ENVIRONMENT DESIGN GUIDE

THE COSTS OF URBAN SPRAWL – PHYSICAL ACTIVITY LINKS TO HEALTHCARE COSTS AND PRODUCTIVITY

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This is one of three companion papers taken from a study that assesses the comparative costs of urban redevelopment with the costs of greenfield development. The first paper, GEN 83: The Costs of Urban Sprawl – Infrastructure and Transportation*, shows that substantial costs would be saved in infrastructure and transport if urban redevelopment were the focus. The second paper* GEN 84: The Costs of Urban Sprawl – Predicting Transport Greenhouse Gases from Urban Form Parameters *discusses the costs that can be linked to the transport carbon emissions that arise from suburban living.*

This paper discusses the health and productivity benefits of active-travel associated with the different urban forms due to levels of density, connectivity, and variety in amenity. It shows healthcare savings related to active forms of travel over a 50-year urban lifetime are quite small at $2.3 million for 1000 dwellings. But if these more walkable developments are pursued then the benefits to employment productivity are large, estimated to have a present value of $34 million. This is a substantial benefit that is comparable in scale to the savings in transport and infrastructure, as well as the social costs of greenhouse gases, and should provide a critical input to urban planning decision-making.

Keywords:
urban sprawl, redevelopment, urban planning, activity, health, productivity

Figure 1: The suburban planning model for many Australian cities puts an emphasis on car travel over more active alternatives such as walking or riding

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1.0 INTRODUCTION

Australian cities are under focus as the Federal Government begins to invest in urban infrastructure and questions are raised about the fuel, Greenhouse Gas (GHG) and health impacts of such investment. This paper examines two alternative approaches to urban development: redevelopment in walkable, transit oriented developments and fringe development in conventional low-density car dependent suburbs. Urban redevelopment is based around present urban areas that are already well served by public transport but can also include new developments, so long as transit accessibility, walkability, and density are implemented in the planning and design process. The two development types are set out in detail in the companion paper GEN 83: The Costs of Urban Sprawl – Infrastructure and Transportation.

The companion papers discuss the physical planning costs associated with the different transport and infrastructure requirements and then examine a new area of public policy – GHG emissions. This paper discusses activity-related health and productivity costs. These are the subjects of increasing interest and their economic costs can then be compared with the more traditional costs of physical planning.

2.0 HEALTH-RELATED COSTS

Recent years have set the stage for increased interest in the topic of urban forms impact on public health. The view that car-dependency has led to the creation of obesogenic (obesity inducing) environments is now supported by a substantial number of studies and the case is being built for urban planning reform for active lifestyle improvements (Ewing et al. 2003; Frank et al. 2004). Nations have made estimates of healthcare costs as experienced by the burden of inactivity among their populations. For instance it is estimated that 1.5-3.0 per cent of total direct healthcare costs are related to inactivity in developed countries (Oldridge, 2008), however, the economic assessment associating the costs of illness, inactivity, and urban form to an urban planning mindset has yet to been done.

The allotting of more residential zones in greenfield areas is a further commitment to car-dependency and inactive travel but has been the conventional model for residential growth since World War II (Newman and Kenworthy, 1999). The environments that we create, aesthetically and functionally, have profound consequences on our emotional connectivity to the people around us and to our physical settings, affecting both our quality of life and the manner in which we interact with the cities we live in (Frank and Engelke, 2005, Stokols et al., 2003).

In addition to psychological effects, research has also been able to link aspects of the built environment directly to human activity patterns and travel choices for both non-discretionary travel and leisure (Frank and Engelke, 2005). The purpose of this research is to economically quantify the health benefit of refocusing future development to inner city type areas where transit and active means of travel can make for a healthier population. We have defined an active-travel neighbourhood as one that is conducive to both cycling and walking, which in daily life activities could lead to most able bodied people engaging in at least 30 minutes of active travel per day.

Walking Cities – is a term associated with traditional cities built before the era of the tram and train (pre-World War II).

Transit Cities – came from the introduction of trams and trains in the late 19th century and saw the creation of walking cities associated with station precincts.

Auto Cities – are said to have formed after the war as personalised transport by car became more widespread, allowing people to travel further and faster.

(Newman and Kenworthy, 1999)

2.1 Background

A growing body of evidence suggests that neighbourhoods characterised by low density, poor connectivity, and poor access to shops and services, are associated with low levels of walking. Moreover, sprawling areas of low walkability have been linked to obesity and numerous other chronic illnesses (Giles-Corti, 2006, Sturm and Cohen, 2004). Australia now has one of the most obese populations, ranking 21st in the world and third among all English-speaking countries (Forbes, 2007).

2.2 Obesity

Between the years 1980 and 2000, obesity levels increased among males (10 per cent) and females (12 per cent) in Australia as measured by a BMI (Body Mass Index) of equal to or greater than $30kg/m^2$

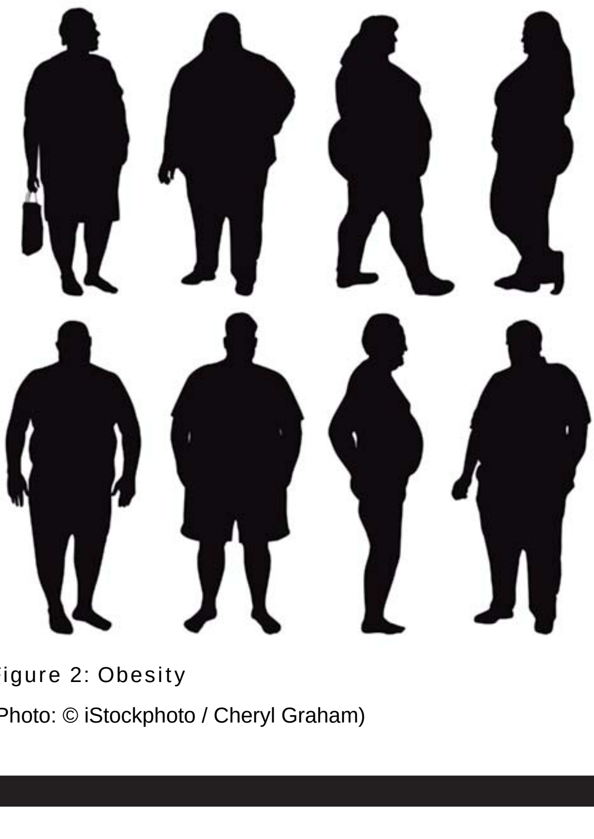

Figure 2: Obesity

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(ANZOS, undated). Over the same period, the portion of overweight Australians increased 17.5 per cent for males and 18 per cent for females, measured by a BMI equal to or greater than 25kg/m^2 (ANZOS, undated). Although not all obesity is attributable to urban form, one study has documented that each additional hour spent in a car per day was associated with a six per cent increase in the odds of being obese, while each additional kilometre walked per day was associated with a 4.8 per cent reduction in the odds of being obese (Frank et al. 2006). This can have significant implications, as another study has shown that individuals in the least walkable environments drive the most per day (74kms), while those in the most walkable environments drive the least (43kms) (Frank et al. 2007a).

2.3 Other Illnesses

Obesity is not the only link to urban form. Other illnesses and costs to the healthcare system arise from inactivity such as falls, coronary heart disease, type-two diabetes, depression, stroke, colon cancer, and breast cancer on which the economic modelling consultancy Econtech reported a cost of $1.5 billion to the Australian healthcare system in 2007 (Econtech, 2007). Furthermore, it is stated that about 54.2 per cent of Australian adults were found to be insufficiently active according to National Physical Activity guidelines in the year 2000 (Econtech, 2007). This suggests an opportunity to substantially reduce direct and indirect costs due to inactivity in Australia by facilitating incidental activity with urban planning. A joint American-Canadian study found that residents of more walkable environments are 2.4 times more likely to meet or exceed the recommended minimum levels of moderate activity than people in the most sprawling areas (Frank et al., 2005), further showing the potential for urban planning policy intervention for healthcare savings.

2.4 Active Travel

Recent advances in research on urban form have researchers starting to identify and separately measure utilitarian active forms of travel from leisure forms of conveyance to acknowledge that sometimes both are accomplished in the same outing, yet also may be affected differently by certain aspects of urban form. In other words, they record and measure how urban form affects walking for the sake of transportation as distinct from walking for the sake of leisure, then cumulatively measure if there is a net gain or loss in active living in walkable neighbourhoods.

2.5 Measuring the Factors

Multidimensional measures of urban sprawl are another advance in urban planning research. They allow for a more objective measure of urban form to be made and thus explain the relationship to travel behaviour with more confidence.

This is done by agglomerating urban features, all of which have been proven to be associated with increased active travel (see companion papers), such as:

- density
- land-use-mix
- proximity
- connectivity
- and degree of centring to make indexes for experimental designs

2.6 Making Positive Change

In their research Newman and Kenworthy (1999) found that 35 people and jobs per hectare was the threshold density for decreased auto dependence and beyond that, travel by car lessens and active travel and transit use begin to increase. This measure will depend on the degree of transit service provided and the walkability of the design. Other research, such as that by Sturm and Cohen, has closely linked overall physical health to urban density. They found that a difference in their sprawl index of 100 points, which would be the difference between Riverside in California, which is very sprawled, and Boston, Massachusetts, which is characterised by a low level of sprawl, was associated with 200 fewer chronic illnesses per 1000 persons (Sturm and Cohen, 2004).

All this implies that a step towards designing our cities around active transport instead of the automobile can have some profound effects on physical health and possibly mental health. As a result, an increase in discretional and non-discretional active transport has the potential to identifiably benefit social capital and public health while saving the healthcare system considerable money. This paper attempts to quantify this potential benefit for the Australian context.

2.7 Data and Method for Healthcare Cost Calculation

The calculation method selected for use in this research is best described as a cost-of-illness approach to economically appraising the health impacts of urban form. Other methods exist such as a Years-of-Life-Lost (YLL) approach or agreeing on a standard value of a 'statistical life;' however, the cost-of-illness approach worked best with the available information and allows for the fewest assumptions to be made.

In the process of the economic assessment, information was drawn upon from two separate areas of study, being the cost of inactivity in Australia and the variation in active travel among cities of differing urban form. The overall calculation is done in a series of parts, starting with a top-down approach to place a value on an hour of moderate-intensity activity per person. Next, the hourly per person savings estimate is attributed to an expected increase in activity levels characteristic of active travel neighbourhoods, and finally, the healthcare savings for the development of a high-density, mixed-use development of 1000 dwellings is calculated.

2.7.1 Identifying the Value of Physical Activity in Australia

Direct Inactivity Costs

In 2007, the Australian government-owned Medibank Private health fund contracted Econtech to produce a report on the direct inactivity costs of Australian adults. This value was estimated at $1.5 billion and included the following seven illnesses: falls, coronary heart disease, type-two diabetes, depression, stroke, colon cancer, and breast cancer (Econtech, 2007). An adult was defined as anyone of the age 18 and over and the value represented the potential savings that could be achieved if more adults became sufficiently active. Their report quoted the 2000 National Physical Activity Survey in stating that 54.2 per cent of Australia's adult population is not getting enough physical activity to remain healthy. Using this figure and assuming that the $1.5 billion estimate can be applied to the inactive portion of the adult population, an overall value of $2.8 billion was estimated for the physical-activity related component of health for all Australian adults.

Indirect inactivity costs

Indirect costs such as losses due to early death or extra sickness that can be related to lack of exercise are more difficult to calculate because of the complexity of the assumptions required. Health Canada's Economic Burden of Illness (1993) assigns an overall ratio to its economic health assessments that approximates indirect costs at 54.3 per cent of the total cost of illness. This approach takes into account productivity losses due to mortality and short and long-term disability. Using this ratio would estimate Australia's indirect cost of inactivity at $1.78 billion , the total cost of inactivity at $3.82 billion , and the total value of all Australian adults meeting recommended activity levels at $6.1 billion.

The best Australian estimate of the indirect health costs for inactivity was from Australia's National Public Health Partnership (ANPHP) which estimates that indirect costs would more than double direct costs but provides no numerical value (Bauman et al. 2002). To be conservative and simply say that indirect costs would amount to double the value of direct costs would produce an estimate of $3 billion. Using this estimate would translate into a total cost of $4.5 billion due to inactivity and a total value for all Australian adults of $8.3 billion.

For the purpose of this calculation the Canadian ratio was used, providing the figure of $6.1 billion for the total health value of activity among Australian adults in determining the estimate for the healthcare savings of active travel neighbourhoods. This was chosen as the ANPHP's indirect-cost estimate mention above lacks sufficient detail.

2.7.2 Demographic Information

The population of Australia is roughly 21 million people (ABS, 2007). The cost of inactivity in Australia, however, was determined for the ages 18 and over. This had to be taken into account when calculating a value for each hour of moderate-intensity activity for the Australian adult population. According to data provided by the Australian Bureau of Statistics, 73.3 per cent, or 15.4 million people, fall within this age group (ABS, 2006).

Furthermore, there is an average of 2.5 people living in each household in 2003-04 (ABS, 2007). With 73.3 per cent of Australia's population over the age of 17, it was estimated that each household contains an average of 1.83 persons within this age group. This figure is used in the overall calculation to determine the health-related savings in developing 1000 dwellings as inner city type developments.

2.7.3 Recommended Minimum Activity Levels and Associated Savings

The National Physical Activity Guidelines for Australians recommends that one should engage in 30 minutes of moderate-intensity physical activity a day over at least five sessions per week to be considered physically active. These 2.5 hours per week can be met by walking 15 minutes to and from the bus during a standard workweek, or more generally by engaging in more active travel. This is the criterion on which the costs of inactivity are based. It is assumed that any increase in moderate activity is associated with a proportional decrease in health costs. In other words, it assumes that if the Australian adults that currently are insufficiently active begin to increase their activity levels by 50 per cent of the required amount, then a cost reduction of 50 per cent would be experienced. Furthermore it is assumed that if the entire adult population became sufficiently active according to National Physical Activity guidelines, then the costs of inactivity would be averted.

By knowing the adult population of Australia , the minimum recommended activity levels , and the estimated value of those activity levels being met by all adults , a value of $3.02 was then determined for each hour that an individual engages in moderate physical activity . The calculation does not account for varying proportions of inactive people by specific region or state. The usefulness of the economic impact estimate is in its versatility in calculating the value of active lifestyles in urban settings, not in making specific economic assessments of specific neighbourhoods or demographics.

2.7.4 Estimated Activity Increase in Active Travel Neighbourhoods

Keeping in mind that the goal of the tool was to monetise the benefits of developing an area that is well suited for active travel, it was important to quantify the health benefits that both cycling and walking could have as people convert to them and away from car dependency. However, studies that objectively measure physical activity with objectively measured urban form have focused on walking for active transport. Cycling-specific data correlated with objectively measured urban form could not be found. Information on walking, conversely, was more readily available and the assumption had to be made that the two would vary proportionally as functions of an area's suitability for active travel.

Research by the US organisation Active Living Research has shown that residents of more walkable areas spend about 30 minutes more per week (20 per cent of the recommended amount) on walking trips than residents in sprawling areas (Active Living Research, 2005). Another study conducted by findings from SMARTRAQ in the US found that 19 per cent more people are likely to meet or exceed the recommended minimum activity quota of 2.5 hours per week (or 130 hrs per year) in highly walkable areas than people in the most sprawling neighbourhoods (Frank et al., 2005). Total potential health-related savings were then calculated using the logic that if 19 per cent more of the total resident population meets the National Physical Activity's minimum recommended level of moderate activity per week in active travel neighbourhoods, then one could expect a 19 per cent discount in inactivity-related health costs.

The annual difference in cumulative time spent walking between active travel and sprawling neighbourhoods was then calculated as 19 per cent x 1000 dwellings x 1.8325 adults per dwelling x 130 hours per year per person, resulting in 45,263 hours. It should be known that this figure is not an estimated difference in total hours of activity between sprawling and walkable neighbourhoods, simply an estimated difference in minimum activity level hours of walking between the two types of developments. It does not include hours that exceed the minimum recommended levels, nor does it include time spent on other recreational or non-discretional forms of activity.

As mentioned before, similar data for cycling was not available so it had to be calculated a little differently. Socialdata Australia provides some data on travel mode distributions among various Western Australian suburbs. A weighted average of bicycle trips as a proportion of walking trips was calculated and determined to be roughly 21 per cent (Socialdata Australia, 2008). Assuming that cycling levels remain proportionate to walking levels and that their average trip duration is approximately the same (Newman and Kenworthy, 1999), the increase in annual hours of cycling for transport in urban redevelopment of 1000 dwellings over a greenfield one was worked out to be 9,505 hours (21 per cent of 45,263). Since the National Physical Activity's guidelines do not distinguish between types of physical activity and simply recommend 'moderate-intensity activity,' it was also assumed that walking and cycling for transportation share the same level of benefit.

2.7.5 An Economic Impact Estimate on Healthcare Costs

The estimated savings benefit due to increased physical activity levels in an active travel neighbourhood was calculated for a development of 1000 dwellings:

Walking at	45,263 hours x $3.02/hr = $136,694
Cycling at	9,505 hours x $3.02/hr = $28,706.
Total	$164,399

Thus, the savings in public health due to an active travel neighbourhood of 1000 dwellings is estimated to be $164,400 per year or $164 per dwelling.

2.7.6 Discounting

When discounting recurring savings such as these there are a few timelines that one could consider, such as using the turnover period for a development, the average life expectancy for an Australian, the average life expectancy of a development, or one could even discount the annual savings as perpetuities if making the assumption that the property will remain zoned for residential use indefinitely. The decision was made to use a period of 50 years, which is considered the minimum duration for which a residential building would be erected for. It is assumed that after 50 years the decision of if and how to redevelop the piece of land will be made once again.

In addition to deciding on the number of years over which to discount the annual savings, a discount rate of three per cent was chosen to reflect Australia's average annual rate of inflation (Reserve Bank of Australia, 2007). A higher discount rate could have been used, however, since the figure represents a savings benefit and not an investment with associated risk, three per cent was considered suitable. Conversely, a lower rate could have been used or future figures adjusted if other technological or medical considerations could be foreseen, but the calculation assumes treatments for the associated illnesses will remain constant.

The final calculation after the aforementioned considerations estimates the present value of the economic health benefits of an active-travel development of 1000 dwellings at $4,229,950. This figure reflects the incremental economic health savings of developing 1000 residential dwellings if deciding to redevelop inner-city type areas as active-travel neighbourhoods as opposed to further expanding into greenfield areas. This is a small figure compared to the transport and infrastructure costs over 50 years and even compared to the social costs of GHG emissions. Thus health-related productivity also needs to be considered.

3.0 THE ACTIVITY – EMPLOYMENT PRODUCTIVITY LINK

While there exists one body of research investigating the link between urban form and activity levels and health, there exists another body of research exploring the impacts of physical activity on workplace productivity. As yet, we are unaware of any studies that directly tie urban form characteristics to employment productivity via the physical activity link, but it does not require a stretch of the imagination to see that such a link could exist. This section pursues this avenue of thought, arguing that active-travel neighbourhoods are likely to have a workplace productivity benefit that is distinct from any potential healthcare savings. The estimated economic impact on productivity will assume the same scenario as with the activity-related healthcare costs: that the impact is from a development of 1000 dwellings with average occupancies of 1.83 adults over the age of 17 per household.

3.1 Background

The majority of empirical studies relating exercise to workplace productivity have been focussed on workplace fitness and wellness programs. The rationale behind their introduction by firms is that if their employees are healthier, this may result in fewer sick days being taken (presenteeism), better productivity on the job, and better employee relationships (Pronk et al., 2004). Furthermore, in the USA for example, firms can expect greater savings in medical insurance expenditure if their employees are healthier (Proper et al., 2002) and can simultaneously improve their corporate image (Aldana and Pronk, 2001). In the US, the percentage of worksites offering health programs and facilities increased from 22 per cent to 42 per cent between 1985 and 1992 (Wattles and Harris, 2003). In Canada, this number grew from 44 per cent in 1996 to 64 per cent in 2004 (Chenoweth, 2007).

The majority of empirical works examining the physical activity/employment productivity relationship do so by employing an experimental design that involves measuring the effects of worksite wellness programs on productivity-augmenting issues such as absenteeism, presenteeism, stress levels, job satisfaction, and job turnover. This is typically accomplished by conducting longitudinal studies involving intervention and control groups where pre and post intervention physiological and mental criteria can be assessed. For the purpose of these experiments, data on absenteeism can with relative ease be retrieved from human resources departments within firms; however, measuring employee job performance tends to be more challenging. Studies typically turn to the World Health Organisation's Health and Work Performance Questionnaire (HPQ), which is a self-report instrument designed to help organisations estimate the employee health costs associated with absenteeism, job performance and work-related accidents and injuries (Kessler, et al., 2003). Although self-report surveys such as this are prone to bias, the HPQ has been reconciled with employer archives on employee performance and good concordance has been found.

Given the difficulties of quantifying the effects of physical activity on employee performance, it is not surprising that these programs have not been economically justified in any rigorous or detailed manner. Some of these difficulties include (but are not limited to):

- clearly understanding who is being impacted by the programs and the respective values of their time (i.e. a CEO missing a day of work is likely to have greater financial repercussions than a lower-level office clerk)
- being able to predict the participation levels of programs
- aggregated results obscure whether the employees participating in workplace initiates are the ones standing to benefit the most
- designing programs well enough to keep participant interest long enough for health benefits to be experienced
- understanding how improved health may benefit employees who work in teams differently from those who typically work alone
- understanding how the varied impact of one employee's absence over another's may affect the flow of output in an organisation (due to the ability of others to act in the role in their absence)

Despite these measurement challenges, larger employers have been opting to provide these facilities and programs for altruistic purposes, to demonstrate good corporate citizenship, and to improve employee well-being rather than solely for pecuniary purposes (Shephard, 1992).

3.2 The Opportunity for Planning

Fitness programs in workplaces

The choice for firms to invest in workplace fitness programs and facilities may be one justified or partially justified on imprecise calculations, but for many smaller firms the whole concept is simply financially unrealistic. In Australia, small businesses (defined as employing fewer than 20 workers) represented 97 per cent of private firms and nearly 50 per cent of employment in 2000-2001 (ABS, 2001). In the US, 50 per cent of companies with over 750 employees offer health programs, yet this number drops to 38 per cent in those employing between 250 and 749 employees and drops a further five per cent in those employing fewer than 49 (Chenoweth, 2007). If similar health benefits can be accomplished through urban design efforts, those particularly geared towards increasing incidental travel by way of walking or cycling, it is logical to see how planning policy can thus influence the economic productivity of cities, which are inclusive of companies of all sizes. In this way, health policy and community-scale urban planning may currently be missing opportunities to effectively improve health and productivity simultaneously and across multiple sectors (Yancey et al., 2007). This is of striking importance because once communities are built, it becomes extremely difficult to reconfigure them and many opportunities may be lost.

Benefits

Berger et al. (2001) do well to put things into perspective when they argue that a firm's investment in workers extends beyond that of wages to include other things that affect performance and tenure, such as health. Furthermore, they argue that health can be viewed as a commodity that gets "used up" and that employees manage their time so that it gets produced and consumed. In this sense, just as worksite wellness programs can be viewed as investments in

Author	Results	Company/Occupation
On-the-job Productivity		
Cox et al. (1981)	2.7% gain over controls	Canada Life
Feigin et al. (1960)	4% increase	Electrical Assembly
Health and Welfare Canada (1976)	4% gain	Office workers
Kmuzoz (1975)	4-10% higher productivity	Worker-athletes
Pravosudov (1978)	2-5% to 10-15% gain	Industrial work
Zoltik et al. (1990)	5.6% gain	Pentagon
Absenteeism		
Bertera (1990)	0.5 days/yr decrease	Blue-collar chemical
Blair et al. (1986)	1.25 days/yr decrease	Dallas School Board
Bowne et al. (1984)	0.8 days/yr decrease	Prudential Assurance
Garson (1977)	2.1 days/yr decrease	Metropolitan Life
Mealey (1979)	1.4 days/yr decrease	Police
Montgomery and Byrne (1988)	0.6 days/yr decrease	
Pravosudov (1978)	4 days/yr decrease	Russian industries
Terborg (1986)	2.8 days/yr decrease	Batelle Memorial Institute
Zoltick et al. (1990)	0.2 days/yr decrease	Pentagon

Table 1: Influence of Employee Fitness programs on Productivity and Absenteeism

(Source: Shephard, 1992)

'replenishing' employee health, a company's choice of location can be viewed as a similar type of investment if it is a comparatively healthier environment and better supports employee wellbeing. In their study on the effects of an employee fitness program on reduced absenteeism, Lechner and Vries (1997) conclude that a significant decline in sick days only occurs for those who participate in the programs at least once per week, which is the threshold that they used to distinguish between "high" and "low" participation. Whilst elevating and maintaining employee participation in these programs could prove to be a challenge, an urban form that allows or even incentivises employees to travel by physically active modes would conceivably be much more effective by getting larger volumes of people more active and sustaining this activity level over longer periods of time.

Figure 3: Productivity

(Photo: © iStockphoto / Dan Tero)

3.3 The Empirical Productivity Evidence

Keeping with some of the assumptions made in the calculation of the activity-related health care benefits and sourcing some empirically estimated productivity benefits from existing studies, we can make some rough estimates of how active-travel has an economic impact on employee productivity through urban form. For the sake of simplicity, we will focus on benefits as they relate to absenteeism and on-the-job productivity – the two most common empirically studied effects. Mills et al. (2007) found that after a 12-month intervention-control study on a multinational corporation, the intervention group benefited from 4.3 fewer absentee days per person and an on-the-job productivity increase of 10.4 per cent. Similarly, Lechner et al. (1997) in their longitudinal pre-test/post-test study found that fitness program participants experienced a decline of 4.8 sick days with a sample consisting of employees in the police force, the chemical industry, and in banking. Furthermore, Sheppard (1992) provides a critical analysis of worksite fitness programs and generates a table summarising the results from a number of reviewed studies. Table 1 displays several results from the Sheppard (1992) study, with results selected on the basis that absenteeism is reported in 'days' gained or lost and on-the-job productivity is reported as a proportional increase.

3.4 An Economic Impact Estimate on Productivity

For the sake of this calculation, for increased activity we will assume a 6.2 per cent on-the-job productivity increase and for absenteeism, we will assume that more active employees benefit from 2.1 fewer sick days, both of which represent averages of the surveyed results. We adopt the neoclassical assumption that employees are remunerated according to the marginal contribution of labour and thus use the Australian weekly earnings average of $1165.40 as the baseline level of productivity. Furthermore, in congruence with the activity-related healthcare savings we will carry out the calculation for a 1000-dwelling development, each inhabited by an average of 1.83 adults of age 18 or over.

Keeping with these assumptions and carrying out the necessary calculations suggests that the productivity benefit due to a reduction in absenteeism would accrue to an annual average of $489.47 per person, with an additional $3,468.23 per person in benefit due to improved presenteeism. For an active-travel development of 1000 dwellings where 19 per cent more of the population meets their minimum physical activity requirements, these values surge to $170,420 and $1,207,550 per annum respectively, with a total annual health benefit of $1,377,970. After discounting over 50-year time spans at rates of three per cent, these values translate to $4,384,900 and $31,070,000 for absenteeism and presenteeism respectively, totalling $35,454,900 for the productivity-related health benefits. These are substantial cost savings.

3.5 Other Sources of Productivity-Related Benefits

The possible benefits suggested here are not trivial and are now possible to be considered and weighted along with other quantifiable costs and benefits of planning. The productivity effect of active travel urban form was calculated here as a function of a reduction in workdays lost due to illness, stress, or waning workplace satisfaction (absenteeism) and of the increased ability for employees to focus on tasks and maintain focus for longer periods of time (presenteeism or on-the-job productivity).

The effects of increased daily activity levels on productivity are not limited to these two benefits, however, outside of them the empirical evidence and causal links are too inadequately explored to justify their inclusion in a quantitative economic estimate. Some of these additional productivity benefits for example may include improved employee relationships, which may enhance synergies within group settings, and lower employee turnover, which may reduce hiring and training costs.

4.0 DISCUSSION OF HEALTH AND PRODUCTIVITY BENEFITS

The process undertaken for economically assessing the health impacts of urban form utilised a 'cost of illness approach', while the productivity benefits were estimated by a bottom-up accounting method. What the data collection endeavour for these calculations revealed was the scarcity of objective data available, more particularly with an Australian context, and the complexity of the subject matters at hand.

A noteworthy limitation of the analysis is the assumption that 19 per cent more of the population meets their minimum daily activity requirements in walkable as opposed to non-walkable neighbourhoods. The findings reported in the study by Frank et al. (2005), from which this figure was sourced, are only reported in relation to the minimum activity threshold. Thus, we have no way to account for increased activity levels among the inactive population that may experience increased activity levels but not enough to surpass the threshold, and the sufficiently active population that may become increasingly active in a highly walkable neighbourhood. Furthermore, since marginal activity increases are likely to benefit the insufficiently active more than the already sufficiently active, we could expect potentially greater financial benefit from increased activity among sedentary individuals. This kind of disaggregation in the effect of walkable neighbourhoods on activity levels among residents would allow a more detailed estimate and likely increase the estimated value as well. Unfortunately, to the author's knowledge such empirical works have not been carried out to date.

It is also worth discussing that critics of the view that urban form affects health and levels of activity commonly refer to neighbourhood selection as the reason for measured differences among communities of varying walkability. They argue that those living in walkable areas choose to do so because they desire an environment conducive to active transport and would be active regardless of where they lived. A study by Frank et al. (2007) does support this to some extent, revealing that environment strongly influences active travel among individuals who prefer more walkable neighbourhoods, but those who prefer car-dependant environments are affected to a lesser extent. A quasi-longitudinal study by Handy et al. (2005), on the other hand, found that over the period of one year after a move to a more walkable neighbourhood, travel behaviours began to change more significantly in their sample population. This may suggest that as people have become accustomed to car-dependant lifestyles, they can also re-adjust over time and adopt healthier transportation habits. There are a number of other considerations that could also be taken into account which suggest that in some instances the economic estimates for the productivity benefits could be undervalued. Sections 4.1 and 4.2 will pursue some of these considerations further.

4.1 International Comparison

The studies reporting empirically measured differences between activity levels were based on US cities and these findings may or may not hold in other countries such as Australia for cultural and/or other reasons. If studies of similar design had been conducted in Australia, that information could have been used instead; however, the differences between the two countries, given the subject matter, are not vast (Newman and Kenworthy 1999). For Seattle and Perth, for instance, it is documented that cycling comprises 2.3 per cent (Nelson and Scholar, c.2006) and 2.4 per cent (Socialdata Australia 2008) of total trips, respectively. The share of total trips for walking is roughly seven per cent in Seattle (Nelson and Scholar, ca.2006) and 11 per cent in Perth (Socialdata Australia 2008). In this sense, using empirical evidence that has originated in the US is suitable for an economic assessment in an Australian setting, though more the results could be more definitive with improved Australian data.

Copenhagen , Denmark is one of many European cities that has shown it is possible to design a city with active modes of travel in mind with a modal split of 27 per cent for driving, 33 per cent for transit, 36 per cent for bicycling, and five per cent for walking (Nelson and Scholar, c.2006). This is a reflection of policy intervention, cultural characteristics, urban design and urban planning. No estimates of the health benefits of this substantial increase in active travel have been found but if done, these would enable a perspective on the upper boundaries of this approach.

4.2 Other Physical Determinants of Urban Form

The objective measurements of urban form include factors such as density, land-use mix, connectivity, and proximity, but they do not measure some very important travel-related design considerations. Often the determinants of a neighbourhood's 'walkability', or orientation to supporting active modes of travel, extend beyond these measures to include a number of other factors. Some of these may include the quality or amount of sidewalk space and bicycle paths, the level of public transport service and the regulations around carrying bicycles on-board, the lighting and sense of safety for travel during darker or less populated hours, and the inclusion of natural landscaping and aesthetic value. The potential for even higher levels of active travel than was considered for this calculation is evident in many European examples, as outlined with Copenhagen.

Gehl Architects in Copenhagen have made some significant alterations and enhancements to cities around the world such as Sydney, Melbourne, Cape Town, London, Zurich and in their own city of Copenhagen, enhancing their urban realms for active transportation . If more studies are conducted on different cities and eventually include factors such as kilometres of bike lanes and widths of pedestrian paths in their measures of walkability, then maybe a larger health cost reduction percentage than the one currently used in the calculation could be substituted. These calculations only draw on the results of studies that suggest that there is a relationship between urban sprawl and physical activity levels. Other factors in the mindset of urban planning such as safety policy, bicycle schemes, education, economic incentives, traffic mitigation and infrastructure could all have a huge impact on active travel levels and potentially, health and productivity; however, the role of urban form remains a fundamental factor.

The objective measurement of 19 per cent more individuals meeting the recommended quota of moderate-intensity physical activity translates into considerable economic health-related and productivity-related savings from a conservative standpoint. In the future, other figures representing expected changes in active travel could be substituted into the calculation as more objective studies linking urban form to activity levels report new findings. The way forward would be to continue to measure urban form's impacts on physical activity levels with factors that make active transport safer, more efficient, and more enjoyable while making driving a more unattractive option. Similarly, it would be interesting to investigate how these factors specifically influence travel behaviour among individuals who are predisposed to auto-dependent lifestyles, for therein potentially lies the greatest benefit in activity increase.

5.0 A CUMULATIVE ECONOMIC IMPACT STATEMENT OF ALTERNATIVE DEVELOPMENT PATTERNS

This paper examines the economic impacts that urban form can have on healthcare costs and workplace productivity via its ability to facilitate active modes of travel. These calculations reveal that in addition to the traditional development costs associated with infrastructure and transportation, and more recently GHG gases, there is strong financial justification for including health and productivity costs in the appraisal. As such, the case has strengthened for inner city and greyfield redevelopment in an urban form that favours active modes of transport.

The cumulative economic benefits of redeveloping inner-city type areas, merging the findings of this paper with its companion papers, are summarised below in Table 2.

The costs figures in Table 2 display the differential cost streams associated with the two alternative development paths of inner city versus greenfield. Many of the estimates were made conservatively: infrastructure costs may vary depending on excess capacity levels and area-specific requirements; GHG costs are dependant on a price for carbon and will go up or down accordingly; and health savings are dependant on the types of mode-specific infrastructure put into place combined with incentive schemes and public education. It should be

Figures are per 1000 dwellings	Inner	Outer	Difference
Infrastructure Costs			
Roads	$5,086,560	$30,378,880	$25,292,320
Water and Sewerage	$14,747,620	$22,377,460	$7,629,840
Telecommunications	$2,576,110	$3,711,850	$1,135,740
Electricity	$4,082,120	$9,696,510	$5,614,390
Gas		$3,690,840	$3,690,840
Fire and Ambulance		$302,510	$302,510
Police		$388,420	$388,420
Education	$3,895,460	$33,147,270	$29,251,810
Health (Hospitals, etc.)	$20,114,870	$32,347,330	$12,232,460
Total Infrastructure	$50,502,740	$136,041,070	$85,538,330
Transport Costs			
Transport and Travel Time	$206,542,060	$342,598,100	$136,056,040
Roads and Parking	$46,937,540	$154,826,100	$107,888,560
Externalities	$2,219,880	$9,705,380	$7,485,500
Total Transport	$255,699,480	$507,129,580	$251,430,100
Greenhouse Gas Cost			
Offset Cost ($25/t)	$2,500,000	$5,400,000	$2,900,000
Social Cost ($215/t) (NB. not included in total)	$21,500,000	$46,440,000	$24,940,000
Total Greenhouse	$2,500,000	$5,400,000	$2,900,000
Physical Activity Costs			
Healthcare Cost		$4,229,950	$4,229,950
Productivity Loss		$34,454,900	$34,454,900
Total Activity Costs		$38,684,850	$38,684,850
Total (excluding social cost)	$308,702,220	$687,255,500	$378,553,280

Table 2: Estimated development costs for an urban redevelopment compared to a fringe development

noted that the infrastructure costs are up-front costs that require payment upon initial development. The transport, GHG, health costs and productivity losses are present values calculated over a 50-year period and could be considered as operating costs of the respective types of development. Furthermore, as the health and productivity costs were calculated as foregone benefits by choosing to develop on the fringe, they appear as a cost in the 'Outer' column.

The magnitude of the different costs does provide some perspective on the overall costs of sprawl. Other studies (e.g. Costs of Sprawl – 2000) have indicated the substantial costs of infrastructure and transport, which the authors too have demonstrated and which should be of considerable concern to cities contemplating a future with plans to continue major greenfield development. However, it can now be seen that two of the newer parameters relating to urban development – the social costs of GHG and health-related productivity – add another substantial cost rationale to the value of redevelopment with more active transport modes built-in.

6.0 CONCLUSION

Despite the variations that can be expected from these types of calculations, the data provided indicate very substantial differences in costs between fringe and inner-city types of development. The dominant factors are infrastructure and transportation costs. The newer topics of GHG and health impacts are a little less yet are still substantial. They are important in policy decisions as they are part of a global and local governance system that will only want to see them reduced, not increased. The newly added productivity benefits are especially significant and comparable in scale to the infrastructure and transport savings.

The benefits to inner-city redevelopment compared to greenfields can be seen across a range of portfolios that go beyond the usual urban planning focus. Town planning decisions will impact on the ability of Australia to meet its GHG targets and the National Physical Activity Taskforce meeting its target of a five per cent increase in sufficiently active Australians. The synergies are numerous and as shown can be economically quantified.

The values of infrastructure, transportation, greenhouse gas, activity-related health and activity-related productivity for the different development types have been calculated from models and methods that can be used to predict values for any other planned development. This type of approach should become standard practice in evaluating different development projects.

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ENDNOTES

The term 'Walking Cities' is associated with pre-World War II times. Auto Cities are said to have formed after the war as personalised transport by car became more widespread, allowing people to travel further, faster.

3 The cost of inactivity in Australia was last calculated in 1993/94 and valued at $377.4 million in 1993 dollars and did not include falls and causally related diseases. Accounting for inflation, falls, increased population, increased obesity levels, and increased inactivity levels would account for most of the difference between this value and the one produced by Econtech Pty. Ltd. for Medibank Private.

4 Calculated as .542/(1-.542)=(1.5*10^9)/x and isolated for 'x' to determine the value of the current Australian adult population meeting sufficient activity levels and then adding 1.5*10^9 for the value attributed to inactivity.

5 Calculated as .457/.543=(1.5*10^9)/x and isolated for 'x'.

6 No estimate was available for the health costs due to inactivity for Australians 17 and under, nor could any objective studies be found linking their activity levels and health to urban form; therefore, they are not accounted for in the calculation.

7 Adult population of Australia roughly 15.4 million (ages 18 and over)

8 Minimum moderate-intensity activity recommendation of 30 minutes per day, 5 sessions a week

9 Lower health-related savings estimate of $3.82 billion and upper estimate of $4.5 billion

10 Value in an hour of moderate-intensity activity per person = Total national savings potential / Adult population of Australia / Recommended hours of moderate-intensity activity per year