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The Built Environment, Health, and Longevity

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The Built Environment, Health, and Longevity: Multi-Level Salutogenic and Pathogenic Pathways

Andrew V. Wister

ABSTRACT. This paper reviews and integrates interdisciplinary literature that investigates the influence of the built environment on the subjective and objective health status of older persons that may improve their quality and quantity of remaining years of life. The development, expansion and synthesis of person-environment and ecological models provides the theoretical foundation. Central to this discussion is the identification and elaboration of salutogenic and pathogenic pathways (Antonovsky, 1979) through which the built environment may influence health, functioning and longevity. Research and knowledge drawn from literature on relocation, housing characteristics and well-being, the meaning of home, delay of institutionalization, technological devices, falls and other injuries, and healthy communities is used to demonstrate environmental pathways to health and longevity.

KEYWORDS. Influence of the built environment, health status, older persons, quality and quantity of life, salutogenic and pathogenic pathways, health functioning and longevity

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INTRODUCTION

Since the middle of the 20th century, we have witnessed dramatic increases in the rate of population aging among the postmodern countries of the world, whether measured as the median age of the population or the proportion aged 65 and over. In tandem with a general pattern of sustained lower fertility, improvements in the life expectancy of these populations have contributed to inflation in the relative size of cohorts of older persons. Noteworthy is the fact that the proportion of the oldest-old, persons aged 80 and over, has continued to increase steadily. Concurrent with this pattern of increasing longevity is a rise in the absolute and relative numbers of persons who live to be 100 years of age and beyond–the centenarians. Although the maximum life span of humans may not have risen substantially, there has been a forward shift in life expectancy; a pattern that has drawn the attention of researchers from many different fields of study in an effort to understand the causes and consequences of these anomalous aspects of human condition–what has been termed the "legacy of longevity" (Stahl, 1990).

Consideration of why more people are able to live into their 80s, 90s, and 100s begs questions about the role of environmental factors, including what has been termed the "built environment." Interest in the interaction between the environment and human evolution has grown since Darwinism made its revolutionary impact on modern thinkers. More recently, aspects of the built environment (e.g., housing and institutional design, assistive devices, ergonomics of the workplace, and air and water quality) have been found to be central components of health promotion and population health models aimed at integrating multilevel determinants of health.

CONCEPTUALIZING LONGEVITY, HEALTH, AND ENVIRONMENTS

In the past, longevity has been measured using life expectancy statistics for populations, which provide estimates of the probability of years remaining in life given an individual's current age and the current age-sex specific mortality rates for the population. In industrialized countries, life expectancy has risen from about 60 to 80, between 1950 and 2000 (Légaré & Carrière, 1999). However, average life expectancy of a population or sub-group does not tell us about the quality of those remaining years. The concept of healthy life expectancy (also termed active life expectancy or disability-free life expectancy) has been developed to refine life expectancy in a manner that reflects the estimated number of years that persons may expect to live free of limitations of

function associated with chronic illness (Wilkins & Adams, 1983). One reason for this development has been an interest in examining whether, and to what degree, observed increases in life expectancy are matched by longer periods of morbidity, thus reflecting on the quality as well as the quantity of life (Robine & Ritchie, 1991). Although inconsistent findings have been reported, research tends to show that healthy life expectancy has increased, but has not kept pace with gains in life expectancy (Crimmins, Saito, & Ingegneri, 1997; Robine et al., 1995).

At the broad conceptual level, health promotion and population health models have provided comprehensive approaches that consider health to be more than the absence of illness (Epp, 1986; Health Canada, 1994; World Health Organization, 1986). For instance, it has been shown that gradual improvements in health behaviours and self-care have translated into better functioning among the very old, and that these health improvements facilitate longevity (Ahacic, Parker, & Thorslund, 2000). Although extensions in longevity are partly the result of improvements in medical screening of illness conditions, surgical interventions and rehabilitation, there is little doubt that healthier lifestyles are also important (Chen & Millar, 2000:9). Furthermore, research has shown that subjective predictors of health can not be accounted by statistically controlling for physical health status and other determinants of mortality, even when employing longitudinal data (Bernard et al., 1997; Idler & Kasl, 1991). We therefore assume that a broad array of objective and subjective health indicators may ultimately influence the aging process and longevity in both positive and negative ways.

Conceptualizations of the physical environment typically entail aspects of the built environment (architecture, design, roadways, community organization, etc.) and the natural environment (air and water quality, ozone depletion, radiation, etc.), but often also incorporate dimensions of the social environment (family and community support). There is an intricate relationship between these milieu. For example, a frail elderly person living alone in a large house may not function as well as the same individual living with a caregiver. And further, a person living in a retirement community is influenced not only by the physical structure and material resources embedded within that environment, but also by its non-material resources and social organization and meanings associated with them. The conception of the built environment adopted in this paper will be confined to architecture, design, and function, but will be connected to other salient elements of the broader environments in which people live, such as the social environment, as well as non-material aspects, such as "meaning of home."

A FAMILY OF ENVIRONMENTAL FRAMEWORKS

Lawton's Model

The most influential of the person-environment theories developing out of this tradition is Lawton's Ecological Model of Aging, which first appeared in a chapter titled *Ecology and the Aging Process* (Lawton & Nahemow, 1973). Drawing from Murray's (1938) equilibrium concept and especially Lewin's (1951) ecological equation (see Parmalee, 1998), the model considers individual behaviour and well-being as a function of the dynamic balance between the demands imposed by the environment (press) and the individual's ability to cope with those demands (competence). Environmental press represents the degree to which the environment demands a behavioural response, whereas competence refers to the ability to respond adaptively in the areas of functional health, social roles, sensory-motor and perceptual functions, and cognition. When the fit is not balanced, the environment is considered to be either too demanding for an individual given their competence (e.g., a psychogeriatric homeless person living in a stressful urban environment), or not demanding enough (e.g., an individual who is prematurely admitted into a long term care facility). The *docility hypothesis* states that individuals with high competence can withstand greater levels of environmental press, whereas those who exhibit lower personal competence are more vulnerable (Lawton & Nahemow, 1973). Coupled with Pastalan's (1982) concept of loss-continuum, which indicates that as people age they experience physical deterioration (albeit at different paces), the docility hypothesis implies that loss in function invariably leads to decreases in well-being and negative response or "maladaptive behaviour," unless there is rehabilitation of the individual, or more often, alterations in the physical and social environment to offset these losses. One would therefore assume that aspects of the physical environment can and do influence longevity, although the pathways of this relationship are not clear from this theory.

Revisions to the Ecological Model of Aging

Lawton's original ecological model of aging has been criticized for displaying too narrow of a focus on negative environmental demands, assuming a passive role of the individual, and limiting the person-environment transaction to mainly housing and institutional design features (Carp & Carp, 1984; Golant, 1998; Kahana, 1982; Rowles & Ohta, 1983; Wister, 1989). As a result, Carp and Carp (1984) developed the congruence model of aging in which needs are balanced through the use of resources and supports within the envi-

ronment. Additionally, Kahana (1982) and Cvitkovitch and Wister (2001; 2002) stress the importance of differential prioritization of perceived need in explaining levels of well-being among older adults of various levels of frailty. Svensson (1996) has also incorporated a life course/time element to this model. And furthermore, Gubrium (1973) places emphasis on symbolic interaction with the social environment that influences adaptive responses to aging (also see Lawton & Simon, 1968). In response to some of these gaps, Lawton (1987) introduced the concepts of proactivity (volitional behaviour to shape one's environment) and resources (personal and environmental) into a revised ecological model of aging. He also added a broad quality of life measure to capture well-being (Lawton, 1998). Together, this family of person-environment theories elucidates the complex ways in which person-environment transactions occur. People play a proactive role in shaping their environments (i.e., human agency), and the environments in turn not only influence behaviour and psychological well-being through the imposition of stressors, but also house a variety of resources (including physical and social) that facilitate adaptive processes of aging.

Applications of the Ecological Model to the Built Environment

While within these theories, "environment" has been conceived as multidimensional, encompassing elements of the physical, social and neighbourhood/community environment, the main applied focus has been on physical design features of housing for an aging population (Carp & Carp, 1976; Gubrium, 1973; Kahana, 1982; Lawton, 1975; Lawton, 1990b; Scheidt & Windley, 1998; Wister, 1989). For example, the ecological model has been widely used to justify the development of specialized housing and housing options that meet the needs of frail older adults (Pynoos & Regnier, 1991). It is assumed that for any set of health characteristics, there is a tailored environmental design that best fits those needs. The ecological model has also been influential in its impact on frameworks supporting the development of housing policies, such as *maximization of choice; aging in place;* and *blending shelter and care* approaches to housing (see Haldemann & Wister, 1993; Wister & Gutman, 1997). While these approaches have clearly improved quality of life of older adults in certain areas, research evidence supporting a relationship between the built environment and improved function, morbidity, and mortality has been modest. Furthermore, some researchers contend that certain forms of assisted housing may actually over-support the elderly because they do not present adequate levels of physical challenge (Shipp & Branch, 1999:321). We turn now to a further development in person-environment modelling, but one that deals more directly with health.

The Homeostatic Capacity Model

Fries and Crapo's (1981) homeostatic capacity model parallels not only the ecological model of aging, but also a number of stress models (see, for example, Antonovsky, 1979; Lazarus & Folkman, 1984; Schooler, 1982) used to understand person-environment interactions. The model assumes that the maintenance and restoration of individual homeostasis is fundamental to health and well-being. Similar to the ecological model of aging, the authors contend that, since reserve capacity declines with age, random environmental challenges or stressors become greater challenges among the elderly. Challenges that are within the ability of the individual (within the adaptation zone of the ecological model of aging and within the homeostasis capacity zone) are not only withstood, but may be positive in their stimulation effect, whereas those outside of this range result in a negative response. For example, an older person with aligned knee joints can withstand the vigors of a walking program and enjoy the cardiovascular benefits. However, an individual with a misaligned knee joint may incur osteoarthritic cartilage damage if they exercise, and yet, if they remain sedentary, may not only experience decreased cardiovascular function, but also exacerbate the arthritis because of reduced motion and blood flow to the joint (Shipp & Branch, 1999). In the most extreme case, Fries and Crapo (1981) contend that death occurs when the magnitude of a random environmental challenge exceeds capacity of an individual to restore homeostasis and maintain health.

Thus, this theory more directly ties person-environment fit to physical, as well as subjective, health status and, in turn, longevity. Moreover, it maintains that stimulation and challenge in life is needed to maintain competence and homeostasis–when "built" into an environment they can act as another type of resource to enhance individual capacity and salutogenic experience. Furthermore, the model implies that the narrowing of people's tolerance level as they age makes them susceptible to environmental press (pathogenic stressors), but does so in those areas for which there is the greatest decline in function. Although the homeostatic capacity model has an intuitive appeal, research has yet to explicate the various pathways by which aspects of the built environment facilitate longer life.

A Theoretical Synthesis: The Social Ecology of Health Promotion

The social ecological model of health promotion has been developed that synthesizes the axioms of the previously discussed ecological models, and directs its focus on pathways to health. Although this perspective is not specific to aging per se, it does offer important insights into the multifaceted ways in

which the built environment can impact health and longevity. Stemming from the social ecology literature, Stokols (1992) integrates interdisciplinary research literature into a systems framework, allowing for multi-level understanding of person-environment interactions and their effect on health. The fundamental assumptions are that: (1) healthfulness is the result of a complex interplay of facets of the physical environment, social environment, personal factors, including genetic heritage, psychological predispositions, and behavioural patterns; (2) environments can be described along several dimensions, including subjective-objective levels, proximate-distal ones, and independent (e.g., lighting, temperature, space) or composite factors (e.g., behavioural context, person-environment fit) with an emphasis on positive environmental resources; (3) participants within these environmental contexts can be studied at the individual, group, family, community, or population level; and (4) the social ecological perspective applies concepts from systems theory, such as interdependence and homeostasis (Stokols, 1992:7-8). Thus, although aspects of the built environment are viewed as directly impacting health, for instance, injury-resistant architecture, effective design of health facilities or workplace settings, and vehicle and road safety, these must be viewed in conjunction with attributes of the individual that may change over the life course as well as other elements of the environment such as social support.

Expanding the work of Antonovsky (1970), several salutogenic and pathogenic envirogenic processes in health and illness are identified by Stokols (1992). The physical and social environment can function as mediums for health (clean water) or disease transmission (water contamination); operate as a stress-reducer or stressor (qualities of institutional environments); can be a source of support, safety, or danger that retards or exacerbates disablement, and may influence the risk of morbidity or mortality (assistive and home technology, falls risks, etc.); enable or act as a barrier for health behaviour (accessibility of health care); and provide health resources (well-organized community health services). It can therefore be observed that the interaction of personal and environmental factors can enhance or slow functioning and health through direct and indirect pathways.

MULTILEVEL ENVIROGENIC PATHWAYS TO HEALTH AND LONGEVITY

As we have observed, relationships between the built environment, other environmental characteristics, and health are complex and multifaceted. The built environment can be construed as a medium to health, acting as both a direct and indirect pathway to health in isolation or in tandem with other ele-

ments of the broader environments in which we live, in particular family, friendship, and community networks. A critical examination of selected literature pertaining to various components of these relationships will be made, followed by synthesis of these discussions for the purpose of identifying research gaps and future directions. The subsequent analysis of literature addresses problems of conceptualization, measurement, data sources, and statistical analyses.

Relocation and Health

Relocation was one of the first environment and aging areas examined for its impact on adjustment, morbidity and mortality. To begin, it is essential to distinguish between what has been called residential relocation or transfer (movement from a community living environment to an institutional environment) and institutional relocation (movement from one institution to another) (Rutman & Freedman, 1988). Typically, it has been assumed that relocation of any type increases stress for the individual and therefore has a negative impact on health outcomes. However, there is some controversy in the literature as to whether relocation increases mortality rates, regardless of residential or institutional relocation (Golant, 1998). Moreover, there appear to be a number of factors that mediate this relationship (Kasl & Rosenfield, 1980). For example, research indicates that movement from the community to an institutional environment can be stressful because of loss of control, fear, attachment to home, etc., but can be ameliorated if the individual feels that they made a voluntary choice, if they become involved in making the new environment their "home," if they are able to psychologically adjust to the new environment; and if social support is maintained (Rutman & Freedman, 1988; Wells & MacDonald, 1981).

In addition, while it has been established in some studies that institutional relocation increases the likelihood of death (e.g., Rowland, 1977), this probability is influenced by a number of other individual and environmental factors, such as psychological preparedness, residents' acceptance of the change, the degree of change, prior setting, alterations in staff and room sharing, etc. (Golant, 1998; Gutman & Herbert, 1976; Kasl & Rosenfield, 1980). Observational research, for example, has shown that way finding and problem behaviors among demented residents in long-term care facilities may decrease after enhancement of special design, colour, and lighting (Gutman, forthcoming). Together, this research suggests that psychological and physiological health status may improve, if the relocation is to a considerably better institutional environment with careful planning and supportive services involved in the transfer.

Unfortunately, there have been few randomized control group studies of relocation that are of adequate sample size and follow-up to isolate environmental components deemed to be important. Most studies tend to be of convenience rather than carefully designed and implemented. Furthermore, few systematic attempts have been made to develop "place therapies" to deal with relocation stress (see Scheidt & Norris-Baker, 1999). What is needed in this field of study are more rigorous longitudinal quantitative and qualitative relocation studies that explicate elements of the physical and social environment, and their interaction, for both short- and long-term behaviour and health outcomes.

Overall, relocation between physical environments alone has not been shown to have a large effect on mortality, and indeed, the residential environment appears to exhibit greater impact on subjective domains (e.g., housing satisfaction, well-being) than objective ones. Furthermore, the physical environment needs to be considered in combination with the social environment, as well as psychological processes of appraisal and adaptation, in order to understand the ways in which the institutional environment affects health. This implies that there are both salutogenic and pathogenic elements connected to environments and that they need to be studied as multidimensional processes.

Community Housing Characteristics and Advancement of Health

A significant body of research has been undertaken to explore relationships between aspects of the built environment and psychosocial factors, such as well-being, morale, life satisfaction, housing satisfaction, valuation of life, and perceived health status. This research is important given that self-reported health has been linked to physiological health condition (Farmer & Ferraro, 1997; Wolinsky & Johnson, 1992). Yet, few studies have examined the impact of housing on health, since this research tends to assume that physical health status dimensions shape housing characteristics/needs, rather than the reverse.

A number of different housing characteristics have been shown to explain a modest amount of variance in the subjective variables noted above–what is termed here "the four percent factor." In his review article, Larson (1978) found that, in general, housing variables explain about 4% in well-being. Examination of elderly persons living in housing projects by Lawton, Nahemow and Teaff (1975) found that sponsorship, building size, community size and height of the building account for a little over 4% of the variance in housing satisfaction, friendship in housing and activity participation. However, only one physical housing attribute–number of floors in the building–exhibited a statistically significant association, and only with housing satisfaction. Doyle (1990) also established that approximately 4% of the variance

in negative affect is explained by objective housing factors (including tenure, age-mix, and housing costs), but that subjective housing factors (belonging, sense of fairness and effective control) account for another 4%. In a recent comprehensive study, Dunn and Hayes (2000) examined the housing costs, impact of tenure, crowding, dwelling type, neighbourhood socio-economic status, street lighting, police protection, satisfaction with the interior of the home, satisfaction with space, satisfaction with air quality, and pride of home on several health variables. The health factors included: perceived health, health satisfaction, mental health, and stress. Interior of the dwelling, tenure, police protection, crowding, satisfaction with space and traffic were associated with self-rated health and health satisfaction, and were mediated through psychological stress (Dunn & Hayes, 2000). These results were interpreted as suggesting that social inequalities manifest themselves in housing and neighbourhood characteristics, and tend to be mediated by multiple overlapping stressors (including material, phenomenological and special dimensions) of everyday life. They are probably most apparent when housing is absent, observed in studies of the homeless. Although this study did not focus on older people, the findings underlie the importance of measuring more specific aspects of the home that ultimately shape individual and population health.

Furthermore, when studies focus on marginalized populations with more extreme housing problems, there is a stronger association between housing characteristics and morbidity/mortality. For example, on Canadian First Nations' reserve communities, almost half of the houses require major repairs (Frideres, 1998). The absence of running water and indoor plumbing influence sanitation and hygiene, and small home size leads to over-crowding and further health problems.

Since there are strong theoretical reasons for believing that physical, social, and psychological elements of the environment interact to affect health; statistically controlling for these latter two environmental domains often results in weak associations for the physical dimensions. Indeed, if these environmental domains are combined, we observe more prominent associations. For example, Golant (1984) demonstrated that aspects of the physical and social environment explain about 14% of the variance in life satisfaction among non-institutionalized elderly, whereas individual characteristics (e.g., health status) explain an additional 39%. However, researchers also need to examine statistical interactions, which tend to be masked using conventional multiplicative interaction terms employed within regression models. Advancements in statistical modelling that is more sensitive to interactions among variables, such as graphical interaction models (Didelez, Pigeot, Dean, & Wister, 2002), may help to identify the intricate ways in

which environmental and personal factors intertwine and combine to influence health and longevity.

The Meaning of Home and Health Enhancement

A relatively large research literature has accumulated on a number of aspects of the built environment that have meaning for the individual and which may act as subtle, yet influential, factors for health enhancement. Studies point to the existence of a number of psychosocial processes that link the person to place, including familiarity of the environment, as well as attachment and meaning associated with personal objects, the home, neighbourhood and community (Chaudhury & Rowles, in press; Rubinstein, 1987, 1989; Scheidt & Norris-Baker, 1999). Furthermore, an individual's sense of control over their life, and reproduction of their social identity and their social status, is connected to their housing and property (Dunn, in press; Marcus, 1995).

These phenomenological dimensions may function as either direct or indirect pathways to health. For example, familiarity with one's home environment may directly reduce the risk of falls and other accidents due to experiential and adaptive processes over time. A blind person living in a familiar setting serves as the most obvious example. The meaning and memories attached to heirlooms, other possessions, and the home itself can be powerful indirect factors that influence feeling states and self-identity, which may, in turn, impact objective health. Social inequalities are reflected and reproduced in the built environment (Dunn & Hayes, 2000; Wilkinson, 1994) and may act as mediating factors on the immune, endocrine and central nervous systems through what has been termed sociobiological translation (Tarlov, 1996). Also, studies suggest that an individual's physical and emotional well-being is enhanced when environments are deemed to be personally controllable (Stokols, 1992). There is no doubt that remaining in one's own home for as long as possible in old age, often embedded within a mutually reinforcing social support system of family and friends, allows a person to maintain a sense of independence and self-identity that may in turn sustain health stamina.

However, research studies have tended to utilize only qualitative accounts and anecdotal evidence to support these relationships (one exception with a focus on the general adult population is Dunn & Hayes, 2000). Measures of these constructs need to be quantified and triangulated with qualitative data in order to establish their influence in a more definitive manner. Again, the impact of subjective elements of "home" may be most prominent in combination with other elements of the person-environment transaction, such as one's ability to manage day-to-day activities and the availability of formal and informal supports.

Home Support as a Means to Delay Institutionalization

Over recent years, there has been a trend to admit people requiring heavier levels of nursing care (DeCoster, Roos, & Shapiro, 1995). One of the primary reasons for this has been the development of home care and community support services in most countries with advanced health care systems, which afford individuals the opportunity to maintain an independent or semi-independent lifestyle for a longer period of time. In this light, independence should be conceived as a relative concept, in that receiving formal support (a semi-independent condition) may ultimately allow that person to live outside of an institution (a dependent condition). Given that the average life expectancy of institutional residents is approximately four years, and that approximately 96% of all persons admitted to a nursing home die there or shortly after being transferred to a hospital (DeCoster, Roos, & Shapiro, 1995), staying out of institutions seems to be associated with longer life. While this appears to be a tautological association on the surface, closer examination reveals important pathways to health that are connected to the physical environment. Whether this is because individuals feel more self-worth, self-identity, autonomy, and sense of control when living in a private home; whether they remain more physically active and challenged, or more socially connected, is an empirical question that needs to be answered through further research. The development of accessible home care and other community support systems (meal delivery, peer support groups, etc.) clearly delay relocation into a long-term care facility and perhaps put off or eliminate institutional death.

The availability and accessibility of informal support from family and friends may also delay institutionalization. Living alone has been identified as a major predictor of institutionalization (Shapiro & Tate, 1988). And, prior living arrangement has been shown to affect the number of ADL limitations of nursing home residents upon admission. Residents who lived alone before admission had 0.61 fewer ADL limitations than persons living with others (Egleston, Rudberg, & Brody, 1999). This suggests that informal support may substitute for formal support thereby allowing some individuals to remain out of institutional environments who would otherwise be living there. More research is required, however, to better understand the complex relationships between long-term care, home care, informal support, and longevity.

Assistive Technology, Home Automation, and Home Health Care

We have witnessed a rapid development of technological devices to increase function among disabled populations (Manton, Corder, & Stallard, 1993), as well as to provide home health care for incapacitated older adults

(Ruggiero, Sacile, & Giacomoni, 1999). These technological innovations have facilitated day-to-day living and have also helped to delay institutional living for disabled and frail populations. While technology, for some, is viewed as the panacea for most social issues, the extent to which technology can be used to extend life is uncertain. Some forms of technology are directly connected to the built environment, while others are for personal use within and outside of the home milieu. Assistive technology, such as powered wheelchairs, scooters, walkers, canes, hearing devices, etc., is widely available to older adults with a disability or illness; approximately 35% of the non-institutionalized population of elderly 75 and over are users (LaPlante, Hendershot, & Moss, 1992). Yet, although they have been shown to increase function (Chappell, 1993), and therefore reduce disability, no studies have directly examined their impact on longevity.

The field of home automation has also witnessed considerable expansion over recent years. Home automation includes technical devices that can be used to perform household tasks for severely disabled or ill persons, and include such operations as opening and closing doors, controlling light switches, kitchen appliances, televisions, and other home technology. While many of these devices are used to allow for an individual to live independently, they may have the additional effect of sustaining a person's capacity for life by keeping them in a more active environment than if they were institutionalized.

Similarly, home health care, which also relies on high-tech home care services, has burgeoned over the last decade (Kaye & Davitt, 1995; Kropf & Grigsby, 1999). Methods of diagnosis, treatment, and rehabilitation supported by specialized equipment in the home are being used in order to allow for early discharge from hospitals and to provide care "at a distance." Most research thus far has focused on programming strategies for implementation of home health care and how it can be funded (Kaye & Davitt, 1995; Kropf & Grigsby, 1999). What is needed is research that establishes its effectiveness through analyses of morbidity and mortality outcomes.

Taking these various innovations in technology and health together, we actually know little about the beneficial impact of technology on an aging population beyond the obvious association it has with increasing personal assistance with instrumental activities of daily living. In addition, despite their activity limitations, a relatively small proportion of community living elderly actually use most technological devices, once we remove hearing aids; and most changes appear to target the bathroom, rather than the whole home (Gutman, 1998). There are also issues of cost and access of technological devices of any kind for segments of the population (Chappell, 1993). Thus, while the potential may be there for technological innovation to further facilitate

community living among persons with severe disabilities or illness, more research is needed to examine the technology-longevity relationship.

Falls, Injuries, and Health

Probably the most direct environmental pathway to health and longevity established in the literature can be found in its influence on the probability of falls and other environmentally induced accidents and injuries, such as burns. Research demonstrates that falls, burns, and other injuries comprise a major health burden to society (Pauls, 1998). For people aged 75 and over, falls are the leading cause of fatal injuries and the sixth leading cause of death, higher than even motor vehicle deaths (Baker et al., 1992).

Falls and other injuries have been shown to be the result of interactions between many personal and environmental risk factors (Gallagher, Hunter, & Scott, 1999; Speechley & Tinetti, 1991; Tideiksaar, 1997). Aspects of the physical environment, such as the absence of railings on stairs and loose rugs, in combination with personal risk behaviour increase the probability of a fall resulting in injury. Often, the injury results in a hip fracture, which has been linked to poor mobility recovery (Visser, Harris, Fox, Hawkes et al., 2000) as well as functional outcomes and mortality (Dolan, Hawkes, Zimmerman, Morrison et al., 2000). However, there is some degree of controversy in the literature surrounding the degree to which the physical environment poses a threat to the individual (see Golant, 1998; Lawton, 1998). In particular, Shipps and Branch (1999) contend that environments, especially those for frail elderly, physically challenge and stimulate an individual in significant ways. For example, they contend that frequent use of stairs in an assisted living facility may help to keep the individual more physically and functionally fit, which actually lowers the risk of falls.

However, there is as yet no direct proof that the presence of stairs in long term care design has a net salutogenic effect and extends longevity. In fact, stairs are the leading cause of serious falls among community-living elderly, accounting for about one-third of all fatal falls (Pauls, 1998). Moreover, it is estimated that stairs were involved in one million hospital emergency room treated injuries in 1994 in the United States; and stairs are the leading product category for injuries in the National Electronic Injury Surveillance System data (CPSC, 1995). It is clear from this literature that the physical environment does indeed directly affect the likelihood of falls and injuries, especially among the very old and frail at a high cost to society. What is not as clear is the degree to which manipulation of the home environment can reduce this risk and whether individuals are willing to make and adhere to changes at the environmental and behavioural level.

Healthy Communities

Finally, a recent development within the health promotion movement has been the advancement of community as an ecological entity of importance in the maintenance of health broadly defined (Pedersen, O'Neill, & Rootman, 1994). Individuals who share a common set of attributes and often a definable ecological space are deemed a community. Furthermore, people may belong to more than one community at a given time. The environmental movement has emphasized various aspects of an ecological space that may influence health in salutogenic and pathogenic ways, but has tended to focus on air and water quality, deforestation, ozone depletion, and population density. These areas of environmental social action have been combined with elements of social organization (e.g., facilitating cohesiveness of a community through the development and enhancement of support systems such as community centres) and policy development (e.g., driving laws to reduce pollution and accidents) into what has been termed healthy communities. While healthy community components can be viewed as closely linked to the built environment, the tendency is to consider mainly shared space outside of the home environment and to target more marginalized communities (e.g., urban core areas, ethnic, and racial enclaves, etc.). Examples of enhancement of healthy communities involving the built environment include: expansion of walking and bike pathways; improved and safer public transportation systems; neighbourhood crime prevention programs; urban renewal; preservation and expansion of green belts; and reduction of noise and air pollution through road design. Although the impact of these programs and policies on health and longevity has yet to be established, there appears to be considerable belief that an ecological approach to health promotion has tremendous potential value. Future research that demonstrates the health impact of community approaches is needed to help direct and expand these efforts in a corporate culture. For example, there may be considerable cost and health benefit in increasing the visibility of road signage for an aging population of drivers, however, environmental standards and their implementation require not only research support, but also development and evaluation of policy.

SUMMARY: PROMOTING HEALTHY ENVIRONMENTS IN A NEW MILLENNIUM

This paper has addressed the relationship between the built environment and longevity from an interdisciplinary perspective. We began with an examination of theoretical developments and synthesis drawn from the rich per-

son-environment and social ecology literatures in an effort to specify envirogenic pathways. Several key dimensions of these relationships were identified. First, the built environment may have both salutogenic and pathogenic effects. Second, the built environment interacts dynamically over the life course with social environments (e.g., social network, neighbourhood, and community), and individual adaptive processes. Third, envirogenic pathways work at several levels–individual, family, group, and societal. And finally, both positive and negative envirogenic influence flow along direct and indirect pathways. Thus, the built environment has multiple dimensions. It may act as a medium for health and illness (e.g., clean or contaminated water); function as a stress-reducer or stressor (e.g., design elements of an institutional environment); operate directly as a source of safety or danger (e.g., falls and injury); enable or facilitate health (e.g., assistive technology, home automation, and home health care); and serve as a health resource (e.g., community home support services).

We elaborate and specify envirogenic pathways to health and illness through a critical examination of selected environment and aging research. The areas covered, include: relocation; community housing characteristics; meaning of home; home support and delays in institutionalization; technological devices; falls and injuries; and healthy communities. The literature pertaining to these substantive topics is highly variable in the degree to which there is demonstration of an environment–healthy aging/longevity association. Indeed, while there is intuitive appeal to envirogenic pathways to health and long life, most research is far from conclusive. For example, relocation between physical environments does not appear to have a large salutogenic or pathogenic effect, and further, seems to exert more influence on subjective domains (housing satisfaction, well-being) than objective ones. Physical movement through time and space also needs to be considered in tandem with the social environment and psychological processes of appraisal and adaptation.

Research indicates that various housing characteristics (e.g., design, quality, size, cost, crowding, esthetics, etc.) influence behaviour, psychological well-being and ultimately health and longevity, but they only account for a modest amount of variance in health measures. Certainly, measurement, design and analysis that is more sensitive to these factors, especially their interaction with other environmental dimensions, would yield more definable and consistent findings, and more importantly, a fuller understanding of these relationships. In addition, the meaning of home is a pervasive but ephemeral concept that may be mutable through "place therapies," such as counselling newly relocated institutional residents.

Probably the most direct and powerful pathogenic environmental condition is the impact of design features of the home on falls and other injuries. Most falls occur as the result of stairs, suggesting that improvements in safety and design may have significant influence on health and longevity. Yet, some researchers contend that some degree of challenge in the environment is salutogenic because of the need to stimulate physical and mental functional processes. Research needs to identify thresholds of environmental mismatch that are positive in their health effect. Furthermore, a compelling argument is that maintaining an independent or semi-independent lifestyle outside of institutional care for as long as possible increases longevity, which may originate from formal and informal sources of support, as well as the application of technological innovations. However, research needs to determine the conditions under which health is enhanced or hindered by "aging in place." Finally, the development of healthy communities through program and policy environments represents the newest and perhaps the most far-reaching physical environmental determinant of health. Expansion of walking and bike pathways; improved and safer public transportation systems; neighbourhood crime prevention programs; urban renewal; green belts; and reduction of noise and air pollution through road design are a few areas gaining attention. In addition, envirogenic factors affecting levels of toxins in our water, air, and food are being targeted with ever-increasing enthusiasm in the post-modern era. This raises fundamental questions pertaining to technological development as well as economic and political systems supporting material competition in a global economy.

In conclusion, this paper has generated more questions than answers. Future research requires incorporation of more sensitive and comprehensive measures of physical, social and other elements of the environment. In addition, longitudinal research is needed to establish a link between envirogenic pathways that impact not only health and illness, but also longevity. Just because the physical environment may have a salutogenic or pathogenic influence does not mean that it will necessarily extend life. This underlines the importance of also recognizing the influence that the built environment has on qualitative elements, such as well-being, happiness, adjustment, and function, as components of healthy life expectancy. Developments in measurements and analyses of interactions among environmental, physical, and psychosocial measures may tap into the subtle but potentially powerful ways in which the built environment can shape the experience of healthy aging. But this research requires methodologies capable of identifying and elaborating intricate mediating and interactive effects–a challenge for interdisciplinary collaborative research initiatives in the new millennium.

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