITH DISABILITIES

Of the estimated 1.4 million seniors with disabilities, 85.3% lived in private households, and 14.7% in institutions in 1991. The rate of institutionalisation increases with increasing age — from 4.6% among persons aged 65-74, to 16.4% among persons 75-84 to 46.1% among persons with disabilities aged 85+. The institutionalisation rate is higher for elderly females with disabilities than for elderly males. Among persons 65+, 17.3% of disabled females lived in institutions compared to 10% of males. The gender difference is attributed to longer life expectancy among females and the probability that they have outlived their spouse and therefore lack the social support that would enable them to remain in the community (Statistics Canada, 1992b).

SEVERITY OF DISABILITY

The severity of disability also increases with age. In 1991, among adults with disabilities, the rate of severe disability was 14.8% among persons aged 15-64 compared with 32.4% for persons aged 65 and over (Statistics Canada, 1992b). Having a severe disability is a risk factor for institutionalisation. In fact, severe disabilities were so prevalent among the institutionalized population that the measurement scale of disability was extended by Statistics Canada for use with the institutional population.

Scoring is first derived by summing the severity scores on screening questions asking about hearing ability, vision, speaking and being understood, climbing and descending stairs, moving about the house, standing for more than 20 minutes, bending down and picking up an object from the floor, dressing and undressing, getting in and out of bed, cutting own toenails, using fingers to grasp or handle objects, reaching, cutting own food, activity limitations, learning disabilities and memory problems. One point is assigned for each partial loss of function and two points for each total inability to perform a function. The total score is then categorised as:

mild	— less than 5 points
moderate	— 5 to 10 points
severe	— 11 or more points

The category 'severe' is further subdivided for persons with disabilities living in health care institutions into:

level 1	— 11-17 points
level 2	— 18-25 points
level 3	— 26-42 points

As can be seen in Table 2, in the age group 65-74 approximately one-fifth of disabled persons living at home and approximately two-thirds living in institutions were at the severe level. These proportions increase to 63.3% and 79.3% in the 85+ population. There is also a shift with increasing age in the severity level of the institutional population — from 21.5% at level 3 in the age group 65-74 to 34.5% at level 3 among those aged 85+.

TABLE 2

Adults with disabilities residing in households and health-related institutions, by level of severity and age group, Canada, 1991.

	TOTAL		IN HOUSEHOLDS		IN INSTITUTIONS	%
	N	%	N	%	N	%
15-64	2,346,455		2,297,135		49,320	
Mild	1,261,825	53.8	1,248,500	54.3	13,325	27.0
Moderate	737,345	31.4	725,430	31.6	11,915	24.2
Severe	347,285	14.8	323,205	14.4	24,080	48.8
65-74	732,715		698,830		33,885	
Mild	336,500	45.9	330,510	47.3	5,990	17.7
Moderate	253,560	34.6	247,445	35.4	6,115	18.1
Severe	142,655	19.5	120,875	17.3	21,780	64.5
Level 1					7,290	21.5
Level 2					7,195	21.2
Level 3					7,295	21.5
75-84	507,835		424,800		83,035	
Mild	149,125	29.4	140,800	33.2	8,325	10.0
Moderate	163,145	32.1	147,170	34.6	15,975	19.3
Severe	195,565	38.5	136,830	32.2	58,735	70.7
Level 1					18,625	22.4
Level 2					19,025	22.9
Level 3					21,085	25.4
85+	208,325		112,325		96,000	
Mild	22,470	10.8	16,110	14.3	6,360	6.6
Moderate	54,045	25.9	40,545	36.1	13,500	14.1
Severe	131,810	63.3	55,670	49.6	76,140	79.3
Level 1					20,160	21.0
Level 2					22,840	23.8
Level 3					33,140	34.5

Source: HALS (1991) Statistics Canada (1992b), pp. 5,11

NATURE OF DISABILITIES

Among both seniors living in private households and seniors living in institutions, mobility and agility disabilities were most common. For all of the categories shown in Table 3, disability rates were higher in institutional settings. The most notable difference is in the category 'other'. The rate for seniors living in households was 25.7%. Among seniors in institutions 65.2% reported/were reported to have limitations deriving from a learning disability, a mental health condition or handicap

or because of how they were 'labeled' by others. Clearly the majority in the 'other' category in institutions are persons with dementia-related cognitive impairment. Speaking disabilities were also more prevalent in the institutional sample (29.3%) compared with those living at home (5.1%).

TABLE 3

Persons aged 65 and over with disabilities residing in households and health-related institutions, by nature of disability, Canada, 1991.

	TOTAL NUMBER	%[1]	PLACE OF RESIDENCE IN HOUSEHOLDS N	%	IN INSTITUTIONS N	%
Total	1,448,875		1,235,955		212,920	
Mobility	1,075,560	74.2	886,600	71.7	188,960	88.7
Agility	941,455	65.0	750,615	60.7	190,840	89.6
Seeing	384,395	26.5	298,370	24.1	86,025	40.4
Hearing	605,530	41.8	508,035	41.1	97,495	45.8
Speaking	125,705	8.7	63,220	5.1	62,485	29.3
Other	456,305	31.5	317,390	25.7	138,915	65.2

[1]Columns cannot be summed as individuals may report more than one type of disability.
Source: HALS (1991) Statistics Canada (1992) *The Daily*, p.12

LONG-TERM ACTIVITY LIMITATIONS BY AGE AND GENDER: NON-INSTITUTIONALIZED PERSONS AGE 45+

The Survey of Ageing and Independence (SAI) was administered to a sample of former Labour Force Survey respondents. The Labour Force Survey is the largest continuing household survey in Canada. It samples approximately 63,000 households monthly and is based on a stratified multi-stage design emphasising probability sampling at all stages. The Labour Force Survey was chosen as the sampling frame for the SAI based on the following conceptual model developed by CARNET (The Canadian Aging Research NETwork):

> *Independent living in later life is influenced by three major factors: physical and mental well-being, social life and income. These factors are shaped in turn by life course experiences such as education and work history. Other characteristics such as age, gender and marital status and area of residence also contribute to determining life circumstances (Statistics Canada, 1991, p.4).*

While its focus was clearly different than the HALS, the SAI contained a series of questions designed to explore the prevalence, nature and implications of long-term disabilities. Approximately one in four Canadians aged 45 and older living in private

households reported in the SAI that they are limited in the amount or kind of activities they can do because of a long-term condition (defined as an illness, physical condition or health problem that has lasted or is expected to last more than 6 months). As shown in Table 4, the proportion with activity limitations increases with age — 14% of males and 21% of females aged 45-54 report activity limitations compared to 33% and 41% respectively of men and women aged 75 and over.

TABLE 4

Long-term activity limitations, by age and gender, households, Canada, 1991.

	MALES N	% WITH ACTIVITY LIMITATIONS	FEMALES N	% WITH ACTIVITY LIMITATIONS
45-54	3,559	14.1	3,507	20.8
55-64	2,837	24.3	2,985	24.4
65-74	2,086	28.1	2,519	33.3
75 +	982	32.8	1,560	40.9

Source: Survey of Ageing and Independence (1991)

Range of Activities Affected

Of those reporting activity limitations, approximately two-thirds in the 45-54 age group and over three-quarters in the 75+ group were limited in what they could do around the house; over three-quarters in all age groups were restricted in the leisure activities they could pursue, with transportation and in other ways (see Table 5) and a substantial proportion of those of workforce age had limitations in the work they could do.

TABLE 5

Range of activity limitations, by age and gender, households, Canada, 1991.

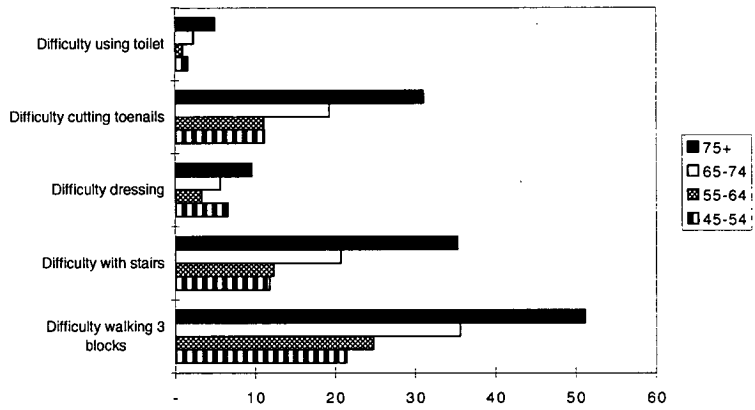
	AT HOME		AT WORK		IN OTHER ACTIVITIES (EG. LEISURE, TRANSPORTATION)	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
45-54	63.8	59.3	46.6	33.6	78.1	71.2
55-64	68.3	71.2	28.5	17.0	75.0	77.1
65-74	69.8	72.2	10.1	2.4	79.7	78.9
75 +	78.9	84.0	4.8	3.0	82.7	83.2

Source: Survey of Ageing and Independence (1991)

Functional Difficulties

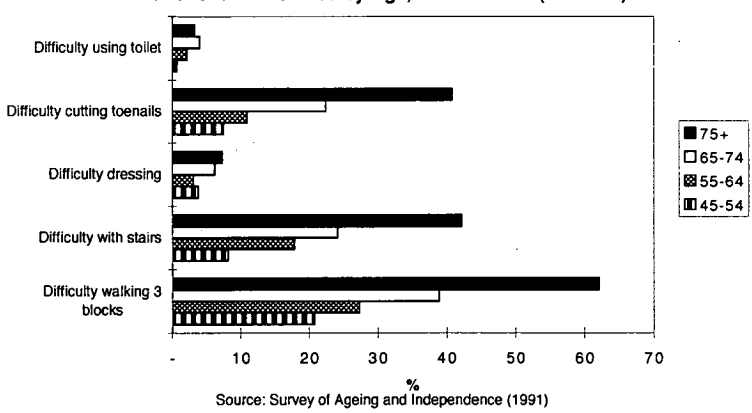
Even at advanced age (85+) relatively small proportions of community-dwelling elderly report difficulty with such personal care activities as dressing and using the toilet. Mobility and agility disabilities reflected in activities such as walking three blocks, going up and down stairs and cutting one's toenails do however affect 11% or more of persons aged 45-54 and clearly increase with age (see Figures 1a & 1b).

Figure 1A
Functional Difficulties by Age, Canada 1991 (Males)



Source: Survey of Ageing and Independence (1991)

Figure 1B
Functional Difficulties by Age, Canada 1991 (Females)



Source: Survey of Ageing and Independence (1991)

Home Modifications

Despite their activity limitations, a relatively small proportion of the community dwelling adults in the SAI sample have acquired mobility-enhancing items such as walkers, wheelchairs or scooters, bought special beds, moved to one-level accommodation or made architectural changes such as adding ramps or widening doorways (see Table 6). Where modifications have been made, most commonly they have been made to the bathroom.

TABLE 6

Home modifications, adults with and without activity limitations, Canada, 1991.

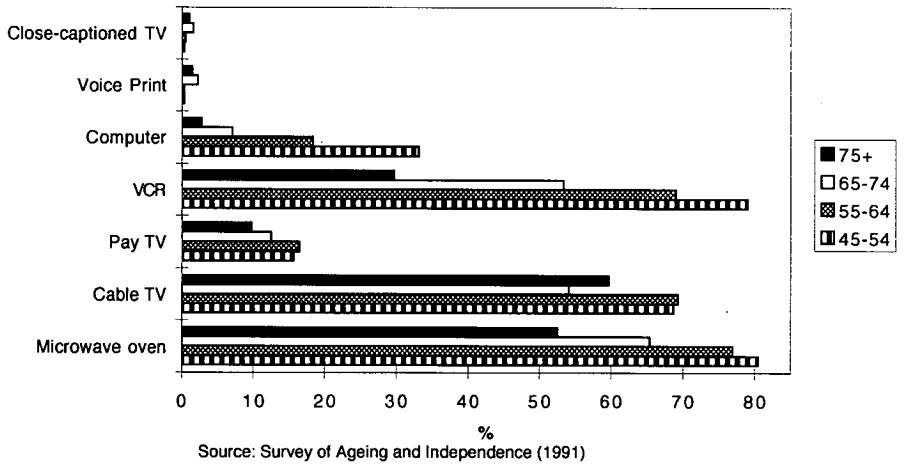
		With activity limitations		Without activity limitations	
		M	F	M	F
Has Bathroom Modifications	45-54	8.4	5.1	1.6	3.1
	55-64	5.8	12.7	2.8	3.9
	65-74	19.4	24.6	6.5	12.1
	75 +	29.1	40.4	17.5	31.3
Has Extra Handrails in House	45-54	4.0	3.5	0.7	1.2
	55-64	4.4	5.9	0.7	0.9
	65-74	10.1	10.3	2.0	4.5
	75 +	15.0	17.3	7.3	6.8
Has Widened Doorway	45-54	5.0	1.6		
	55-64	1.4	1.8		
	65-74	2.1	3.5		
	75 +	5.4	4.8		
Has Street-level Entrance	45-54	10.6	4.3	5.5	7.1
	55-64	5.3	5.8	6.8	5.4
	65-74	10.2	17.5	9.9	11.8
	75 +	14.8	19.1	13.6	18.6
Has Elevator or Lift Device	45-54	0.9	1.1		
	55-64	0.9	1.4		
	65-74	2.6	0.9		
	75 +	2.0	1.2		
Has Other Mobility-related Modifications to Home	45-54	0.4	0.5	0.4	0.1
	55-64	0	0.2	0	0.2
	65-74	0.4	0.6	0.2	0.4
	75 +	0.2	1.0	0.2	0.3

Source: Survey of Ageing and Independence (1991)

Ownership and Use of Modern Kitchen and Communication Technology

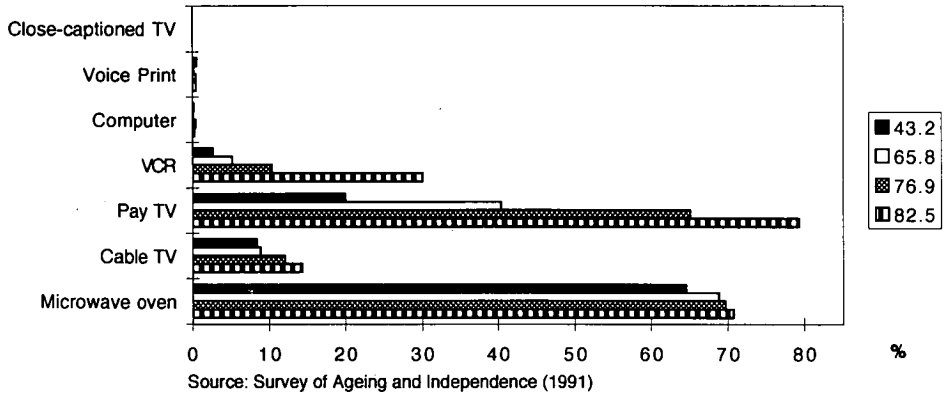
As shown in Figures 2 a & 2b, there are major cohort differences in ownership and use of modern kitchen and communication technology. Four out of five men and women in the age group 45-54 own and use a microwave oven compared with approximately half of men and women aged 75 and over. About four out of five men and women aged 45-54 own a VCR compared with less than 30% aged 75+. Approximately one-third of men and one-fifth of women aged 45-54 own a computer compared with less than 3% aged 75+. Use of technological adaptations to compensate for sensory fading such as Voice Prints (National Broadcast Reading Services via radio or cable system designed for the visually impaired) and closed-caption TV is minimal in all age groups.

Figure 2A
Ownership and Use of Modern Kitchen and Communication Technologies (Males)



Source: Survey of Ageing and Independence (1991)

Figure 2B
Ownership and Use of Modern Kitchen and Communication Technologies (Females)



Source: Survey of Ageing and Independence (1991)

CONCLUSION: A LOOK AHEAD

Reasons often cited for non-use or low-use of assistive devices and other technology by seniors include: technophobia, fear of stigmatisation, cost, lack of coverage by third party payers, difficulty accessing needed items, lack of knowledge as to what is available and/or where to obtain it, denial of need and device-based barriers such as size, weight, and lack a manoeuvrability (Aminzadeh & Edwards, 1997; Chappell, 1993; Harvey, 1995; Smithers, 1995). A key question is whether these barriers will apply to seniors of the future. Given the data shown in Figure 2 as well as continuation of the trends towards an increasing educated population and more and more women entering the paid labour force, it would seem reasonable to expect technophobia (if it exists even now among more than a very minute segment of the population) to be less prevalent in future. For the same reasons, seniors of the future are likely to be better equipped to search (e.g. via the Internet) for devices and other mechanisms and systems that will compensate for disabilities. A key theme of the chapters in this volume, however, is that if we wish the development, production and ready availability in Canada of useful, reliable and cost-effective health care and 'ecological' technology (Haber, 1986) we must have the will to blend the research, public and private sectors and overcome real and imagined boundaries between them.

REFERENCES

Aminzadeh, F, & Edwards, N. (1997). *The Use of Assistive Devices in Fall Prevention Among Community-living Seniors.* Ottawa: University of Ottawa Community Health Research Unit.

Chappell, N. (1993). Technology and aging. *Journal of Canadian Studies, 28*(1), 45-58.

Danford, S. (1983). Dynamic Reciprocal Determinism: A synthetic transactional model of person-behaviour-environment relations. In D. Amedeo, J. Griffin & J. Potter (Eds.), *EDRA 14: Proceedings of the Fourteenth International Conference of the Environmental Design Research Association* (pp. 19-28). Lincoln, NE: Environmental Design Research Association, Inc..

Granger, C., Hamilton, B., Keith, R., Zielezny, N. & Sherman, F. (1986). Advances in functional assessment for medical rehabilitation. *Topics in Geriatric Rehabilitation, 1*(3), 59-74.

Haber, P. (1986). Technology in aging. *Gerontologist, 26*(4), 350-357.

Harvey, J. (1995). Enhancing independence, community living and access to technology: the role and needs of informal caregivers. Paper presented at the 2nd International Seminar on Information Technology and Housing for Older Persons, Bologna, Italy, March 23-25.

Smither, J. A-W. (1995). *Technology and Aging: Policy Framework for Florida.* Orlando, FL: University of Central Florida Initiative on Aging and Longevity.

Statistics Canada. (1990). *Barriers Confronting Seniors with Disabilities in Canada* (Catalogue No. 82-615). Special Topics Series for Health and Activity Limitation Survey. Ottawa: Minister of Supply and Services Canada.

Statistics Canada. (1991). *Microdata User's Guide - Survey of Ageing and Independence.* Ottawa: Statistics Canada, Special Surveys Group.

Statistics Canada. (1992a). *Health and Activity Limitation Survey 1991 Back-up Tables Provinces and Territories —Revised.*

Statistics Canada. (1992b). 1991 Health and Activity Limitation Survey highlights. *The Daily,* October 13. (Catalogue No.11-011E)

U.S. Government. (1988). *Technology Related Assistance for Individuals with Disabilities Act.*

World Health Organisation. (1980). *International Classification of Impairments, Disabilities, and Handicaps.* Geneva, Switzerland: World Health Organisation.

CHAPTER 2

BRINGING THE PRODUCT FROM THE DESIGN CONCEPT TO THE MARKETPLACE

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INTRODUCTION

There is a significant opportunity to improve the quality of life of many elderly people through the design of better products. Manton, Corder and Stallard (1993) provided evidence for this assertion when they described how the proportion of seniors not being able to use the telephone decreased by nearly 10% between 1982 and 1989. This reduction occurred despite an increase in the average age of the senior population. The use of a telephone can give much pleasure and has important practical and safety-related functions especially for elderly people living alone. The large increase in the proportion able to continue using the phone was most probably related to improvements in design such as memory dial functions and large keypads. Reduction in their cost may also have made it possible to install extension phones within reach in more locations in the home. Consequently, improvements to this technology appear to have had a significant effect for seniors. Reduction in activity limitations related to laundry and meal preparation were also reported. Washing machines and dryers became easier to use. More prepared foods and microwave ovens may have been important factors affecting the ease of meal preparation.

But these are consumer products developed by industry. Why do we need university/public sector involvement at all in the development of assistive products for elderly people? Why not leave these developments to the private sector? The reason is that technology for people with significant mobility impairments is inadequate and a special effort that uses all available expertise is needed to fill this gap if the movement to maintaining greater numbers of elderly people in the community with a greater level of independence and quality of life is to succeed. Manton, Corder and Stallard (1993) also showed that the proportion of seniors experiencing limitations

with heavy housework and outside mobility increased significantly over the time span that phone use, laundry and meal preparation became easier.

LaPlante, Hendershot and Moss (1992) reported that the proportion of the U.S. non-institutionalized general population using some assistive technology increases with age from 1% for those under the age of 25 years to 35% for those aged 75 years and over. The biggest increases with age were reported for mobility and hearing devices. Despite these facts, there is a perception that the market for mobility devices is small since such devices do not appeal to the larger market of people without disabilities. The economic incentive is lacking for big companies to develop mobility devices because costs are high and profit margins are small. The problem is that mobility devices include mostly mechanical components and materials. Mechanical system costs have increased whereas electronic system costs have declined considerably even while their function has increased dramatically.

A pattern has emerged in recent years where a small number of larger companies have been increasing their share of the assistive devices market by purchasing smaller companies. Rather than invest heavily in their own research and development, they have adopted a strategy of purchasing innovation. The smaller companies have the risk-taking, dynamic environment that is conducive to innovation. However, these smaller companies can often benefit from partnerships with university and hospital research facilities since they cannot afford to sustain their own in-house multidisciplinary clinical/design/engineering research and development capability.

Potential academic partners with experience in assistive product development for the elderly are uncommon. Unfortunately, academic centres in gerontology and rehabilitation have been placing increasing emphasis on evaluative research. While the greater emphasis on evaluation and evidence-based medical practice may be appropriate in some spheres, it is premature for mobility-related assistive devices. It is my view that there is not much innovative technology yet to evaluate and the priority must be changed to emphasize product research and development. Besides, evaluation should ideally be done by centres involved in product development since they will have a better understanding of the opportunities for improvement. The outcome of an evaluation is of greater value if it includes practical suggestions for improvement to the product. A rating, alone, of the usefulness of the device is much less helpful.

The purpose of this chapter is to provide assistance and encouragement to university research centres in gerontology and rehabilitation to become involved in device development in partnership with industry. The steps from concept development to introduction to the marketplace will be illustrated by some of our own successes and failures.

Recognition of an Opportunity

Conventional wisdom is to designate this responsibility to a consumer or group of consumers. Although this is a good way to define need it does have limitations.

1. Need and market are not the same. The observation that a proportion of the population has a particular need does not mean that these same individuals will have the resources or be prepared to spend those resources solving that need.
2. The saying that "necessity is the mother of invention" may not be totally accurate. Sometimes the need for a device is not apparent until after its invention. The advantages that the device offers then become apparent and a need for these advantages is perceived.
3. Sometimes a need for a device is perceived but consumers are unaware that devices that meet the need already exist.
4. An opportunity only exists if the potential for developing an affordable solution is recognized. This judgement requires technical skills and experience.

In our experience, the best way of defining an opportunity is to have consumers and developers interact. The developers observe the consumers and identify potential opportunities. Consumers then provide the reality check — "Would this be likely to solve an important problem?" Appreciation of the value of a new concept will often have to await at least a preliminary working model. Photorealistic computer graphics models have helped us convey concepts to consumers for review but cardboard and sculptured foam mock-ups are still often more effective. The quality and extent of feedback received is in proportion to the quality and detail of the model or illustration. When computer illustrations are used, we find it is important to include images of manikins to provide a sense of scale.

Many products are conceptually good but fail in their detail. Even a small detail can become very important to a user when function is so critical and when the user has very little margin of reserve capacity. Feedback from consumers becomes increasingly important as the product concept is developed to greater levels of detail.

Concept Development

Much has been written concerning the creative design process. Lateral thinking and a willingness to take risks are essential characteristics of the members of the design team. It is important to create an atmosphere where all suggestions, however crazy they may appear, are welcomed and explored. If the correct solution could be reached by way of a logical stepwise progression of ideas then it most likely would have been solved previously elsewhere.

Our proposed solution to the problem that toilet seats are too low for many people

may serve to illustrate this lateral thinking approach. Currently, most toilet seats are approximately 14 to 15 inches (35 to 38 cm) above the floor. Many elderly people have great difficulty in rising from such a low height. Other seats in the home are generally between 2 and 4 inches higher (5 to 10 cm) and the seat height of wheelchairs is usually 19 inches (48 cm). One of the most common assistive devices is a raised toilet seat. We had received numerous complaints about the safety and appearance of these devices. They are often quite unstable and cause falls. Also, they have a tendency to be difficult to clean and there is a stigma associated with their appearance. For example, visitors may find them disconcerting.

Presumably, the problem has previously always been articulated to product developers along the lines of: "Can we design a better raised toilet seat?" Lateral thinking led us to propose an alternative approach. Instead of placing something on top of the toilet we proposed to place the toilet on top of something. First reactions, as always, were to dismiss such a radical idea as impractical. However, the idea was pursued to the construction of a crude wooden functional prototype and computer illustrations of the anticipated appearance (see figures 1 and 2). Consumer feedback was strongly in favour of the concept. The breakthrough in the practicability of the design came when a simple geometrical solution was found that allowed the same product to fit all known common toilet shapes.

FIGURE 1

An early wooden prototype of the toilet modification kit used to explore its feasibility and to consider alternative concepts for adding armrests.

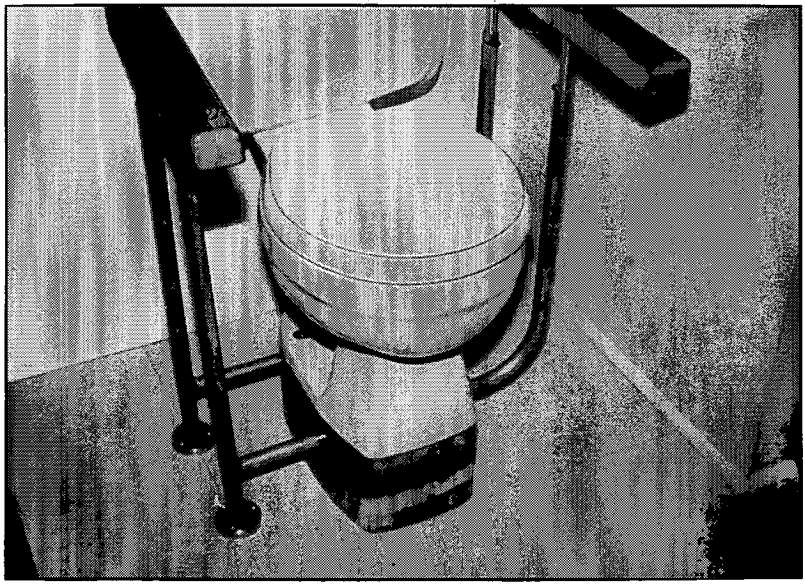
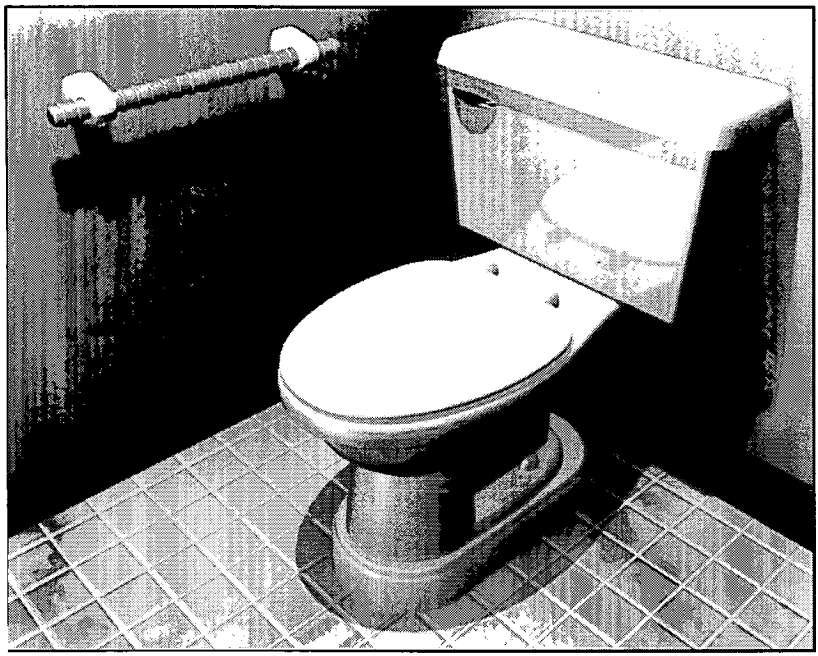


FIGURE 2

A computer simulation used to explore an alternative for the detailed appearance of the toilet modification kit.



Resistance to investing in the manufacture of the device was encountered because of the perception that there would be a reluctance to go to the trouble and expense of installation. The kit is actually very simple for any amateur handyman to install but it is accepted that some people may wish to engage a plumber. When the two solutions are compared (as in figure 3) we find that consumers state that the advantages of safety and cleanliness are so great that the additional expense of hiring a plumber is acceptable. Usually people do not even notice the presence of the new device and a prototype has been in use in a test installation in the home of an elderly couple for more than a year with no problems. The system is a less expensive solution than purchasing a higher toilet and has the advantage that it can easily be removed to return the bathroom to its original appearance.

FIGURE 3

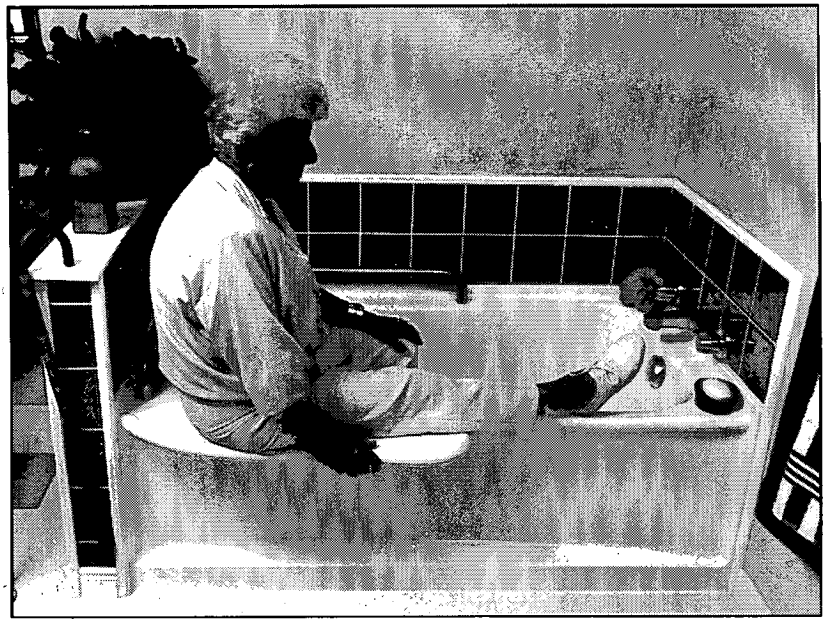
The conventional solution and the proposed product placed side-by-side for comparison. The proposed product has none of the cleaning and stability problems of raised seats and many people do not even notice its presence.

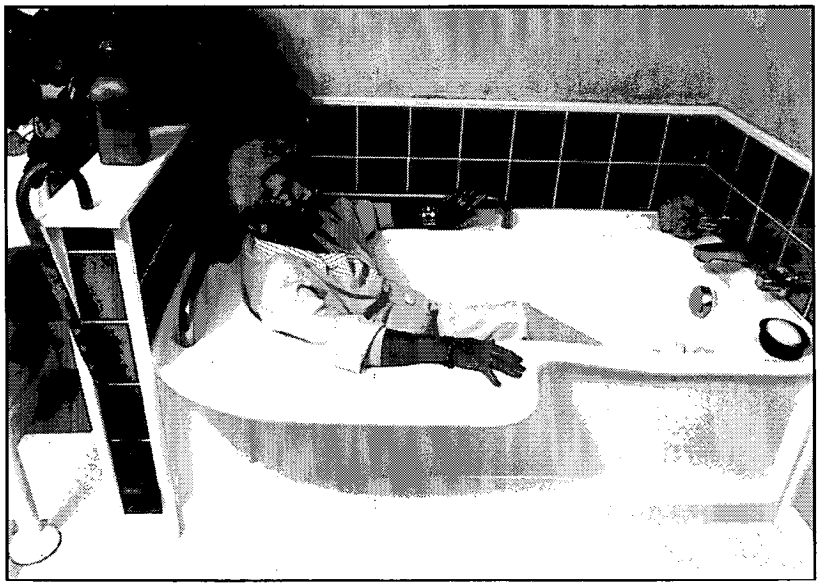
Resolving Function Versus Universality

The concept of universal design has been promoted (see for example Pirkl, 1995). A universal solution is a product that will appeal to everyone, regardless of the presence of a mobility impairment. There are many advantages to this approach. We attempt to follow the principles of universal design and sometimes (not always) think that we have succeeded. For example, figure 4 shows a consumer volunteer testing our recent design of an accessible bathtub. This bathtub was designed to provide increased ease and safety in use by people with mobility impairments. The most obvious feature is the wider portion of the side of the tub. The user transfers in and out by sitting on the side and swivelling. There is no longer a need for a transfer bench although some users may choose to place a stool inside the tub. The full length of the near edge is designed for easy graspability and the grab bar on the opposite edge and head end is an integral component. The tub is available in left and right models and with two seat heights. It fits standard bath alcove dimensions.

FIGURE 4 A, B, C

This sequence demonstrates transfer into the new 'Access' bathtub. Note the wider side for sitting and the hand holds provided by the edge of the tub (near side) and the built-in handrail (far side).





It was decided at an early stage that the design of this bathtub would avoid the use of mechanisms such as doors and elevating seats. The target was to design a tub that would appeal to everyone, regardless of ability. This design appears to have achieved that goal. For example, parents have said that it is comfortable for supervising small children and adults have commented on its attractive shape and the convenience of the wider side for resting books and drinks during a leisurely bath. Most importantly, this broader appeal makes it possible to plan for higher volume of production and for distribution through regular, non-specialized, retail stores. Consequently, the cost of the product is significantly lower than other special designs for the elderly. Ownership of this tub does not identify the user as disabled. Rather, there is a sense of pride of ownership of an attractive product that appeals to most people.

Creating a Migration Strategy

From the beginning, it is important to envisage a strategy for a family of products and for a pathway of improvements or cost reductions. Investors are looking for more than a single product. They anticipate that, despite patent protection, competitors will produce similar products within 18 months to two years. They must have confidence in a strategy that will have improved and/or lower cost versions of the product ready to introduce when competitors arrive on the market.

This can be illustrated by our wheeled walker invention. Figure 5 shows the first version of this product, known as 'SturdyWalker™'. This walking aid incorporates various advances of design. Most importantly, the walker is equipped with a novel brake design that allows speedy and effective application of the brakes by users with limited hand function. The feature of most relevance to the migration strategy is the novel modular construction. The legs and seat support frame are straight tubes that are held together by moulded hinge components. This allows the manufacturer to produce the walker in any height and width without additional tooling cost simply by cutting the tubes to different lengths. It also enables a migration strategy where components can easily be upgraded or changed.

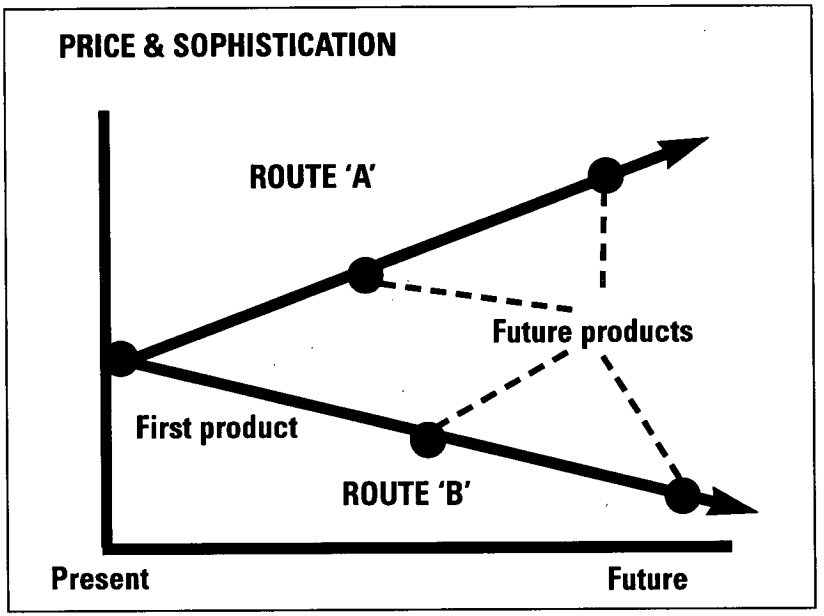
FIGURE 5

The author's son helps his grandmother test a prototype of the new 'SturdyWalker™'.

The migration strategy is outlined in figure 6. Two paths are proposed. The top path involves the development of increasingly sophisticated walking aids to meet special needs of people with different disabilities at various stages in their rehabilitation. For obvious reasons the details cannot be disclosed, but proposed technologies include electronic braking and speed control and novel folding mechanisms. The downward path involves the development of products that will appeal to people with less significant disabilities or no impairment whatsoever. These products include shopping aids and products to help transport materials in manufacturing and other commercial applications. The upward migration path will be associated with increasing function for the same or increasing price with the objective of staying ahead of competitors by being the first with new technologies. The downward migration path will result generally in larger sales volumes and decreasing prices. The objective will be to stay ahead by being the first to identify and meet new market needs. It is hoped that future products will benefit from new technologies and economies realized through both strategies.

FIGURE 6

An overview of a migration strategy for the walking aids. Route A involves the development of products with increasing sophistication and functional capabilities such as electronic controls. Route B targets reductions in cost and products with appeal to broader markets of people with more minor or absent mobility limitations.



Prototyping

Prototyping skills and resources are essential. The technology used must be selected to match the stage of development and the nature of feedback needed. The most common methods include: the creation of a virtual prototype on a three-dimensional computer-aided design software package, cardboard assemblies using a heated glue gun, appearance models constructed from stiff blue building insulation foam, shapes fabricated from sheet plastic that can be bent with the help of a hot air gun and welded easily with solvent, and fully functional mechanical or electronic prototypes produced in a workshop by many different manufacturing methods. Each of these technologies is better suited to different types of product and to the nature of the uncertainties that are to be resolved.

FIGURE 7

A concept for a powered chair illustrated by a three-dimensional computer model and including a computerized 50th percentile male mannikin to aid in soliciting consumer feedback. Note the mismatch of the arms and armrest length.

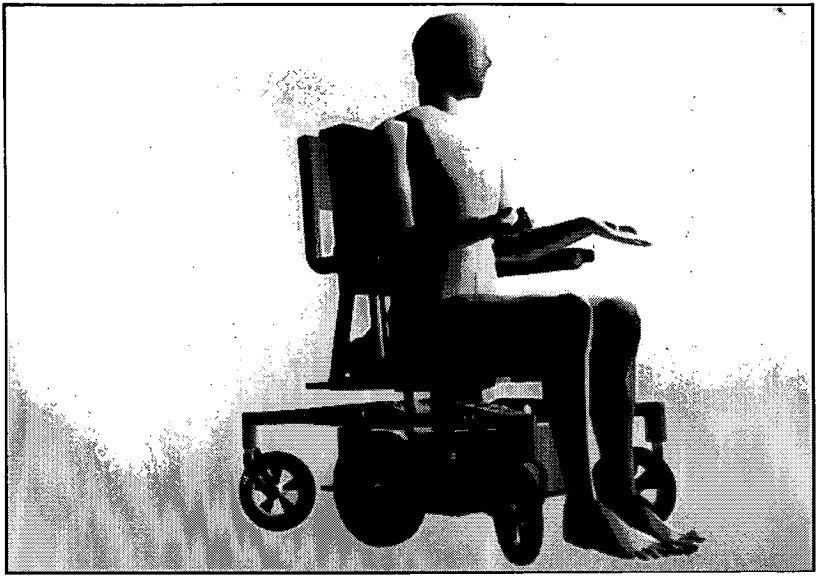


Figure 7 shows a simple computer model of some features of a new powered chair design. The computer mannikin can be sized to match different population percentiles and can be posed by rotating the different body segments about the anatomical joints. The image can include textural information, shadows and different surface reflectance and opacity. It is easy to view the prototype from different directions and it is possible to record an animated sequence of movements. In the case of the powered chair, sketches and simple computer models were used to explore and illustrate basic concepts but the effort moved quickly to the construction of working prototypes. These fully functioning prototypes were needed at an early stage since the viability of the project depended on demonstrating the feasibility of new concepts for the powering, steering and suspension systems. Typically, several modifications will be needed to the physical prototype until satisfactory function is achieved. We will then return to the computer screen and to scale models to illustrate concepts for the final appearance of the product that can be explored with consumers. This step is necessary in order to check important details economically. The final prototype will resemble the proposed product in appearance and function and will be expensive to produce.

Usually industry is far less enthusiastic about a prototype than the inventors. The industrial partners are not interested in prototypes — they want an affordable product

as quickly as possible. The prototype must resemble a manufacturable product as closely as possible in order to attract investment.

Protection and Patenting

Advancement in academia is based upon the researcher's publication record. Sometimes very coarse measures are used — such as the number of publications. I was once a member of a national granting agency panel where every time a grant proposal was discussed one of the members would announce the results of his calculation of publications divided by funds expended. This ratio was his benchmark for productivity. In order to be promoted and to impress granting bodies, researchers feel compelled to disclose their inventions at an early stage.

Patents can be applied for in Canada and the U.S. up to one year following publication but prior publication prevents patenting in Europe and elsewhere. Consequently, no papers should be submitted for publication and no information should be presented at conferences before filing a patent.

In the U.S., patents are still awarded on a first-to-invent basis whereas patents in Canada are now awarded on a 'first-to-file' basis. The date of making the invention is no longer relevant to a Canadian patent. Delaying filing a patent is, therefore, associated with a risk that someone else will file first. On the other hand, premature filing may incur extra costs for revising the submission or preparing a second submission to protect improvements. Also, the filing of a patent triggers other events. International agreements allow patents to be filed in other countries with filing dates that are backdated to the first patent filing. Such foreign patents must be filed within twelve months of the filing date of the home patent. Worldwide patenting is an extremely expensive process and inventors will want to delay the start of this process as long as possible in order not to exclude the possibility but also not to incur the costs until a licensee is in place to subsidize that cost. However, any delay past twelve months from the home filing date will lose the benefit of back dating.

The most effective protection is secrecy. A patent provides protection but it also results in the publication of a description of the invention. All documents, such as reports to funding agencies, that require the invention to be described should be marked prominently as "Confidential proprietary information — do not disclose". Descriptions and prototypes should only be shared following signing of a non-disclosure agreement. In addition to non-disclosure agreements that are specific to each invention, we find it convenient to print our visitors' sign-in book in the form of a general non-disclosure agreement. Our book repeats the non-disclosure agreement on each page and has room for several signatures at the bottom of each page to save on paper. Research and Development areas should be enclosed and labeled "Restricted entry — R & D personnel only".

Licensing and Development Contracts

The public sector has a reputation (deserved or not) of being less efficient than private industry. It is important to be prepared to conduct efficient and effective negotiations. The ownership of inventions is not always a simple matter. Sometimes funding agencies, universities, hospitals and individual researchers all have some claim. These relationships must be clarified and an individual must be empowered with the responsibility of negotiating licensing arrangements. The licensee will want an assurance that the licensor has clear title to the invention.

Efficiency is improved if the licensor has developed a master set of agreements for product development and licensing. Our standard agreement has three schedules that are attached to customize each agreement. The invention is described in the first schedule, preferably with reference to patents filed or published. The second schedule states the royalty rate and the third schedule sets out minimum required sales volumes for each year of the lifetime of the agreement.

The licensee will want to review and, perhaps, negotiate revisions to the standard clauses. The important standard clauses address the following points:

1. Territory and exclusivity, e.g. exclusive worldwide.
2. Duration of the license, e.g. five years, automatically extended.
3. Terms under which the licensee may sublicense the invention, e.g. on terms consistent with the licence and ensuring that the sublicense is not used as a device to reduce payments to the licensor.
4. Who will apply for patents and who will pay the costs.
5. Who will have control of the defense of any lawsuit and who will pay costs.
6. Who will take proceedings against infringement and who is entitled to proceeds and liable for costs.
7. Product specifications, design and manufacturing quality must be satisfactory to the licensor to protect its good name. The licensor must approve all advertising and promotional materials carrying its name.
8. Any improvements made by the licensor are automatically part of the licence agreement.
9. Improvements made by the licensee will be assigned to the licensor.
10. Mutual confidentiality.
11. Requirement of the licensee to manufacture and sell the products in a businesslike manner. This will include minimum required sales or royalty payments. Failure to meet these targets may lead to loss of exclusivity or termination of the agreement.

12. Royalty payment terms, e.g. quarterly based on the agreed percentage of aggregate net sales of the licensee and sublicensees.
13. Mutual indemnification.
14. Conditions under which the agreement can be terminated by either party.

These terms may not be suitable for every situation and are offered simply as an aid to increase understanding of the issues that should be addressed. Normally the licensor would be responsible for obtaining patents and protecting them from infringement and would have to provide some indemnification to the licensee with respect to the performance of the invention. However, public research institutions are not usually in the business of funding these activities and accepting such responsibilities. In these cases the private sector licensee assumes greater responsibilities and the royalty rates may, therefore, be somewhat lower.

Support

The role of the hospital/university research and development team does not end with the signing of a license agreement. The degree of involvement beyond this point depends on the capabilities and resources of the licensee. In many cases the licensee is a relatively small company or even a group of investors with no existing manufacturing or marketing facilities. Inevitably the researchers must continue to provide support if the technology transfer is to be successful. Assistance may be required with tasks that include: designing for production; selecting materials, processes and suppliers; testing to standards; establishing quality control procedures; checking of marketing materials; assisting with presentations to potential investors and briefing sales staff. In addition, the researchers should be prepared to stand by their design and to respond immediately to crises that will inevitably arise during the introduction of a totally new product.

DISCUSSION

This chapter began by outlining a need and an opportunity for public sector research and private sector industry to collaborate to develop new products to help elderly people overcome limitations of mobility. There are signs of changing attitudes by universities to collaboration with industry. To date, however, the performance of the university and hospital sectors in transferring technology directly to industry has been generally poor. Hoffman (1994) reported on a survey of 250 institutions in the U.S. and Canada. The gross royalties received by these institutions totalled $380 million in fiscal year 1993 on an investment of $17 billion. This represents a return of approximately 2%. Separating out the Canadian institutions produced figures of $5 million of royalties received for total sponsored research expenditures of $687 million. This is a return of less than 1%. The 11 major Canadian universities that were included in the survey filed only a total of 88 new patent applications in the U.S. in 1993.

Understanding the most probable reasons for failure may help improve the chances of fruitful collaboration between the sectors in the future. I think that a significant factor is a lack of understanding of what is required for successful technology transfer.

- Ideas are over-valued by researchers and their institutions. The 'D' in 'R & D' is underestimated and attempts are made to sell a concept at too early a stage.
- Resources for prototyping are inadequate in most research environments.
- The public sector has unrealistic expectations with respect to timelines — the elapsed time from the start of a development to the launch of a product is typically between four and seven years.
- Private sector partners usually want to interact directly with the researcher who is the 'Champion' of the product. A 'Technology Transfer Office(r)' may provide support to the researcher but cannot substitute for direct contact with the researcher
- The demands on the time and energy of the researcher for these technology transfer activities are not rewarded. Academic recognition is tied to journal publications. Some recognition is extended to published patents but products are usually not acknowledged.
- There is a perception in the private sector that interactions with public sector research organisations are complex and are often associated with indecisiveness, lack of clear ownership of intellectual property, inadequate protection against disclosure and unclear lines of responsibility

Corey and Kahn (1995) suggest further reasons for the lack of an appropriate return on investment include unrealistically low royalty rates negotiated by researchers. They present a table of royalty rates received for different categories of product. The closest match to assistive devices is 'medical instrumentation' where the rate ranges from 4% to 10% of sales revenues with upfront signing payments of between $5,000 and $150,000.

CONCLUSION

The design of mobility devices for the elderly is an important challenge that should be addressed by university researchers and industry working together. However, the performance of the public sector in direct technology transfer has been poor to date. More university centres of gerontology should be involved in product development as well as product evaluation but they will only succeed if realistic resources are devoted to the 'D' in 'R & D'.

The design and development process should involve consumers to provide checks on the accuracy of the identification of the problem and to give feedback on the design at a very detailed level. Lateral thinking and risk taking should be encouraged during

the concept development stages. It is not always possible to achieve a universal design of a mobility product without compromising critical functional performance. But, if that goal can be achieved then the product will be less stigmatizing and more affordable.

Many factors influence the likelihood of attracting an industrial partner. The most effective credential is, of course, a record of past successfully transferred products. Prototyping capabilities are not only key to the development process but also play an important role in the ability to attract private sector partners. Non-disclosure practices must be followed and patents must be filed with careful consideration to timing. The research organisation should have draft licensing agreements in-hand and clearly designated responsibilities for negotiating with the private sector in a simple and direct manner.

Increasingly, innovation is the role of smaller companies, especially startups. Many larger companies innovate by acquisition. So university researchers must find and interact with smaller companies. These companies will need greater levels of support and the academic community must acknowledge and reward researchers for success in this activity, as well as for publication.

REFERENCES

Corey, G. D. & Kahn, E. (1995). How to successfully negotiate reasonable royalty rates for licensing bioproducts. *Genetic Engineering News*, September 1, 4-38.

Hoffman, D. C. (1994). *AUTM Licensing Survey*. Norwalk, CT: Association of University Technology Managers Inc.

LaPlante, M. P., Hendershot, G. E. & Moss, A. J. (1992). Assistive technology devices and home accessibility features: prevalence, payment, need, and trends. *Advance Data: Centres for Disease Control, 217*, 1-11.

Manton, K. G., Corder, L. S. & Stallard, E. (1993). Changes in the use of personal assistance and special equipment from 1982 to 1989: results from the 1982 and 1989 NTLCS. *Gerontologist, 33*, 168-176.

Pirkl, J.J. (1995). Transgenerational design: prolonging the American dream. *Generations, 19*(1), 32-36.

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CHAPTER 3

HOW TO EFFECTIVELY RESEARCH AND MARKET TECHNOLOGY TO OLDER PEOPLE

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INTRODUCTION

Effective research and marketing is based on understanding one's customers, developing products they want and communicating the benefits of the product to them in language that reinforces their self-image. Throughout this chapter the term 'product' will be used interchangeably with the word 'technology'.

Four facts cause new product developers to run amok when they decide to develop technology for the mature market:

- there are more than 32,000,000 people aged 65 years and older in the U.S., and more than 3,170,000 in Canada and in both countries the first of the baby boomers turned 50 this past year;
- the 65+ age group has more discretionary income (more money left over after all their bills are paid) than any other age group;
- persons aged 65+ experience changes in their abilities which increase the proportion among them who need assistance; and
- technology can do more things for more people for less money today, than ever before.

All of the above facts are true. But, the size, wealth and need for assistance among the older adult market and the wonders of technology will not make a product successful. The mature market spans a 40 year period. Because people are 'elderly' according to the product developer's standard does not make them of one mind. Because they are older does not mean that all will need, want, use or even consider purchasing a product.

People are different from each other. Just think of any two siblings you know. They

are of the same generation and likely to be only a few years apart in age. Yet, one enjoys classical music, the other 'new age'; one likes funny movies, the other prefers science fiction and horror shows; one spends conservatively while the other feels good spending money and buys compulsively. If people from the same gene pool are this different, why do we expect someone upon reaching the age of 65 years to become a lemming?

This chapter covers three topics: the process of new product development, market research methods and the application of market research in marketing efforts. Each of these topics is discussed in turn in the following sections.

THE PROCESS OF NEW PRODUCT DEVELOPMENT

Technology Push or Market Pull?

There are two paths of new product development. 'Technology push' characterizes many product development efforts. A great idea, new features and new capabilities are discovered and a new product is born. The microchip can do everything — with a quick push of a button, another program command, it will even wash windows. As product developers we are in love with our creations. We know every advantage our product has over every other product on the market; we've pulled out the stops and created a product that builds on every technological capability of materials and electronics.

Many new products for older adults are created because a family member needed it. A home made product was developed, funds were found to improve and mass produce it, the product was made, packaged and sales have been slow. The product developer is baffled. The technology will more than solve the problems encountered by older adults, the price seems reasonable, yet no one is buying it. They have the perfect technology, why isn't the older adult market buying it?

'Market pull' describes the scenario when the market wants something and is willing to pay for it. Matching a technology to 'market pull' creates success. The key is to know what the market wants. Needs can be ignored, overcome, gotten around, sometimes forgotten, but when someone wants something they have the internal drive to get it.

MARKET RESEARCH IN THE NEW PRODUCT DEVELOPMENT PROCESS

New product development can be accomplished with or without market research. Many product developers have given up on market research because they tried a few focus groups once, didn't feel they got anything from their efforts or expenditures and believe the product is selling fine despite the research. Perhaps, the philosophy of the company is, "Just do it."

For many products and services a "Just do it" attitude is successful. Sometimes

success is gained because the company was first. Or perhaps, they were just right. Capturing the older consumer, however, may not be the same as capturing other markets. And, making marketing and sales assumptions based on demographic trends and needs of older adults has been shown to be misleading.

Product development incorporating market research can improve the time-to-market process by incorporating iterative research enmeshed in the product development cycle. Consumer input should begin with the concept development phase and should continue throughout initial designs, prototyping and the development of marketing plans. The product should be consumer tested at every stage (concept, design, prototype and production).

The people who test the product should be the targeted market — not the people who will sell the product, not other people in the company who will benefit from the sale of the product and never the individuals involved in the development of the product. The buyers and intended end-users should be employed to provide feedback at several stages of development

Market research includes:

- identifying opportunities;
- evaluating the feasibility of new products, market penetration and acceptance;
- determining product design, presentation and positioning; and
- pricing.

There are several types of research to assist in completing the steps listed above. These include a competitive analysis, a trade or industry analysis, qualitative analyses, quantitative analyses and consumer testing.

Identifying Opportunities

The more one learns about a market the more opportunities one will find to meet the expectations of that market. Market research is particularly beneficial during the concept development phase of product development. Through focus groups and other methodologies that allow face-to-face communication with the intended market the researcher can gain new product ideas, obtain valuable feedback about the prospective features of the product and gain design input.

Identifying market opportunities also comes from a competitive analysis. By lining up and dissecting the product offerings, product features and benefits of the competition, the researcher learns where holes exist, or conversely learns that his/her novel idea isn't so novel after all.

There are two types of competition: direct and indirect. Direct competition includes all of the products in the market place the consumer could purchase to do the same, or

nearly the same function as the proposed product. Indirect competition includes everything that would preclude the customer's purchase of the product. In the realm of technology for older adults indirect competition includes:

- services that could be employed instead of the proposed product to accomplish the intended objective;
- the older adult's gradual adaptation to his/her environment without the proposed technology;
- the older adult's change in his/her habits to avoid or overcome the need for the product;
- the stigma associated with products intended for 'the elderly' or 'the handicapped'; and
- the attitude of the prospective consumer to the desirability of the product or the benefits received for the costs expended.

Trade Analysis

In addition to learning everything about the competitors' products the product developer needs to know everything possible about the industry. What are the industry organisations and associations? How do the associations benefit the members? Who are the members? Who are the industry leaders? Why are they the leaders? Have they achieved this recognition through sales volume or do they represent the highest quality product?

What do the industry publications say about the market? Are sales up or down? What is forecast for the future? Who prognosticates for the industry? What are his or her qualifications?

How do others in the industry distribute their products to consumers? Are these distribution techniques effective? Why are these distribution channels used? Where do others advertise? What features/benefits of the products do they advertise? What are their marketing budgets?

Qualitative Market Research

Qualitative market research is important to obtain in-depth feedback on products. Three types of qualitative research are prevalent. These information resources include: 'My mother', sales representatives and focus groups. All of these sources have their benefits and limitations.

Many new product decisions are based on whether or not 'my mother' would use the product. In many instances this source of information is an excellent gauge of the acceptability of the product. We all know our mothers, perhaps better than most other people. We understand the parameters of what this person will and will not accept.

Thus, if a product is unattractive, too complex, limited in benefit, etc., it would be wise to listen to what our mothers say. On the other hand, Mom is a sample size of one. She may voice her acceptance or rejection of a product, but she does not speak for the other 31,999,999 individuals in the USA or 3,169,999 in Canada aged 65 and older.

Sales representatives are often seen as excellent sources of information about what consumers want. After all, these people come in direct contact with the customer. They see what the customer purchases, they receive the complaints, they work with the people and product. While sales representatives are an excellent source of feedback, they are not good predictors of the benefits, features and new products consumers want. They are influenced by the vocal and loudest of their customers and do not hear much from those who don't voice their opinions or complaints.

In a comparison of sales force and customer's preferences for features on a high technology product, Strub and Herman (1993) found that sales force judgments bore little resemblance to customer judgments. The sales force was considerably more optimistic about sales volume, exhibited different patterns of preferences for the physical design of the product, and had very different judgments regarding the desirability of various feature packages. Strub and Herman concluded that it would not be wise to use the sales force as a surrogate for the customer.

Focus groups provide a wealth of information about products. Focus groups are an excellent source of qualitative information because they allow the participants to see, hear, use and ask questions about the prospective technology. The focus group moderator can gain information from the facial expressions and body language of the participants. Their enthusiasm (or lack of it) for new product ideas come through quickly. We have introduced product prototypes where the participants sat around the table and waited until the item was passed to them for their opportunity to look at it. And, we have introduced product prototypes where as soon as the prototype was placed on the table several participants jumped up from their seats to come over to the head of the table to get a better look — they couldn't wait for the product to be passed to them. This enthusiasm is difficult to see in a paper and pencil survey.

Focus groups, though, are both good and bad. They are highly subjective and can be influenced by the moderator, participants within the group or an offhand comment made by someone at the beginning. Every focus group is different and needs to be taken in context. Focus groups do not tell us how many products we will sell, and whether or not we will be successful. They give us an indication of whether our ideas, designs, prototypes and marketing plans are on the right track. Focus groups should never be the sole source of information for launching a new product.

Quantitative Analyses

Quantitative analyses generally involve some form of survey technique: intercept, telephone or written. A feasibility study which usually predicts the size of the market

likely to purchase the product should be based on quantitative studies. The feasibility study often forms the basis for making the 'Go or No Go' decision.

When conducting quantitative research the goal is to assess the opinions of a sample representative of the target market. The sample size selected depends on the size of the market for which the projections will be made, the type of research to be completed and the expected results.

Intercept surveys are often completed in an area where the prospective consumer is likely to be encountered. The interviewer is stationed in this area and intercepts individuals to ask if they would be willing to complete a survey. The participant either completes a written survey or is interviewed by the researcher on location.

Telephone surveys generally range from a minute or two up to 30 minutes. The researcher defines the population to be sampled, the number of surveys to be completed and the methodology through which the prospective participants are identified. The most representative surveys are those where the sample was selected through a completely randomized process. This process is often slower and more costly than purchasing a list of names and telephone numbers of individuals who meet pre-selected criteria. While this is not a random sample of the population, information obtained from a sufficient number of the respondents should be representative of other individuals who have the same characteristics as those who appeared on the list.

Written surveys are often used to assess market perceptions of new products. Short surveys with clear, objective questions are likely to be completed and returned. Long surveys, with confusing or misleading questions are likely to be thrown away. Written surveys allow the product developer to include photographs, drawings and descriptions of the product under development. Well-designed surveys permit the product developer to assess who is interested in purchasing the product and the characteristics of the prospective purchaser.

One research method particularly beneficial for gathering information about the impact of product features on market share is 'Conjoint Analysis'. Conjoint analysis can be employed in telephone or written surveys or used as part of focus groups. This research methodology does not ask the respondent discrete questions, but rather provides a series of descriptions about alternative versions of the prospective product and competitive products. The participant reads each product description and rates his/her likelihood of purchasing the product described. Usually several features and the price of the product are included in each description.

Through the use of sophisticated software programs, the researcher learns the features of the product most likely to influence the purchase decision, how much each feature influences the purchaser's decision and the impact of pricing in the decision process.

Conjoint analysis is an important tool in market research because it provides a

realistic assessment of the features of a product important to the prospective customer and the price the customer is willing to pay to obtain the features. It is one of the most powerful methodologies available for product development research.

Market Segmentation

Just because someone has a significant need for a product does not mean he/she will buy it. The key to market research is to learn the features of the product that appeal to the greatest number of people, then learn the characteristics of those people who are willing to buy.

Conjoint analysis combined with traditional survey research facilitates market segmentation analyses. Product-specific market segmentation analyses based on conjoint analysis (or other choice-modeling procedures) allow segmentation of the participants into groups based on the features of the product they like, their likelihood of purchasing a product and their personal (socio-demographic) characteristics.

In a simple product-specific market segmentation analysis there are four segments that can be defined:

- those who like the product and plan to purchase it;
- those who like the product but don't plan to purchase it;
- those who don't like the product but plan to purchase it anyway; and
- those who don't like the product and don't plan to purchase it.

The characteristics of the market can be defined for each of these product-specific segments.

Consumer Tests

A final component of market research is to ensure that the product is useful to and usable by the intended market. Too often product design focuses solely on the primary function of the product. The focal point of hearing aid design, for example, is the quality of the acoustic signal reaching the user's eardrum. The second design focus has been to conceal the hearing aid. It is of little surprise that many older adults have had difficulty using and have abandoned their hearing aids because they have had difficulty replacing the batteries and operating the device. They cannot see nor feel the controls on the device sufficiently well to be able to turn it on and off or to adjust the volume control. They have difficulty determining that 'o' means 'off' and 'n' means 'on'.

Consumer test panels should be initiated with a foam core or pre-production prototype. Laboratory 'sets' can be constructed so that the consumer can evaluate the product in realistic use settings. For example, jar openers can be tested on never-

before-opened jars of varying sizes. Scooters can be driven on different surfaces, backed up, cornered, maneuvered in tight spaces, put together, charged, taken apart, and anything else a consumer would do with the product when he or she got it home.

We have learned that consumer test panels, particularly those employing individuals who are design-sensitive, identify design flaws quickly. Usually from 30 to 50 consumers will identify 90% to 95% of the problems likely to be encountered with a product. If these individuals are design sensitive i.e., if they are shorter, weaker, have less mobility and dexterity and have poorer vision and hearing than the average young adult male, it is likely they will tax the ease-of-use and usefulness of the product. These consumers will provide valuable feedback about the product and are likely to significantly reduce the number of products that are returned. The few thousand dollars required to rigorously evaluate the product before it goes into production will more than pay for itself in increased sales, satisfied customers and fewer returns.

Using Market Research

If you are afraid to ask questions or if you plan to build the same product regardless of the results of market research — don't bother spending the time and money to do it right. It is amazing, but some product developers avoid market research because they do not want to learn the market's response. They fight obtaining feedback because they have a gut-level feeling some of it will be negative. Others spend money on market research, ignore or rationalize the results and develop the product regardless of what they have learned.

Market research is interactive. The more the researcher knows about the product, and the more the product developer knows about the ins and outs of research, the greater the likelihood the results will be directly applicable to the development process. Market research must be conducted in context. The market researcher should be aware of product design and development constraints. For example, if a product cannot be made any lighter, if it will only be available in one color, if the cost will be doubled to use one type of housing as opposed to the other — the market researcher should know this. The research questions, focus group presentations and conjoint analysis studies can work around these constraints and learn the impact of these immutable parameters on the acceptance of the product in the marketplace.

Expected Market Research Results

Market research should tell the product developer six things:

1. Who the customers are for the product.
2. What the customers want.
3. How many customers are likely to purchase the product in a given period of time.

4. The features of the product the customers prefer.
5. The features of the product the customers would pay more to have.
6. The customers' minimum expectations for the product.

Effective Marketing of Technology to Older People

Even though some companies have developed an excellent product for mature consumers they have been disappointed in their sales volume. These disappointments may be a result of the way the product is being marketed. This section provides some tips and rules for marketing to older adults.

The product developer must know what the consumer wants and must market to that want. When the fundamental reason for wanting a product is known, then the marketer has the platform on which to build a marketing plan. For example, it is unlikely that consumers want a personal emergency response system to feel safe, secure or independent. What consumers 'want' is to know that someone is there. They want to know that if they need help, the response center will be there, reliably and without fail, to provide assistance.

It may seem like an insignificant difference — but the marketing platforms are miles apart. If the marketer sells the product on the premise that the consumer wants "safety, security or independence" the marketer is defining the consumer as someone less than those who do not need this product. The message being conveyed to the consumer is "You will not be safe, secure or independent without this personal emergency response system".

If, on the other hand, the marketer understands that what the consumer wants is to know that someone is 'there', that he/she has someone who will respond at any time of the day or night when called, the marketer will tout the quality of their system, the responsiveness of their monitoring personnel and the reliability of their company. The focus of the sales pitch will be — "our equipment is the best and will not fail, we are here 24 hours a day, without fail to provide the service you want." The focus is not on the frailty of the individual but on the benefits and quality of the product and service provided.

The first marketing approach diminishes the individual. The second marketing approach puts across the message that the customer is 'king' and deserves the best quality equipment and service. The second enhances the self-image of the individual.

The following marketing rules are fundamental tenets that are often violated by people marketing to older consumers. For some reason, people think that when we reach our 65th birthday we have undergone a rite of passage that makes us identify with everything labeled 'senior citizen.' While these rules are not profound, they should not be violated.

Marketing Rule #1: People know how old they are.

Do not label the product as one for 'the elderly', 'senior citizens', etc. A person's age has nothing to do with whether or not he/she will purchase a product.

Marketing Rule #2: People know what they can and cannot do.

Do not label the product as 'handicapped accessible' or use marketing copy that tells how the product will compensate for the inabilities of the individual. A person using a wheelchair can look at a ramp and determine that it will be much easier to use than the stairs. The ramp doesn't need the little sign with the wheelchair on it. Avoid language and images that stigmatize the product.

Marketing Rule #3: Market the benefits of your product.

Tell what the product does. Tell how good the product and company is and tell the truth.

Marketing Rule #4. Be positive.

Use positive images of people of all ages, who are healthy, happy and representative of the person next door.

CONCLUSION

Effective market research and marketing of technology to older adults requires doing one's homework. People 65 years of age and older are a diverse group. Their age does not predict their purchasing habits, but their life stage, personality, health and attitudes about the future do.

Market research, product development and marketing should be highly interactive. Market research will be effective in product development only if the market researcher, designer, engineer and manufacturer collaborate in the design and application of the research studies. The best developed product could well fall flat on its face if the marketing department doesn't understand the older consumer. Packaging, advertising and promotions need to enhance the consumer's perception of him or herself and must address why the customer wants (as opposed to needs) the product.

REFERENCES

Strub, P. & Herman, S. (1993). Can the sales force speak for the consumer? AT&T dispels the myth that salespeople make good stand-ins for customers in new product research. *Marketing Research*, 5(4), 32-35.

CHAPTER 4

TECHNOLOGICAL APPROACHES TO MANAGEMENT OF 'PROBLEM' BEHAVIOURS IN HOME AND INSTITUTIONAL SETTINGS

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INTRODUCTION

This chapter focuses on 'problem' behaviours encountered by caregivers in both home and institutional settings and technology that might assist them with patient management. In particular, it is concerned with the problem behaviours that are associated with persons who are classified as psychogeriatric patients. To set the stage for a discussion of technological approaches to management of problem behaviours, the chapter begins by describing the nature, prevalence and frequency of problem behaviour expression. Data derive from two sources: a) an extensive literature review conducted as part of a study of psychogeriatric client groups (Gutman, MacFadgen & Killam, 1995) and b) from the author's analysis of caregiver data collected as part of the first wave of the Canadian Study of Health and Aging (Canadian Study of Health and Aging Working Group, 1994). Environmental design approaches to problem behaviour management are discussed next. This is followed by a description of falls prevention devices and wanderer monitoring systems, the technology that has received most attention in the published literature concerned with problem behaviours. A review of efficacy studies of these devices and systems comes next. The chapter concludes with discussion of further research that is needed and with speculation about future applications of surveillance and movement monitoring technology that might aid caregivers and improve the quality of life of older persons.

CLASSIFICATION OF PROBLEM BEHAVIOUR

Throughout the chapter the eight category scheme shown in Table 1 is used to classify problem behaviours. It was developed as part of the Gutman, MacFadgen &

Killam (1995) study. The objective of that project was to provide a comprehensive description of the diverse client groups that are typically included under the umbrella term 'psychogeriatric'. A key question underlying the project was whether the various diagnoses typically included under this rubric identify unique patient characteristics, behaviours and corresponding needs that argue for specialized staff and segregated living arrangements or whether the diverse client groups can and should be grouped together according to functional abilities or the problem behaviours they exhibit. Related questions concerned the amount of staff time and effort required to care for persons with different types of psychogeriatric impairment compared with elderly persons with mainly physical disabilities.

In approaching the task, a broad definition of 'psychogeriatric disorder' was used including within it older adults with:

- Dementia (e.g. Alzheimer's disease, vascular dementia, alcohol-related dementia, dementia post head trauma, dementia post-anoxia, dementia associated with specific neurological disease such as Huntington's or Parkinson's, dementia associated with AIDS and dementia of unknown origin)
- Delirium
- Mood Disorders (e.g. depression, bi-polar disorders)
- Anxiety Disorders (e.g. panic disorders, phobias, obsessive-compulsive disorders and generalised anxiety disorders)
- Schizophrenia and Paranoia
- Psychoactive Substance Disorders (e.g. alcohol, therapeutic agents, industrial compounds, illicit drugs and other chemicals having an effect on the CNS).

While the primary focus of the project was on persons aged 65 and over, where appropriate younger adults (e.g. those with pre-senile dementia) were included.

The categories shown in Table 1 were derived by listing and then clustering the various types of problem behaviours referred to in literature describing these diagnostic groups. One advantage of this classification scheme is that it disaggregates agitated behaviour into four subclasses based on whether the behaviour is aggressive or non-aggressive and whether it is physical or verbal. Collapsing the various behaviours into one category, as some researchers do, may mask important differences in precipitating or 'trigger' factors as well as in the efficacy of management strategies.

TABLE 1

Problem behaviour classification scheme.

AGITATED/AGGRESSIVE – PHYSICAL (e.g. assaultive/violent behaviour, throwing objects, hitting, kicking, biting, pulling hair, damaging property, making threatening gestures)

AGITATED/AGGRESSIVE – VERBAL (e.g. angry/hostile outbursts, verbal harassment, screaming, cursing, obscene/profane language)

AGITATED/NON-AGGRESSIVE/PHYSICAL (e.g. wandering/pacing aimlessly, elopement, following people inappropriately, hyperactivity, repetitious mannerisms/actions, restlessness)

AGITATED/NON-AGGRESSIVE – VERBAL (e.g. repetitive sentences/questions, strange noises, muttering, complaining/negativism, demanding/requests for attention).

IDEATIONAL (e.g. hallucinations, delusions, paranoia, phobia, compulsiveness)

EMOTIONAL/AFFECTIVE (e.g. anxiety, depression, suicidal impulses, slow reactions e.g. Brandphrenia)

SOCIALLY UNACCEPTABLE (e.g. inappropriate dressing/undressing, indecent exposure, inappropriate sexual advances, obscene gestures, faecal smearing, urinating in public places, spitting, throwing food, taking others' possession, pica — i.e. craving for unusual substances such as dirt or paint)

PROBLEMATIC ADLS (e.g. bladder/bowel incontinence, inability to feed, dietary aberrations, sleep disturbance, danger of harming self or others — e.g. leaves stove on)

PREVALENCE AND FREQUENCY OF PROBLEM BEHAVIOURS

In attempting to answer questions concerning how many psychogeriatric patients exhibit problem behaviours and how often they do so, separate literature reviews were conducted for community- and institution-dwelling patients. A summary of findings is presented below. Data are also presented from the caregiver portion of the Canadian Study of Health and Aging (1994).

Community-based studies

Typically, in community-based studies, family members providing daily care to persons with a psychogeriatric condition are presented with a list of problem behaviours and asked which the care recipient has exhibited during a specified time period, usually the last month. Some studies also ask how stressful the behaviour was for the caregiver and some (e.g. Haley, Brown & Levine, 1987) ask how well equipped the caregiver felt to handle the problem behaviour.

Across studies:

- 30-61% of community-dwelling psychogeriatric patients are reported to be agitated;
- 21-55% are reported to be physically aggressive;
- 36-50% are reported to have hallucinations or delusions;
- 30-65% are reported to lose or hide things, but
- only a small proportion (.03-6%) are reported to show socially unacceptable behaviour.

A number of authors (e.g. Argyle, Jestice & Brook, 1985; Deimling & Bass, 1986; Haley, Brown & Levine, 1987; Silver & Yudofsky, 1987) report that although families find the care receiver's loss of the ability to perform ADLs and IADLs to be distressing, they typically take over daily care functions and accept that the patient's skills in these areas are gone. Family caregivers learn to cope with disorientation by using strategies such as not arguing with the patient's mistakes. They manage incontinence by such strategies as using toileting schedules, regulating fluid intake or using adult diapers. They also report good tolerance of a reduced social life, conflicting family demands and being embarrassed in public by the care receiver's behaviour. However, they have difficulty coping with behaviours that occur unpredictably (e.g. physical aggression, hallucinations), that require constant vigilance (e.g. wandering, dangerous behaviour) or that involve socially unacceptable behaviours (e.g. urination in inappropriate locations, faecal smearing) the latter which Argyle, Jestice and Brook (1985) term the "the problems nobody likes to talk about."

Studies conducted in institutional settings

Prevalence estimates of problem behaviours are considerably higher in institutional as compared to community-based studies. For example:

- 22-95% of residents of institutions are reported to be verbally agitated/aggressive;
- 23-60% to be non-compliant/resistive to care;
- 30-36% to exhibit delusions/paranoia;
- 12-68% to be physical agitated/aggressive;
- 7-38% to pace or wander; and
- <5-34% to exhibit socially unacceptable behaviour.

Data from the Canadian Study of Health and Aging

A key theme in the literature on institutions is that, more and more, nursing homes and chronic hospitals are becoming custodians of persons with organic and functional psychiatric illness. This is seen to be a consequence of underutilization of outpatient services by older persons, the trend in many jurisdictions to reduce admissions to state mental institutions, as well as population aging. As more and more people live to be very old, the number of psychogeriatric patients will increase dramatically. In support of this prediction, various studies, including the first wave of the Canadian Study of Health and Aging (Canadian Study of Health and Aging Working Group, 1994), show age related increases in rates of dementia (in the CSHA from 2.4% among persons 65-74 to 11.1% among those 75-84 to 34.5% in the 85+ group). The CSHA data are also instructive with respect to prevalence rates and the frequency with which problem behaviours are seen in home and institutional settings.

In the CSHA, the primary caregivers of study participants with a diagnosis of dementia and the caregivers of institutionalised persons with no cognitive loss completed the Dementia Behaviour Disturbance Scale (Baumgarten, Becker & Gauthier, 1990). This scale lists 28 problem behaviours encompassing six domains: agitation, aggressiveness, diurnal rhythm disturbance, eating disturbances, passivity and sexually inappropriate behaviour. Respondents indicated the frequency each behaviour had been exhibited by the care recipient in the prior week. Scale points included 'never', 'rarely', 'sometimes' 'frequently' and 'all the time'. Table 2 shows the proportion of study participants reported by their caregiver to exhibit the listed behaviour 'frequently' or 'all the time'; data are cross-tabulated by diagnosis and by client place of residence. As can be seen, across all groups the problem behaviours most frequently exhibited were: lack of interest in daily activities, incontinence, repeats questions, sleeps excessively during the day, loses, misplaces or hides things, and hoards things for no reason. Consistent with the greater proportion in institutions with severe dementia (55.4% vs. 10.0% see CSHA , 1994) fewer at home were incontinent and more asked repetitive questions and woke at night. It is especially interesting to note that, contrary to popular belief, such behaviours as wandering, emptying drawers, aggression, and inappropriate sexual behaviour are relatively rare events. However, rare or not, some of these behaviours are very disturbing to family caregivers and very disruptive in a care facility environment. Other behaviours such as self or other-directed aggression give cause for concern that the client will injure him/herself, other residents and/or staff.

TABLE 2

Percent of subjects reported by caregivers as exhibiting selected 'problem' behaviors 'frequently' or 'all the time', by final diagnosis and place of residence, CSHA, Wave I.

	NO COGNITIVE LOSS		PROBABLE AD		POSSIBLE AD		VASCULAR DEMENTIA		OTHER DEMENTIAS		UNCLASSIFIED DEMENTIA		TOTAL ALL DEMENTIAS	
	HOME	INST. N=86	HOME N=133	INST. N=218	HOME N=82	INST. N=137	HOME N=69	INST. N=101	HOME N=17	INST. N=36	HOME N=24	INST. N=46	HOME N=325	INST. N=538
Lack of interest in daily activity	N/A	10.6	33.1	66.5	26.8	67.9	37.7	55.4	47.1	58.3	33.3	47.8	33.2	62.6
Unwarranted accusations	N/A	2.3	21.1	8.7	15.9	10.9	8.8	9.9	5.9	5.6	12.5	15.2	15.7	9.9
Verbally abusive, curses	N/A	1.2	10.5	3.2	3.7	5.1	4.4	6.9	0	8.3	13.0	10.9	7.1	5.4
Empties drawers or closets	N/A	0	13.5	9.1	2.4	4.4	4.4	5.0	5.9	2.9	8.7	6.5	8.0	6.5
Dresses inappropriately	N/A	2.3	11.3	6.0	4.9	3.6	4.4	4.0	5.9	5.6	8.7	4.3	7.7	4.8
Exposes self indecently	N/A	0	0	0.5	1.2	2.2	1.5	0	0	0	0	0	0.9	0.7
Screams for no reason	N/A	2.3	4.5	1.8	1.2	1.5	2.9	0	0	0	4.3	2.2	3.1	1.3
Physical attacks	N/A	0	1.5	0.5	0	4.4	0	0	0	0	0	4.3	0.6	1.7
Inappropriate sexual advances	N/A	0	0.8	0	0	0	1.5	0	0	0	0	0	0.6	0
Paces up and down	N/A	1.2	6.7	6.4	7.3	8.1	5.9	4.0	0	2.8	4.3	4.3	6.2	5.9
Moves arms in restless way	N/A	0	11.3	6.4	3.7	13.9	7.3	7.9	0	13.9	4.3	13.0	7.4	11.5
Lost outside	N/A	1.2	13.5	11.5	6.1	12.4	13.2	5.9	17.6	8.3	0	19.6	11.1	11.2
Incontinent of urine	N/A	8.1	15.0	58.1	10.5	50.4	13.4	60.8	5.9	57.6	30.4	51.2	14.2	56.1
Incontinent of stool	N/A	4.7	7.5	39.2	1.2	34.3	8.8	39.6	0	50.0	13.0	28.3	6.2	38.5
Wakes up at night for no reason	N/A	7.0	23.3	11.0	7.3	7.3	16.2	9.9	5.9	13.9	26.1	15.2	17.0	10.4
Wanders in the house at night	N/A	1.2	9.8	4.1	6.1	5.1	4.4	2.0	0	0	8.7	13.0	7.1	4.5
Sleeps excessively during the day	N/A	12.8	26.3	30.7	20.7	33.6	36.8	37.6	29.4	47.2	26.1	26.1	27.2	33.5
Overeats	N/A	2.3	6.1	3.7	3.7	3.6	4.4	3.0	5.9	2.8	4.3	6.5	5.0	3.7
Refuses to eat	N/A	3.5	5.3	6.0	2.4	9.5	4.4	8.9	0	11.1	0	2.2	3.7	7.4
Cries or laughs inappropriately	N/A	0	3.8	5.0	3.7	7.2	1.5	11.9	5.9	8.3	4.3	8.7	3.4	7.4
Refuses to be helped	N/A	4.7	15.9	6.9	8.5	6.6	7.3	3.0	5.9	5.6	17.4	10.9	11.8	6.5
Throws food	N/A	0	1.5	0.5	0	1.5	0	0	0	0	0	0	0.6	0.6
Wanders aimlessly outside	N/A	1.2	6.7	6.9	2.4	8.0	1.5	3.0	0	0	0	10.9	4.0	6.3
Hoards things for no reason	N/A	8.1	20.3	15.7	6.1	12.4	5.9	6.9	5.9	11.4	13.0	10.9	12.4	12.5
Destroys property, breaks things	N/A	1.2	3.8	1.8	0	0	0	0	0	0	0	2.2	1.2	0.9
Loses, misplaces or hides things	N/A	5.8	39.1	20.6	26.8	21.1	19.1	10.0	23.5	14.3	17.4	17.4	29.4	18.0
Asks same question again	N/A	8.1	51.9	35.9	42.7	29.9	32.3	25.7	35.3	22.2	43.5	23.9	44.0	30.5
Repeats the same action	N/A	4.7	14.3	23.9	12.2	17.5	4.4	15.8	23.5	8.3	8.7	23.9	11.8	19.7

ENVIRONMENTAL DESIGN APPROACHES TO PROBLEM BEHAVIOUR MANAGEMENT

The most common management strategy for agitated behaviour and for many other types of problem behaviour has been to apply physical and/or chemical restraints. Since the 1970s, however, researchers and clinicians have recognised the role that environmental design can play in exacerbating or reducing problem behaviour expression. For example, Drance (1996) notes that settings that are too large or complex overwhelm persons with Alzheimer's Disease and that it is important to keep the house/facility layout as constant as possible, to consider levels of stimulation, to control noise levels and to provide adequate walking space. Other more specific design recommendations include:

To minimise over-stimulation:

- avoid glossy paint and use low-gloss or matte finishes (Schiff, 1988; Schultz, 1987; Peppard, 1986a&b)
- avoid highly waxed, shiny floors (Schiff, 1988)
- minimise the glare of sunlight and avoid shadows from blinds (Peppard, 1986b)
- avoid 'busy' patterns, stripes or very small prints in wall or furniture coverings, drapes, bedspreads (Schiff, 1988; Peppard, 1986a,b)
- lessen the noise on a unit by using sound absorbing floor, wall and ceiling coverings, minimising the number of telephones, avoid public address system and schedule housekeeping activities at times when residents are away from the unit (Coons, 1985; Hall, Kirschling & Todd, 1986; Hiatt, 1985; Peppard, 1986a; Weaverdyck & Coons, 1988);
- avoid fluorescent light fixtures that flicker. Flickering light is thought to evoke seizures or behaviour problems in dementia patients (Peppard, 1986b)
- avoid unnecessary lines or patterns on the floor (Schiff, 1988)
- minimise the glare of sunlight and avoid shadows from blinds (Peppard, 1986b)
- remove potentially disturbing or misleading stimuli such as mirrors and TV sets and replace traditional artwork with simple geometric patterns (Hall, Kirschling & Todd, 1986)

To prevent unauthorised exiting:

- paint two-dimensional grid pattern on the floor in front of exit doors (Hussian & Brown, 1987).
- paint exit doors same colour as surrounding wall (Weaverdyck & Coons, 1988)

- install sheers or curtains so doors are perceived as windows (BC Long Term Care Association, 1987)
- place cloth shields over door knobs (Butler & Barnett, 1991)
- hang a theatre rope across the doorway (Ontario Ministry of Community and Social Services, 1988)

USE OF SURVEILLANCE AND MOVEMENT MONITORING TECHNOLOGY

In the early 1980s, surveillance and movement monitoring technology began to be applied to the long term care setting. For example, in 1983, *Secure Care* introduced a wanderer security system specifically designed for nursing home applications. Shortly thereafter, *Patient Security* offered an adapted department store system. *WanderGuard* introduced its product in 1985. By 1987 these three companies and several others had sold their products to hundreds of nursing homes (Contemporary Long Term Care, 1987) and trade magazines were exhorting their adoption.

> *Until now it has probably been possible to claim that the use of an electronic system is not a normally used approach to a wandering resident's care. But with so many facilities that now have such equipment, it is going to be hard to explain why a nursing home reporting an injury incident was not doing more to prevent the accident. A wanderer security alarm system is a technology that exists and that is appropriate for the industry. The technology should be adopted by most 'at risk' facilities at an earlier rather than a later date (Contemporary Long Term Care, 1987, p. 59).*

Much of the impetus for the application of surveillance and movement monitoring technology to long term care settings can be traced to the passage, in the United States, of the nursing home reform amendments included in the Omnibus Budget Reconciliation Act (OBRA '87). Designed to improve the quality of care and the quality of life in nursing homes, OBRA '87 generally eschewed the use of physical and chemical restraints. Since payment was tied to compliance with the act, care facilities had a vested interest in exploring alternate ways of managing wandering and unauthorised exiting. Falls prevention and thus litigation avoidance was another strong motivating factor.

Alternatives to physical restraints can be classified into two broad groups: a) devices that signal when an at-risk person is attempting to leave a bed or chair and b) devices that signal room or facility exiting. Ostensibly, the first group target falls prevention and the latter, wandering and unauthorised exiting but there is considerable overlap.

FALLS PREVENTION DEVICES

Products that are claimed to prevent bed/chair falls include: i) bed and chair switches; ii) pressure mats; iii) infrared scanners; iv) tilt sensors; and v) accelerometers.

The *Restraint-Free Alarm*, available from Mid-Michigan Sales, Inc. is an example of a bed/chair/wheelchair switch. This device has an adjustable cord that attaches to the client. When the client moves beyond a predetermined distance, the alarm is activated, emitting a variable audible tone to alert the caregiver. Similarly, one end of the *Monitech Wheelchair Monitor* clips onto the back of a wheelchair and the other end clips onto the client's clothing. A magnetic switch sounds an alarm if the client attempts to leave the seat. A door and bed alarm manufactured by the same company have similar mechanisms.

Examples of pressure mats include pressure-release devices such the *Pre-Alert I* monitoring system, available from Health Care Product Solutions. This system consists of a speciality chair cushion with an alarm (high pitch shrill sound) that activates as the resident begins to stand up. The *Bed-Check Sensormat* is a device placed under the sheets. Time delays are reported to allow for normal patient movement in bed; an alarm sounds when the patient is in an unsafe part of the bed. RF Technologies, Inc. manufacture an under mattress sensor as well as disposable bed and chair sensors. The *SoundMat System* (SMS) consists of a non-skid pressure sensitive mat (3 ft. x 2 ft. in size, designed to simulate a low-pile carpet), a transmitter unit (attached to the mat and mounted to a wall), and a separate receiver or alarm unit (that plugs into any electrical outlet). When foot pressure is applied to the mat (e.g. patient sits on the edge of the bed with one or both feet on the mat, and/or leaves the bed and either stands on or walks across the mat), the transmitter unit detects the activity and relays a signal to the receiver unit (that may be located up to 100 feet away from the transmitter unit), which in turn sounds an alarm. The SMS may also be placed in other fall-risk locations (e.g. beside chairs, stairway landings, front/back doorways) and may be used to detect wandering and prevent elopement.

Infrared scanners relay an inconspicuous signal to the nursing station when a patient leaves the bed. The system consists of directional sensors that respond to changes in infrared energy at an elevation of approximately three feet above the floor. The scanner activates a bedside call button and an alarm sounds at the nursing station.

The *Ambularm* is a small plastic-encased unit attached above the patients knee with a fabric band. It emits an intermittent sound when the patient swings a leg over the edge of the bed.

WANDERER MONITORING SYSTEMS

Wanderer monitoring systems (also known as elopement control systems) range from simple door alarms to complex computer systems that identify the wanderer by name, date, time and location while triggering an alarm and locking doors in protected

areas. Accessories include voice alarms, code locks, elevator deactivation devices, wanderer identification systems, pager alarms, colour graphic alarm displays, and portable locators that are useful for finding tags that may have been cut off and hidden by a wanderer (Bruck, 1995; Sanford, Fazenbacker & Connell, 1993).

The basic components of wanderer monitoring systems consist of:

- an identification tag generally placed around either the wrist or ankle of residents considered at risk of elopement,
- a detection/monitoring unit,
- a control device.

A system's capabilities are primarily determined by which component transmits signals (the active component) and which receives signals (the passive component). Tags, as well as monitors, can be transmitters and/or receivers. Thus, both can have active, passive, and transponder (active and passive) capabilities. These components are currently available in three configurations: 1) active tag/passive monitor; 2) passive tag/active monitor; and 3) transponder tag/transponder monitor (Bruck, 1995; Sanford, Fazenbacker & Connell, 1993).

There are two ways in which active tag systems are used to monitor a controlled area. Both use radio frequency technology, but differ in the way the technology is applied. The first, **boundary monitoring**, is designed to monitor within a few feet of a designated boundary. In this case, an alarm is activated when a continuously emitted signal, from a battery powered transmitter in a tag worn by an at-risk resident, is detected in the monitored area. In the second case, **area monitoring**, an active tag system is used to monitor a large area in which residents have freedom of movement. Here, an alarm is activated when an at-risk resident is *not* detected in the monitored area.

Bruck (1995) notes that some active tag systems are 'non-intelligent', meaning that they are unable to identify the wanderer; others can identify specific residents or more than one person going through an exit. Sanford, Fazenbacker and Connell (1993) consider the resident identification capacity to be a major advantage of active tag systems. Other advantages include greater sensitivity of active than passive tag systems and thus, greater reliability (Sanford, Fazenbacker & Connell, 1993) and the possibility of using the signal transmitter as a homing device to locate a resident who has left the monitored area (Butler & Barnett, 1991; Sanford, Fazenbacker & Connell, 1993). The limited life of the batteries is one disadvantage of active tag systems that is compounded, from the cost point of view, in some systems by the battery being sealed in the tag so that the entire tag must be replaced when the batteries lose power (Bruck, 1995). The limited life of the batteries also creates a situation where at-risk individuals might be able to elope undetected, at least in the case of boundary-monitoring active tag systems. The opposite problem occurs with area-monitoring systems. When a battery

dies, the monitor no longer receives a signal, thus activating an alarm even if all at-risk residents are still in the monitored area (Sanford, Fazenbacker & Connell, 1993).

Among advantages of area-monitoring over boundary-monitoring systems are that while boundary-monitoring systems require a separate detection system at each restricted exit, area-monitoring systems need only one detection unit connected to multiple antennas. Boundary-monitoring systems are, however, more precise. With a sensitivity of three to five feet, staff can be alerted when an at-risk resident approaches an exit whereas in area-monitoring, notification of an elopement is after the fact (Sanford, Fazenbacker & Connell, 1993).

Passive tag detection systems are a concept borrowed from the retail market. Rather than emitting a signal of their own, tags in these systems resonate when they come into contact with an electromagnetic energy field broadcast by an active monitor at the door being secured. This creates a disruption in the emitted energy field that is detected by the monitor. Passive tags, because they do not transmit signals, have the advantages of being relatively inexpensive and requiring no batteries. However, passive tag systems have a limited range of operation — typically within a few feet of the monitor. Other disadvantages include false alarms and non-detection (Bruck, 1995) and an inability to distinguish between at-risk residents (Sanford, Fazenbacker & Connell, 1993). For example, if access to a specific wing of a nursing home is to be available to some at-risk residents, but restricted to others, the passive tag system would not be able to distinguish among residents.

Transponder tag detection systems are essentially an active sensor in a 'sleep mode'. The transmitter in a transponder tag worn by an at-risk resident is activated when the resident is within a few feet of a monitor. This type of boundary-monitoring system incorporates the advantages of active tags without the drawback of a short battery life (Sanford, Fazenbacker & Connell, 1993). 'Smart tags' are transponder sensors which provide the option of wanderer identification, an array of alarm tones, and an operating life of seven years or more (Bruck, 1995).

EFFICACY STUDIES

A search of the literature yielded only a small number of studies investigating the efficacy of the devices and systems described above. In the case of falls prevention devices, these included a study by Tideiksaar (1996) in which 20 community-dwelling older persons (mean age 88, 70% with mild to severe dementia) and their primary caregivers were given a SoundMat system (SMS) and were followed for an average of 20 months. Guarding against night-time falls when patients leave their beds to toilet or wander was the most common reason given for using the SMS. However, although 60% of the caregivers used the SMS in one location (beside the bed), 40% used it in multiple locations (e.g. bathroom entrance, basement steps, stair landings, beside chairs/sofas, front/back door). Seventy-five percent of the caregivers reported that the patient had had one or more falls in the home prior to installation of the SMS (the

average was five falls per patient). At the end of the follow up period, 50% of the caregivers reported no further falls and 50% reported an average of two falls per patient. At 20 month follow-up, all of the caregivers reported the SMS to be user-friendly; all reported a reduction of burden. Of those caregivers who had complained of insomnia, all reported an improvement in sleep patterns. Several adult children who employed home attendants to care for their parent reported a decrease in staff turnover. Four patients with severe dementia initially objected to the pressure-sensitive mat, removing it from beside the bed or circumventing it by crawling out of bed by the foot board. Placement of the mat under existing carpeting solved the problem.

Dubner and Creech (1988) report a decrease in night-time falls by introducing infrared scanning. The greater the number of rooms scanned, the greater the decrease in number of falls.

Widder (1985) tested the *Ambularm* with 16 patients on a hospital's orthopaedic and general medicine units and subsequently made the device available to all medical-surgical and critical care units. Nurses were enthusiastic about the device and found that it reduced the need for restraints. Since the device has been used, patient falls have been reduced by 45% on the general medical unit which has a high percentage of geriatric patients and 33% on the orthopaedic unit.

In the case of wanderer monitoring systems, the literature is replete with statements about the costs of *not* having a system in place.

> *The expense of a massive search (averaging about $2500 per episode), a lawsuit (one in California was for $1,248,000), or the death by exposure or accident to a "critical wanderer" (4 deaths in 450 episodes) far outweigh the nominal price of electronically protecting the wanderer (Butler and Barnett, 1991).*
>
> *Resident elopement account for 10% of the total claims against health care facilities. Based on national claim statistics, the average elopement claim costs a health care facility about $100,000 in indemnity and defence costs alone. This figure does not include costs for staff time expended by the facility to assist in the defence (Foxwell, 1993-94).*

Despite this, there are a series of articles (Bruck, 1995; Contemporary Long Term Care, 1987; Davis, 1996; Sanford, Fazenbaker & Connell, 1993) admonishing potential purchasers to ask questions about the capabilities of the products and companies providing them. These include questions about:

1) Product Reliability

What is the percentage of false alarms? What is the percentage of tag failures? Is the system able to detect real wanderers without false alarms from electrical interference from the TV, vacuum cleaner, clothes dryer, etc.?

2) Ease of Installation and Servicing

Is the system simple enough for the user to install? In the event of problems, does the company have a local authorised representative to provide assistance? (Some manufacturers require that the equipment be shipped back to the factory if there are problem with it.)

3) Ease of Signal Detection

Does the system provide a readily detectable audible and/or visual signal when activated? Can the system's activation signal be seen and/or heard during peak periods of facility activity?

4) Method of Deactivation

Does the system remain activated until a formal reset procedure is performed? Does the system require reset at the point of activation?

5) System Overide

Does it have a standardised operation method (e.g. a four-digit code) that allows easy staff access but deters unauthorised or random system release/override?

6) Extent of Coverage

Does the system have blind areas? Davis (1996) suggests that it is a good idea to walk through the facility and check for areas in which alarms can not be heard and where a second alarm system or an annunciator (audible alarm) panel may be needed. "High-risk" exterior perimeter doors may also need to be alarmed.

7) Back-up and Testing

Does the system have a battery backup or emergency generator connection to ensure operability during electrical power outages? Does the system have a test/calibration function to periodically test/verify its operability?

8) Hidden Costs

Is there an installation cost for each door or other protected area? What are the short-term and lifetime costs of the tags?

9) Company Stability and Guarantees

How long has the company been in business? Will it still be there over the long haul? Does the company provide certificates of product liability insurance? What about warranty repairs, exchange programs, etc.? Who pays for what?

10) Life Safety Standards

Does the system comply with all applicable fire safety regulations (e.g. NFPA Life Safety Code)? When in doubt consult with local fire/code enforcement personnel concerning the installation and use of monitoring/security devices.

Among the small number of efficacy studies located to date is a study by Sanford, Fazenbaker and Connell (1993) which provides a useful comparison of the system configuration and product features of seven commercially available wanderer monitoring systems.

Blackburn (1988) conducted a before and after study of a wanderer monitoring system in a UK district general hospital. The focus of the study was a psychogeriatric short term and respite ward with a high percentage of very confused, wandering patients. Benefits highlighted by the study included: a reduction in patients leaving the ward or attempting to leave it, a reduction in staff anxiety levels and more effective use of nursing time (e.g. staff could concentrate on patient care instead of worrying about patients leaving the ward; they had longer uninterrupted periods to carry out patient care). Blackburn also noted that while initially some staff had worried that the patients would object to wearing the monitoring device, some patients wore them with pride like a badge. Two problems that were encountered included one where the monitoring device was taken apart by an inquisitive patient who wanted to find out how it worked, and the second was when a tag was sent to the laundry. Both problems could be overcome by heatsealing the plastic envelopes containing the device.

Watzke and Wister (1993) investigated staff attitudes towards wanderer monitoring devices and found them to be predominately positive.

While these studies are encouraging, like the falls prevention devices studies they are few in number and they have some methodological limitations. Many questions remain unanswered.

WHERE DO WE GO FROM HERE?

From the research perspective, performance-based user satisfaction studies rather than attitude studies should be encouraged as many people have difficulty visualising how they will react to a particular device or system when applying it in a 'real' situation. There is also a need for more comparative testing — that is, ascertaining the technical capabilities of a group of similar products, comparing them in terms of user friendliness, consumer satisfaction, consumer acceptance, cost-effectiveness, etc.

In both research and practice there is a need to take greater cognisance of the heterogeneity of the elderly population — both among those who are able-bodied/cognitively intact and among frail elders. There may be some environmental or technological approaches that will work for a person with vascular dementia that will not work for people with Alzheimer's disease because of differences in where in

the brain deficits occur. There may be some approaches that work for a person in one stage of a progressive degenerative disease but not in a later stage.

We are beginning to be more sophisticated in our questions — to ask what are the factors that cause a particular person to engage in a particular type of problem behaviour at a particular time and another person to do something different. Why, for example, do some people sit in their room and make odd noises hour after hour while others wander or bang on a table repetitiously or unexpectedly strike out at staff? What are the environmental or inter- or intra-personal cues that elicit particular types of problem behaviour from Mrs. Jones? Do these same factors elicit the same type of problem behaviour across people and settings? Answers to such questions need to be more aggressively sought.

Audio/video recording technology used in conjunction with falls prevention and wanderer monitoring equipment, could potentially provide answers to some of these questions — as discussed in the next chapter by Connell.

Wanderer monitoring technology could possibly be utilised to cue individualised service approaches. Davis (1996) notes, for example, that monitoring technology will be greatly enhanced over the next several years, with the capability to insert personal profiles into transmitters and alert staff instantaneously to the identity of residents attempting to exit and their precise location. At the same time, information about words and actions that are soothing to the incipient eloper (or that are irritating and should be avoided) could be added.

Finally, as Davis notes, some of today's 'pricier' wanderer monitoring systems are becoming more affordable. As this happens, it opens the door to application by a much broader clientele. Up to now these systems have been produced mainly for hospital and care facility environments. However, with more and more older people being maintained in the community for longer and longer periods, there is a need to expand product development, testing and marketing to the home-based client and caregiver. As evidence of demand, Blackburn (1988) notes that after evaluation of the hospital-based wanderer monitoring system began, relatives began to ask if they could obtain a system for home use "so that they would know when granddad has gone for a pint at three in the morning" (p.55). Other hitherto hospital-focused technologies such as falls prevention devices may also have wide home-based care market potential.

REFERENCES

_____(1987). Electronics for wanderer security. *Contemporary Long Term Care, 10*(5), 56-57.

_____(1994). Wanderer monitoring/security systems guide. *Provider, 20*(11), 51-59.

Argyle, N., Jestice, S. & Brook, C.P.B. (1985). Psychogeriatric patients: Their supporters' problems. *Age and Ageing, 14*(6), 355-360.

Baumgarten, M., Becker, R. & Gauthier, S. (1990). Validity and reliability of the dementia behavior disturbance scale. *Journal of the American Geriatrics Society, 38*, 221-226.

Blackburn, P. (1988). Freedom to wander. *Nursing Times, 84*(49), 54-55.

Bruck, L. (1995). Wanderer departure systems: High-tech, low-worry. *Nursing Homes, 44*(2), 32-34.

BC Long Term Care Association. (1987). *Special Care Task Committee Report.* Vancouver: The Association.

Butler, J. P. & Barnett, C.A. (1991). Window on wandering. *Geriatric Nursing, 12*(5), 226-227.

Canadian Study of Health and Aging. (1994). Patterns of caring for people with dementia in Canada. *Canadian Journal on Aging, 13*(4), 470-487.

Canadian Study of Health and Aging. Working Group (1994a). Canadian Study of Health and Aging: Study methods and prevalence of dementia. *Canadian Medical Association Journal, 150*(6), 899-913.

Coons, D. (1985). Alive and well at Wesley Hall. *Journal of Long Term Care, 21*(2), 10-14.

Davis, C. (1996). Making the most of wander control technology. *Nursing Homes, 45*(2), 34-35.

Deimling, G.T. & Bass, D.M. (1986). Symptoms of mental impairment among elderly adults and their effects on family caregivers. *Journal of Gerontology, 41*(6), 778-784.

Drance, E. (1996). Aggression in dementia: Understanding the role of the physical and interpersonal environments. *B C Medical Journal, 38*(10), 541-545.

Dubner, N.P. & Creech, R. (1988). Using infrared scanning to decrease nightime falls on a psychogeriatric unit. *Hospital and Community Psychiatry, 39*(1), 79-81.

Foxwell, L.G. (1993-94). Elopement—exposure and control. *Journal of Long Term Care Administration, 21*(4), 9-12.

Gutman, G., MacFadgen, L. & Killam, J (1995, July). *Psychogeriatric client identification project - Phase 1 Final Report.* Report submitted to the Continuing Care Division, B.C. Ministry of Health and Ministry Responsible for Seniors.

Haley, W.E., Brown, S.L. & Levine, E.G. (1987). Family caregiver appraisals of patient behavioral disturbance in senile dementia. *Clinical Gerontologist, 6*(4), 25-34.

Hall, G., Kirschling, M.V. & Todd, S. (1986). Sheltered freedom: an Alzheimer's unit in an ICF. *Geriatric Nursing, 7*, 132-137.

Hiatt, L. (1985). *Wandering behavior of older people in nursing homes: A study of hyperactivity, disorientation and the spatial environment.* Unpublished doctoral dissertation, City University of New York.

Hussian, R.A. & Brown, D.C. (1987). Use of two-dimensional grid patterns to limit hazardous ambulation in demented patients. *Journal of Gerontology, 42*, 558-560.

Ontario Ministry of Community and Social Services. (1988). For elderly people who wander. *Window on Technology, 4*(6), 4-5.

Peppard, N.R. (1986a). Special nursing home units for residents with primary degenerative dementia: Alzheimer's disease. *Journal of Gerontological Social Work, 9*, 5-13.

Peppard, N.R. (1986b). Effective design of special care units. *Provider*, May, 14-17.

Sanford, J.A., Fazenbaker, S.H. & Connell, B. R. (1993). Alarm system technology in elopement prevention. *Technology and Disability, 2*(1), 22-33.

Schiff, M. (1988) quoted in Higgs, M. Designing environments for confused elderly. *B.C. Health Association News*, 10-11.

Schultz, D.J. (1987). Special design considerations for Alzheimer's facilities. Contemporary *Long Term Care*, November, 48, 50, 52, 54, 56, 112.

Silver, J.M. & Yudofsky, S. (1987). Aggressive behavior in patients with neuropsychiatric problems. *Psychiatric Annals, 17*(6), 367-370.

Tideiksaar, R. (1996). Evaluation of the SoundMat system: A pressure-sensitive alarm device designed to prevent falls and injury (pp.117-124). In: *Facts and Research in Gerontology*. Supplement on Falls. Springer.

Watzke, J. & Wister, A.V. (1993). Staff attitudes: monitoring technology in long term care. *Journal of Gerontological Nursing, 19* (11),23-29.

Weaverdyck, S.E. & Coons, D. (1988). Designing a dementia residential care unit: Addressing cognitive changes with the Wesley Hall model. In: G. Gutman & N.K. Blackie (Eds.). *Housing the Very Old*. Vancouver: The Gerontology Research Center, Simon Fraser University.

Widder, B. (1985). New device to decrease falls. *Geriatric Nursing, 6*(5), 287-288.

CHAPTER 5

A PICTURE IS WORTH 1000 WORDS: USING VIDEO-BASED TECHNOLOGY TO UNDERSTAND BEHAVIOUR PROBLEMS IN LONG TERM CARE SETTINGS

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INTRODUCTION

Falls, dementia-related behavioural disturbances, and difficulty and dependence in daily activities are complex behavioural problems that threaten the safety and well-being of physically and cognitively frail residents of long term care settings. These types of problems also have implications for staff and organisational outcomes such as care burden and staff stress.

Research on these types of behavioural problems has often used self-reports from older individuals, proxy reports from staff, and archival data to determine incident rates and to characterize phenomena and their circumstances. For example, studies of falls often entail interviews with fallers or a review of incident reports filed by staff to characterize behavioural and environmental antecedents of falls. However, a number of problems threaten the accuracy and reliability of self-report, proxy, and archival data in research on behavioural problems common in long term care settings.

The broad concern is that self-report, proxy, and archival data may provide incomplete or biased information about behaviours and events of interest. Older individuals as well as staff may selectively report details — because they are unaware of all potentially relevant factors and so omit details that they consider unimportant,

[1] This chapter builds on a symposium presentation by Bettye Rose Connell, PhD, Dale Strasser, MD, Jon Sanford, MArch, Connie Archea, BS, Mary Beth Megrew, MS, James Boyette, MSCIS, and Cyril Gryfe, MD, "Using video technology in studies of naturally-occurring behavior in long term care settings" at the Annual Meeting, Gerontology Society of America, Atlanta, GA., November 20, 1994. Thanks to Mary Beth Megrew, MS and James Boyette, MSCIS for their review and comments on an earlier draft of the chapter.

or because they fail to detect critical details at the time of an event and are unable to provide complete reports when asked to do so at a later point in time. For example, staff may be aware of the higher level of movement and noise on a unit at shift change but may not view that as potentially relevant to agitation and other indicators of mental distress exhibited by demented residents around the same time as shift change. Similarly, staff may find a frail individual lying on the floor between a chair and the individual's wheelchair with the wheels unlocked, and report, perhaps incorrectly, that the wheelchair *scooted* from under her during a transfer. Age-related memory loss, common among nursing home residents, also can make it more difficult for older individuals to recall details of behavioural events as well as to understand and articulate 'cause-effect' sequences. Finally, some behavioural problems, such as falls, occur comparatively infrequently, their occurrence is unpredictable, and they happen so fast that those directly involved in them may have limited insight about what happened. In contrast, other behavioural events, such as routine patterns of social interaction, occur all the time and staff and residents are so accustomed to seeing them that they may not pay enough attention to provide accurate reports about them or may have reasons to not provide accurate reports.

OBSERVATIONAL TECHNIQUES

Observational data collection techniques offer another approach to the study of behavioural problems in long term care settings. Although observational techniques are well known in social science research and related fields such as environment-behaviour research (As, 1975; Bakeman & Gottman, 1986; Koncelik, 1976; Patterson, 1974; Webb, Campbell, Schwartz, et al. 1972; Zeisel, 1981) and are used in some types of clinical research (Athlin, Norberg, Axelsson, et al. 1989; Kihlgren, Kuremyr, Norberg, et al. 1993) they have not been widely used in aging research on complex behavioural problems in long term care settings.

In choosing data collection methods to study problem behaviours in long term care settings, it is desirable to avoid situations analogous to that of the little boy with the hammer. Observation techniques are not only appropriate but also the best choice for the study of some questions about problem behaviours. However, they are not appropriate to address all questions about the same behaviours. Observational techniques lend themselves to questions about the frequency, duration, temporal and/or spatial correlates of behaviours of interest, social ecology, space use, and environmental adequacy. For example, observational techniques would be appropriate to address questions about the percentage of waking hours a disoriented individual walks up and down the hall, if signs of mental distress among individuals with dementia are more prevalent at shift time, a frequent faller's reliance on unstable handholds when ambulating or transferring, the nature and frequency of staff-resident interactions, where and how residents spend their time, and the 'environmental demands' associated with using objects, such as when rising from a chair. In contrast,

questions that focus on study participants' attitudes and beliefs about the behaviours of interest can not be accessed with observational techniques. For example, one can observe an individual's gait and balance and his/her choice of handholds in ambulating across a room, but observational techniques will not tell you anything about the individual's perception of his/her safety or fear of falling. Similarly, the number of times a disoriented individual attempts to leave the unit can be determined through observation, but the impact of these attempts on staff's job stress can not. In most cases, observational techniques are most effectively used in conjunction with other approaches, such as standardized instruments to ascertain affective responses or beliefs. This strategy will enable researchers to document both problem behaviours and the affective responses of the older individual, other residents, staff, and/or family to that behaviour.

Typically, observational techniques entail a researcher who is physically present in the study setting, classifying observed behaviours according to pre-established coding categories and recording who (by demographic characteristics or role in a setting) is engaging in those behaviours. Frequently, the location and duration of behaviours also are recorded. Observation, classification, and recording of behaviours typically occur in 'real time,' which can make observational data vulnerable to inaccuracies and inconsistencies unless appropriate safeguards, such as periodic inter-rater reliability checks, are taken. In general, obtaining an adequate amount of appropriately sampled observational data can be time-consuming and labour-intensive, which may help to explain the limited adoption of observational techniques in aging research. In addition, because behaviours are observed and coded in 'real time,' it is important for the researcher to have a good understanding of the study problem prior to beginning data collection. This seemingly circular methodological problem can be resolved by preliminary pilot studies to identify and operationally define the behavioural coding categories of interest. However, once behaviours are coded, there are inherent difficulties in using data collected for one purpose to address other types of problems. For example, if one were interested in and collected data on mobility patterns of physically frail residents in hallways, these data might or might not be usable to study a related problem involving some of the same residents, such as wandering behaviour of frail demented residents.

In recent years, there have been new developments in the implementation of observational techniques to enhance their feasibility and utility for aging researchers and practitioners. Two developments include the use of laptop computers (Burgio & Yurick, 1993) and bar-code technology (Hyde, 1995) to code observations. These technologies also have the advantage of compiling data from individual observations for later data analysis. However, data collection still occurs in 'real time' and requires an observer to be physically present. Other barriers to the use of observational techniques are not resolved by these technologies, including the labour intensive nature of data collection, the need for trained data collectors, and the limitations of using observational data coded in 'real time' for secondary analyses of other problems.

A third development, and the focus of this paper, is the use of video technology to record behaviours as they occur and create a durable record (i.e., video tapes) of those behaviours (Connell, 1994). Although video-based observation does not require that an observer be present to capture data and 'uncouples' data capture and behavioural coding, it shifts rather than eliminates the labour intensive aspects of observational data collection. Sooner or later someone has to review and code the video tapes. However, because data are captured in a durable format, secondary analyses to examine different questions are feasible. In addition, durable records enable review of the "raw data" by multiple individuals. For example, it might be desirable to have an expert panel review tapes of naturally-occurring behaviour and provide assistance in establishing coding categories to answer specific research questions.

ADVANTAGES AND DISADVANTAGES OF VIDEO-BASED DATA COLLECTION

Video-based observation, in comparison to other approaches to observational data collection, offers a number of advantages in terms of scientific rigor and cost-effectiveness of research. In contrast to person-based observation techniques, it is easier to obtain more comprehensive data collection throughout the hours of the day and days of the week as well as in more spaces in a facility. These are particularly important characteristics when one is interested in 'low base rate' behaviours, such as falls or attempts by wanderers to exit the facility (i.e.,'elopement'). The more time and space that can be observed the greater the probability that comparatively infrequent behaviours will be observed. Video-based data collection also is virtually error free because behaviour observation (what is video taped) and behaviour coding (classification of observed behaviours) are 'uncoupled.' This uncoupling also allows for improved reliability in data coding because if inconsistencies are identified through inter-rater reliability checks, tapes can be recoded after the source of coding inconsistencies are identified and corrected. In addition, when the behaviour problems of interest are highly complex and poorly understood, for example the multi-factorial nature of falls, video tapes can be submitted to multiple experts for review and development of better problem definitions, guidance on how to proceed with coding and analysis, and identification of additional data needs. Finally, video-based observation typically entails non-discriminate recording of all naturally occurring behaviours within the recording range of the camera. With advance planning in the handling of organisational agreements to conduct video-based data collection and informed consent with individuals regarding use of their behaviour on the tapes as data, video-based observations can be readily used for subsequent secondary analyses, even on problem areas not identified at the time data were collected, without incurring additional data collection costs.

There also are important disadvantages to video-based data collection. Coding and analysis is time and labour intensive, and may require more time than to code an equivalent amount of behaviour in 'real time' particularly if the technical quality of the

video tapes is poor. For example, with the cameras and lenses likely to be used by most researchers, it is probably not reasonable to expect to be able to readily resolve facial expressions of individuals standing 20 or more feet from a camera. A second potential problem is the need for an adequate amount of secure space for archiving tapes. Projects with multiple cameras and 12 hours of taping per day can quickly generate hundreds of video tapes that need to be stored. Secure storage is important to ensure the confidentiality of 'raw data,' an informed consent issue. There also may be aversions to the use of video-taping for data collection, in contrast to person-based observation. Although these aversions typically stem from concerns that the personal privacy of residents and staff may be violated, they may also extend to staff concerns that management could access the tapes and use them in administrative actions. Despite the best and most honourable intentions of researchers, pre-existing organisational problems between administrators and floor staff will likely create hard-to-overcome levels of distrust that preclude implementing effective video-based observational procedures. Finally, the initial cost of the equipment needed to conduct video-based observation may represent a significant disadvantage, particularly to those who do not anticipate its use in multiple studies over an extended period of time.

CONSENT ISSUES

The one issue related to consent processes that is most likely to be misunderstood is that when video taping naturally occurring behaviour, it is not possible to selectively video tape only those individuals who have agreed to participate in a research study. Thus, 'consent' does not concern permission to video tape or not video tape an individual. Rather, it concerns permission for the researcher to treat their recorded behaviour as data — to code it and include it in the project data set. Typically, administrators give permission to video tape in a facility; individuals give permission for their recorded actions to become *data*. However, as discussed below, most concerns that are likely to be raised by review boards as well as by individuals are more related to video taping as a methodology than to the use of individual actions as data.

At one level, consent issues for video taping are no different from those that must be addressed when other types of data collection techniques are used, for example, ensuring privacy and confidentiality and providing elderly individuals or their surrogates with a genuine right to refuse to participate with no adverse consequences. However, with regard to securing the approval of review boards to use video-based observational techniques, there may be greater expectations for assuring privacy and confidentiality because of the medium involved and the vulnerability of the study population than would be the case for person-based observation or use of self-report/proxy methods. For example, there may be very reasonable demands that researchers ensure even greater-than-usual levels of confidentiality when videotaping populations or in locations that may result in recording situations that compromise personal dignity (e.g., disrobing and sexually inappropriate behaviour by demented

individuals in public spaces in a nursing home).

One of the dilemmas in ensuring privacy and confidentiality of video data is that, unlike other types of 'raw data', the uncoded visual images themselves are often valuable as educational materials in published articles and public presentations. However, even if a person is not named in published or oral presentations, they may still be identifiable from the visual images. One way to address this problem is to have faces electronically masked prior to publication or presentation, similar to the technique used by local news programs. Another approach is to use photographic/video release forms, in addition to the research consent forms, to obtain permission to use images for educational purposes so long as the person is not identified by name, or to incorporate the language of video release forms into other consent forms.

When staff behaviours also are being examined as part of the study (e.g., frequency of staff-resident interactions), consent needs to be obtained from staff. Sometimes, staff object to what they perceive as potentially excessive oversight and 'big brother' technology. In other cases, their underlying concerns relate to fears that activities coincidentally captured on the video tapes can be used against them in administrative actions. The latter is particularly an issue in facilities with underlying organisational problems where staff are predisposed to believe that the research project and the video taping are an excuse for supervisors to 'spy' on them. Sometimes the concerns voiced by staff may seem implausible and researchers are suspicious that the real concerns remain unstated, such as in the case where a staff person was concerned that if she was seen hugging a resident, she would be open to a sexual abuse charge. In contrast, there are real and important issues regarding the potential of unintentionally capturing behaviours that one feels a professional responsibility for reporting, such as a housekeeper observed disconnecting one of two cameras in a study area and subsequently rummaging through a resident's bedside table. Perhaps he was responding to a request from the resident to bring him his glasses, but probably not. Researchers and staff need to be aware of the potential for such situations and agree in advance on guidelines to cover them.

It is inevitable that there will be residents, staff assigned to the unit, staff who occasionally are on the unit, and family members who are not part of a study who will be video taped. Many will notice the cameras and be curious about what is going on. Prior to installation of cameras and implementation of the consent process, it is a good idea to provide written information to family members, residents able to comprehend written materials, and to staff. The purpose of the project, its importance and how results will be used should be described, along with an explanation that video taping will be done and an outline of the consent process. A local person that can be contacted for more information should be named. In addition, notices should be posted at the entry points to the unit announcing that a research project involving video taping in _____ (name of spaces) is in process.

A final consent-related issue pertains to anticipating the capability to conduct secondary analyses with the video-based observational data at some time in the future. Unless the language of the original consent forms and any related materials, such as video release forms, expressly allow for subsequent secondary analysis, it will be very difficult to ethically use the video observational data in this way.

TECHNOLOGICAL COMPONENTS

There are three basic components that are needed to conduct video-based observation: cameras, lenses, and video recorders. Additional components that may be needed or useful for different types of studies are devices that trigger video taping and splitters that enable images from multiple cameras to be recorded to one tape. Finally, the video taping technology can be tied in with other technology for specific applications.

Cameras

The cameras that are used for video-based observation are the small surveillance cameras commonly used in banks and other commercial installations. They typically are mounted near the ceiling, both to provide some measure of security to the equipment and to facilitate their unobtrusiveness, which fosters natural behaviour rather than performing for the camera. These cameras often have infrared capability and can be used in conjunction with infrared lighting if the study problem necessitates data collection at night when the lights are off, such as in studies of night time falls and sleep patterns.

Lenses

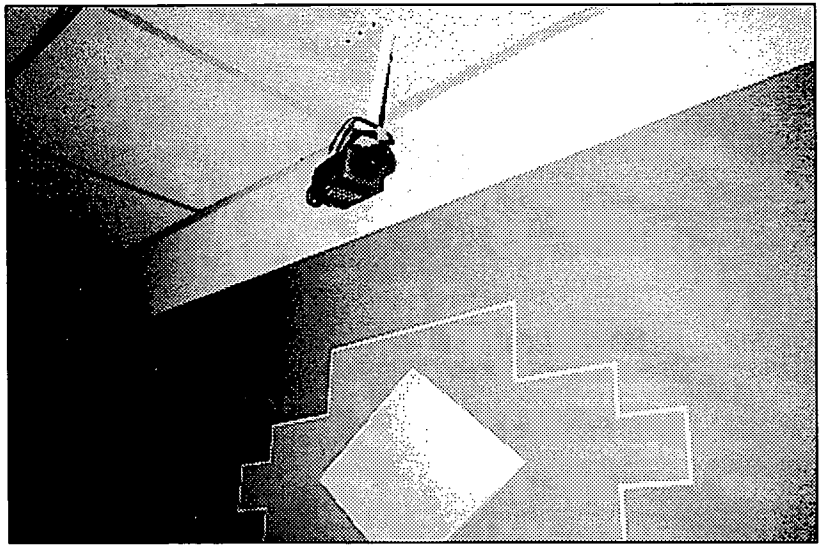
As for single lens reflex cameras, *wide angle* and *long* lenses are available and their appropriate use can greatly enhance the quality of the video images. *Auto iris* lenses automatically adjust to changing levels of natural and artificial light so as to not over- or under-expose recorded images.

Recorders

Commercial grade recorders, not those one might use for home entertainment, are the best choice for research applications. Recorders that enable extended recoding modes can be useful in stretching the recording time of tapes and limiting the number of tapes that are generated in a study. Time lapse capabilities also are useful for studies in which recording is selectively triggered, but there is a requirement for recording to begin instantaneously when triggered, such as in studies of naturally occurring falls in which the fall would be over before recording could begin unless the tape was already in motion and the recording head positioned near the tape.

FIGURE 1

Surveillance camera, installed near ceiling.
LED tied into wanderer alarm system can be seen hanging near top edge of lens.



Triggers

Different types of *triggers* can be used to record selectively. Most recorders can be programmed to record on a specified time interval, time-sampling the on-going, naturally-occurring behaviour in the range of the camera. Time sampling might be used to reduce the volume of video data that has to be coded in studies that examine problems that occur with a high degree of frequency. Person-based observation studies often use some type of time sampling. Devices such as motion sensors also can be used to trigger recording and limit the amount of *empty* tape that is generated when a space is not occupied or there is no movement in a space. For example, if one were studying falls in resident rooms there is no point in recording except when the room is occupied and occupants are moving around. However, motion sensors are unable to differentiate between the resident at risk of falls, the staff person coming in to give medications, and the housekeeper coming in to clean. Thus, some taping extraneous to the study is likely to occur, but the amount of tape unrelated to the study topic would be minimized.

Other technology, such as programmable wanderer alarm systems, can be tied in with the video recording technology to trigger video taping without interfering with their monitoring of those at risk of elopement. In simple terms, Mr. Jones might wear a tag because he is a wanderer. The wanderer alarm system can be programmed to initiate the staff alarm sequence if he is detected near hazardous locations and to simultaneously initiate video taping.

Splitters

Splitters feed the images from as many as four cameras into one video tape. The order of the images (e.g., clockwise) can follow the sequencing of cameras that are being used in a long hallway, enabling tape coders to track an individual's movement up and down a hallway without having to switch tapes to do so. Splitters also can dramatically reduce the number of tapes that are generated and thus the amount of time required to review and code them. However, the images are smaller and it may be more difficult to discern details that are needed to address research questions, such as foot placement in a falls study, or nonverbal expressions in a study of staff-resident interaction.

Audio

Audio can be obtained by using dispersed ceiling microphones and recording sound as well as images to video tapes. However, there typically is a great deal of background noise. Expectations that spoken language can be captured as data, such as the content of verbal exchanges between staff and residents, are often unrealistic. Omitting audio may be a compromise to reduce staff concerns about video-based observation projects. However, there are occasions in which auditory information is needed. For example, if one were interested in staff response times to wanderer alarm system alerts, the sound of the alarm is the obvious way to know when to start timing staff responses. However, if audio is not available, other methods of providing equivalent information may be possible. For example, small LEDs, suspended in front of a camera, can be wired into the auditory alarm; when the alarm sounds the LED flashes and is recorded on the time-stamped video image.

APPLICATIONS OF VIDEO-BASED OBSERVATION TECHNOLOGY TO BEHAVIOURAL PROBLEMS IN LONG TERM CARE SETTINGS

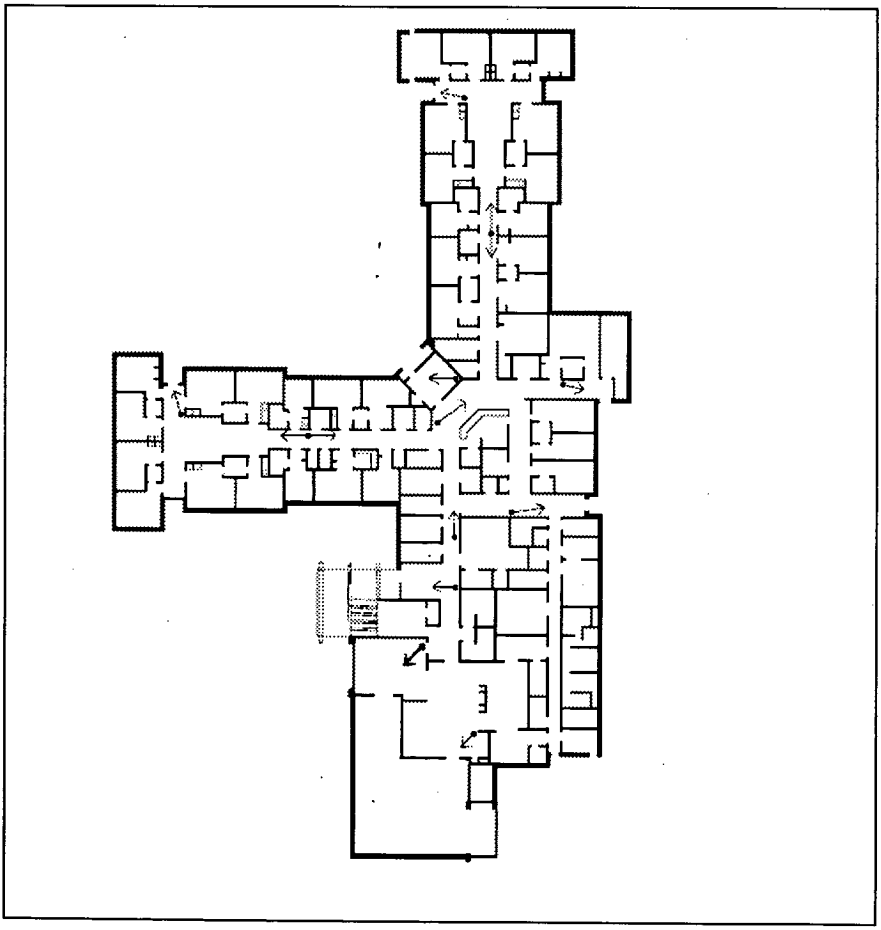
To date, researchers at the Rehabilitation Research and Development Center on Aging at the Atlanta Veterans Affairs Medical Center have used video-based observation in studies of naturally-occurring behaviour and in intervention studies. Studies to develop a taxonomy of wandering behaviour, environmental and behavioural contributions to falls in frail nursing home patients, and factors precipitating restraint use have been completed using this technology (Connell, 1993; Martino-Saltzman, Blasch, Morris, et al., 1991; Whittington, Strasser, Archea, et al., submitted). An ongoing intervention study is evaluating the impact of wanderer alarm signals and access to secure outdoor space on the frequency of actual and attempted elopement incidents among demented nursing home residents, staff response times, and where demented individuals spend their time. A proposed study will use this technology to compare the impact of conventional auditory alarms and pager-based wanderer alarm system signaling on staff response time to alerts.

In all of these studies, video-based observation has been one part of a larger data

collection protocol. For example, in the on-going intervention study we are interested in determining the effect of an alert signal that is less aversive than conventional wanderer alarm system signals and access to outdoor space on behavioural disturbances in demented subjects and on staff stress. An instrument derived from the Minimum Data Set questionnaire (Morris, Hawes, Murphy, et al., 1991) is being used at each phase of the study to obtain staff ratings of the frequency and severity of demented subjects' dementia-related behaviours. The Maslach Burnout Inventory (Maslach & Jackson, 1986) a standardized instrument to assess staff stress, also is being administered in conjunction with each phase of the study.

FIGURE 2

Floor plan of skilled nursing facility participating in study of elopement behaviour by wanderers. Circles and arrows show location and orientation of cameras.



OTHER POTENTIAL APPLICATIONS

Video-based observation is a potentially useful data collection approach in studying a variety of other types of behavioural problems in long term care settings. For example, many facilities are implementing innovative activity programs for their demented residents, with the expectation that these programs will impact behavioural outcomes. Video-based observations would provide accurate documentation of the frequency of target behaviours before and after the program intervention. Similarly, many facilities are undertaking building renovations to create more appropriate and supportive environments for their residents. Video-based observation would enable researchers and administrators to determine before and after levels of behaviours that are expected to be changed by the renovations. For example, if sitting spaces are created midway on long hallways, do those with mobility problems and limited stamina ambulate more often? Are improvements in lighting associated with fewer falls? Does the level of social interaction among residents increase when small, conveniently located sitting areas are added?

A second potential application of video-based observational materials is their use in alerting administrators to the need for staff training as well as in the creation of visual materials to be used in such training and evaluation of the effectiveness of the training. In an earlier study of falls, it became apparent that some transfer problems experienced by non- and semi-ambulatory residents were related to the type of assistance being provided by staff — although residents had become more frail, staff continued to use techniques that were more appropriate when residents were less frail. These videos would be useful for in-service training to remind staff of the changing needs and abilities of residents. They also could be used in conjunction with video taping done after in-service training was completed to determine if staff practices changed. However, staff agreement to be routinely video taped and the video tapes used in these ways must be secured in advance for this to be a viable application.

Finally, an important potential use of video-based observation is in helping researchers and administrators to identify and define emergent problems. For example, little is known about multiply disabled nursing home residents and how, for example, hearing loss in addition to mobility problems might impact participation in the social life of a facility and thus residents' quality of life. Observation of the social interaction patterns of those with mobility problems and comparison of those with and without hearing loss, would help to determine if there are unique problems of multiply disabled individuals and provide some ideas about potential interventions to reduce the effects of these disabilities.

FIGURE 3

Video recorders and monitor used for periodic checks that recorders are taping.

CONCLUSION

Video-based observation is an underutilized technique for studying behavioural problems in long term care settings. However, it is important that those adopting this technique take care to clearly define the research questions of interest and ensure that those questions can best be answered with observational techniques. In most, if not all cases it is advisable to supplement observational data with other types of information relevant to the problems of interest.

Video-based observation also requires that appropriate equipment be used to collect data. This can represent a substantial investment and researchers need to think in terms of programs of research rather than single projects to ensure the investment is worthwhile.

Video-based observation changes, but does not eliminate, the labour-intensive nature of observational data collection. Assistants must be available to routinely change tapes or agreements made with staff to assume responsibility for this task. Trained data coders also must be available to screen and code an often overwhelming number of tapes.

Finally, establishing open working relationships with administrators and staff in

facilities in which data collection is to be done is essential. Video-taping is potentially intrusive and it is important that staff as well as residents and family members feel comfortable with the procedure and are able to trust researchers to honour their agreement to protect individual confidentiality.

REFERENCES

As, D. (1975). Observing environmental behavior: The behaviour setting. In W. Michelson (Ed.), *Behavioral Research Methods in Environmental Design*. Stroudsburg, PA: Dowden, Hutchinson and Ross.

Athlin, E., Norberg, A., Axelsson, K., Moller, A. & Nordstrom, G. (1989). Aberrant eating behavior in elderly Parkinsonian patients with and without dementia: Analysis of video-recorded meals. *Research in Nursing and Health, 12*, 41-51.

Bakeman, R. & Gottman, J. (1986). *Observing Interaction. An Introduction to Sequential Analysis*. New York: Cambridge University Press.

Barker, R. (1968). *Ecological Psychology*. Stanford, CA: Stanford University Press.

Burgio, L. & Yurick, A. (1993). Studying behavior and contextual events in the nursing home context using laptop computers: Applications and procedural issues. *Gerontologist, 33* (Special Issue 1), 306.

Connell, B.R. (1993). Patterns of naturally occurring falls among frail nursing home residents. *Gerontologist, 33* (Special Issue 1), 58.

Connell, B.R. (1994). Using video technology in studies of naturally-occurring behavior in long term care settings. *Gerontologist, 34* (Special Issue 1), 159.

Hyde, J. (1995). Linking established methodologies to special care unit outcomes research: The next generation. *Gerontologist, 35* (Special Issue 1), 371.

Kihlgren, M., Kuremyr, D., Norberg, A., Brane, Gorel, Karlson, I., Engstrom, B., & Melin, E. (1993). Nurse-patient interaction after training in integrity promoting care at a long term ward: Analysis of video-recorded morning care sessions. *International Journal of Nursing Studies, 30*, 1-13.

Koncelik, J. (1976). *Designing the Open Nursing Home*. Stroudsburg, PA: Dowden, Hutchinson, and Ross.

Martino-Saltzman, D., Blasch, B., Morris, R. & McNeal, L. (1991). Travel behavior of nursing home residents perceived as wanderers and nonwanderers. *Gerontologist, 31*, 666-672.

Morris, J.N., Hawes, C., Murphy, K. et al. (1991). *Resident Assessment Instrument Training Manual and Resource Guide*. Washington, D.C.: Health Care Financing Administration.

Patterson, A.H. (1974). Unobtrusive measures: Their nature and utility for architects. In J. Lang, C. Burnette, W. Moleski, & D. Vachon (Eds.), *Designing for Human Behavior*. Stroudsburg, PA: Dowden, Hutchinson, and Ross.

Webb, E.J., Campbell, D.T., Schwartz, R.D., & Seechrest, L. (1972). *Unobtrusive Measures. Nonreactive Measures in the Social Sciences*. Chicago: Rand McNally.

Whittington, F., Strasser, D., Archea, C., Hennessey, C., Miller, S., McNeely, B., & Myers, D. (Submitted for review.) Changing ecology of a nursing home: Findings from a multi-method inquiry of restraint use, 1988-1994.

Zeisel, J. (1981). *Inquiry by Design*. Monteray, CA: Brooks/Cole.

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CHAPTER 6

ENVIRONMENTAL DESIGN: ENABLING TECHNOLOGY FOR AN AGING SOCIETY

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INTRODUCTION

In anticipation of the approaching 'age wave' associated with the graying of the 'baby boom' generation (Dychtwald & Flower, 1989), society is finally beginning to grapple in earnest with the daunting task of searching for alternative ways of dealing with the concomitants of aging such as physical impairments that will arrive with this incoming tide. While one might like to characterize this search as a dispassionate examination of practicable yet compassionate options, the reality is that as the age wave gets closer, the tone of the discussion seems to be growing increasingly urgent and political.

Long-standing implied social contracts between governments and their aging constituents would appear to be undergoing accelerated unilateral renegotiation (Gutheil, 1996; Hudson, 1996). Despite the far reaching implications of such renegotiations, governments worldwide are feeling compelled by fiscal exigency to make these changes. The hand-writing on the wall is now growing clearer: the traditional ways of responding to concomitants of aging will no longer be viable options. In response to the approaching age wave, contemporary society has neither the time nor the resources to build and sustain facilities and services on the scales required and of the type implied by historical precedent. Consequently, society would seem to have no choice but to look for alternatives.

In response, both the public and private sectors are turning to technology. The

[1] This research was supported through funding from the National Institute on Disability and Rehabilitation Research, U.S. Department of Education.

number of companies manufacturing and/or marketing assistive technologies that can maintain and even restore functional performance and independence in aging populations is rapidly expanding (Miller, 1996). Government funding is being channeled not only into research and development of such technologies but also into public education and dissemination of information on the availability and benefits of those technologies (Pool, 1991; Brickell & Bishop, 1995). Even long-established professions and disciplines are beginning to reinvent themselves as technologies that can offer ways of contending with the inevitable concomitants of an aging society (e.g., RESNA's certification of service providers).

Facing demands from both the public and private sectors that their design artifacts be more responsive to the needs of an aging society, the environmental design professions are finding it necessary to reconceptualize the very purpose and consequent nature of design. Rather than ends in and of themselves, their design artifacts are now being asked to function as means — i.e., as tools for facilitating functional independence and performance for aging populations. In response, the environmental design professions are finding it necessary to complement their historic focus on the manipulation of space with a new focus on the management of person-behaviour-environment transactions (Danford, 1978).

PERSON-BEHAVIOUR-ENVIRONMENT TRANSACTIONS

How a person behaves in a particular situation is not a simple property of either the person or that person's environment but rather the interaction between the two (Mead, 1934; Cronberg, 1975). This view of the nature of person-behaviour-environment relations is the defining characteristic of what has come to be know as a 'transactional' perspective (Moore, 1976; Wandersman, Murday & Wadsworth, 1979; Stokols, 1981, 1987; Altman & Rogoff, 1987).

Virtually all such transactional models are at least partially grounded in Kurt Lewin's (1951) classic concept of 'Life Space' which is defined by the equation B=f(PE). Simply stated, Lewin conceived of behaviour as being a function of the interaction of personality and other individual factors and the perceived environment of the individual. Contemporary transactional models, although typically fashioned in terms reflecting somewhat more complex and sometimes more behavioural conceptions of person-behaviour-environment relations, nevertheless generally acknowledge behaviour as a manifestation of the person-environment interaction.

A second concept which is widely reflected in many transactional models is the 'Environmental Docility Hypothesis' which postulates that environment exerts a 'press' upon the person in terms of its being either supportive or challenging and that

the consequence of that press depends upon the 'competence' of the person encountering that environment (Nahemow & Lawton, 1973). Nahemow and Lawton argue that mismatches between the functional capabilities an environment requires of a person, on the one hand, and the functional capabilities that person may possess, on the other hand, can lead to person-environment encounters in which the person's functional independence and performance could be seriously compromised — a position endorsed by most contemporary transactional theories.

A third concept invariably reflected in transactional models is Albert Bandura's (1978) 'Reciprocal Determinism'. Bandura's model emphasizes the reciprocity that exists between person, behaviour and environment — each influencing the other two and, in return, being influenced by the consequences of its own effects on those other two. Transactional models typically take this reciprocity as a given and focus on defining the dynamic nature of those reciprocal linkages between person, behaviour and environment.

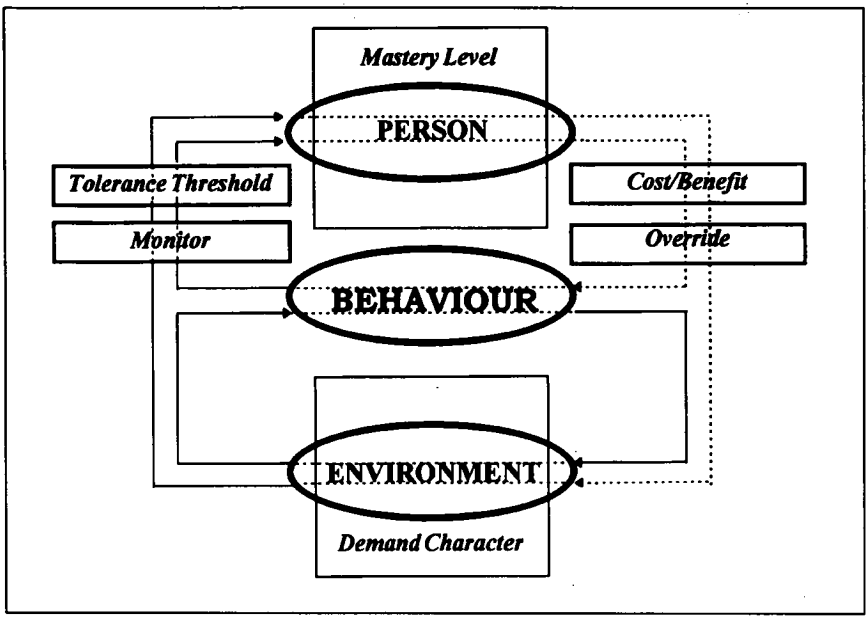
DYNAMIC RECIPROCAL DETERMINISM

One such contemporary model is the synthetic and transactional model called 'Dynamic Reciprocal Determinism' (Danford, 1982; 1983; 1985). This model melds the three aforementioned concepts and then proceeds to define the dynamics of the reciprocal linkages between person, behaviour and environment in terms which can even explain widely divergent outcomes in the same setting. Dynamics are proffered (see Figure 1) which can explain instances where the environment's influences would seem at one time to be negligible and at another time to be the primary or even sole determinant of the outcomes resulting from specific person-behaviour-environment transactions.

Mechanisms are offered to suggest how and why the person 'monitors' the on-going (or anticipated) behaviour-environment transaction and typically submits to the influence of the environment. As long as the behaviour-environment relation being required or even demanded of the person does not violate certain 'tolerance thresholds' (i.e., does not violate the person's values, expectations or capabilities) sufficiently to prompt that person to attempt to 'override' that inappropriate behaviour-environment relation, the environment effectively determines the outcomes. The consequence of this particular dynamic is that "most of the time, most people behave in ways that are compatible with or adaptive to the settings they occupy" (Wicker, 1974, p. 599).

FIGURE 1

Dynamic Reciprocal Determinism model of person-behaviour-environment transactions.



How successful a person might be in attempting to override an inappropriate behaviour-environment situation is determined by how well the person's 'mastery level' matches up against the environment's 'demand character'[2]. If, for example, the person's mastery level is too weak or the environment's demand character is too strong, the outcome could be ineffective or even maladaptive attempts by the person to override — attempts that would, over time, extinguish for lack of reinforcement.

This dynamic provides another way of conceptualizing the phenomenon the gerontological literature has referred to as 'disengagement' (Cumming & Henry, 1961; Carp, 1976; Tallmer & Kutner, 1976). Viewed in terms of the Dynamic Reciprocal Determinism model, disengagement may not be so much a natural precursor to death as it is the outcome resulting from an aging person's repeated futile attempts to effect change in an intolerable behaviour-environment relationship. The consequence of this dynamic would be the person's resignation to a sense of helplessness.

A term often employed to characterize the appropriateness of a particular person-behaviour-environment transaction is 'fit' or 'congruence' (Fisher, Bell & Baum, 1984). In the context of the Dynamic Reciprocal Determinism model, fit would be reconceptualized as merely a behaviour-environment transaction that is tolerated by the person. The person concludes either that the benefits to be derived from changing

[2] 'Mastery Level' as used here is similar to what Moos (1975) calls 'capabilities'; 'demand character' is similar to what Murray (1938) calls 'environmental press'.

an inappropriate behaviour-environment situation are simply not worth the costs in terms of the effort necessary to effect the requisite changes or that the changes are not even possible due to the magnitude of the mismatch between the person's mastery level and the environment's demand character. Obviously, such a definition of fit covers a broad range of person-behaviour-environment outcomes.

It could be a fit resulting from an environment's demand character making appropriate and effective accommodation for the aging person's declining mastery level — thereby enhancing that person's ability to attain preferred behavioural outcomes such as maintaining or even enhancing functional independence and performance. However, it could also be a fit resulting from an environment making intolerable demands upon the person which he/she simply does not have the ability to contend with — leading ultimately to a compliant resignation to the outcomes of the inappropriate behaviour-environment situation. The outcome one would be looking to achieve when seeking appropriate person-behaviour-environment fit for the aging person would typically (but, perhaps, not always) be the former. Particularly when looking to achieve appropriate person-behaviour-environment fit through home modifications, the outcome sought would typically be one characterized by the facilitation of enabling habitable outcomes that are tolerable to the person.

RECONCEPTUALIZING HOME MODIFICATIONS

In transactional terms, home modifications for the aging person are perhaps better conceptualized as purposeful interventions into interdependent person-behaviour-environment systems. They are attempts to effect habitable outcomes through facilitation of the transactions occurring between three interdependent, reciprocally deterministic arenas of influence — i.e., person, behaviour and environment. They are personalized interventions designed to ensure appropriate person-behaviour-environment fit that will accommodate concomitants of aging so that the person's functional independence and performance can be maximized.

Home modifications for the aging person are interventions designed to leverage the person's existing mastery level by providing an environment whose demand character is neither overly challenging (i.e., unaccommodating) nor overly supportive (i.e., over-accommodating) — either of which would yield undesirable outcomes. An overly challenging environment's failure to accommodate exhibited concomitants of aging would effectively prey upon the aging person's impairments and disable or even handicap him or her. An overly supportive environment's accommodation of as yet unexhibited concomitants of aging could engender dependency and could actually precipitate those concomitants' manifestation.

Home modifications for the elderly are interventions designed to achieve an appropriate and sustainable fit between person, behaviour and environment. They are attempts to establish patterns and sequences of transactions between these three

arenas that collectively enhance functional independence and performance. They are intended to enable habitable outcomes that will be facilitated by the environment and tolerated by the person.

The difficulty, of course, is knowing how to assess which home modifications to do and how much of them to do to achieve an appropriate and sustainable fit. The challenge is knowing how to avoid making home modifications whose demand character is either too challenging or too supportive for the person's mastery level.

ACCESSIBILITY STANDARDS AND FIT

It might at first seem reasonable to recommend an unquestioning compliance with accessibility standards such as the Americans with Disabilities Act Accessibility Guidelines (ADAAG). There are, however, at least four reasons why such a strategy might not yield the desired fit (Rubin & Elder, 1980).

First, there is the inertia of the regulatory process itself which tends to work against a timely response to changing technologies (e.g., building practices, health care delivery services, social customs) with the result that the standards could become not just obsolete but actually counterproductive to the goal of facilitating appropriate person-behaviour-environment fit.

Second, accessibility standards are typically written to ensure achievement of minimum levels of facility accessibility. Unquestioning application of such standards in home modifications could unwittingly shift the goal toward merely ensuring such minimums rather than facilitating functional independence and performance maximums.

Third, accessibility standards are largely insensitive to individual differences — i.e., they prescribe unvarying response in the face of varying individual needs. They provide prescriptive guidelines that can compel environmental design changes that may be neither warranted nor beneficial to the individual in question.

And fourth, such standards are too rarely the product of a cumulative body of empirical data evidencing their beneficial consequences. Often they are merely derived from anecdotal accounts and backed up with little more than 'expert' opinion on whether their costs are justified by the benefits intended. Too often such standards are merely reactions to design failures combined with a measure of good intentions with the result that the person-behaviour-environment fit afforded by their actual application can sometimes be less than appropriate.

MEASURING ENABLING AND HANDICAPPING ENVIRONMENTS

The aforementioned transactional focus and the difficulty of determining the appropriateness of a particular person-behaviour-environment fit provide the motivation for several of the activities of the Center for Inclusive Design and Environmental Analysis (IDEA) at the State University of New York at Buffalo. With

funding provided by the U.S. Department of Education's National Institute for Disability and Rehabilitation Research (NIDRR) through organisations such as the Rehabilitation Engineering Research Center on Aging (RERC/Aging) and the Rehabilitation Research and Training Center on Functional Assessment and Evaluation of Rehabilitation Outcomes (RRTC/FAERO) at the State University of New York at Buffalo, IDEA has undertaken a multi-year program of research aimed at developing methods for measuring and analyzing the appropriateness of person-behaviour-environment transactions — methods that acknowledge the dynamic, reciprocally deterministic nature of such interactions.

In this program of research, IDEA is developing outcome measures of the influence of designed physical environments on the functional independence and performance of persons manifesting various concomitants of aging — e.g., mobility impairments, reduced grip strength, etc. These measures examine how environments which fail to accommodate such concomitants of aging can disable or handicap a person and, conversely, how environments which provide appropriate accommodations can enable or even enhance the aging person's functional independence and performance.

This outcome measurement capability becomes particularly important when one observes negative changes in the aging person's functional independence and performance following discharge from a rehabilitation program. Such outcome measures can enable one to discern whether the negative changes are attributable to an attenuation in the benefits of the rehabilitation program over time or whether it is the person's home environment that might be responsible for the change.

The focus of this research program has thus far been primarily on the development, testing and refinement of outcome measures as complements to the widely employed Functional Independence Measure instrument, more popularly referred to as the FIM℠ (Granger, et al, 1986). This has been done not only to enable the identification of enabling person-behaviour-environment match-ups but also to permit diagnosis of the specific disabling match-ups that might begin to explain maladaptive or undesirable outcomes such as a person's post-rehabilitation decline in functional independence upon return to the home environment.

As complements to the FIM℠ , outcome measures have been sought which can:

- obtain individuals' self-reports on the ease or difficulty of functional performance in selected environments,
- examine a person's functional independence and performance in the context of mediating environmental demand character,
- quantify the person's level of effort expended toward task performance, and
- assess the caregiver's burden in assisting the aging person's performance.

Thus far three outcome measures complementary to the FIM℠ have been developed, tested and refined.

1- Usability Rating Scale (URS℠)

This scale has the person rate the perceived ease or difficulty of using specific task environments.

2- Environmental Functional Independence Measure (Enviro-FIM℠)

This scale scores the person's functional independence in the context of specific designed physical environments.

3- Functional Performance Measure (FPM℠)

This scale scores two things:

1) the person's **Level of Effort** toward completion of a task, and

2) the caregiver's (if applicable) **Level of Assistance** toward completion of that task.

The initial testing and refinement of these three outcome measures was conducted by studying the functional independence and performance of 24 female subjects with mobility impairments (12 wheelchair users and 12 walking aid users) in environments whose demand character systematically varied.

RESEARCH DESIGN

The research design for the testing and refinement phase of this program of research had subjects simulate the performance of several activities of daily living (ADL) such as grooming, toileting, and bathing in three full-scale simulated bathrooms. In these three bathrooms five sets of design attributes typically addressed in accessibility standards were systematically varied to provide three distinct levels of demand character:

- size of the open floor area inside the room,
- entry door characteristics,
- lavatory/vanity characteristics,
- toilet characteristics and
- bathtub/shower characteristics.

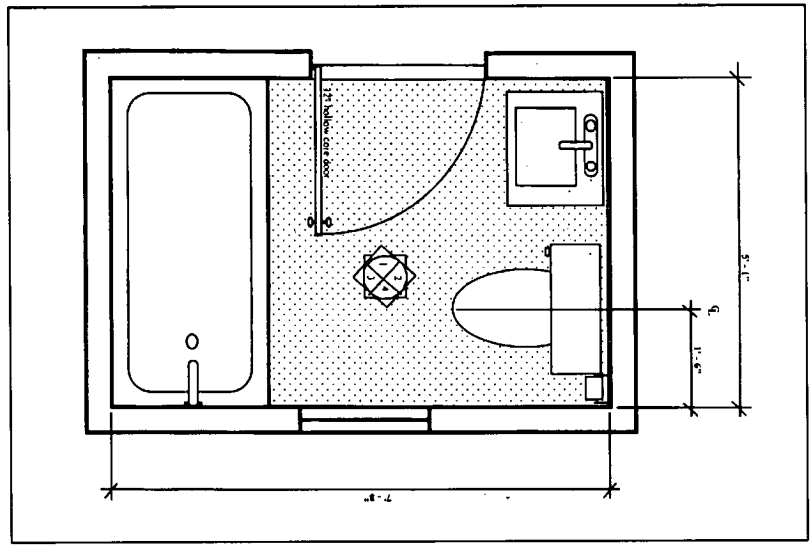
There was a challenging (i.e., unaccommodating) bathroom configuration (see Figure 2) characterized by:

- only 15 square feet of open floor area,
- a 32" entry door equipped with conventional door knob handles with a swing that swept across the open floor area inside the room,
- an enclosed vanity with a small (20"x20") countertop and traditional dual knob faucets and a high-mounted (47") mirror/cabinet,

- a 16" high toilet with no attached grab bars or wall grab bars, and
- a 15" high bathtub with a fixed position shower head, no wall grab bars, and a single knob handle faucet mounted on-center.

FIGURE 2

The challenging bathroom configuration.

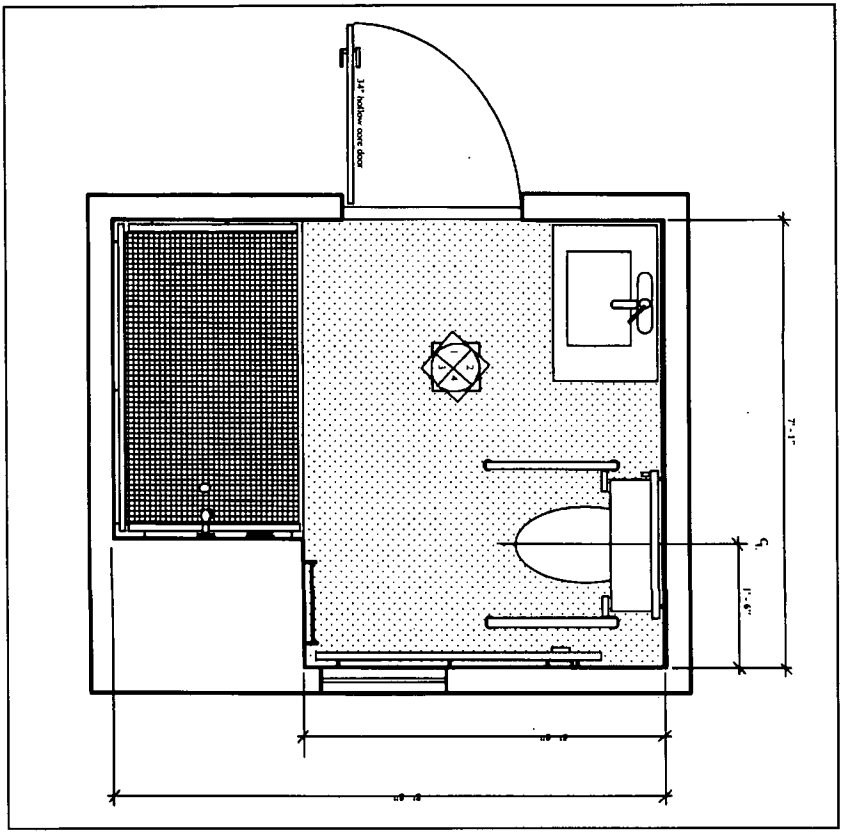


There was a supportive (i.e., accommodating) bathroom configuration (see Figure 3) characterized by:

- a 25 square foot open floor area,
- a 34" entry door equipped with lever handles with a swing that swept away from the inside of the room,
- an open vanity with a large (20"x30") countertop, single lever handle faucet and a low-mounted (40") mirror/cabinet plus an adjustable wall-mounted mirror,
- an 18" high toilet equipped with both attached grab bars and wall grab bars, and
- a roll-in shower stall with an adjustable position hand-held shower head, wall grab bars, and a single lever handle faucet mounted off-center.

FIGURE 3

The supportive bathroom configuration.

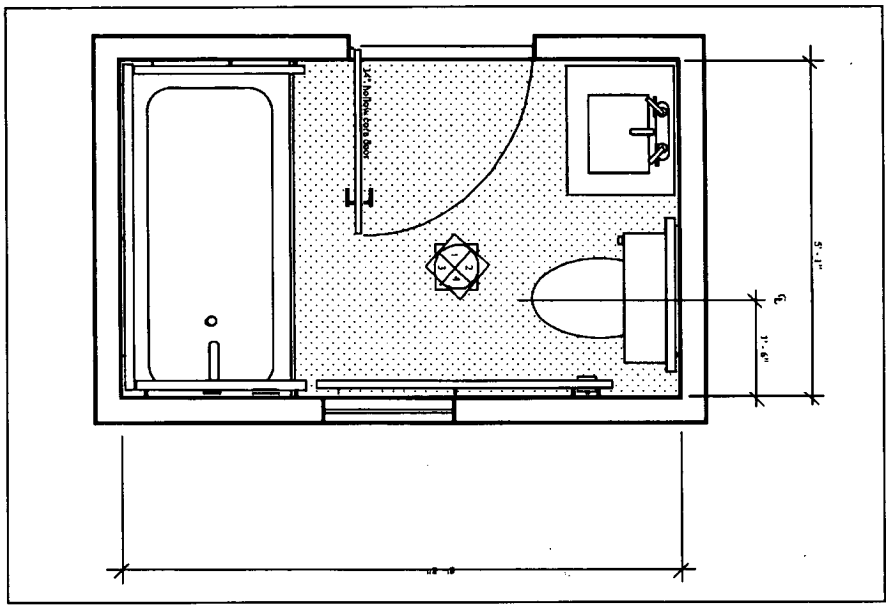


And there was an intermediate (i.e., neither strongly challenging nor supportive) bathroom configuration (see Figure 4) characterized by:

- a 20 square foot open floor area,
- a 34" entry door equipped with lever handles with a swing that swept across that open floor area inside the room,
- an open vanity with a 20"x24" countertop, double lever handle faucets and a high-mounted (47") mirror/cabinet plus an adjustable wall-mounted mirror,
- a 16" high toilet with wall grab bars, and
- a 15" high bathtub with a fixed position hand-held shower head, wall grab bars, and a single lever handle faucet mounted on-center.

FIGURE 4

The intermediate bathroom configuration.



In addition, the 24 subjects were asked to negotiate their way through 26 distinct door configurations (including entering and exiting doors for each of the three bathrooms). These door configurations varied systematically in terms of their:

- door width,
- direction of door swing,
- latch type,
- handle type,
- latch-side clearance,
- force required to open, and
- interior/exterior projections.

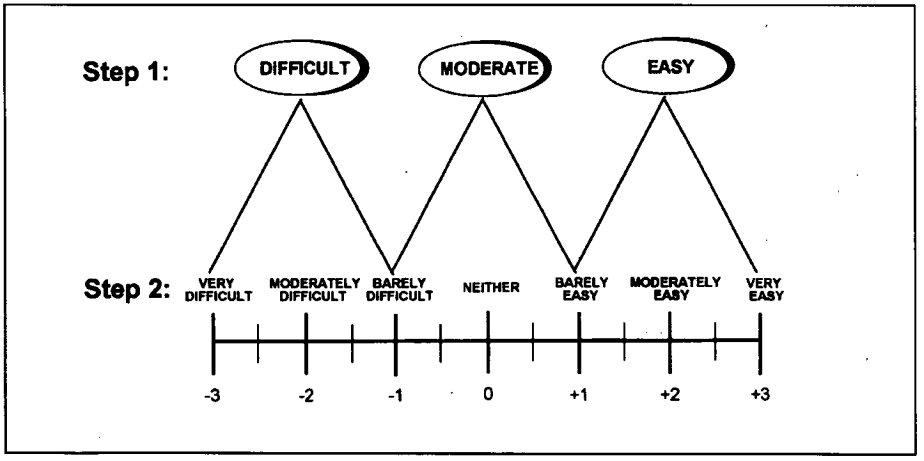
The bathroom and door trials were counterbalanced to control for possible order effects and standardized instructions were provided for each activity to be performed (e.g., simulating use of the toilet) including each activity's component tasks (e.g., flushing the toilet). At the end of each activity, each subject was asked to rate how easy or difficult it had been to perform the requested activity in that environment (see Usability Rating Scale below). Each subject's performance of each of the requested activities in each environment was also videotaped to permit more detailed analysis at a later time (see Environmental Functional Independence Measure and Functional Performance Measure below).

USABILITY RATING SCALE

The Usability Rating Scale (URS[SM]) (see Figure 5) is an adaptation of a previously developed, tested and published sequential judgment scale (Pitrella & Kappler, 1988) that was simplified to a 7-point bipolar rating scale. The URS[SM] was designed to examine subjective responses to the designed physical environment through a sequential two step process involving an initial choice between 'difficult,' 'moderate' and 'easy' characterizations of the activity's performance followed by locating the activity at a specific position on the relevant subsection of the 7-point scale. Subjects' self-reports about the relative ease or difficulty of use of environments were hypothesized to be globally reflective of the environments' influences on functional independence during simulated performance of the requested activities.

FIGURE 5

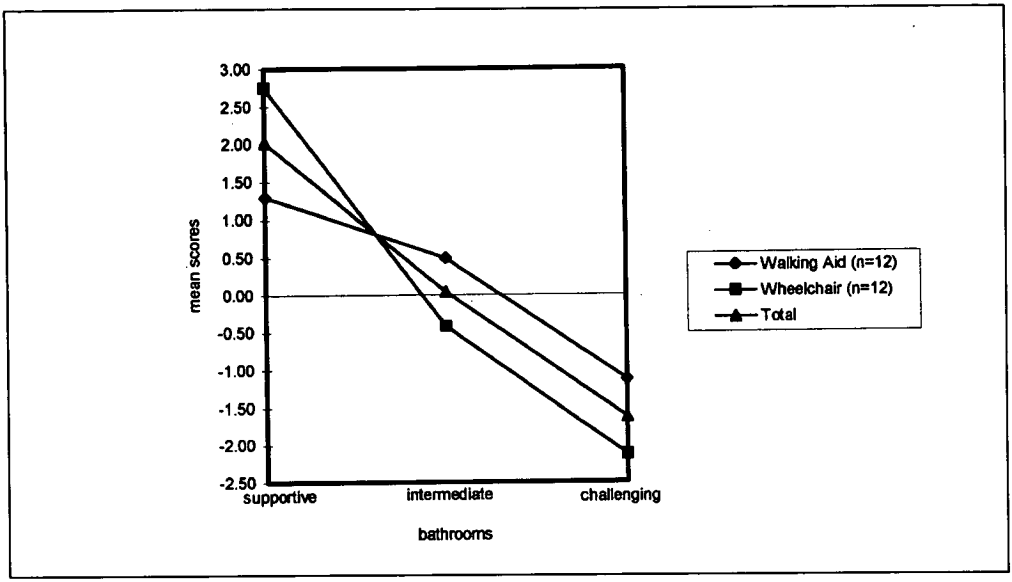
The two step Usability Rating Scale (URS[SM])



Examination of the URS[SM] ratings of the three bathrooms by these subjects (see Figure 6) supported our hypothesis. Particularly interesting was how the wheelchair users' perceptions suggest that they were more disabled by certain design features in the moderate and difficult bathrooms and more enabled by the design features of the supportive bathroom when compared to their walking aid counterparts.

FIGURE 6

Mean USR℠ scores for the supportive, intermediate and challenging bathrooms.



ENVIRONMENTAL FUNCTIONAL INDEPENDENCE MEASURE

The Environmental Functional Independence Measure (Enviro-FIM℠) (see Figure 7) is a derivative of the 7-point Functional Independence Measure. It expands the FIM℠ instrument's score of "6" into four scores to create a 10-point measurement scale. In addition, the content of the FIM℠ was expanded to address additional design features (e.g., doors) which were hypothesized to influence individuals' functional independence and performance. The Enviro-FIM℠ was designed to identify, at a global level, possible enabling and disabling match-ups between physical designed environments and individuals with impairments, based upon those environments' influences on functional independence and performance.

Tests of both inter- and intra-rater reliabilities (see Table 1) demonstrated relatively high levels of agreement in use of the Enviro-FIM℠ that were only marginally affected by the passage of time (i.e., 2 weeks).

FIGURE 7

Decision tree for Enviro-FIM℠.

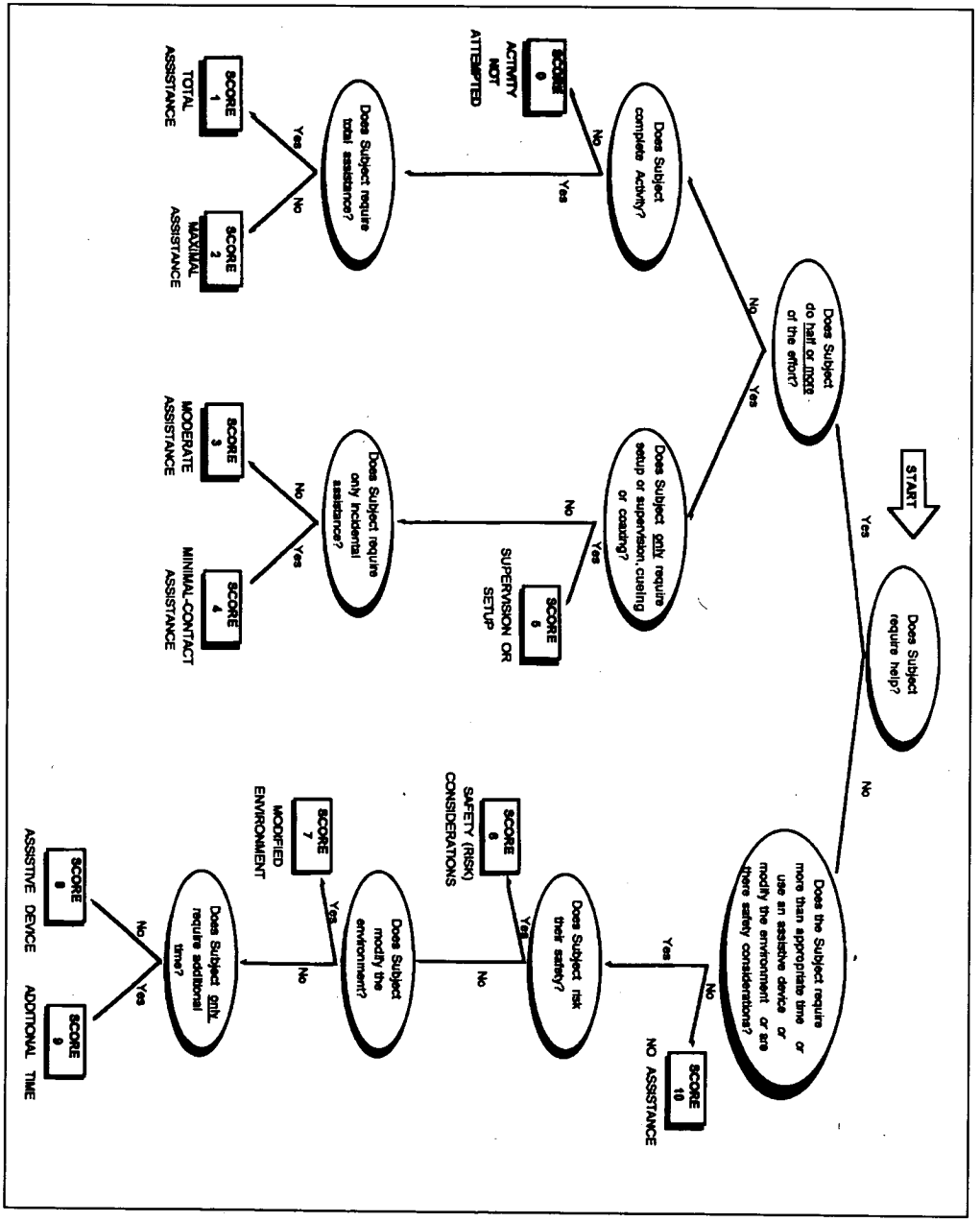


TABLE 1

Enviro-FIM℠ reliabilities.

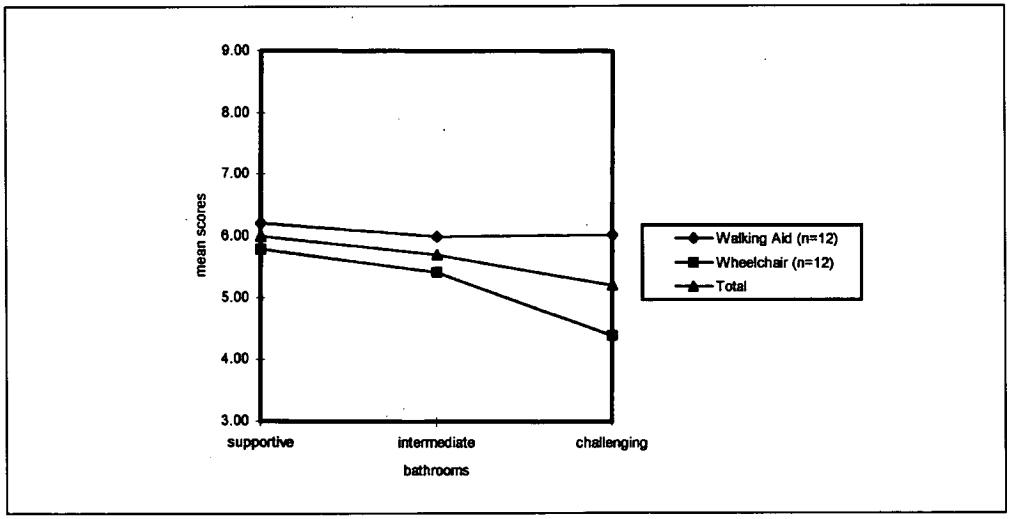
Type of Reliability	n	Agreement
Inter-rater (1)	164	96%
Inter-rater (2)	164	87%
Intra-rater (1)	164	92%
Intra-rater (2)	164	89%

(1) Initial Trial (2) Second Trial — 2 weeks later

Examination of the scores assigned by a certified FIM℠ scorer in the three bathrooms (see Figure 8) demonstrated that the FIM℠ scores are not, in fact, independent of the environmental context in which they are assigned. The wheelchair users' functional independence was more markedly affected by these three environments, particularly the challenging bathroom.

FIGURE 8

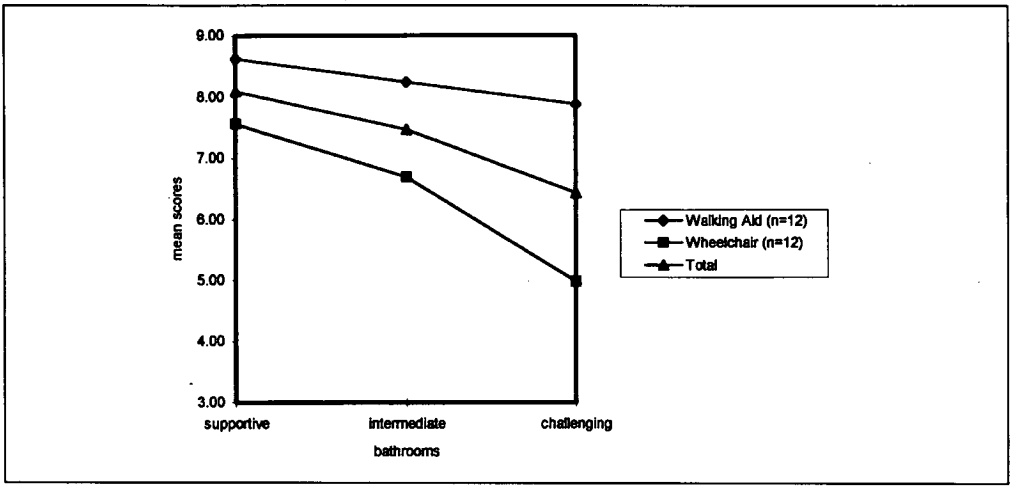
Mean FIM℠ scores in the supportive, intermediate and challenging bathrooms.



Examination of the Enviro-FIM℠ scores of the 24 subjects in the three bathrooms (see Figure 9) demonstrated, again, that wheelchair users were more dramatically affected by the challenging bathroom's design characteristics.

FIGURE 9

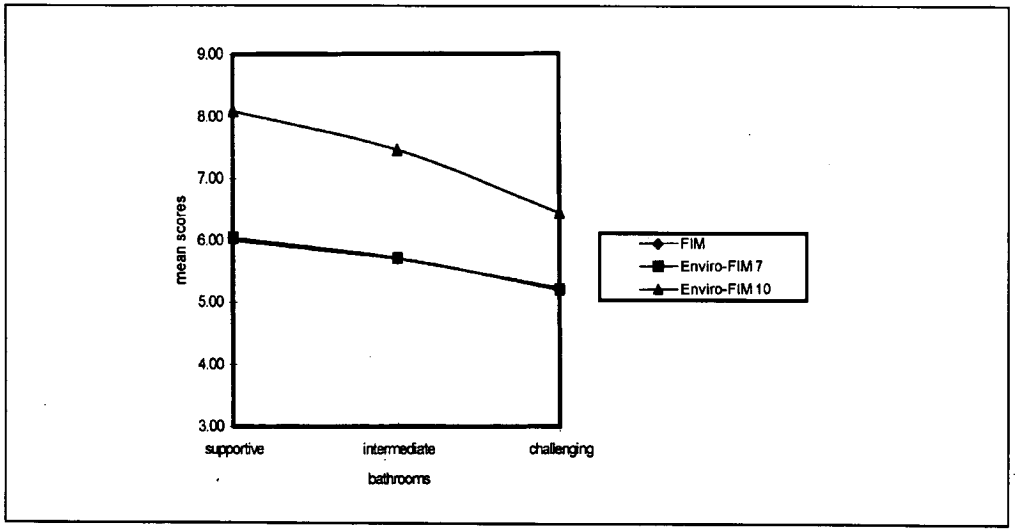
Mean Enviro-FIM℠ scores in the supportive, intermediate and challenging bathrooms.



Comparison of the FIM℠ and Enviro-FIM℠ scores (see Figure 10) demonstrates similar effects of the environments on the subjects' functional independence scores. When the 10-point Enviro-FIM℠ scale is collapsed back into a 7-point scale the two sets of scores fall remarkably close to one another.

FIGURE 10

Mean FIM℠ and Enviro-FIM℠ scores in the supportive, intermediate and challenging bathrooms.



FUNCTIONAL PERFORMANCE MEASURE

The third outcome measure, the Functional Performance Measure (FPM[SM]), employs two 8-point rating scales to score the Level of Effort expended by the subject toward task performance and the Level of Assistance provided by the caregiver during task performance.

Which of the eight Level of Effort scores the individual receives (see Figure 11) is determined by such factors as:

- whether successful performance of the task in question is actually required for accomplishment of the activity (e.g., operating the latch for a door that is not equipped with a latch = Level 0) and, if so
- whether any physical effort is required for successful task performance at all (e.g., closing a door that is equipped with an automatic closer = Level 0) and, if so
- the frequency of complaint by the individual as an expression of aggravation, inconvenience or anxiety during task performance,
- the frequency of interruption in the continuity of the individual's task performance,
- the amount of time taken for task performance, and
- the number of attempts made toward task performance.

Which of the eight Level of Assistance scores the caregiver receives (see Figure 12) is determined by such factors as:

- whether successful task performance is required for accomplishment of the activity (i.e., not required = Level 0) and, if so
- whether any assistance is required for successful task performance (i.e., no assistance required = Level 0) and, if so
- whether the provided assistance is merely incidental to task performance (e.g., touching or verbal expression intended solely as encouragement or praise = Level 1),
- whether the provided assistance directly facilitates the individual's task performance (e.g., instructing, prompting, performing set up, etc. = Level 2) and
- whether the assistance provided in fact constitutes direct performance of the task for the individual by the caregiver (i.e., caregiver performs the task for the person = Level 3).

Level of Assistance scores 4-6 are directly comparable to Level of Effort scores 4-6.

FIGURE 11

Decision tree for FPM SM Level of Effort score.

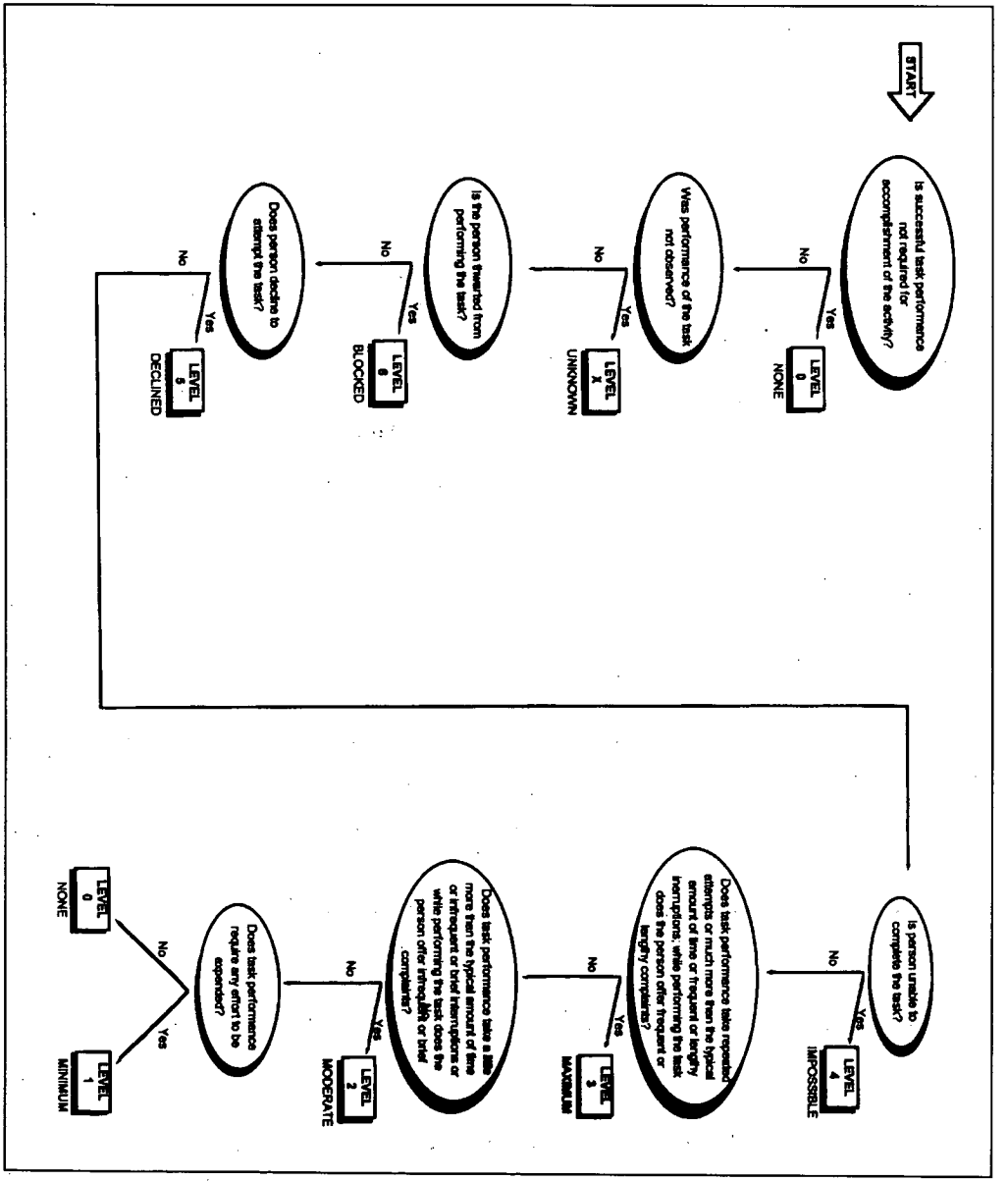
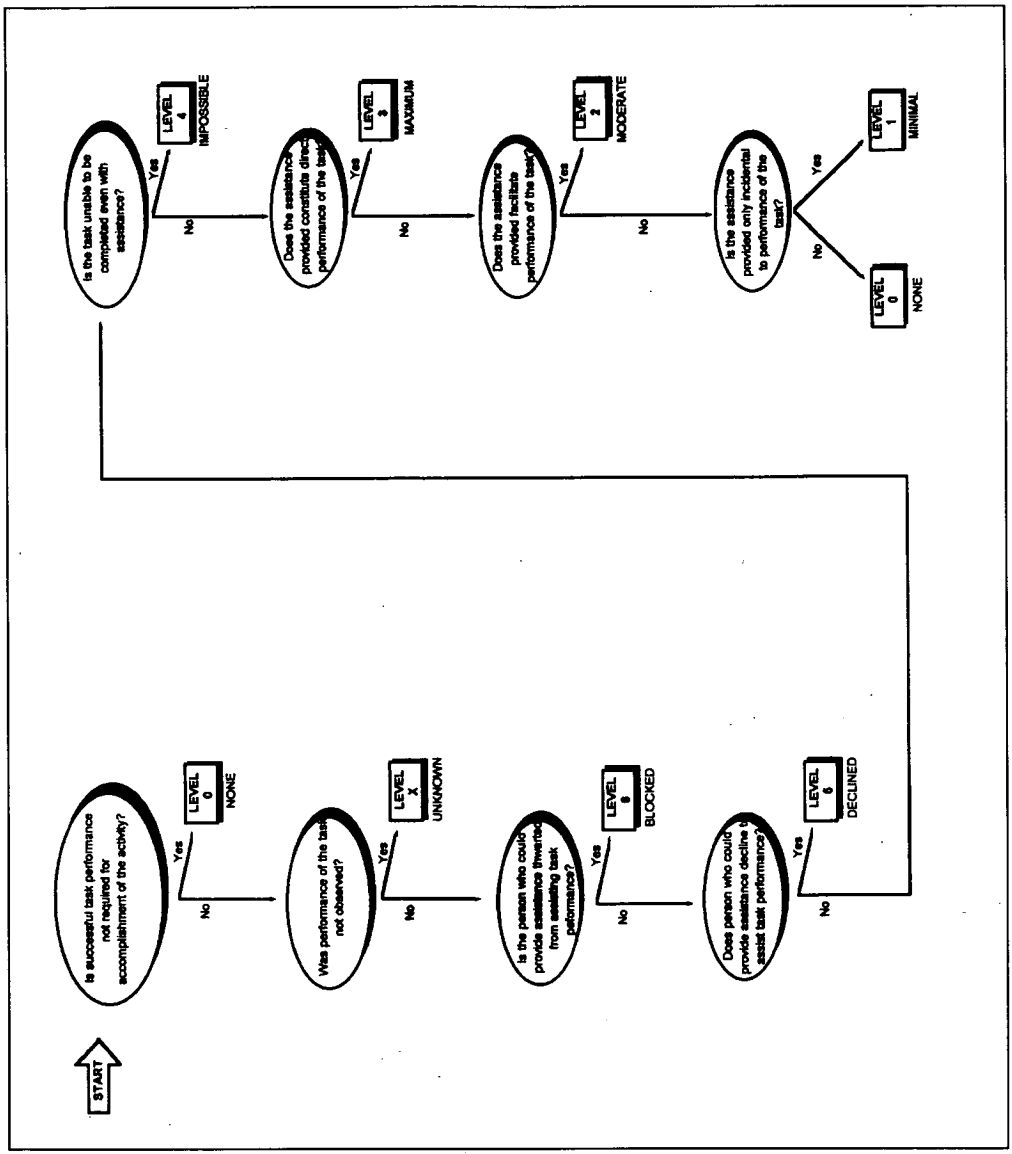


FIGURE 12

Decision tree for FPM℠ Level of Assistance score.



Of the 24 subjects analyzed using the FPM[SM]'s Level of Effort and Level of Assistance scales, four (two wheelchair users and two walking aid users) were re-scored to permit both intra- and inter-rater reliabilities to be examined. This involved rescoring each of the 283 tasks performed by every subject in the three bathrooms with all 26 doors — a total of 1132 Level of Effort judgments and 1132 Level of Assistance judgments.

As shown in Table 2, the intra-rater reliability analysis showed exact score matches on the 8-point Level of Effort scale of 97% and on the 8-point Level of Assistance scale of 99%. The inter-rater reliability analysis showed exact score matches of 84% on the Level of Effort scale and 96% on the Level of Assistance scale. Of the 16% 'mismatches', only 1.5% differed by more than one point — which is remarkable since this was achieved without benefit of a formal training program or a written user manual detailing all of the coding conventions during this testing and development phase.

TABLE 2

FPM[SM] reliabilities.

Type of Reliability	Level of Effort		Level of Assistance	
	n	Agreement	n	Agreement
Inter-rater (1)	1132	84%	1132	96%
Intra-rater	1132	97%	1132	99%

(1) Level of Effort scale inter-rater agreement variance: 1 point off = 14.5%; > 1 off = 1.5%

The Level of Effort scores (see Figure 13) — with the y-axis effort score of 0 meaning 'no effort', 1 meaning 'minimum effort', 2 meaning 'moderate effort' and 3 meaning 'maximum effort' — show that the walking aid users expended a relatively constant Level of Effort across the three bathrooms environments but the wheelchair users expended a progressively increasing Level of Effort as they moved from the supportive to the intermediate to the challenging bathrooms.

The Level of Assistance scores (see Figure 14) show that the walking aid users received negligible assistance in any of the bathrooms but the wheelchair users received a progressively increasing Level of Assistance as they moved from the supportive to the intermediate to the challenging bathrooms.

FIGURE 13

Mean FPM℠ Level of Effort scores in the supportive, intermediate and challenging bathrooms.

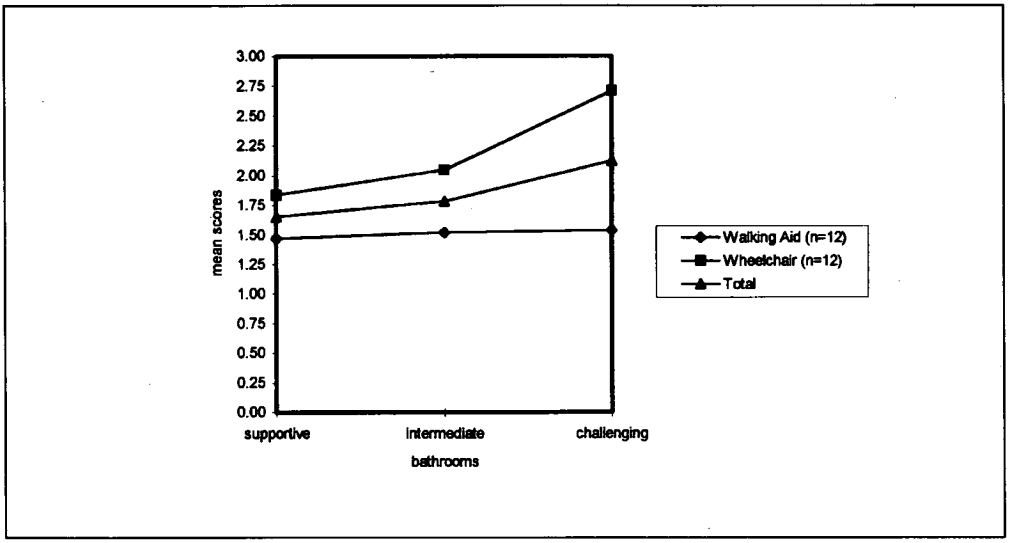
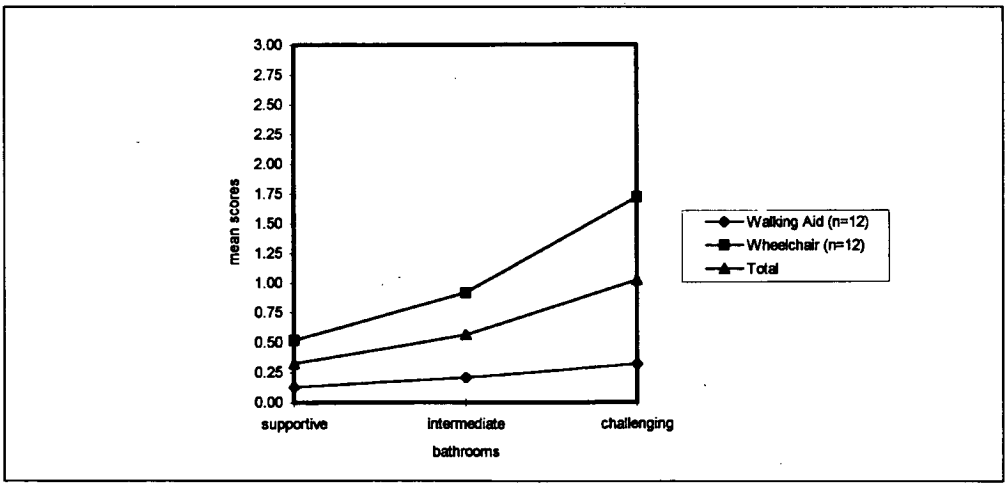


FIGURE 14

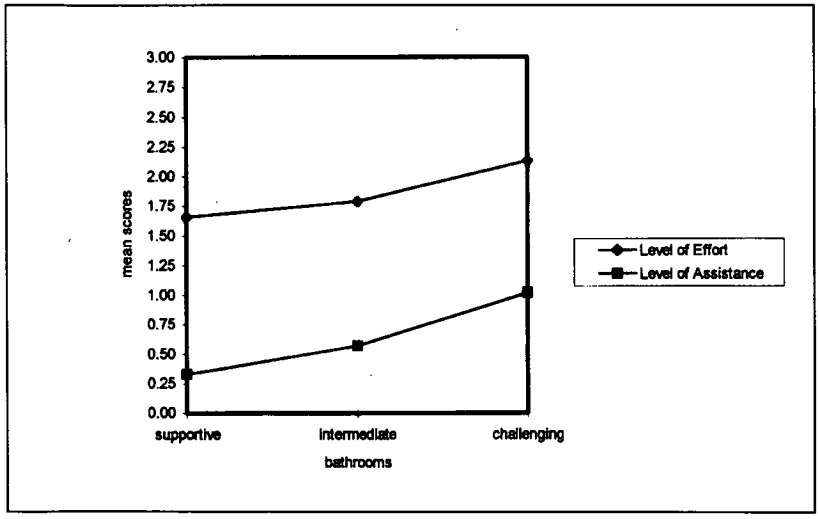
Mean FPM℠ Level of Assistance scores in the supportive, intermediate and challenging bathrooms.



Plotting average Level of Effort and Level of Assistance scores for the 24 subjects in all three bathrooms (see Figure 15) clearly shows the effects of environment not only on the effort required from the individual but also on the assistance required from the caregiver as they moved from the supportive to the intermediate to the challenging bathrooms.

FIGURE 15

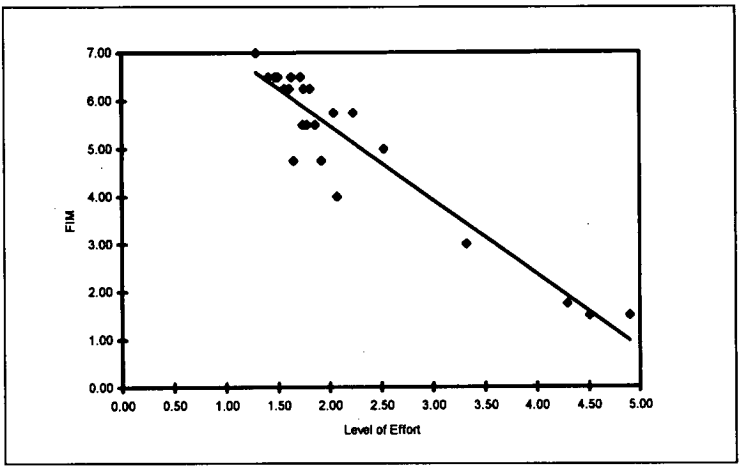
Mean FPM℠ Level of Effort and Level of Assistance scores in the supportive, intermediate and challenging bathrooms.



Plotting the mean Level of Effort scores for all grooming, toileting and bathing tasks performed by the 24 subjects against their FIM℠ scores for these activities in the challenging bathroom (see Figure 16) shows a remarkably strong inverse relationship. As expected, the lower the subject's FIM℠ score the higher the Level of Effort required to perform the tasks.

FIGURE 16

Mean FPM℠ Level of Effort scores and FIM℠ scores.



UTILITY OF OUTCOME MEASURES

The initial motivation for the development, testing and refinement of these three measures was to tap into information about environmental influences on the individual's functional independence and performance that the FIM℠ theoretically ignores.

The Usability Rating Scale enables examination of subjects' perceptions of the relative ease or difficulty of performing selected activities of daily living in different physical environmental contexts — thereby demonstrating how perceptions of ease or difficulty can be influenced not only by the individual's functional capabilities but also by prior experiences, expectations, etc. The URS℠ also enjoys the advantages of most such survey instruments — i.e., low costs of administration compared to the FIM℠. And when used to assess the perceptions of individual subjects, the URS enables measurement of individual differences which may be significant correlates of subsequent functional independence and performance.

The Environmental Functional Independence Measure provides a means for evaluating design artifacts in terms of their impact on the functional independence of an individual or a group (e.g., assessing effects of alternative door configurations on the functional independence of wheelchair users). The Enviro-FIM℠ also enables a global assessment of fit between subjects and designed physical environments. This outcome measure provides a means for determining if a mismatch exists between an environment's demand character and a subject's mastery level.

The Functional Performance Measure provides direct measurement of caregiver burden through its Level of Assistance scale and, thereby, a means of assessing how that burden is affected by changes in a specific environment's demand character. The

FPM℠ also permits the identification of specific design characteristics in physical environments responsible for problematic activity performance by either individuals or groups. Consequently, the FPM℠ can be used to identify needed design changes in specific task environments that will improve subsequent task (and therefore activity) performance — i.e., enabling one to fine-tune designed environments to facilitate specific outcome changes in the functional independence and performance of either individuals or groups.

A quick demonstration of how these measures are employed to these ends would perhaps be helpful. Table 3 shows average URS℠ and Enviro-FIM℠ scores for door use in each of the three bathrooms. Door configurations encountered while entering and exiting the supportive bathroom (doors D1E2 and D4E1 respectively) are clearly perceived as being easy to use by the 24 subjects. The mean Enviro-FIM℠ scores also substantiate this. In contrast, the door configuration characteristics encountered while entering and exiting the challenging bathroom (i.e., doors D9DI1 and D12DI2 respectively) are just as clearly perceived as being more difficult to use. And again, Enviro-FIM scores substantiate this with overall mean scores for functional independence during door use that are barely above the level (even with the walking aid users' much higher scores included) where help would typically be required. Clearly, the wheelchair users are disabled by the demand character present in these door configurations.

TABLE 3

Utility of URS℠ and Enviro-FIM℠ for identifying problems.

DOOR	APPROACH & SWING	DEMAND	ENVIRO-FIM	URS
D1E2	Enter & Out	supportive	7.83	2.38
D4E1	Exit & Out	supportive	8.08	2.83
D5M1	Enter & In	Intermediate	7.04	0.88
D8M2	Exit & In	Intermediate	7.67	1.19
D9DI1	Enter & In	challenging	6.04	-0.40
D12DI2	Exit & In	challenging	6.04	-0.04

Enviro-FIM℠ Scale: 1 to 10, 10= complete independence
URS℠ Scale: -3 to +3, +3 = very easy

Comparing the FPM's average Level of Effort and Level of Assistance scores (see Table 4) on the first of the two door configurations for the challenging bathroom (door D9DI1 — entering the difficult bathroom) for wheelchair users and walking aid users quickly enables us to zero in on the specific door use activity tasks that are the causes of the problems indicated by the URS and Enviro-FIM℠ scores. Maneuvering to close

the door and then actually closing the door after entering the room are tasks that the wheelchair users (but not the walking aid users) found virtually impossible to perform (recall that a Level of Effort score of 3 means 'maximum effort' was required and a Level of Effort score of 4 means that task performance was "impossible" even with maximum effort).

By next examining the design characteristics of the challenging bathroom (return to Figure 2) that are relevant to entering, it becomes readily apparent that two specific design characteristics have combined to disable the wheelchair users. The 'open floor space' inside the bathroom is only 15 square feet and the door's interior projection of 32" sweeps into the bathroom and across large portions of that 15 square feet when opened. This combination leaves insufficient space for the wheelchair to get out of the way so that the door can be closed once the person is inside the bathroom.

TABLE 4

Utility of FPM℠ Level of Effort and Level of Assistance scores for identifying causes of problems.

DOOR NO. D9DI1	LEVEL OF EFFORT			LEVEL OF ASSISTANCE		
TASK	Wheelchair	Walking Aid	Total	Wheelchair	Walking Aid	Total
Approach	1.33	1.25	1.29	0.00	0.00	0.00
Opening maneuver	1.00	1.42	1.21	0.00	0.00	0.00
Latch use	1.58	1.25	1.42	0.25	0.00	0.13
Opening	2.42	1.83	3.13	0.00	0.00	0.00
Through passage	2.17	1.83	2.00	0.00	0.00	0.00
Closing maneuver	3.67	1.86	2.77	2.25	0.00	1.13
Closing	4.25	1.86	3.06	2.58	0.29	1.44

Level of Effort: 0 to 6, 0 = no effort required
Level of Assistance: 0 to 6, 0 = no assistance required

ENVIRONMENTAL DESIGN AS ENABLING TECHNOLOGY

Most of the time people perform the way the environment demands and when they are no longer capable of such performance the environment disables them. Confronted by environments demanding the same capabilities they possessed when they were young, aging people can become increasingly disabled by those environments as the concomitants of aging begin to manifest themselves. With age comes impairment; with impairment comes disability; and with disability comes burden — which society has been required to bear. Historically, that is the way it has always been.

The sheer magnitude of the burden that will arrive with the graying of the baby boom generation is driving society to look to technology to save us all from drowning under the rising tide of impairments that the age wave will deliver. Contemporary transactional models of person-behaviour-environment relations point to environmental design as the technology with the requisite answers for our aging society. Because most of the time people do indeed perform the way the environment demands, the answers must, of necessity, come from those who design that environment. They must do more than manipulate space; they must manage person-behaviour-environment transactions to ensure appropriate outcomes.

This shift in focus represents a major paradigm shift in environmental design. Suddenly environmental design artifacts must be means rather than just ends — i.e., they must be tools for facilitating appropriate person-behaviour-environment fit for an aging society. This pressure is pushing environmental design to reinvent itself as an enabling technology — an enabling technology whose application must, for the good of society, be able to guarantee not only that its design artifacts will not prey upon the impairments of aging people but also that its design artifacts will facilitate functional independence and performance of aging people even in the face of their declining capabilities.

Toward these ends, the Center for Inclusive Design and Environmental Access at the State University of New York at Buffalo has developed, tested and refined a first generation of outcome measures designed to position environmental design to make such guarantees. These outcome measures will be used to validate existing design standards and to develop new ones by assessing those standards' actual benefits to their targeted populations relative to their costs. These measures will be used to ascertain which design standards to employ with aging people on an individual case-by-case basis; benefits will be maximized by avoiding the design of both overly challenging and overly supportive environments. These measures will be used to show how environments can be designed not only to maintain but also to restore and even extend the functional independence and performance of aging populations. These measures will be used to focus attention on the consequences of relying upon precedent, hunch and intuition rather than inquiry, analysis and problem-solving as the bases for designing enabling environments for an aging society. These measures will be the enablers of the enabling technology that environmental design must, of necessity, become.

IN CONCLUSION

Impairments are natural and inevitable concomitants of aging; disabilities are not. Human capabilities naturally and necessarily decline as we grow old; human performance need not. Environmental design is the enabling technology best positioned to ensure these preferred outcomes.

REFERENCES

Altman, I. & Rogoff, B. (1987). World views in psychology: Trait, interactional, organismic and transactional perspectives. In D. Stokols & I. Altman (Eds.), *Handbook of Environmental Psychology, Volume 1* (pp. 7-40). New York: John Wiley & Sons.

Bandura, A. (1978). The self system in reciprocal determinism. *American Psychologist, 33*(4), 344-358.

Brickell, K. & Bishop, J. (1995). NOAA/Industry cooperative activities in marine technology. *Marine Technology Society Journal, 29*, 35-38.

Carp. F. (1976). Some components of disengagement. In B. Bell (Ed.), *Contemporary Social Gerontology: Significant Developments in the Field of Aging* (pp. 37-42). Springfield, IL: Charles C. Thomas.

Cronberg, T. (1975). *Performance Requirements for Building — A Study Based on User Activities*. Sweden: Swedish Council for Building Research.

Cumming, E. & Henry, W. (1961). *Growing Old*. New York: Basic Books.

Danford, S. (1978). Managing the person-environment interface. In S. Weidemann & J. Anderson (Eds.), *Priorities for Environmental Design Research, Part 1* (pp. 10-13). Washington, DC: Environmental Design Research Association, Inc.

Danford, S. (1982). Therapeutic design for the aging. In A. Horton (Ed.), *Mental Health Interventions for the Aging* (pp. 155-171). New York: Praeger Publishers.

Danford, S. (1983). Dynamic Reciprocal Determinism: A synthetic transactional model of person-behaviour-environment relations. In D. Amedeo, J. Griffin & J. Potter (Eds.), *EDRA 14: Proceedings of the Fourteenth International Conference of the Environmental Design Research Association* (pp. 19-28). Lincoln, NE: Environmental Design Research Association, Inc.

Danford, S. (1985). The reciprocal roles of settings and behaviour. In R. Johnson, D. Bershader & L. Leifer (Eds.), *Autonomy and the Human Element in Space* (pp. 60-70). Washington, DC: National Aeronautics and Space Administration.

Dychtwald K. & Flower J. (1989). *Age Wave: the challenges and opportunities of an aging North America*. Los Angeles: J.P. Tarcher, Inc.

Fisher, J., Bell, P. & Baum, A. (1984). *Environmental Psychology*. New York: Holt, Rinehart and Winston.

Granger, C., Hamilton, B., Keith, R., Zielezny, M. & Sherman, F. (1986). Advances in functional assessment for medical rehabilitation. *Topics in Geriatric Rehabilitation, 1*(3), 59-74.

Gutheil, I. (1996). The many faces of aging: Challenges for the future. *Gerontologist, 36*(1), 13-14.

Hudson, R. (1996). The changing face of aging politics. *Gerontologist. 36*(1), 33-35.

Lewin, K. (1951). *Field Theory in Social Science*. New York: Harper and Row.

Mead, G. (1934). *Mind, Self and Society*. Chicago: University of Chicago Press.

Miller, C. (1996). Boomers come of old age. *Marketing News. 30*(2), 1 & 6.

Moore, G. (1976). Theory and research on the development of environmental knowing. In G. Moore & R. Golledge (Eds.), *Environmental Knowing: Theories, Research, and Methods* (pp. 138-164). Stroudsburg, PA: Dowden, Hutchinson & Ross, Inc.

Moos, R. (1975). Synthesizing major perspectives on environmental impact: a social ecological approach. In B. Honikman (Ed.), *Responding to Social Change* (pp. 211-222). Stroudsburg, PA: Dowden, Hutchinson & Ross, Inc.

Murray, H. (1938). *Explorations in Personality.* New York: Oxford.

Nahemow, L. & Lawton, M. (1973). Toward an ecological theory of adaptation and aging. In W. Preiser (Ed.), *Environmental Design Research, Volume 1* (pp. 24-32). Stroudsburg, PA: Dowden, Hutchinson & Ross, Inc.

Pitrella, F. & Kappler, W. (1988). *Identification and Evaluation of Scale Design Principles in the Development of the Extend Range Sequential Judgment Scale.* Wachtberg, Germany: Research Institute for Human Engineering.

Pool, R. (1991). Research commercialization: SBIR is good business. *Nature, 353,* 488.

Rubin, A. & Elder, J. (1980). *Building for People: Behavioural Research Approaches and Directions.* Washington DC: National Bureau of Standards.

Stokols, D. (1981). Group x place transactions: Some neglected issues in psychological research on setting. In D. Magnusson (Ed.), *Toward a Psychology of Situations: An Interactional Perspective* (pp. 393-415). Hillsdale, NJ: Erlbaum.

Stokols, D. (1987). Conceptual strategies of environmental psychology. In D. Stokols & I. Altman (Eds.), *Handbook of Environmental Psychology, Volume 1* (pp. 41-70). New York: John Wiley & Sons.

Tallmer, M. & Kutner, B. (1976). Disengagement and the stresses of aging. In B. Bell (Ed.), *Contemporary Social Gerontology: Significant Developments in the Field of Aging* (pp. 43-50). Springfield, IL: Charles C. Thomas.

Wandersman, A., Murday, D., & Wadsworth, J. (1979). The environment-behaviour-person relationship: Implications for research. In A. Seidel & S. Danford (Eds.) *Environmental Design: Research, Theory and Application* (pp. 162-174). Washington, DC: Environmental Design Research Association, Inc.

Wicker, A. (1974). Processes which mediate behaviour-environment congruence. In R. Moos & P. Insel (Eds.), *Issues in Social Ecology: Human Milieus* (pp. 598-615). Palo Alto, CA: National Press Books.

CHAPTER 7

STAIR SAFETY AND ACCESSIBILITY: STANDARDS DEVELOPMENT IN THE BUILDING AND HOUSING INDUSTRY

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INTRODUCTION

Movement difficulties often accompany aging. For example, there are difficulties related to balance, vision and hand grasp to name only three of particular relevance to stair usability and safety, the prime focus of this chapter. Readily appreciated are the demographic changes that will increase the proportion of the population facing these difficulties. Not so widely known are the failures of the building and housing industry to adequately address the environmental aspects of the problems posed by movement difficulties, especially the serious problem of injurious falls.

There are, using the terminology of building codes and standards, two basic problems: first, accessibility or barrier-free design and, secondly, safety — specifically, environmental intervention to prevent injuries. The former is increasingly addressed under the labels 'usability' or 'universal design' (essentially, design for everyone) although the regulatory community has not begun to use the term 'universal design' to the extent that it has caught on in academic circles.[1]

Fortunately, there is substantial congruence between universal design and environmental intervention to prevent injuries. In other words, safety is — or at least, should be — an intrinsic aspect of universal design, a theme running through this chapter. Moreover, in considering safety benefits and costs in relation to stairs, we need to keep in mind that there can be, for any one stair, many hundreds of thousands of improved, injury-free stair uses. To place the potential benefits in perspective, it should be noted that Archea, Collins and Stahl (1979) estimated the average daily use of stairs

[1] One indication of the movement to universal design in education of designers is the recent book *Strategies for Teaching Universal Design* (Welch, 1995).

in the U.S. to be at 20 to 25 flight uses per person. This puts stair improvements into a totally different category from other building code required improvements such as systems for smoke detection and fire suppression that serve only in a rare fire condition.

Beginning about 1985, there were indications of a major shift in emphasis for U.S. national model building codes which, when adopted locally, set requirements for building design and use. For example, partly in response to growing concern about the costs and other impacts of injuries, increased attention was given to movement (circulation) safety. This was a shift from a traditional focus on circulation efficiency or rapid egress in case of emergency, especially fire.[2] If followed through, this shift should have had particular influence on the design of dwelling units, the site of most fall-related injuries. However the shift has been, from the beginning, strenuously resisted by the home building industry.

It is only since about 1993 that there has been a concerted effort, by one U.S. model code organisation, to go beyond traditional capitulation to the home building industry on matters of dwelling unit design affecting movement safety. While the initial arguments for improved dwelling design to reduce risk of falls came mainly from a very small number of research-oriented individuals, there began to be more pressure from the building regulatory community which increasingly challenged traditional, reactionary arguments from home builders — arguments that almost invariably blamed fall victims for their injuries while exaggerating cost impacts for making improvements in dwelling unit design to enhance both safety and usability.

Notably these developments occurred in the U.S. In Canada, although since 1947 the national model building code development process has been the responsibility of the publicly-funded National Research Council (NRCC), home builders continued to dominate what little debate was even permitted on the issue of improved dwelling unit design. This is especially ironic because, from about 1970 to 1987, NRCC supported world-class research on movement of people in and around buildings and collaborated closely with leading researchers such as John Archea and John Templer in the U.S. and others overseas (Pauls, 1985). NRCC committees and staff responsible for the *National Building Code of Canada*, unlike their counterparts in at least one privately-funded U.S. model code organisation (the Building Officials and Code Administrators International — BOCA), have resisted for at least 15 years some changes to stair design that were made in a fraction of that time in the U.S. Having paid for world-class research, Canadian buyers have not benefited to the same extent as their U.S. counterparts when it comes to improved usability and safety of stairs. Because buildings built during the last decades will be in use for many decades to come, and because key aspects of stair construction cannot be easily retrofitted, the huge social costs of the regulatory failures will continue well into the future.

[2] If compared to fall injuries on stairs, civilian fire-related injuries are a numerically much smaller problem. In the U.S. stairs are associated with about 35 times as many injuries as are fires.

THE INJURY TOLL AND ITS COSTS

Falls

Epidemiological data, such as those presented by Baker, O'Neill, Ginsburg and Guohua (1992), identify falls as a major injury problem. In the U.S., as in some other countries, falls are the leading cause of *nonfatal* injuries (exceeding those related to motor vehicles) and the second leading cause of spinal cord and brain injuries. Each year at least one person in 20 receives emergency room treatment because of a fall; this totals to over 12 million a year in the U.S. After motor vehicle incidents, falls are the second leading cause of fatal injuries.

For people aged 75 years and older, falls are the leading cause of fatal injuries (and the sixth leading cause of death), accounting for twice as many deaths as motor vehicle incidents. In the U.S. in 1986, among persons aged 65 and over, fall fatalities totaled 8,319, while motor vehicle fatalities totaled 6,457 (National Safety Council, 1989). Baker, O'Neill, Ginsburg and Guohua (1992) report that there were 254,000 hip fractures leading to hospital admission in 1988 in the U.S., each resulting in an average hospital stay of over 13 days. They note:

> *These figures exclude the many days of nursing home care and do not convey the tragic changes in life style and loss of independence that commonly ensue (p. 134).*

It should also be noted that disabilities from falls or the fear of falls are a leading reason for seeking permanent nursing home care.

Falls Involving Stairs

Stairs are the leading site for serious falls and account for about one-third of the fatal falls for which a site is recorded. When exposure or extent of usage is taken into account, stairs are clearly a relatively hazardous environmental feature. For example, although we tend to spend much more time standing and walking on floors than on stairs, more injuries treated in hospital emergency rooms involve stairs than floors. While the absolute number of serious fall injuries by the elderly is about one and a half times greater for floors than for stairs, when the reduced exposure of the elderly is factored in, stairs are more dangerous. Recent National Electronic Injury Surveillance System (NEISS) data on nonfatal and fatal injuries reported by the U.S. Consumer Product Safety Commission (CPSC, 1995) as involving (but not necessarily attributed to) stairs, reveal that stairs were involved in an estimated one million hospital emergency room treated injuries in 1994. In fact, stairs are the leading product category for injuries covered by the NEISS data.

Relative Risks

Although the data need to be interpreted with caution because of inadequate statistics on injury occurrence and relative severity, an attempt has been made in Table 1 to provide a rough indication of the relative risks of various injury-causing events.

TABLE 1

Approximate relative chance of injury from various events.

Structural collapse	1
Burns generally & fire injuries	1,500[1]
Falls on stairs	2,000
Motor vehicle incidents	5,000
Falls generally	12,000
Walking mishaps generally	14,000
All causes	57,000

[1] Small minority to civilians in structural fires

Cost of Injuries

Table 2 presents an overview of injuries from all causes in 1985 as reported in *Cost of Injury in the United States*, a report to the U.S. Congress (Rice et al., 1989). As can be seen, during 1985, injuries occurred to 57 million people and the total lifetime cost of these injuries was $158 billion in 1985 dollars (post-1985 costs are converted to 1985 dollars using a 6% discount rate).

Table 2 is based on what is called the *human capital approach* which values productivity lost or reduced due to injury. For example, on average, injury deaths represented 36 years of life lost per death and a productivity loss of over $300,000 per death. Almost three-fourths of this is cost incurred in 1985 for the injuries occurring in 1985, with the remainder incurred in subsequent years. Note that the human capital approach does not assign costs to pain, suffering, and reduced quality of life as would be the case with the cost estimation method called the *willingness-to-pay approach.* It simply measures costs at market values. For example, for injuries causing a person's death, the method calculates the amount of income that person would have otherwise earned over his or her lifetime. Thus it undervalues the lives of some people earning low wages.

Because of rising costs, the lifetime cost of injuries incurred in 1985 had risen to $180 billion by 1988 based on the 6% discount rate and using the human capital approach. An update put the cost of injuries occurring in 1990, in the U.S., at over $205 billion. Of this, about $50 billion was due to falls.

In the early 1990s, persons aged 65 and over comprised 12% of the population but accounted for 22% of hospitalizations due to injury and 56% of hospitalizations due to stair-related injuries. By 2050, persons aged 65 and over will comprise 23% of the population but account for 38% of hospitalizations due to injury.

TABLE 2

Number of injuries sustained in 1985 in the U.S. and their total lifetime costs (in 1985 dollars).

CAUSES	FATAL INJURIES	HOSPITALIZED INJURIES	NON-HOSPITALIZED INJURIES	LIFETIME COSTS (BILLION $)
Motor vehicles	45,923	523,028	4,803,000	$48.7
Falls	12,866	783,357	11,493,000	$37.3
Firearms	31,556	65,129	171,000	$14.4
Poisonings	11,894	218,554	1,472,000	$8.5
Fires/burns	5,671	54,397	1,403,000	$3.8
Drownings	6,171	5,564	26,000	$2.5
All others	28,487	696,707	35,001,000	$42.4
Total injuries	2,568[1]	2,346,736	54,369,000	
Lifetime cost (billion)	$49.4	$80.0	$28.2	$157.6
Percent of total cost	31%	51%	18%	100%

[1]An additional 13,097 deaths occurred in later years due to injuries sustained in 1985.

Role of Litigation

Rice et al. (1989) note, in the *Cost of Injury in the United States*, that:

> *The cost of injury goes far beyond initial medical treatment and includes housing, disability-related equipment, long-term rehabilitation, education, and vocational training. For most individuals, the ability to financially survive a catastrophic injury depends on winning a large legal settlement in addition to having good private insurance coverage (p./ii).*

Litigation could play a larger, multifaceted role in the injury field. First and as noted above, it is a means of obtaining badly needed compensatory damages. Secondly, it can make the problem areas more public and encourage prevention or mitigation. Thirdly, and this is the least utilized of its roles, it can serve as an input to the revision of codes and standards, providing detailed technical information about specific environmental factors contributing to injury occurrence and severity. Related to this third role, expert witnesses could use income from litigation work to support their time-consuming, costly participation in codes and standards hearings — something which (aside from

the author's pattern of doing so) is rarely done. Since litigation currently plays only a small role in injuries occurring in the home, insights from litigation will be largely based upon, and will influence, design and management of public settings.

INJURIES RELATED TO RESIDENTIAL STAIRS

Costs

Residential stairs are the site of the vast majority (about 85%) of injurious falls on stairs. This should not come as a big surprise. After all, stairs in dwelling units are typically designed, constructed and maintained to significantly lower standards than those applying to stairs elsewhere. Yet residential stairs are used very extensively and under the most difficult of conditions by people with the widest range of capabilities. The bottom line is that, currently in the U.S., the conservatively estimated annual cost of injuries related to home stairs exceeds the annual construction cost of such stairs by a factor of at least two. For 1990 the annual cost of U.S. home stair injuries was estimated (by the author) at about $10 billion or just about one-fifth of the $50 billion cost of all fall injuries. The estimated cost of home stair construction for the same year was under $5 billion. With its double-digit percentage increases during some recent years, U.S. health care costs are rising twice as fast (or more) relative to construction costs. The ratio of stair injury costs to construction costs could increase to 3:1 before the end of the century because of the advancing average age of the U.S. population.

What is Wrong with Stairs in Homes?

Generally, home stairs are more likely than other stairs to encourage a misstep and a fall. Moreover, home stairs are less likely than other stairs to facilitate a recovery from a misstep or fall. In other words, they are more likely to cause 'architecturally-triggered human error' or 'environmentally-triggered human error' and they will often be 'unforgiving' of such 'errors' (Archea, 1985; Archea, Collins & Stahl, 1979; Templer, 1974; Templer, Archea & Cohen, 1985; Templer et al., 1989).

Pauls' (1982, 1984, 1991a,b,c), building on the work of Archea, of Templer and of Alessi et al. (1978), has provided detailed criticisms of stair features implicated in falls and has recommended solutions for design and retrofit. Stated succinctly, most stairs in homes fail to meet at least two of the three most basic criteria for successful, injury-free stair use:

1. The steps must be clearly seen (a function of stair surfaces as well as its surroundings),
2. The risers and treads must fit human gait and provide secure footing, and
3. Functional handrails must be within reach.

Given the large role of the environment in falls involving stairs, we must understand that 'architectural-triggered human error' is not the fault of the victim.

Stair Riser-Tread Geometry Requirements in Codes

Since 1985 there has been a recurring debate within U.S. model building code organisations about the need for stairs within dwelling units to be designed and constructed to the same riser-tread geometry rules as apply to other stairs. An early version of the debate — between Pauls and a representative of the National Association of Home Builders (NAHB) — was titled *The '7-11' Stair Story: Should it be Required in Residential Construction?* (Dacquisto & Pauls, 1985). The debate has been most intensive within BOCA in relation to the National Building Code. In 1991, BOCA's membership vote sustained the recommendations of its code change committee and approved the deletion of an exception to the so-called *'7-11'* step geometry requirement. This exception permitted dwelling units to have stairs with maximum riser heights of 8.25 inches (210 mm) and minimum tread depths of 9 inches (229 mm) rather than the generally required maximum riser height of 7 inches (178 mm) and minimum tread depth of 11 inches (279 mm), the minimum-standard geometry commonly referred to as '7-11.' In 1992, the NAHB mounted a political campaign to roll back the change; it succeeded in September 1992; however, within a few months the president of BOCA set up an Ad Hoc Committee on Stairway Safety which held six days of public hearings during the first half of 1993. Although the committee membership was heavily weighted with home builders — four builders versus one person with a research/safety background plus several building officials, an architect and an engineer — it narrowly recommended that BOCA adopt an intermediate step geometry requirement for dwellings.

In 1994 the BOCA membership narrowly approved the intermediate requirement — with riser heights no higher than 7.75 inches (197 mm) and tread depths of at least 10 inches (254 mm). The same proposal was submitted to the Committee responsible for the national model code for dwellings, the CABO *One and Two Family Dwelling Code*, and it was again narrowly approved.

In 1995, in another major campaign to turn back even this compromise requirement, the home builders failed. In what amounted to a strong rejection of the flawed arguments about cost impacts and 'affordable housing' and the political pressures used by the home builders, the vote by the BOCA membership in September, 1995 was overwhelming in favor of improved dwelling-unit step geometry requirements (albeit not quite as good as required for other buildings). Thus at this time there is finally a nationally recommended, but not yet nationally adopted model code requirement in the U.S. for somewhat improved step geometry requirements for dwellings.

The latest edition — 1995 — of the *National Building Code of Canada*, for the first time, requires the '7-11' stair, i.e., with 11-inch (280 mm) treads, for larger buildings — not dwellings. In new dwellings, tread depths of only 8.25 inches (210 mm) are still permitted. In what amounts to an immense disservice to Canadians, the NRCC committee responsible for dwellings — in Part 9 of the Code — bowed to pressures

from home builders on the committee and refused to budge on its traditional thinking or even to allow the proponent of the improved step geometry to testify fairly during committee deliberations held in 1993. Ironically those deliberations were held within a few metres distance of the author's former NRCC office where much of the Canadian research on stair safety had been managed during the 1970s and within the same city — Ottawa — where other less extensive but still notable research was done on the central issue of step size and human gait (i.e., work by Lockwood & Braaksma, 1990).

Adaptation to Undersized Treads

There is a common adaptation which stair users unconsciously employ, especially with undersized stairs which they typically characterize as 'steep.' This is to twist the feet (sometimes the entire body) to the side in what is called a 'crab-like gait.' Although this helps to get adequate footing on undersized treads, it might cause other difficulties in the otherwise unnatural and awkward gait which results. This is because one has to continually step over ones feet. Almost completely uninvestigated is the phenomenon of *preferred direction* of body or foot twist, an adaptation that has important implications for handrail location (on right or left side) as well as handrail height.

Dimensional Uniformity of Steps

Perhaps the most potent of geometric factors responsible for many falls is dimensional nonuniformity (Jackson & Cohen, 1995; Templer, 1992). Riser heights and tread depths need to be fairly consistent from one step to the next because users typically make unconscious, automatic measurements of step dimensions within the first few steps of a flight. Any significant departure from these critical perceptions can readily trigger a misstep, for example with a foot being placed where a step nosing is expected but finding the nosing set an inch or so back from where it should be. This sets one up for what is the most common single stair fall scenario ending in injury, that of an overstepping fall in descent (Alessi et al., 1978). Reasonable, code-mandated limits on nonuniformity relate fairly well with what is suggested by research, i.e. that nonuniformities should not exceed 3/16 inch (5 mm) between adjacent treads and adjacent risers. Unfortunately, home builders and code inspectors have not respected these limits very well; typical dimensional nonuniformities on new home stairs are often close to 1 inch (25 mm), about five times greater than the code-permitted limit (Pauls, 1992).

The most common consistent nonuniformity occurs at the top of stair flights where the floor-level nosing does not project as do the tread nosings below it; the result is that all the treads below the first one are relatively undersized — thereby increasing the chance of an overstepping misstep in descent, the most common injurious-fall scenario. Field observations suggest that one's risk of misstepping is increased by orders of magnitude, e.g., a hundred or a thousand times beyond what would otherwise be the case when there is a significant dimensional nonuniformity.

Carpeting of Stairs

Thick, soft carpet installations — especially with resilient undercushion — might be thought to make the stair more 'forgiving,' or impact absorbing, if one falls and hits the stair steps, a proposition extensively explored by Templer (1992) and Templer, Boulet, Hanagud and Hyde (1989). Maki, Holden and Fernie (1986) also examined the impact attenuation, for simulated hips and hands, on floor coverings. However, because thick coverings make it more difficult to get a firm footing — partly because the effective tread depth is reduced by the same amount as the thickness of the carpet and undercushion *plus any movement over time of the carpet away from the nosings*, one is more prone to fall on carpeted stairs. Thus, a common first recommendation by the author, to someone wishing to make an existing stair as safe as possible, is to remove the carpet and cushioning in order to maximize the typically sub-minimal tread depth. For example, on many Canadian home stairs, typical thick carpet treatments reduce effective tread depths to about 7 inches (180 mm) when the stair is new and as little as 6 inches (150 mm) if the carpet stretches or shifts forward, away from the critically important step nosings. The adaptation of crab-like gait, described above, will be especially pronounced on such stairs.

Opposition to Improved Stairs Based on Cost and 'Affordable Housing'

Throughout the debate on improved step geometry requirements in model codes, the home building industry argument has been that the cost of providing improved stairs is very large. Their estimates range, for the '7-11' step geometry, from $1,500 dollars per dwelling to a purported figure of $20,000 which is based on adding the maximum flight length increase (under 5 feet or 1525 mm) across the entire width of the house, resulting in an area increase of about 150 square feet (14 square metres) per dwelling and fewer dwellings on a given plot of land. Industry representatives typically do not address the benefits (in monetary terms or otherwise) of better stairs. The home builders' inflated cost arguments have continued unabated even though the intermediate step geometry they were opposing (and which two model codes adopted in 1995) takes up only 0.17% more of dwelling unit area than the step geometry requirements (with 9-inch, 230 mm, tread depths) which they had been advocating in public hearings in 1994.

Arguments Based on Dwelling Floor Areas

Between 1973 and 1993, new homes in the U.S. increased in size from an average of 1,555 square feet (145 square metres) to 2,100 square feet (195 square metres), according to the NAHB. This average increase of 545 square feet (51 square metres) represents a 35% increase over the 1973 figure. The increase that will result from the code change in 1995 is only 1 to 4 square feet (0.1 to 0.4 square metres) per floor of the dwelling; in other words, a minimal effect on dwelling size and layout in comparison to what the industry has done since 1973 — *with no improvement of stairs.*

The relatively large dwelling areas available per person in the U.S. should itself be noted. The average household size in the U.S. in 1990 was about 2.6 persons. According to data from the World Bank and the United Nations (reported in *The Washington Post*, November 6, 1993) the average dwelling unit area per person in the U.S. was 742 square feet (69 square metres) — the highest in the world. The next high-ranking country, Australia, had 549 square feet (51 square metres) per person. Norway, Canada and Sweden were the next high-ranking countries.

In relation to elderly persons, based on an analysis of U.S. Census Data, Roberts (1993) notes that:

> *. . . among elderly householders, 76 percent owned their own homes, which have a median size of 1,575 square feet (146 square metres), or 965 square feet (90 square metres) per person. . . . For most, the home in which they live is the only one they had ever owned. Their homes are smaller than those of owners overall, but poor people who owned their own homes were less likely to bump into each other: They had 713 square feet (66 square metres) per person compared to 688 (64 square metres) for all households; reflecting, perhaps, the high proportion of poor homeowners who are elderly and preside over depleted households (p. 157).*

Need for Improved Stairs

Clearly, the home building industry's reference to 'affordable housing' can be partly countered with the argument that homes with inferior stairs — and resulting high injury costs as well as minimal usability — can hardly be termed 'affordable.' After all, affordability is a function of lifetime costs. According to a survey by the American Association of Retired Persons (1993) about 85% of people over 55 years of age wish to stay in their homes and never move. The same survey indicated that inability to use the stairs in their homes ranks as one of four chief usability problems faced by respondents. Today, stairs in new homes are typically no better, and often are worse than stairs in homes built earlier this century.

Unlike most other major hazards we deal with, such as fatalities from fires, motor-vehicle crashes and commercial aircraft crashes, an examination of CPSC/NEISS statistics suggests that the toll from stair-related injuries in the U.S. has grown dramatically — averaging about 3% per year at a time (1975-1992) when the population grew by only 1% per year and fire-related deaths decreased by an average of 3% per year. Costs of stair-related injuries are rising at an even greater rate and, in 1995, are roughly estimated to exceed $15 billion each year in the U.S. Most of this is from home stair falls.

RAILINGS FOR STAIRS

Handrails are our only 'safety net' when a misstep occurs on a stair. The number of faulty/missing handrail-related, injurious falls are estimated to exceed the number of

fire-related injuries in buildings. Handrails serve other important functions, especially for elderly users. These functions include indicating where the stair flight begins and ends as well as providing support to help maintain balance and to help pull oneself upwards. Unlike the situation for step geometry, functional handrails generally cost much less than the mainly decorative railing systems typically installed on home stairs. Often, the more money one spends on a stair railing, the worse it will be in functional or ergonomic terms. This is largely because the more expensive railings tend to be oversized and awkwardly shaped. That is, they provide poor graspability.

Graspability of Handrails

Taking their lead partly from two U.S. national standards (ANSI/NFPA 101, the *Life Safety Code*, and CABO/ANSI A117.1, *American National Standard for Accessible and Usable Buildings and Facilities)*, most U.S. model building code organisations have attempted to 'mainstream' (their term for 'universal design') certain ergonomically-justified requirements for handrails, most notably handrail graspability. The limits on handrail size are based on biomechanical research (principally by Maki, 1985, as interpreted by Pauls, 1987, 1989, 1991c). Subsequently, in Canada, similar requirements were adopted for the 1995 edition of the *National Building Code* — ten years after Maki's *Canadian-funded* research on this was completed.

Graspability Research and Requirements

Maki's studies were performed with younger and older adults; however the sample of older adults did not include those with arthritis. Translated into enforceable language of building codes, the geometry-based requirement — to permit a power grip as opposed to a pinch grip — is at the upper end of the permitted size range, a maximum perimeter dimension of 6.25 inches (159 mm) and a maximum cross section dimension of 2.25 inches (57 mm). These permit the most useful circular sections as well as oval and (approximately) rectangular sections.

If these criteria were applied strictly, they would rule out for code-required handrails use of some traditional (e.g., colonial style) decorative or ornamental rails. Providing only an uncomfortable and largely ineffective pinch grip or hook grip, many of these decorative rails have dimensions even in the horizontal dimension exceeding 2.5 inches (64 mm) and maximum cross section and perimeter dimensions well in excess of the criteria. Even a relatively small example of such a decorative rail fared badly in Maki's biomechanical testing of forces and moments a person could exert with a stair railing as well as in his assessment of people's preferences in holding the rail. The decorative rail even generated avoidance responses.

Stairway Industry Opposition to Ergonomic Criteria for Handrails

Shortly after Maki completed his early studies of handrail height, shape and

graspability, a new industry organisation, the Stairway Manufacturers Association (SMA), was formed — apparently, in part, to defeat or weaken ergonomically-founded, model code requirements for handrail height and shape. Sharing with the National Association of Home Builders (NAHB) the goal of keeping code requirements for dwellings as lax as possible, the SMA has continually argued that very large, awkwardly-shaped, purportedly traditional sections provide 'equivalent graspability' or 'equivalent gripping surface.'

In 1995, the SMA commissioned a consulting engineering firm to conduct some tests to prove its case; the test was much less sophisticated than those performed ten years earlier by Maki in Canada and consisted of subjects simply pulling transversely on two railing sections using a hook grip. On the basis of this test they concluded that the most commonly used of the traditional shapes was equivalent in graspability to the largest code-permitted circular shape (with a 2-inch, 51 mm, diameter).

In addition to being difficult or impossible to grasp with a thumb-and-fingers power grip, many of the decorative stair railing systems marketed by members of the SMA as code-complying functional stair handrail and guardrail systems, have widely varying heights: e.g., 30 inches to 46 inches (760-1170 mm) *within a single stair flight* (because of the use of traditional fittings such as goosenecks and volutes or turnouts). Maki's work, as well as some less-formal field studies by Pauls, suggested strongly that the most appropriate handrail heights were in the range of 34 to 42 inches (864-1067 mm) (Maki, Bartlett & Fernie, 1984, 1985). Heights considered both more comfortable and functional are at about one's elbow height, an easy criterion for elderly persons to keep in mind when adding a handrail on a stair. Tragically, some widely used guidance materials illustrate stairs incorporating 'good' features but having handrail heights typically shown down at about 24-inch (600 mm) height, i.e., about 12 to 16 inches (300-400 mm) too low! This compounds the problem of convincing elderly persons that a higher railing is both more-preferred and safer. Appearances and long-held beliefs are difficult to change.

OTHER MAJOR POINTS OF DISAGREEMENT AMONG SAFETY EXPERTS, REGULATORS AND HOME BUILDERS

Two other controversial issues relate particularly to stair flights with only one or two (sometimes three) risers. These turn out to be among the most hazardous of stairs, yet home builders appear only too willing to build them and promote them as aesthetically important selling features in new homes, as with sunken living rooms and slightly elevated dining areas. Based on some very badly flawed reasoning, code authorities have traditionally permitted such designs and have compounded the error by exempting such stairs from handrail requirements. Thus, the stairs with the greatest incidents of missteps — often due to a person walking into or over an isolated single step — lack one of the most effective cues to the step's existence as well as the only 'safety net' if one needs to arrest a fall. (A very large portion of the author's litigation-

related work deals with such one-riser and two-riser stairs, usually in public settings — not because the falls only occur there, but because litigation is extremely rare after falls in dwellings.)

The serious problems posed by such steps must be dealt with by prohibiting their installation or, if they are absolutely necessary, by designing them with complete attention to the three most basic stair safety criteria noted above; i.e., step visibility, appropriate step dimensions, and handrails. The conclusions of the late John Archea, once the leading stair researcher, have special relevance to such stairs.

> *The key to stair safety lies not so much in the hazard itself as it does in the users' awareness of their vulnerability to it. . . . So long as the users know they are coming to a stair, where to place their feet on the treads, and where to grab if they should lose their balance momentarily, then they are most likely to make it to the top or bottom of the flight without an accident (cited in Asher, 1977, p. 29).*

Archea (1989) restates these principles as follows:

> *The user's awareness of a hazardous condition becomes as critical to successful stair use as the hazard itself. Visual distractions that draw a user's attention away from the stair and visual deceptions built into the design of the stair itself thus emerge as two of the leading causes of stair accidents (p. 2).*

Stairs with one or two risers are especially hazardous for older people who already have difficulty with depth perception as a result of normal aging.

The problems of limited elevation differences are not solved by simply replacing a step with a short ramp. Ramps also require attention to visibility and handrails, especially for elderly users who have more difficulty perceiving small slope differences and maintaining balance on ramps. (One can gain first-hand awareness of this by carefully watching older passengers walking down a typical, variably-ramped loading bridge to transfer from an airport terminal to an aircraft; it is a precarious trip.)

Of all the major standards and codes used in the U.S. and Canada, only the *Life Safety Code, ANSI/NFPA 101*, addresses such limited elevation differences reasonably well. Significantly, this is one issue addressed by the Ad Hoc Committee on Stairway Safety set up by BOCA in 1993; a helpful, but compromised revision resulted in the 1996 edition of the *BOCA National Building Code*. This calls for either step nosing marking or a handrail for such limited-elevation changes.

Step Visibility: Surfaces and Illumination

Until very recently, code requirements for illumination of stairs in homes were inadequate if indeed there were any requirements at all. Minimum lighting levels of about 10 foot-candles or 100 lux, preferably twice that, have been recommended in the Illuminating Engineering Society (IS) criteria but these have, until recently, not been required by building and housing codes.

Those taking a reactionary stance against such requirements in codes (e.g., the home builders and some regulatory officials) argue that such criteria are difficult to enforce. They argue in favor of some easy-to-apply criteria based on watts of lamp power; e.g., at least one 60-watt bulb per stair flight. Unfortunately, this is too simplistic an approach as it fails to address the increasingly wide range of illumination sources including high-output, low-energy lamps as well as the major effect of reflective wall and ceiling surfaces.

As this chapter was written, attempts are still being made by the author to have a set of simple criteria adopted in minimum requirements in the *CAB One and Two Family Dwelling Code*, a model code used widely in the U.S. (and soon to be renamed as an 'International Code' as the U.S. model code organisations agree to single model codes, a development slated to occur by the year 2000). The simple criteria would be for two fixtures to be installed for each stair, each capable of handling 150 watts of incandescent lamps or 30 watts of fluorescent lamps. Notably, no one has yet tackled the centrally important issue of relative light levels; that is, the stair should be no less well illuminated than the spaces surrounding the stair.

Codes do not deal well with difficult-to-quantify or impossible-to-quantify criteria. For example, very difficult is the challenge of addressing the nature of surfaces, including the prohibition of floor patterns that make it more difficult to visually discriminate the stair itself as well as the exact location of each step nosing, a special problem for aging eyes. Unfortunately, many home safety guides suggest sticking colored marking tape on some treads to make them more apparent. As well as being tacky (pun intended), these quickly come loose and create an even worse problem than the one initially addressed. A more-effective solution is paint; even on carpet a uniformly wide strip painted at the nosing of the tread and having suitable, consistent friction characteristics is more effective.

Preventing Slips

Given our woefully inadequate, commonly used language for falls — with over-reliance on the vague term 'accident' and on the expression "I must have slipped" — many falls are mischaracterized and thus no meaningful, effective measures are taken to prevent re-occurrence. For stairs, a simple yet effective criterion is that if the tread surfaces are suitable, in terms of slip-resistance, for level flooring, they are suitable for the treads. Given the highly constrained gait on stairs, a slip on a stair (as the initial part of a misstep) is much less likely than a slip on a level or ramped floor. Adding special (misnamed) 'nonslip' treatments to stairs in homes will almost certainly leave stairs as dangerous as before, often because relevant factors other than slip resistance are not examined and treated appropriately. Even worse, new hazards such as tripping on tape or metal nosing strips, make the stair even more dangerous.

On floors, a common problem is the use of small area rugs, scatter rugs and mats. Again, as with stairs, falls are often mischaracterized as slips. Some interventions, such

as addition of rubber pads under such rugs, will actually exacerbate the originally undiagnosed problem. That is, the rug or mat creates a tripping hazard. Some elderly persons tend, with time, to reduce the height of their swinging foot when walking. Shuffling becomes more pronounced and trips more likely. Small rugs should ideally be removed, not made thicker.

SOME CLOSING THOUGHTS

Comparing Dwellings and Automobiles

Unlike automobiles, stairs in homes are still built to outdated standards and with relatively crude construction methods. One could easily argue, for example, that if home builders were responsible for car design and construction, cars would still have narrow, wood-spoke wheels and other archaic, dangerous features of early automobiles. Moreover, these features would be marketed as valuable traditional design elements. In fact, over the last few decades, while automobiles have become safer and more user-friendly — with relatively good ergonomic design — newly constructed stairs in dwellings are often of lower quality and safety than those constructed several decades ago.

Attitudinal Impediments

An impediment often encountered in public hearings on code changes is that industry spokespersons talk mainly of costs without reference to the benefits of certain changes. We need to address benefit-cost issues in a more balanced, complete way; for example:

There are benefits consisting of . . .

When paying costs amounting to . . .

For implementing . . . .

Of course, determining costs and benefits in a balanced fashion is not easy; our knowledge is always limited and research funds are shrinking with government cutbacks in the U.S. and Canada. Not everything can be quantified. Notable in this regard are remarks by Carol Runyan (1993), Director of the University of North Carolina Injury Prevention Research Center:

> *There is more to understanding injury problems than epidemiology alone can deliver; the problems are complex, and such an understanding requires many different kinds of information, both quantitative and qualitative. . . . The world is not tidy. . . . We cannot wait for precise quantification before we attempt to collect and use the information available to us. . . . We must be clear [that] our quest for scientific purity does not divert attention from the epidemic (p. 637-638).*

While Machiavelli, in *The Prince*, was not thinking about building safety, usability

and regulations — specifically changes to codes and standards, his views on the difficulties of achieving change are relevant.

> *There is nothing more difficult and dangerous or more doubtful of success, than an attempt to introduce a new order of things in any state. For the innovator has for enemies all those who derived advantages from the old order of things while those who expect to be benefited by the new institutions will be but lukewarm defenders. This indifference arises in part from fear of their adversaries who were favored by the existing laws, and partly from the incredulity of men who have no faith in anything new that is not the result of well established experience. Hence, whenever the opponents of the new order of things have the opportunity to attack it, they will do it with the zeal of partisans, while the others defend it but feebly, so that it is dangerous to rely upon the latter (cited in Crocker, 1963, p. 22)*

Unfortunately, although the codes-revision process is supposed to provide a level playing field (especially as it is carried out in a very public fashion in the U.S.), participation is not always well balanced. Reactionary or traditional forces greatly outnumber newcomers or visitors who might have relevant personal insights or technical information about a relatively ignored safety issue on the code change agenda. The former often try to squelch a change with the line, "If it ain't broke, don't fix it." Too often, something is indeed 'broke' when this line is heard.

Importance of Participation in Code-development Process

The key to bringing change to codes — to bring about building features that are more usable, more forgiving of human error and less likely to disable elderly people — is to increase the diversity of participation in the process. This requires a long-term commitment and adequate resources; there are no short-cuts. A person (or an organisation) simply cannot be fully effective in the process of improving model codes and standards unless one (it) is at the very least present, visible, and heard at such hearings and meetings in which personality, perceived experience, and especially continuity of participation carry more weight than even a brilliantly executed, one-shot presentation. In other words, one has little likelihood of having a proposal accepted in a model code hearing unless one personally participates in presenting and defending the idea. Moreover, a person will fail to gain much support for a proposal if ones hearing participation is limited to coming in at the last moment and leaving immediately after the item is completed. The hours, if not days, of observing how the process works are an important investment if one wishes to become an effective player in this game. Somehow, professionals concerned with the well-being and safety of the elderly — *and elderly people speaking for themselves* — must become more active in the process of code development.

We have some distance to go before there is a widespread appreciation among builders and regulators of the importance of universal design, that is design that does not require any distinctions to be drawn between environmental needs of younger and

older adults. This chapter has presented some aspects of stair design that, if properly executed, serve everybody much better than is usually the case today.

REFERENCES

American Association of Retired Persons. (1993). *Understanding Senior Housing for the 1990's*. Washington, D.C.: American Association of Retired Persons.

Alessi, D., Brill, M. & associates (1978). *Home Safety Guidelines for Architects and Builders*. Gaithersburg, MD.: National Bureau of Standards (NBS-GCR 78-156).

Archea, J.C. (1985). Environmental factors associated with falls by the elderly. *Clinics in Geriatric Medicine* (Symposium on Falls in the Elderly: Biologic and Behavioral Aspects), *1*(3), 555-569.

Archea, J.C. (1989, September). Visual distractions and deceptions that can trigger falls on stairs. Paper presented at the First World Conference on Accident and Injury Prevention, Stockholm, Sweden.

Archea, J.C., Collins, B.L. & Stahl, F.I. (1979). *Guidelines for Stair Safety*. Gaithersburg, MD.: National Bureau of Standards (NBS-BSS 120).

Asher, J.K. (1977). Toward a safer design for stairs. *Job Safety and Health*, *5*(9), 29.

Baker, S.P. & Harvey, A.H. (1985). Fall injuries in the elderly. *Clinics in Geriatric Medicine* (Symposium on Falls in the Elderly: Biologic and Behavioral Aspects), *1*(3), 501-508.

Baker, S.P., O'Neill, B., Ginsburg, M.J. & Guohua, L. (1992). *The Injury Fact Book* (2nd. Ed.). New York: Oxford University Press.

CPSC. (1995). *Product Summary Report (CY 1994), product code 1842 for stairs and steps*. Washington, D.C.: U.S. Consumer Product Safety Commission.

Dacquisto, D.J. & Pauls, J. (1985). The '7-11' stair story: should it be required in residential construction? *The Building Official and Code Administrator*, May-June, 16-35.

Jackson, P.L. & Cohen, H.H. (1995). An in-depth investigation of 40 stairway accidents and the stair safety literature. *Journal of Safety Research*, *26*(3), 151-159.

Lockwood, I.M. & Braaksma, J.P. (1990). Foot accommodation on various stair tread sizes. *Journal of Architectural Planning and Research*, *7*(1), 1-12.

Machiavelli, N., translated by C.E. Detmold, edited by L.G. Crocker (1963). *The Prince*. New York: Washington Square Press.

Maki, B.E. (1985). *Influence of Handrail Shape, Size and Surface Texture on the Ability of Young and Elderly Users to Generate Stabilizing Forces and Moments*. Ottawa: Editorial Office, Division of Electrical Engineering, National Research Council of Canada (NRC 29401).

Maki, B.E., Bartlett, S.A. & Fernie, G.R. (1984). Influence of stairway handrail height on the ability to generate stabilizing forces and moments. *Human Factors*, *26*(6), 705-714.

Maki, B.E., Bartlett, S.A. & Fernie, G.R. (1985). Effect of stairway pitch on optimal handrail height. *Human Factors*, *27*(3), 355-359.

Maki, B.E., Holden, J.M. & Fernie, G.R. (1986). *Experimental Investigation of the Impact Attenuation Provided by Floor Coverings in Human Falling Accidents.* Report prepared for Health and Welfare Canada.

NSC. (1989). *Accident Facts, 1989 Edition.* Chicago: National Safety Council.

Pauls, J. (1982) *Recommendations for Improving the Safety of Stairs.* Building Practice Note No. 35, Ottawa: Division of Building Research, National Research Council Canada.

Pauls, J. (1984). What can we do to improve stair safety? *Building Standards,* May-June,pp. 9-12, 42-43; July-August, pp. 13-16, p. 42; *Southern Building,* April-May, pp. 14-20; June-July, pp. 22-28; *The Building Official and Code Administrator,* May-June, pp. 30-36; July-August, pp. 10-15.

Pauls, J. (1985). Review of stair-safety research with an emphasis on Canadian studies. Proceedings of STFA '84, an International One Day Conference on Slipping, Tripping and Falling Accidents, April 1984, *Ergonomics, 28*(7), 999-1010.

Pauls, J. (1987). Are functional handrails within our grasp? *Proceedings of Environmental Design Research Association Conference,* Ottawa, 121-127.

Pauls, J. (1989). Are functional handrails within our reach and our grasp? *Southern Building,* September/October, 20-30.

Pauls, J. (1991a). Cost of injuries in the United States and the role of building safety. *The Building Official and Code Administrator,* January/February, pp. 19, 31-35; Building Standards, July/August, pp. 18-22, 24; *Southern Building,* July/August, pp. 6, 8, 9, 10, 12, 51; *Safety News* (Newsletter of the Safety Technical Group of the Human Factors Society), *19*(3), 1, 3, 16-21.

Pauls, J. (1991b). Safety standards, requirements, and litigation in relation to building use and safety, especially safety from falls involving stairs. *Safety Science, 14,* 125-154.

Pauls, J. (1991c). Are functional handrails within our grasp? *Building Standards,* January/February, pp. 6-12; *The Building Official and Code Administrator,* March/April, 25-32.

Pauls, J. (1992) What should inspectors look for regarding safe stair construction? *The Building Official and Code Administrator,* July/August, 32-39.

Rice, D.P., McKenzie, E.J. & Associates (1989). *Cost of Injury in the United States: A Report to Congress.* San Francisco, CA: Institute for Health & Aging, University of California, and Injury Prevention Center, The Johns Hopkins University.

Roberts, S. (1993). *Who We Are: A Portrait of America Based on the Latest U.S. Census.* New York: Times Books.

Runyan, C. (1993). Progress and potential in injury control. *American Journal of Public Health, 83*(5), 637-638.

Templer, J.A. (1974). *Stair Shape and Human Movement.* Doctoral Dissertation, New York: Columbia University.

Templer, J.A. (1992). *The Staircase: Studies of Hazards, Falls and Safer Design.* Cambridge, MA: MIT Press.

Templer, J.A., Archea, J., & Cohen, H.H. (1985). Study of factors associated with risk of work-related stairway falls. *Journal of Safety Research, 16,* 183-196.

Templer, J.A., Boulet, J.A.M., Hanagud, S., & Hyde, P. (1989). Symposium: Injury Reduction and Stair Falls (consisting of three papers). *Proceedings of the Human Factors Society 33rd Annual Meeting, 2,* 1144-1157.

Trauma Foundation. (1992). Puzzled by building codes? *Injury Prevention Network Newsletter, 9*(1 & 2).

Welch, P. (Ed.) (1995). *Strategies for Teaching Universal Design.* Boston, MA: Adaptive Environments and Berkeley, CA: MIG Communications.

CHAPTER 8

BLENDING RESEARCH, PRIVATE AND PUBLIC SECTOR AGENDAS IN THE INFORMATION ECONOMY

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INTRODUCTION

This chapter provides a context to integrate material from the earlier chapters and to position the various viewpoints within the larger picture of the information economy with respect to its potential impact on seniors. Where complaints have been made, it is important to understand why current structures do not work and to act to resolve problems. Furthermore, where change is imminent, it is wise to prepare for it and take advantage of it.

Canada is at the cusp of change. While the old economy gives way to the new information economy, Canada is in the grip of restructuring. New industries are blossoming while 'rust and dust' economic activities are on the wane. Structural unemployment affects some workers while there is a shortage of information workers. There is a shift in the economic enterprises that create wealth — from manufacturing to knowledge-based activities.

UNDERSTANDING THE INFORMATION ECONOMY

Never before have we been able to generate, process, store, transmit and manipulate information in the form of data, text, sound and images using the same means. For example, before we transmitted voice information through the telephone and picture images through television broadcasting. Now, we can transmit voice, data and images using the telephone and we can link the television to it to create the videophone or we can link the computer to it to transform the information before transmitting it elsewhere. We can shift from one medium to another in pursuit of the same bit of information — cross-referencing, called hypermedia.Technical

[1] The views expressed in this chapter are those of the author and they are not intended to reflect the view of any organisation with which the author is associated.

improvements increase the flexibility, accuracy, immediacy, geographic independence, volume and complexity of the data that we can access. Furthermore, vast amounts of data can be organized into information that can be manipulated and validated to create knowledge. This results in a high degree of connectedness between knowledge, experience and communication. Knowledge has become a valued commodity and trade in knowledge-based goods and services is the growing component of international trade and commerce. For productive activity based on knowledge, work is related to learning. Knowledge and expertise in its application is held by individuals and by networks of people. The knowledge economy relies on human capital and its capacity to acquire knowledge, manipulate it and share it. The relationship between people and technology is changed. While industrial technology was a tool of production, reducing the consumption of human energy and power, information technology is a means of production using human capital. Simply put, the development of the chip has changed, and improved, the way in which people use their knowledge, expertise and relationships.

CANADA AND THE INFORMATION ECONOMY

Canada is well positioned to usher in the Information Age because it has a well developed electronic research capacity, an emerging information technology industrial base, a supportive public sector and an increasingly computer literate public.

The infrastructure is adapting quickly to the information economy. A coast-to-coast fibre optic system which can move huge amounts of voice or computer information using light rather than conventional electronic signals is close to completion. The *information highway* is a national *network of networks* which forms a web to link a wide variety of electronic machines which can create, store, and exchange information. The telephone is a key link and other devices communicate through it. More than 98% of Canadian households have telephones and 68% of them have two or more (Statistics Canada, 1992). Cable systems are capable of handling the transmission of high quality graphics, video and interactive computer applications. Currently, there are about 1,800 cable systems in Canada serving nearly 8 million households. About 97% of Canadian households are located in areas that are wired for cable service (Frank, 1995).

Production of goods based on information technology is accelerating. For example, in 1990, the typical home had roughly 75 controller chips while the estimate for the year 2000 is 225 such chips (The Economist, 1994).

Canadians are a sophisticated labour pool. Information industries help drive Canada's economy and some experts suggest that they employ as much as half of the labour force as knowledge workers. According to the 1994 General Social Survey, 56% of adult Canadians, amounting to 12.3 million potential workers, were able to use a computer. This is a rise of 9% compared to 1989. In addition, 41% of Canadians aged 15 and over had taken at least one computer course (Frank, 1995). A third of all workers, accounting for 4.2 million Canadians, used personal computers at work in

1991 (Statistics Canada, 1992).

Ownership of home computers has been increasing dramatically. In 1994, 2.6 million or a quarter of all Canadian households had a home computer, a rise of 10% from 1986. This excludes computers that were strictly for business purposes or those that could only be used to play games. To gain the maximum benefit, computers need to be linked to each other through modems. One in three of these home computers was equipped with a modem (Frank, 1995). Link Resources estimates that by the end of the decade over half the world's personal computers will be in the hands of consumers not businesses (The Economist, 1994).

According to a Decima Research poll of 1,500 people, Canadians are also willing to dial for a bank account transfer or pay their bills, order a movie or sell stock from their living room when new technology permits such transactions (Kainz, 1993). The poll found that 12% of Canadians were willing to try out new services that will be available when television, telephones, computers and satellite services merge in the next few years. It also showed that the next technological purchase made by the average Canadian will be a home computer, with 21% saying they will buy within the next twelve months.

SENIORS AND TECHNOLOGY

It is people that contribute the information in the term 'information technology'. They do it through their knowledge, expertise and communication with other people and other databases of stored information. This has been facilitated by technological developments that have reduced the computational power per unit cost, increased the speed of communication and simplified access for consumers. These developments affect the way seniors as well as others acquire and use information and the way in which they interact with other people. In a survey of seniors and seniors organisations conducted by the Centre for Information Technology Innovation (CITI), respondents were asked about the principle functions of multimedia technologies for seniors. Sixty five per cent viewed these as access to up-to-date, accurate essential information and 52% as a way of increasing social interaction (Geoffroy, 1994).

Familiar technologies such as the telephone, TV and computer have been enhanced by linkages to other technologies. Their capabilities have been augmented by the addition of new functions and services, growth in interactive services and increasing multimedia capability. Because of their widespread ownership and use by seniors, the telephone and television and increasingly the computer are important entry points for information and communication.

TABLE 1

Trends and developments in information technology of relevance to seniors.

TECHNOLOGY	TRENDS AND DEVELOPMENTS			
	ENHANCEMENTS	INTERACTIVE SERVICES	MULTIMEDIA CAPABILITY	MOBILITY
Telephone	• Voice mail • Call waiting	• Conference calls • Transactions (eg. telephone banking)	• Videotelephone • Fax	• Cellular telephone
Television	• Pay programs	• Electronic shopping	Videoconferencing	• Portable TVs
Computers	• Internet • Bulletin boards	• E-mail • Chat rooms	• Telephony • Text and image transfer	• Lap or palm top computers

Telephone

The importance of telephone contact between family members has been widely recognized. In recent years, many new functions and services have been linked to the telephone that are of relevance to seniors (see Table 1). These include access to databases, programmed dialing, messaging services, call waiting, and conference calls. Bowe (1988) found that seniors were prepared to pay for telephone-linked services such as electronic directories, home safety alarms (fire, burglars) and medical advice. Seniors can call information databases to find out about the weather, interest rates or flight schedules. Telephone banking services have advantages for seniors over using automated bank tellers. Reassurance calls have been automated; a databank of people are automatically called and if there is no response, a designated number is called for assistance. Conference call technology has permitted 'chat lines' and voice-based entertainment. Seniors can remain in touch with family and friends or access emergency care via mobile telephony and many prefer the multi-use cellular telephone with its broader range to the personal emergency response pendent or bracelet. Linkage via the fax machine facilitates transmission of text and images, whether it is the latest information on mutual funds or the grandchild's latest art work. Videotelephones will offer additional benefits when they become cheaper and commercially available. In particular, their potential for substantially reducing doctors visits and health monitoring costs has been cited (Van Noorden & McEwan, 1991).

Television

Seniors in Canada view television for more hours per week (20.5 hours) than the average person aged 15 years and over (13.3 hours) and their hours of viewing are second only to Japan among industrialized countries (OECD, 1986). Cable TV, enhanced by telephone linkup and interactive capabilities, offers seniors a number of new opportunities and services. For example, the Berkes Community Television Service in the US, operated and managed by elderly people, provides two way interaction in addition to specifically designed programming. Services include social service information, communication with peers, intergenerational contacts and interaction with government. Two way interaction takes place from locations in apartment complexes fitted with video-cameras and through telephone for other subscribers (Cullen & Moran, 1992).

Time Warner Cable, the US grocery chain Wynn-Dixie Stores, Inc., and ShopperVision have combined to offer 4,000 homes in Orlando, FL, a home grocery shopping service based on an interactive cable system. The television set becomes a virtual reality grocery store (20,000 items). By zooming in using the remote control, consumers can read labels and nutritional information; by clicking they can choose items for purchase. The order is sent automatically to the participating Wynn-Dixie store nearest the customer's home. Within 24 hours, the groceries are delivered by couriers in a mini-van (Statelier, 1994). In Montreal, the cable company Videotron Ltd. will soon test a similar service. In a survey conducted in June 1992 by New Technologies Research Laboratory for Videotron, it was found that 33% of interactive television viewers were aged 55 years and over (Geoffroy, 1994). Other simpler home shopping services are already available.

Computers

While the use of computers is not high among elderly people compared to other age groups at present, as shown in Table 2, it is likely to increase rapidly due to the large percentage of computer owners in the cohorts that will reach 65 years of age within the next 20 years. Furthermore, because of heavy use of computers in the work place, more households are likely to purchase computers. Access to computers will also widen as they are used more in public places such as computer cafes and seniors centres.

TABLE 2

Home computer ownership and use by age of household head.

AGE OF HOUSEHOLD HEAD	% OWNING COMPUTERS	% OWNING MODEMS
under 35	29.2	13.4
35 - 44	37.8	15.1
45 - 54	39.8	16.9
55- 64	24.4	9.5
65 +	10.8	3.8

Source: Evanson, 1996. Data from Statistics Canada

In an American survey, Thompson (1996) asked 132 respondents how information technology would be used if they lived alone, if they were disabled or if they were homebound. Seventy-five percent indicated that they would use computers for daily activities, 70% said for socialization and 60% said for security. Using a computer, seniors can access information through the Internet, shop, read newspapers and consult with professionals. More than 10,000 homes in Washington and Detroit have telephones equipped with credit card scanners and a light wand for scanning bar codes when shopping from the screen. Electronic messaging is quick and easy. Networks, such as Seniornet, are available for communication and for staying informed. Linkages to CHESS, the Comprehensive Health Enhancement Support System, give seniors round-the-clock access to a library of medical information and put them in touch with others with a similar illness. Via computer they can ask questions they might find embarrassing to ask their doctor and they can share personal experiences with illness. They can also check several bulletin boards, including MedSIG used by health experts or Prodigy's *Medical Support* which a number of virtual communities of people who share medical problems consult. These systems enable seniors to get an impartial assessment of medical options and to make informed personal decisions.

CAN SENIORS ACCESS INFORMATION TECHNOLOGY?

Research has shown that technology adoption is more closely related to interest in technology than to age. However, access may not be possible because some services may not be equally available across the country.

Some regions of the country are pioneers. In Quebec, 34,000 households in the Chicoutimi-Jonquière area will be part of an electronic network at the cost of $750 million over the next decade. This will allow residents to use their home television sets to order movies, pay their utility bills, purchase goods, read electronic mail and order food from restaurants. New Brunswick has plans for a completely digitalized communication infrastructure that will be the most advanced in Canada. NBTel has already spent more than $500 million on a 3,400 kilometre fibre optic cable system that will put 75% of the 280,000 homes in New Brunswick within 5 kilometres of fibre optic

lines. Everyone will have voice mail at home and all schools will be linked to the internet. TeleEducation courses that use interactive video teleconferencing will be available at 50 sites. Computerized kiosks will allow residents to order drugs and talk with a pharmacist via an interactive television screen. The Health Net system will hook up all doctors and hospitals (Brehl, 1994).

WHAT DOES THE FUTURE HOLD FOR SENIORS?

With 12% of the Canadian population aged 65 and over, seniors constitute an important consumer segment. There continue to be, however, some discussions about 'effective demand' — whether seniors are willing to spend in order to meet their needs. Though there is a sizeable proportion of seniors, particularly unattached women, who are poor, the absolute numbers of seniors whose discretionary income permits them to enjoy consumer products is high.

Other questions that face Canada as it jumps headlong into the information economy that are more difficult to answer include: Will the use of technology be a major factor in creating chasms between the generations, with earlier cohorts being technology shy and later ones technology confident? What mechanisms are available to maximize the positive outcomes from the use of technology and to minimize the negative outcomes for all segments of the population, including seniors? How can the research, public and private sectors work collaboratively to ensure equitable access across the country and all segments of the population?

THE LACK OF SYNERGY

Despite the advances into the information economy, the lack of synergy between the research, the private and the public sectors is blamed for slow progress (Brink, 1994). The research sector has not been well linked to private industry to transform research results into wealth creating activities. Private industry has chafed under regulation imposed by the public sector and decried the need to engage in research and development itself to fuel its own growth. Though the public sector has identified information technology as a promising area for growth, it has hampered growth by adding to the costs of production by regulation, imposition of a tax burden and by reduction of funding and incentives for relevant research. In a global economy, such a lack of synergy has inflicted a cost on our national competitiveness.

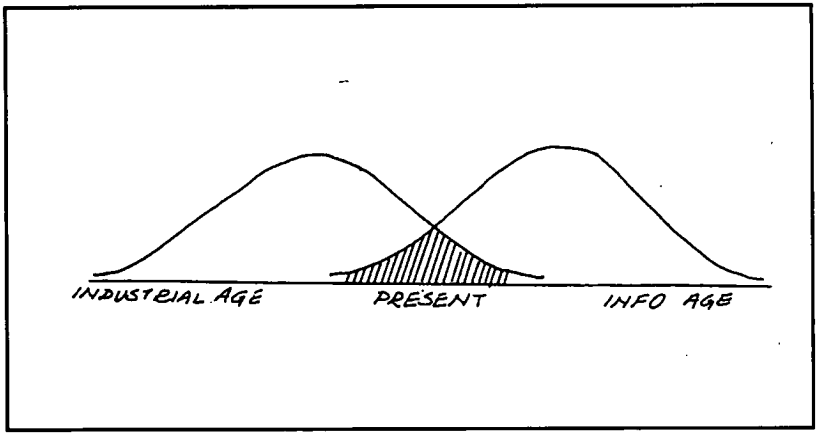
This lack of synergy is, however, unlikely to persist. Under the shift to the new economy, the sectors and their roles are undergoing transformation. For example, in the past, major technological breakthroughs such as the *green revolution* were created through the effort of the public sector. The information revolution, however, has not had major involvement of the public sector. While the private sector has made significant contributions, consumers have stoked the change. This has given rise to the world-wide phenomenon called the Internet, which is neither owned by the private sector nor controlled by the public sector.

OLD STRUCTURES AND NEW DEMANDS

While the Industrial Age gives way to the Information Age, there are tremendous dislocations (Figure 1). The traditional public, private and research sectors are under stress. The period of transition is difficult because the responses to the demands of the new economy are made with the strategies, structures and tools of the old. Fernie (chapter 2 this volume) has pointed out that there is little assistive technology for seniors to evaluate and that many of the evaluations that are done are not useful for improving products. The economy continues to be measured by the health of manufacturing industries while data on the information economy is not available. For example, no data on the number of cellular telephones is available. Furthermore, trapped in the change, it is not possible to create the institutions and tools that are necessary. At present, one can only speculate on the consequences of the changes that are linked to the shift to the information era. Nonetheless, some solutions are evolving. The information industries are traded on Nasdaq, rather than the national stock exchange. Many large corporations have created their own institutions of learning and research, bypassing the existing research structures.

FIGURE 1

The period of transition with new demands and old structures.



Reconciling the Agendas

The agendas of the research, private and public sector are defined by the needs of the time. Thus, for example, monasteries were once the institutions of learning. Manuscripts were prepared by literate monks and documents were retained in libraries. With the dawn of the Industrial Age, it became clear that there was a need for a disciplined and informed labour force. Schools emerged to provide 'primary

education' for the masses. The church became heavily involved in education in schools and colleges, where religious education was only a minor part of the curriculum.

According to Harlan Cleveland (1985), information is the dominant resource in the post-industrial society. Information has substantially different characteristics from other inputs of production. The characteristics he lists are: Information is (1) expandable; (2) not resource hungry; (3) substitutable for capital, labour and physical resources; (4) transportable at very high speeds; (5) diffusive; and (6) sharable with added value rather than loss, unlike other commodities. This information revolution implies a dramatic shift in concepts, assumptions and practice.

Each era is associated with its own concepts and practices linked to work and the creation of wealth (Brink, 1994b, 1995). Based on the changes that are already occurring, the potential changes linked to the information economy can be traced and compared to the Agricultural and Industrial Eras (See Table 3). These changes can result in goods and services that are based on new needs (the needs driven products described in earlier chapters) as well as products arising from new technologies (the technology driven products.) For example, in the Agricultural Era, it was not essential for individuals to tell time precisely and the sundial was accurate enough. With the arrival of the Industrial Era, to facilitate mass production using the assembly line, people needed to begin and finish work at the same time. As a public service, factories installed whistles that could be heard throughout the town. Churches installed clocks on their towers. As technology advanced, clocks could be made smaller, small enough to carry on a chain in a pocket. Finally, as every one learned to tell time and time became money, wrist watches became common. In the shift from the Industrial to the Information Era, technology has already made the typewriter and the secretary obsolete and it may very soon make the word 'office' meaningless. The way work is done to complete the agendas will undergo drastic change.

TABLE 3

The Agricultural, Industrial and Information Eras and their impact on work.

	AGRICULTURAL ERA	INDUSTRIAL ERA	INFORMATION ERA
Primary commodity	Produce, natural resources, crafts	Manufactured goods	Information as a tradable product or process
Location of work	Land and home	Factory or office	Virtual office located anywhere, often mobile.
Type of work	Work from start to finish	Division of labour based on specific skills	Consolidation of work around outcome. Global division of production.
Competition	Local	National and international	Global

Because information is the key resource, agendas previously built around other resources, such as land, capital and labour will diminish in importance. This change has already been captured in census data, which show the reduction of jobs in the agricultural and manufacturing sectors accompanied by a rise in the number of knowledge workers. The primary agenda is to use information for national, private and personal benefit. The traditional allocation of responsibilities will probably change as well as how these responsibilities will be carried out.

In the beginning of an era, the agenda consists of building the appropriate infrastructure, generating the means for investment, developing the skills required and stimulating the exploitation of the resource. For example, in the case of the Industrial Era, as energy made possible mechanization of production, roads were constructed, financial instruments were created to generate capital, managers and engineers were trained and public and private companies began production. What are the parallels in the Information Era? Though the agenda is emerging, it would certainly involve the creation of 'infostructure', the generation and management of information, the development of human capital in a labour force of knowledge workers and the creation of enterprises that will develop products based on information for trade and commerce.

- **Infrastructure:** The shift to the information economy requires its own infrastructure. Because information is diffusive, transportable at high speeds and sharable with added value, the 'infostructure' is radically different from existing infrastructures. The cost for constructing a completely new infrastructure is unknown as its characteristics are still evolving. Each sector, therefore, in its current role should contribute in determining the characteristics and investing in it. This is, in fact, what is happening. CANARIE, for example, is a partnership of government, business and educational institutions building a multi-media network of researchers and industry. Both the private and public sectors are engaged in constructing the *information highway* through which information can flow efficiently so that it can be tapped and used by the appropriate people at the right time and place.

- **The generation and management of information:** Because it is expandable and substitutable for land, labour and capital, it is unlikely that any one sector will have a monopoly over information. Since only the value-added component of information is tradeable, both new ways of making meaning and new processes acquire value and may be copyrighted or patented. Rather than the linear production paths used in the Industrial Era, the production lines will tend to be multiple, shared and reiterative, necessitating 'conjoint analysis', as described by Wylde (chapter 3 this volume). The speed of the transformation of information into benefits requires that as many people as possible have access to it. Fernie (chapter 2 this volume) has pointed out that production cycles are shrinking and may be as low as five years. Benefits can occur at any point to various stake holders. This phenomenon is also beginning to become evident. For example, public and private sectors are jointly working to extract benefit from business and trade information. Public research scholarships are provided to graduate students to conduct their research in industry, shortening the production cycle.

- **The development of human capital:** Since knowledge has a short half life, emphasis will shift from what you know to what you are learning. Learning will be the process of building on existing knowledge in a perpetual learning curve. Therefore, learning will become a life-long process. The emphasis is shifting from how people can be taught to how people can learn. Therefore, the business of learning will occur at many sites: the class room, the shop floor or the work station. Individuals will have the right to benefit from information that they use and apply. Ways will be developed to consolidate the learning of individuals because human capital is likely to be mobile. Rather than people adapting to technology as was the case in the Industrial Era (parodied in Chaplin's famous *Modern Times*), the value of technology will depend on the operator. All sectors will compete and share in human capital. Indeed, with the decline of salaried jobs, the same knowledge worker may carry out tasks for all sectors simultaneously.

- **The creation of new enterprises:** There is much speculation about the form of these new enterprises. There are those who believe that these enterprises could be transnational and virtual, based on a network of knowledge workers around the world linked to a common objective. Others see self employed workers or *cottage industries.* Regardless of the form, for competitiveness, it is essential that all sectors encourage the development of newly evolving enterprises better suited to the information economy.

The convergence of the agenda at the global scale, will make it necessary for Canada to be a player in the international information economy. The costs of restructuring the economy will be high; however, they will not be as high as the costs of not gaining momentum in the new economy.

BLENDING THE SECTORS

Much has been said about partnerships. However, old paradigm partnerships will not be successful. The analogy for such partnerships is the symphony orchestra. Each musician is an expert and plays the instrument from a score. Each musician in the large orchestra has a fixed role and expertise. One musician alone cannot produce successful music. Though they all play together, they do not assist each other. Nor can the trumpeter take over the music of the harpist. The conductor leads the whole orchestra. Rehearsals improve performance. Flexibility is possible but within the limits of the score and the skill of the musicians. When this model is applied, partners compete for control of the score or the role of the conductor. The new era requires small, flexible, innovative, fast moving and self managed partnerships — more like a jazz combo. They are a closely knit unit and playing together as in a conditioned reflex. Each adjusts to the strengths and weaknesses of the others. Each player has the freedom to improvise and to try out riffs and rhythms. When one is playing strong, the others may not play at all. There is no conductor, but there is a bond which heightens performance.

The nature of information and its exploitation has major consequences for the research, private and public sectors, blurring their boundaries and affecting their roles. All three sectors will compete for knowledge workers, who will collect, manipulate, transmit and store data in order to add value to information and to generate economic activity. Information will not be exclusive and it will become the currency for the relationship between the sectors.

It would be impossible for any one sector to manage the sheer volume of information. It is estimated that 70% of the costs are associated with the collection and management of raw data into information (organizing, updating, setting in context and making accessible). Such information is a national asset and must be managed equitably and profitably for both public and private benefit. The rapid exploitation of information will result in shorter and shorter production cycles and, therefore, products with shorter and shorter shelf lives.

Therefore, the current division of labour around production of research information, production of goods, and consumption is not tenable. The responsibilities of the stakeholders, whether or not they are assembled in the present sectors, will therefore be reassigned around the need to use information in an optimum way.

Though distinctive roles may evolve for the sectors, it is likely that synergy and partnerships will be the rule. For example, investments required to construct the 'infostructure' are enormous and cannot be undertaken by any one sector alone. Such an expensive undertaking, which crosses jurisdictions, which offers the potential for commerce, learning, and governance and which can affect the quality of life of individual citizens cannot be the exclusive purview of any one sector.

CONCLUSION

Technology promises to change not only how we conduct our activities but the activities themselves. This is because information technology enriches our capacity to generate, manage and to use information for knowledge-based decisions and actions. These changes can immeasurably improve our quality of life, particularly during our later years. Effective strategies must be implemented to facilitate the adoption of each new generation of technology-assisted products and services at all stages of life.

The Information Era is occurring at the same time as the seniors boom. What will it mean for an aging society, and will individual seniors benefit? In general, it can be said that seniors will benefit directly and indirectly. Connell (chapter 5) and Gutman (chapter 4) have pointed out ways that the understanding and care of those with psychogeriatric problems may be improved by technology. Many seniors will directly benefit, however, because, unlike physical strengths or skill, learning is not limited by age. Information technology extends the capabilities of the human brain. In the absence of neuro-degenerative diseases such as Alzheimer's, the brain is less affected by age than is our capacity to act. Therefore, the productive capacity of the labour force can be increased if seniors can continue to contribute productively to the information economy.

Since learning will be the motor of the economy, in the information economy the relationship of the individual to public, private and research institutions will change. Workers will have greater control over the means of production - information - and therefore, their relationship to the institutions of the private sector will change. As an informed public, individuals will transform the institution of democracy, altering the relationship between citizen and state. As voters and as consumers, using information technology seniors can overcome the obstacles of reduced mobility and of sensory loss. Because relationships may be conducted using information technology rather than face-to-face, age will become irrelevant.

The Information Economy is dependent upon mobilizing the intellectual capacity of the entire population. Seniors can be active participants and beneficiaries in the new

Information Age. The research, public and private sectors will be charged with new responsibilities around a joint agenda, to ensure that information is used for the benefit of all stakeholders, including seniors.

REFERENCES

— (1994). The computer industry. *The Economist*, Survey section, September 17.

— (1994). High-tech highway gathers speed. *Ottawa Citizen*, January 25.

Bowe, F. (1988). Why seniors don't use technology. *MIT Technology Review*, 91(6), 35-37.

Brink, S. (1994a). Bridging the technology gap: the links between research, development, production and policy for products supporting independent living. In G. Gutman and A. Wister (Eds.), *Progressive Accommodation for Seniors: Interfacing Shelter and Services* (pp. 211-222). Vancouver: Gerontology Research Centre, Simon Fraser University.

Brink, S. (1994b). Breach of promise: the tenuous link between technology and elderly people (pp 63-71). *Proceedings of the International Seminar: Potential of Information Technology for Solving Housing Problems of Aging People.* Tokyo: Building Research Institute, Ministry of Construction, Government of Japan.

Brink, S. (1995). *Boon or Bane? The impact of services transformed by information technology on the aging consumer.* Paper presented at the 24th Annual Scientific and Educational Meeting, Canadian Association on Gerontology, Vancouver, October 26-29.

Brink, S. (1996). Improving quality of life for dependent people through technology (pp.455-467). *Actes du Premier colloque Européen de la prévention des risques, placé sous le haut patronage du Parlement Européen et de Commission Européenne avec le soutien du Conseil Régional Poitou-Charentes*, Niort, France, October 16-22.

Brink, S. (1997). The twin challenges of information technology and population aging, *Generations, 21*(3), 7-10.

Brehl, R. (1994). Info highway fast lane — New Brunswick on leading edge of information technology, *Ottawa Citizen*, May 24.

Burns, R. (1988). A two way tv system operated by senior citizens. *American Behavioral Scientist, 31*(5), 576-587

Cleveland, H. (1985). The twilight of hierarchy: speculations on the global information society. *Public Administration Review, 20*, 185-195.

Cullen, K. & Moran R. (1992). *Technology and the Elderly - The role of Technology in Prolonging the Independence of the Elderly in the Community Care Context.* Luxembourg: Commission of the European Communities.

Frank, J. (1995). Preparing for the information highway: information technology in Canadian households. *Canadian Social Trends, 38*, 2-7.

Geoffroy, C. (1994). *Communication and Information Technologies and Older Adults.* Montreal: Centre for Information Technology Innovation (CITI) .

Kainz, A. (1993). Canadians embracing technology. *Ottawa Citizen*, November 25.

OECD. (1986). *Living Conditions in OECD Countries: A Compendium of Social Indicators.* Paris: OECD.

Stiteler, R. (1994). Cyber shopping. *Kiwi In Flight,* October/November, 26-27.

Statistics Canada. (1992). *Canada, A Portrait.* Ottawa: Statistics Canada.

Straka, G. A. (1986). Television and the elderly — from broadcasting to narrowcasting. *Education and Aging,* 93-120

Van Noorden, L. & McEwen J. (1991). Pilot applications for advanced communication technology in care for the elderly in Europe (pp. 271-276). *Gerontechnology: Ist International Conference on Technology and Aging.*

CHAPTER 9

TIDE – TECHNOLOGY FOR THE INTEGRATION OF DISABLED AND ELDERLY PEOPLE: A EUROPEAN MODEL FOR RESEARCH AND DEVELOPMENT IN ASSISTIVE TECHNOLOGY

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RESEARCH AND TECHNOLOGY DEVELOPMENT IN THE EUROPEAN UNION

In accordance with its treaties, Research and Technology Development (RTD) programs in the European Union [1] are organised on the basis of five year plans, called Framework Programs. Currently, the Fourth Framework Program (IVFW, 1994-1998) is in operation. The objectives of these programs are both economic and social. The programs aim to increase the competitiveness of European industry and secure the best prospects for its economic growth for the benefits of its citizens. Keywords are therefore — industrial competitiveness, sustainable economic growth, employment creation and quality of life.

The Fourth Framework Program for research, technological development and demonstration has an initial budget of $18.8 million Canadian (11.1 million ECU[2]) divided among four activities :

- RTD and Demonstration Programs
- Co-operation with Third World Countries and International Organisations
- Dissemination and Optimisation of Results
- Stimulation of the Training and Mobility of Researchers.

The bulk of this funding, almost $16 million Canadian (9.4 million ECU) i.e. 85% of the budget, is allocated to RTD and Demonstration projects which cover six major

[1] The 15 European Union countries are: Austria, Belgium, Denmark, France, Greece, Finland, Germany, Italy, Ireland, Luxembourg, The Netherlands, Portugal, Spain, Sweden, United Kingdom.

[2] ECU = European Currency Unit

areas of scientific endeavour: (1) Information and Communication Technologies, (2) Environment, (3) Life Sciences and Technologies, (4) Non-nuclear Energy, (5) Transport and (6) Targeted Socio-economic Research. For the most part, this research is carried out on a cost-shared basis and involves the participation of partners from industry, universities, user organisations, etc.

RTD in the area of Information and Communication Technologies (ICT) accounts for 36% of the RTD & Demonstration budget. There are three distinct but interrelated programs under the ICT banner: Telematic Applications, Communication Technologies and Information Technologies. TIDE — Technology for the Integration of Disabled and Elderly people is part of the Telematics Applications program.

THE TIDE PROGRAM: OBJECTIVES AND SCOPE

The economic and social goals of the Fourth Framework Program are mirrored in the TIDE program. TIDE's industrial goal is to improve the European industry and market in products and services that meet the needs of older people and people with disabilities. From the social perspective, TIDE aims to develop new technological tools and applications for disabled and elderly people to facilitate them to live autonomously and participate more fully in the social and economic life of the European Community.

TIDE is a program in Assistive Technology. Assistive Technology (AT) can be defined as technologies, services or systems that can help prevent or compensate for functional limitation, facilitate independent living and which can enable elderly and disabled people to realise their potential.

The role of technologies and services in supporting independent living is gaining increasing attention. These technologies and services are perceived to have important implications for the quality of life of older people and people with disabilities as well as for the market for assistive technology (both products and services) and for the possible containment or reduction in health and care budgets.

A broad range of basic technologies are utilised in AT applications, i.e. AT incorporates developments in a wide range of fields, for example ICT, material science, biomechanics, etc. The TIDE fields of application focus on information, communication and control technologies. TIDE supports the development of new products and services which meet the needs of older people and people with disabilities. In the development of new products and services TIDE actively promotes the 'design for all' principle. Application of this principle aims to ensure that general consumer products and services as well as environments are accessible to and usable by as large a group of people as is feasible — including older people and people with disabilities. Application of the 'design for all' principle helps expand the market potential of products and services by widening the customer base and can lead to greater economies of scale and hence decreased costs for products and services which

are responsive to the needs of older people and people with disabilities.

In addition, there remains a need for specialized products and services. Hence, TIDE fosters the development and production of two types of assistive devices: (1) adaptations, devices, and interfaces which make products and services available in the general market accessible to users with functional limitations and (2) dedicated technologies and stand alone systems for the specific compensation of sensory and cognitive limitations.

BACKGROUND TO THE TIDE PROGRAM

TIDE activities address three main groups of people. In order of their numerical strength, these consist of: 1) the majority of older people who require some support and assistance in everyday life, yet are unlikely to define themselves as having a disability; 2) older people with a disability, including both people who encountered disability earlier in life perhaps even from birth or early childhood, and older people who confront disability for the first time relatively late in life; and 3) younger people with a disability. It is recognized that while these groups have many interests, needs and problems in common, they also have particular interests, needs and problems.

Since 1950 there has been a general trend towards aging of the European population. It is estimated that by the year 2020 almost 27% of the population of the EU will be aged 60 years and over. The percentage of very old people is also increasing. The majority of older people are in good health and are capable of caring for themselves — in fact, many are carers themselves. Nevertheless, a sizeable minority of between one quarter to one third of those aged 70 and over experience health problems and require some assistance in carrying out activities of daily living (Walker et al., 1993).

Some 70% of people with disabilities are aged 60 and over. Thus, disability is strongly related to age. In addition to disabilities associated with age-related pathologies, the prevalence of disability generally is increasing in society. This is partly due to advances in medical treatments which reduce mortality rates for those with developmental disabilities and degenerative diseases. In addition, emergency and trauma medicine, prenatal, perinatal and postnatal care enable people to survive injuries and other traumas that heretofore were fatal.

There are a number of important societal implications of these developments. Chief among these is the fact that the demand for social protection, social and health care services is outreaching the capacity of societies to respond. Cost containment has become an increasing priority throughout the Union. The containment of costs is being implemented in the context of a move towards the delivery of health and social services by means of community care programs. The community care approach, as presently practised, relies heavily on voluntary and informal care and support systems. However, a number of societal and lifestyle trends are eroding the capacity of

these traditional systems to respond. In particular, the traditional caring potential of society is affected by the choices of women, the traditional carers, who are availing themselves of opportunities for economic independence and are participating in the paid labour force. They are thus less often available for care giving. Other factors important in this context are increased urbanization, long distance geographical mobility of family members, emigration, etc., all of which put strain on the traditional informal infrastructure for care. In other words, while the demands for care are increasing, the caring potential, as traditionally construed, is declining in the EU. Parallel with these trends is the widespread and growing desire of older people and people with disabilities to maintain autonomy and to remain living in the community, preferably in their own homes, for as long as possible. Significant also is the growing assertiveness of these groups in demanding equal access to societal resources and their growing political power.

These demographic, societal and cultural trends in society are giving rise to demands for a range of products and services which can assist the maintenance of autonomous living in the community. It is roughly estimated that the EU market for such products and services is $17 billion Canadian ($10 billion ECU) and is growing at a rate of 10-20% per annum. In addition, there is the developing market for consumer goods which is arising following the application of the 'design for all' principle and the niche market for lifestyle products and services (e.g. off-season holidays).

CHARACTERISTICS OF THE ASSISTIVE TECHNOLOGY MARKET IN EUROPE

There are a number of barriers to the exploitation of the market for AT related products and services. Firstly, the large potential market for general consumer products and services which, in addition to addressing the needs of the general population and also addressing the needs of older people and people with disabilities in line with the 'design for all' approach, is a relatively new phenomenon. The major barriers here are related to awareness and what is often a conflict between targeting the users who can benefit from such products and services while avoiding 'stigmatisation' of the product. With respect to the more specialized market, the EU market for AT is highly fragmented with many small companies with limited resources and a limited product base involved. This is particularly true for the more specialized types of products. Geographical, cultural and political differences also act as barriers. For example, national regulations and standards regarding reimbursement lists differ across countries and have a strong influence on the market. Different standards and testing methods hamper co-operation as do the different backgrounds of industrial players (e.g. mechanical construction, sanitary product manufacturers, etc.). In addition, players often belong to different linguistic groupings.

The HEART study of the AT industry in Europe (Ohlin et al, 1995) identified, inter alia, lack of information as a significant problem for the AT industry, its users, professional service providers and authorities. This and other TIDE studies found a

lack of statistical studies about potential markets and a lack of databases on sector actors. The study concluded that users need to be far more involved in requirements analysis, development, testing, standardisation and training in the use of AT (Buhler et al., 1994; Ohlin et al., 1995). These findings are relevant for both the general and specialized markets.

The progressive completion of the internal market in the EU will impact strongly on the market conditions outlined above, giving way to an Europe-wide market for the first time. This will provide opportunities for greater economies of scale and scope and for new entrants to the market. The internal market, however, is also likely to expose small and medium sized enterprises to strong competition and to a range of risks. For the small EU suppliers to survive and compete they will need to form strategic alliances and to work co-operatively with large enterprises. In addition, user involvement in the development and marketing of products will be a prerequisite to successful exploitation of the potential AT market.

TIDE STRATEGY AND MODEL

In order to achieve the industrial and social goals outlined above, TIDE has created a framework for co-operation and co-ordination between the parties involved in AT in Europe — industries, researchers and users. This is done through supporting collaborative RTD projects involving partners from different sectors in the different member states. As with other European Union RTD programs, TIDE funding for RTD projects amounts to 50% of costs, with participants providing matching funding. In addition to the RTD projects, TIDE is helping to develop the supportive infrastructure and market conditions for a successful European AT industry. Important in this context are the TIDE 'horizontal' or 'support actions' (which are not R&D actions per se), which analyse the AT market along with factors involved in the uptake and use of AT. These include initiatives which encourage standardisation, regulation and rationalisation. These projects receive 100% funding from the TIDE program.

The TIDE model involves the participation of the parties involved (industries, researchers, users and their organisations) — to a greater or lesser extent — throughout the different stages of the RTD process. First, the program of work (i.e. the research agenda) is developed in collaboration with the sector actors. Secondly, each research consortium bidding for RTD funding through the submission of a project proposal, following a formal call for proposals by the European Commission, is required to have a mix of these actors. In addition, the consortium must involve transnational collaboration (at least 2 non-affiliated partners from different member states of the EU[3]). Finally, the proposals are evaluated by sector actors against technical, financial, management and strategic criteria which reflect the needs and aspirations of the parties involved.

[3] Or one from a member state and one from an associated country.

The TIDE model requires that proposals submitted take into account what we call the five TIDE principles. Thus, it is required that development of AT under TIDE is (1) geared towards the market and towards developing prototype products and services with good industrial potential. Projects are requested to explicitly describe the market segment and to submit plans for exploitation of the results of the project (market-oriented principle); (2) developments are to focus on innovation and adaptation of new technologies to satisfy the needs of elderly and disabled persons and, in addition, to indicate where contributions are to be made to standards (technology adaptation and innovation principle); (3) TIDE projects are required to address the multidisciplinary nature of technological development, uptake and use and to demonstrate an appropriate balance of disciplines to support their particular technological development objectives (multidisciplinary approach principle); (4) of prime importance, is the requirement for projects to take user needs on board, to study user requirements and incorporate findings in their work (user-focused principle); (5) finally, it is required that developments are evaluated by users or consumers (technology verification principle).

THE PILOT AND BRIDGE PHASES OF TIDE

The TIDE program started on a pilot basis in 1991 with a budget of $31 million Canadian ($18 million ECU). Twenty-one technology development projects were supported (see TIDE pilot action synopses, CEC 1993). A major study of assistive technology in Europe, the HEART study (Ohlin et al., 1995), was also supported at this stage. HEART surveyed, analysed and assessed the critical factors influencing the market for AT in Europe (e.g. standards, legislation, training, etc.). This was followed by a Bridge phase which had a budget of $71 million Canadian ($42 million ECU). The TIDE Bridge Phase will run to the end of 1997.

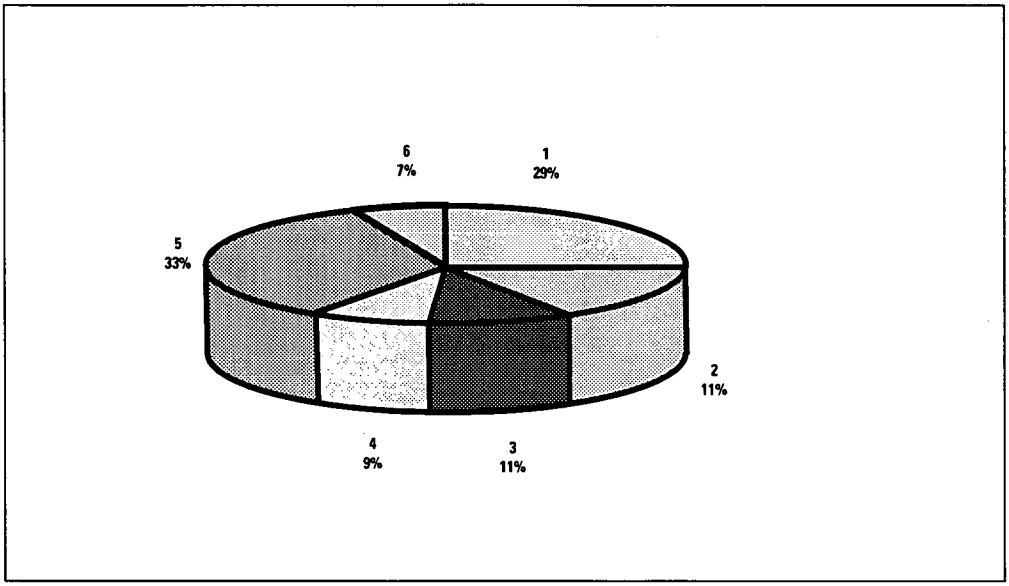
As a result of an independent evaluation process carried out by experts from the sectors, 55 Bridge Phase projects were chosen for funding. The consortia which made proposals displayed a good mixture of industry, universities, research establishments, user and other non-profit organisations. Small and medium size enterprises were particularly well represented in the proposals received. The proposals also included a number of major companies, for example, consumer electronics, telecommunications and transport companies. Participants in the 293 proposals received came from 22 countries.

Figure 1 shows that 33% of the projects funded in the Bridge Phase fall into the 'Restoration and Enhancement of Function' domain, which covers the more traditional areas of rehabilitation technology. The second largest group (29%) deals with the facilitation of access to technology and related services for older and disabled persons. Projects supporting technologies in the increasingly important domain 'Life at Home and Remote Care', constituted 11% of funded projects; a similar percentage of projects address mobility and transport concerns. The remaining 15% of projects are divided

between those which address technologies for control and manipulation (9%) and projects which deal with user and market issues (7%) (CEC 1994a).

FIGURE 1

Distribution of projects funded in bridge phase.



1=Access to technology and related services; 2 = Life at home and remote care; 3 = Mobility and transport; 4 = Control and manipulation; 5 = Restoration and enhancement of function; 6 = User and market issues.

Table 1 (CEC, 1994a) shows a heuristic classification of projects by the six domains outlined in the pie chart and further broken down by application area. The table cross-classifies projects by the major type of disability addressed and, where projects specifically deal with a service or the issue of aging, this is also indicated. The table serves to illustrate the scope and variety of the projects funded. For more information on each project see the synopses of the Bridge Phase projects (CEC, 1994a).

TABLE 1

APPLICATION DOMAINS / APPLICATION AREAS	PROJECT ACRONYM	PROJECT NUMBER	DISABILITIES/IMPAIRMENTS							
			MOBILITY	VISION	HEARING	SPEECH	LANGUAGE	COGNITION	AGING	SERVICE
1. ACCESS TO TECHNOLOGY AND RELATED SERVICES										
Educational and Vocational Support	MATHS	1033		X						
	WANTED	1088						X		
	VICAID	1199						X		
Teleworking	HYPIT	1175	X	X	X	X	X		X	X
	COMBAT	1135	X	X	X	X	X		X	X
	AVISE	1251*	X	X	X	X		X	X	X
Telecommunication and Teleinformation	SPLIT	1215			X				X	
	IBIDEM	1038			X				X	
	INSIDE	1150	X						X	X
	MART	1113*								
	HARMONY	1226*		X					X	X
Computer Environment and Public Terminals	ACCESS	1001	X	X		X	X	X	X	
	ETRE	1021	X	X						
	TACIS	1229	X	X						
	LAMP	1249	X		X	X				
	SATURN	1040	X					X	X	X
2. LIFE AT HOME AND REMOTE CARE:										
Home Systems	DEFIE	1221		X	X	X				X
	HS-ADPTED	1102	X	X		X				X
	HEPHAISTOS	1004	X	X						X
Location and Remote Support	SCALP	1002	X					X		
	CASA	1068		X						X
	HELPME	1105		X	X					
	IMSAS	1078	X						X	X
	AURORA	1027	X							X
3. MOBILITY AND TRANSPORT:										
Advanced Wheelchairs	OMNI	1097	X						X	
	SENARIO	1045	X						X	
Orientation	ASMONC	1228	X	X					X	
	OPEN	1182	X	X						
	MOBIC	1148	X	X					X	
Information on Public Transport	TURTLE	1194	X						X	X
4. CONTROL AND MANIPULATION:										
Integrated Controls	FOCUS	1092	X						X	
Robotic Systems	MOVAID	1270	X						X	
	EPI-RAID	1024	X							
5. RESTORATION / ENHANCEMENT OF FUNCTION:										
Training of Natural Speech or Signing	HARP	1060			X	X	X			
	DICTUM	1189			X	X	X			
Synthetic Speech Devices	VAESS	1174				X	X			
	ALADIN	1035				X	X			
Tools for Sign Language	SIGNBASE	1282			X	X	X			
	ESLI	1242			X	X	X	X	X	X
	SIGN PS	1202			X	X	X	X	X	X
Augmentive Communication Solutions	COMSPEC	1169	X				X	X	X	X
Hearing Enhancement	OSCAR	1217					X		X	
	SICONA	1090					X		X	
	HEARDIP	1094					X		X	
	PROSOUND	1230					X		X	
Vision Enhancement	POVES	1211		X						
Motor Rehabilitation	AMBLE	1064	X						X	
Functional Electrical Stimulation	APECES	1083	X							
	MULOS	1057	X						X	
	FESTIVAL	1250	X						X	
Abilities Training	VETIR	1216	X							X
6. USER AND MARKET ISSUES:										
	USER	1062*	X	X	X	X	X	X	X	X
	MARTEL	1058*							X	X
	TT-RT-SMEs	1144*	X						X	
	CERTAIN	1264*	X	X	X	X	X	X	X	X

EVALUATION OF THE TIDE PILOT PHASE

As already noted, the TIDE pilot action, which started in 1991, funded 21 technology development projects that had an average duration of 18 months. However, half the projects were extended and have now been completed or are about to be completed. An evaluation of the TIDE pilot action was carried out between February and September 1994 by a committee of independent experts (CEC, 1994 b&c). The evaluation involved an analysis of the reports produced by the 21 projects and an opinion survey of all participants from the organisations involved. The reviewers who monitored the projects on an on-going basis in collaboration with the Commission services were also surveyed. The evaluation was carried out with reference to the objectives of the TIDE initiative as a whole and on the specific objectives of the pilot action.

The main findings were as follows:

- **A strong framework for RTD in the Assistive Technology area was established.**

  The TIDE pilot action was found to be remarkably successful in mobilising and co-ordinating a diverse group of organisations and workers across the European Community. A strong identity of interest between the social, commercial and technical objectives of the participants was found. The investment made was considered to be extremely worthwhile.

- **User involvement was found to need support.**

  Projects did not always have the expertise to effect meaningful user involvement. There was a need for greater user involvement at the early phases in particular. It was concluded that users need to be provided with all the means necessary to make the contribution which is required of them in a truly multi-disciplinary project approach.

- **Technological innovation in the projects was considered impressive.**

  New technologies, adaptations, new areas and new methods were explored to good effect. It was concluded that projects were motivated more by technology push and user needs than by market opportunity.

- **Products and exploitation were found to need support.**

  Commercialisation of the results of TIDE involves many challenges due to the nature of the AT market. Projects require advice, support and expertise to exploit the market effectively. Unexpected spin-off developments occurred which reinforced the importance of the 'design for all' approach (e.g. products developed for the specialized market were found to have potential in the general market). The need for TIDE to exert influence in product definition and in the design process in industry at large was stressed.

- **Standardisation activities by projects were found to need support and guidance in relation to selection of relevant standards, relevant standardisation bodies, etc.**
- **Ethical and human rights issues involved in the development, uptake and use of AT products and services need greater attention.**

The findings from the Pilot Phase evaluation were very encouraging and constructive. Clear pointers to issues requiring attention were provided. These are now being taken on-board by the program.

CURRENT STATUS OF TIDE: CALL FOR PROPOSALS

A Call for Proposals under TIDE in the context of the Fourth Framework Program of Community Research and Technological Development was opened on the 15th of September 1995 and closed on 15th January 1996. Proposals were invited in relation to two main lines of research and development: one focused on access to technologies and services to support independent living; the second focused on technologies which compensate for functional limitations. In this latest phase of TIDE, the scope of the work in the first RTD line has been broadened to include projects dealing with information and communication technologies (ICT) in support of services for independent living (CEC 1995a).

The first line encourages the development and access to a wide range of products and services which can support autonomy and help improve the quality of life of disabled and older persons. In a complementary manner, the second line aims to develop special devices and services for disabled and older persons which can compensate for functional limitations and so can help them to integrate more fully into society. In addition, a number of horizontal or support activities will be supported which aim to enhance the impact of RTD on the quality of life of disabled and older persons (e.g. studies of uptake and use of technologies) and to support and facilitate the European AT industry and markets (e.g. market studies).

The two R&D lines outlined above are elaborated in greater detail, i.e. in terms of particular areas, sub-areas and tasks in the 'Background to the Workplan' document (CEC, 1995a). A new feature of the 1995 Call was an emphasis on Large Cluster Based projects which involve a combination of tasks organised in a coherent manner to achieve a specific goal. These large projects are expected to a have synergistic effect and achieve realistic and usable AT solutions for end users.

TIDE AND INTERNATIONAL CO-OPERATION

The EU has a number of agreements with non-EU countries regarding co-operation in the different areas of RTD (CEC, 1995b). An agreement between the EU and Canada has recently been ratified. As a result of this agreement, Canadian participation in RTD projects in the Telematics area will be possible. Canadian participants will be require

to bring their own funding (100% of their costs) to any such projects selected.

In addition, co-operation in the context of Program Support Actions of the Telematics Program is possible. An application can be made throughout the life of the Fourth Framework Program 1994-1998. The final closing date for such calls is 1/3/1998. The tasks relevant for support include Fact Finding Missions, Co-operation Activities (e.g. program evaluation methodologies, standardisation) and support for Participation in the Activities of International Bodies (CEC, 1994d).

In addition to the formal mechanisms of co-operation which involve participation, the TIDE program welcomes exchange of information and experience with interested sector actors from all countries.

EU RTD PROGRAMS: INFORMATION AND ASSISTANCE

The EU makes available comprehensive information on its RTD programs through a range of publications, meetings, etc. CORDIS is particularly important in this context. CORDIS is a centralised information service on all EU research and technological development activities. It consists of ten databases providing complete information on all aspects of community RTD. CORDIS, in addition, provides all of the services needed to help participants, or those interested in participating in EU research, to go from project submission to market innovation (CEC, 1995c; CORDIS 15/9/95).

Following is a selection of some of the CORDIS information databases most relevant in the present context :

- RTD-News: provides information on calls, tenders, events, legislation, general policy, etc.
- RTD-Projects: provides information on projects newly funded, existing and completed projects. The TIDE Bridge Phases Synopses will be accessible here shortly.
- RTD-Contacts: provides contacts of players in the EU RTD process.
- RTD-Partners: helps participants in projects find partners etc., some contacts for TIDE players can be found here.
- RTD-Results: enables researchers to specify what type of collaboration they require to bring results to market.

The CORDIS service can be accessed via the European Commission Host Organisation (ECHO) using a direct telephone line, via the Internet and EuropaNet networks, via Minitel and via gateways from other systems. The CORDIS World Wide Web (WWW) Server can be accessed on the Internet using browser software and the URL http://www.cordis.lu/. Each program of the Fourth Framework Program has a home page. Documents such as Calls for Proposals, Work Programs and Information Packages are available as both text and hypertext files and can be downloaded to a PC.

The ten CORDIS core databases are also available on CD-ROM.

Any reader wishing to receive further information regarding TIDE activities should contact the TIDE Office at the following address :

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Email : tide@dg13.cec.be

REFERENCES

Buhler, C. et al. (1994). *Coherence Between and Among Rehabilitation Technology Industrial Sectors. HEART Report.* DGXIII, CEC.

Ohlin, P. et al. (1995). *Technology Assisting Disabled and Older People in Europe. The HEART Study.* DGXIII, CEC and The Swedish Handicap Institute.

Walker, A. et al. (1993). *Older People in Europe: Social and Economic Policies. The 1993 Report of the European Observatory.* CEC, DGV-Employment, Social Affairs, Industrial Relations.

Commission of the European Communities (CEC) Publications :

CEC. (1993). *Technology Initiative for Disabled and Elderly People: Pilot Action Synopses.* DGXIII. Office for Official Publications of the European Union, Luxembourg.

CEC. (1994a). *Technology Initiative for Disabled and Elderly People: Bridge Phase Synopses.* DGXIII. Office for Official Publications of the European Union, Luxembourg.

CEC. (1994b). *An Evaluation of the Pilot Action of TIDE 1992-1994. Summary and Recommendations.* DGXIII, September 1994.

CEC. (1994c). *An Evaluation of the Pilot Action of TIDE 1992-1994.* Full Report. DGXIII, September 1994.

CEC. (1994d). *Telematics Applications Program 1994-1998.* Work Program. DGXIII, 15 December 1994.

CEC. (1995a). *Background to the Workplan for the IVth Framework Program – TIDE.* Brussels, 21/3/95.

CEC. (1995b). *Telematics Applications Program 1994-1998.* Information Package. Brussels. 15/9/95.

CEC. (1995c). CORDIS focus. *Fourth Framework Program Supplement.* Supplement 7, 15 September 1995.

GERONTOLOGY RESEARCH CENTRE AT SFU

RESEARCH

The Gerontology Research Centre conducts research on aging and the aged, and consults on research design and program development and evaluation. Research activities are most intense in five areas:

- Aging and the built environment
- Health and aging
- Prevention of victimization and exploitation of the elderly
- Older adult education
- Changing demography and lifestyles

EDUCATION

Since 1983, SFU has offered a post-baccalaureate Diploma in Gerontology. A Masters Degree commenced in September 1996. Both are coordinated by the Gerontology Program which has offices within the Centre.

INFORMATION SERVICES

The Gerontology Information Centre, managed by a professional librarian, offers a specialized collection and assistance with information search and retrieval.

PUBLICATIONS

The Centre publishes books, reports, bibliographies, and two newsletters: GRC News and Seniors' Housing Update.

CONFERENCES

Each year, the Centre organizes a minimum of two conferences: a housing conference and the John K. Friesen Lecture Series.

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