# Valuing the health benefits of active transport modes

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# Executive summary

There is a growing awareness that traditional economic evaluation methods tend to undervalue the wider public health benefits provided by active transport modes, which include walking, cycling, and their variants, such as skates and scooters. The objective of this project is to determine the monetary value of the health benefits of active transport modes, in order to include it in cost-benefit analyses for transport and other government sectors.

In transport cost-benefit analysis, the Land Transport NZ *Economic evaluation manual* (EEM2) currently values these health benefits at 40 c/km (for new pedestrians only) and 16 c/km for existing and new cyclists. The 2007 BECA report (commissioned by Land Transport NZ) reassessed the benefits associated with moving a person from inactive to active health status in terms of willingness-to-pay (WTP) for disability adjusted life years (DALYs), health sector resource costs, and lost output resource costs. In the BECA report, benefits were then evaluated at 80 c/km for walking and 40 c/km for cycling, with a cap on the annual health benefits of $1,000 per user.

The specific procedures required to undertake the economic efficiency evaluation of walking and cycling are laid out in EEM2. The monetised benefits currently considered in this process are summarised here in table 1.

**Table 1 Benefits of active transport modes as currently treated in EEM**

| Benefit | Breakdown of benefit elements | Current value |
|---|---|---|
| Motorised traffic reduction | Perceived Vehicle Operating Costs (VOC) and travel time savings for people who change modes | Variable: The congestion reduction benefits of a walking or cycling project result from the number of private vehicle trips that are replaced by walking or cycling. This depends on location and time of day. There is no congestion-reduction benefit in places or at times when there is no congestion. |
| | Resource cost corrections for unperceived VOC | |
| | Travel time and VOC savings for other road users | |
| Accident costs | New pedestrians | 4 c/km (included in composite value) |
| | All cyclists | 0 c/km, neutral benefit |
| Health benefits | New pedestrians | 40 c/km (included in composite value) |
| | All cyclists | 16 c/km (included in composite value) |
| User cost savings | Based on the amount of modal change | These are generally zero for times other than peak periods and are included in the overall perceived value of modal change. |

| Benefit | Breakdown of benefit elements | Current value |
|---|---|---|
| Environmental benefits (monetised and non-monetised impacts) | Congestion reduction, vehicle emissions | 10 c/km (included in composite value) |
| Community liveability | Benefits resulting from new or improved pedestrian or cycle facilities are proportional to the change in average distance to such a facility from residences in the community – will only be significant if a network of facilities is provided. | No given value |
| Consumer travel options | Mentioned, but not given an explicit value | No given value |

The gap analysis of current economic evaluation of active transport modes identified benefits that should be considered, but are not currently included. These are shown in table 2.2.

**Table 2 Benefits not considered in current EEM for active transport modes**

| Benefits not considered | Explanation |
|---|---|
| Health benefits | Not recognised for existing pedestrians. |
| | Other active mode users (skates and scooters). |
| Parking cost savings | The cost of parking is not currently included in the vehicle operating costs (VOC). Whether a car park is paid for by the user or not, it has a value that should be considered as a benefit when the user changes mode and no longer requires the car park. |
| Exercise time savings | By commuting by active mode, already active new users may save time that they currently use to exercise. This should be valued at the same level as non-market values of travel times used elsewhere in the EEM. |
| Noise reduction | Reduction of traffic noise associated with mode change is not currently considered for active modes. Road evaluations can incorporate the hedonic pricing of traffic noise impacts. |
| Productivity | If robust evidence can establish a relationship between active mode use and increased work productivity, this benefit should be measured as increased output (e.g. fewer sick days). |

### Health linkages to physical activity and active transport

There is a body of research demonstrating that physical activity reduces the risk of numerous chronic conditions. Specific evidence exists for the protective effect of active transport engagement on cardiovascular disease (CVD), certain cancers, and obesity, all of which are serious health concerns in New Zealand.

Neighbourhood design and form probably influence travel choices and opportunities, and there is strong evidence that those who live in environments that support walking and cycling have better health profiles than people in neighbourhoods with poorer walkability. The research done by Turner, Roozenburg and Francis in 2006 showed that that a modal shift to active transport did not cause an increase in traffic injuries, because of the 'safety in numbers' effect. In other words, the risk to each pedestrian and cyclist drops as the number of users increases. Air pollution will also reduce if a modal shift occurs, and this indirect health benefit should be reflected in the economic evaluation process.

The literature review identified five diseases for which there is robust evidence of relative risk reduction from increased physical activity. The following table summarises these diseases, the relative risk reduction, and the burden of each of these diseases in New Zealand in terms of disability-adjusted life years (DALYs) lost. It also shows the relative risk of all-cause mortality due to inactivity, as described in 2000 by Andersen, Schnohr, Schroll and Hein.

**Table 3 Diseases with an evidence-supported link to inactivity, relative risk reduction if sufficiently active, relative risk and NZ-specific DALYs attributable**

| Factor | | RRR[a] of activity (cited in text) | Source | RR[b] of inactivity *1/(1-RRR)* | NZ DALYs attributable (MoH 2001) |
|---|---|---|---|---|---|
| All-cause mortality | | 55% | Bijnen et al. 1999, *Baseline and previous physical activity in relation to mortality in elderly men: The Zutphen elderly study*; Erikssen et al. 1998, *Changes in physical fitness and changes in mortality* | 2.22 | n/a |
| CVD | | 20–35% | Macera et al. 2003, *Major public health benefits of physical activity* | 1.25–1.54 | 24% |
| Cancer (all) | | | | | 20% |
| | Colon | 30–40% | Lee 2003, *Physical activity and cancer prevention: Data from epidemiologic studies* | 1.43–1.67 | 3.2% |
| | Breast | 20–30% | | 1.25–1.43 | 2.4% |
| | Lung | 10–20% | | 1.11–1.25 | 2.9% |
| Type 2 diabetes | | 33–50% | Lynch et al. 1996, *Moderately intense physical activities and high levels of cardiorespiratory fitness reduce the incidence of non-insulin-dependent diabetes mellitus in middle-aged men*; Manson et al. 1992, *A prospective study of exercise and the incidence of diabetes among US male physicians* | 1.49–2 | 5% (All endocrine conditions) |
| Depression | | 22% | Dunn et al. 2001, *Physical activity dose-response effects on outcomes of depression and anxiety* | 1.28 | 3.6% (All mental illnesses) |

a) The relative risk reduction is relative to mortality in all disease states except depression, in which case it is incidence.

b) Relative risk

### Valuing the health benefits

The literature review revealed a number of different approaches to valuing health benefits as part of a comprehensive cost-benefit analysis (CBA) of active mode investments. Most of the approaches reviewed used the local value of a statistical life (VoSL) as the measure of monetary value. The different assumptions and values used in each of the following methodologies is summarised in the following table.

**Table 4 Summary of methodologies and assumptions from literature review**

| Study | Diseases considered | Mortality/ morbidity | Additional costs included | Monetary value assigned | Threshold, dose response, or other[a] |
|---|---|---|---|---|---|
| **Saelensminde 2004**, *Cost-benefit analyses of walking and cycling track networks taking into account insecurity, health effects and external costs of motorized traffic* | · Cancer (5 types)<br>· High blood pressure<br>· Type 2 diabetes<br>· Musculoskeletal ailments | *Mortality + morbidity*<br>(Social costs of health care, treatment, lost productivity) | · Health care costs<br>· Treatment costs<br>· Potential productivity lost<br>· Welfare loss (60% of all other costs) | Social costs of 4 diseases from NCNPA 2000 (cited in Saelensmind, 2004). | Annual user benefit applied directly to 50% of new walkers and cyclists |
| **Cavill et al. 2007**, *Economic assessment of transport infrastructure and policies: Methodological guidance on the economic appraisal of health effects related to walking and cycling* | · All-cause mortality (adults) | *Mortality only*<br>Reduced risk of all-cause mortality (0.72) | n/a | VoSL (undiscounted)<br>*€0.81/km cycling only* | *Linear dose response* |
| **DfT (UK) 2007**, *Guidance on the appraisal of walking and cycling schemes* | · CVD<br>· Colon cancer | *Mortality only*<br>Number of preventable deaths<br>(ERR x 0.09 x deaths due to diseases considered) | n/a | VoSL (undiscounted)<br>*0.00001 x VoSL* | Annual user benefit applied directly to each additional walker and cyclist |
| **BECA 2007**, *Health benefits of walking and cycling* | · DALYs due to inactivity (only including ages 15–65) | *Mortality + morbidity*<br>1996 DALYs due to inactivity (0.07 of all DALYs) | · Health sector costs<br>· Lost resource output | VoSL<br>Undiscounted to value DALYs but discounted to attribute annual value | *Linear dose response capped at 30 min per day* |
| **Stokes et al. 2008**, *Estimating the effects of light rail transit on health care costs* | · Obesity | *Morbidity only*<br>Increase in individual yearly medical costs associated with obesity | · WTP for weight-reduction programmes | · Average annual medical costs<br>· WTP for weight-reduction programmes | Annual user benefit applied to proportion of projected light-rail users who are obese |

| Study | Diseases considered | Mortality/ morbidity | Additional costs included | Monetary value assigned | Threshold, dose response, or other[a] |
|---|---|---|---|---|---|
| **Boaranet et al**. 2008, *Walking, urban design, and health: Towards a cost-benefit analysis framework* | · CHD<br>· Sudden death<br>· All-cause mortality | *Mortality only* | · n/a | VoSL (undiscounted)<br>Two different values used (low and high)<br>*Total project benefits only calculated* | Annual user benefit (lives saved) based on users who walk enough to move from the first to second tertile[b] of physical activity |

a) A dose-response curve represents the relationship between the amount of exposure (dose) to a variable, in this case physical activity, and the resulting changes in body function or health (response). A linear curve assumes equivalent benefits at any dose.

b) Each tertile represents one third of the population, broken down by the distribution of physical activity levels.

We employed two different methodologies to calculate the annual mortality and morbidity costs per person. In both methodologies, the 2007 base VoSL was used to determine willingness-to-pay (WTP) for increased life expectancy and reduced disability. The first methodology results in a low and high figure, and the second results in a figure that is roughly between the high and low values of the first methodology. This gives us confidence in the final values assumed (see table 5), which are averages of the two results.

**Table 5 Comparison of values for methodology A & B**

| 2007 | Low | High |
|---|---|---|
| A. Mortality ratio and YLD | $2,289 | $3,854 |
| B. DALYs | $2,686 | |
| Average of A & B | ***$2,488*** | ***$3,270*** |

Specific disease-related health sector costs were not available from the Ministry of Health, and we therefore estimated health sector costs due to inactivity using percentages of deaths associated with inactivity – 5.5 percent as a low estimate of the per-capita ratio, and 10.1 percent as a high estimate. (The percentage of DALYs attributable to inactivity is 7 percent, which is very close to the mean of the low and high percentages of deaths we employed.)

**Table 6 Per-capita health sector costs (public and private) attributable to inactivity**

| | Low | High |
|---|---|---|
| **2004 total health sector costs (public and private)** | 5.5% | 10.1% |
| | $12,680,845,000 | |
| | $697,446,475 | $1,280,765,345 |
| Inactive adults in 2004 | 1210613 | |
| 2004 per-capita health sector costs | $576 | $1,058 |
| **2007 values (CPI calculator)** | **$624** | **$1,147** |

The low and high total annual values of an inactive person becoming active are listed in the next table.

**Table 7 Total annual value of health benefits**

| 2007 values | Low | High | *Mean* |
|---|---|---|---|
| Morbidity + mortality attributable to inactivity | $2,488 | $3,270 | |
| Health sector (public and private) costs per inactive adult | $624 | $1,147 | |
| **Total** | **$3,112** | **$4,417** | ***$3,765*** |

Activity levels in the general population are used to weight and distribute benefits to calculate an annual benefit per user for cycling. Prevalence of inactivity is taken from the Ministry of Health's 2006/07 New Zealand Health Survey. Benefit weights are attributed according to the relative risk reduction between activity levels (adapted from research by Andersen, Schnohr, Schroll and Hein in 2000).

**Table 8 Per-km weighted health benefits of walking**

| **Walking** | | *Benefit weight* | | | **Weighted sum = annual benefit per person** |
|---|---|---|---|---|---|
| | | 1 | 0.85 | 0.15 | |
| | | *Activity status* | | | |
| | | Sedentary | Inactive | Active | |
| | | *Prevalence* | | | |
| Scenario of annual health benefits | | 15.0% | 34.5% | 50.5% | |
| Low | $3,112 | $467 | $913 | $236 | $1,615 |
| Mean | $3,765 | $565 | $1,104 | $285 | $1,954 |
| High | $4,417 | $663 | $1,295 | $335 | $2,292 |
| | | *Km over which benefits are received* | | | ***Weighted per-km benefit*** |
| | | *625* | *450* | *312* | |
| Low | | $0.75 | $2.03 | $0.76 | $3.53 |
| Mean | | $0.90 | $2.45 | $0.91 | $4.27 |
| High | | $1.06 | $2.88 | $1.07 | $5.01 |

We assumed that cycling has:

- an average speed of 20 km/h i.e. is 4 times faster than walking, and therefore carries ¼ of the benefit on a per-km basis
- a metabolic equivalent unit (MET) intensity double that of walking i.e. people only need to be active for half the amount of time to receive the same benefits. (MET is a measure that expresses the ratio of the associated metabolic rate for the specific activity divided by the resting metabolic rate. It allows us to compare the relative intensity of different transport modes.)

Therefore, cycling should carry half the benefit per km of walking (¼ x 2 = ½).

**Table 9 Per-km weighted health benefits of cycling**

| **Cycling** | | *Benefit weight* | | | **Weighted sum = annual benefit per person** |
|---|---|---|---|---|---|
| | | 1 | 0.85 | 0.15 | |
| | | *Activity status* | | | |
| Scenario of annual health benefits | | Sedentary | Inactive | Active | |
| | | *Prevalence* | | | |
| | | 15.0% | 34.5% | 50.5% | |
| Low | $3,112 | $467 | $913 | $236 | $1,615 |
| Mean | $3,765 | $565 | $1,104 | $285 | $1,954 |
| High | $4,417 | $663 | $1,295 | $335 | $2,292 |
| | | *Km over which benefits are received* | | | ***Weighted per-km benefit*** |
| | | *1250* | *900* | *624* | |
| Low | | $0.37 | $1.01 | $0.38 | $1.77 |
| Mean | | $0.45 | $1.23 | $0.46 | $2.14 |
| High | | $0.53 | $1.44 | $0.54 | $2.51 |

Health benefits for existing pedestrians are not currently considered in the EEM methodology, although existing cyclists receive benefits. For several reasons, we strongly recommend that benefits be counted for both existing walkers and cyclists in accordance with the rule of half. Data from the Ministry of Transport's most recent New Zealand Household Travel Survey indicates that on a nationwide level, commuting by active mode has been consistently falling and mode share by private vehicle has been consistently increasing. Given this trend, and the trend of increasing insufficient activity (and obesity) levels in New Zealand, investment in new cycling and walking infrastructure may reduce the likelihood of some current users from switching mode at a later point, and thus realise health benefits that would otherwise be lost. By applying the rule of half, those current users who are encouraged to continue walking or cycling because of the intervention receive full benefits, whilst those users who would otherwise have continued receive zero benefit.

One of the scenarios in the next table should thus be applied in full to all new walkers and cyclists, whilst half the benefits should be applied to existing walkers and cyclists. This report favours the adoption of the medium value. These values are in 2007 NZ$ and thus should be updated periodically.

**Table 10 Per-kilometre benefits**

| **Scenario** | **Annual benefit** | **Per km walking** | **Per km cycling** |
|---|---|---|---|
| Low | $3,112 | $3.53 | $1.77 |
| Medium | $3,765 | $4.27 | $2.14 |
| High | $4,417 | $5.01 | $2.51 |

This report identifies a number of areas for further research:

1. Develop models that predict how specific changes to walking and cycling conditions, and specific education and promotion programmes, affect active transport engagement in a particular situation,

with special attention to changes in physical activity and fitness by the people who are most at risk of sedentary living.

2. Valuation of potential injury and accident reduction benefits that would result from increased volumes of active transport mode users.
3. Ascertain the air pollution exposure for people using active modes in various rural and urban New Zealand locations, also relative to other modes, and provide guidance for developing non-motorised facility networks that minimise exposure to air pollution.
4. Establish a quantifiable relationship between active transport modes and the incidence or treatment of musculoskeletal conditions, in order to quantify the benefits that could be realised from increased use of active modes.
5. Establish a causal relationship between increased physical activity and a reduction in morbidity and health sector costs related to COPD and URTI (respiratory diseases).
6. Investigate the relationships between physical activity, mental health and human happiness.
7. Establish the relationship between active transport mode use and increased workplace productivity, measured as reduced absenteeism or presenteeism through longitudinal studies.
8. Investigate the stress people experience from various transport modes, as well as the health impacts of stress.
9. Develop better tools for quantifying and monetising the impact that improved walking and cycling facilities may have on indirect health benefits, such as increased community cohesion (positive social interactions among people in a community), improved transportation affordability (which can reduce emotional stress), and improved access to medical services.

One longitudinal study following users of active transport modes may be sufficient to obtain enough data to create a more complete methodological approach to valuing the benefits of active transport mode participation in New Zealand.

# Abstract

This report seeks to provide a per-kilometre value for the health benefits of active transport modes (such as walking and cycling) that is compatible with the Land Transport New Zealand Economic Evaluation Manual Volume 2 (EEM2). The first two sections of the report begin by explaining the scope of the project and the background. Section 3 investigates the evidence of the connection between physical activity and health outcomes. Section 4 clarifies the role of active transport modes as physical activity, and reports the New Zealand-specific data about active transport mode engagement. Section 5 gives a brief comparative summary of the literature review of cost-benefit analyses and valuation techniques used overseas to value the health benefits of active modes.

This report uses population attributable fractions (PAF) to estimate the annual burden of mortality and morbidity costs per inactive adult. Annual estimates of the costs of inactivity are applied to the New Zealand adult population using a weighted sum to establish a per-kilometre value for each mode.

The valuation presented in this report is limited by a poverty of data, but the final values are considered to be a reasonable estimate of the health benefits of active modes. While further research is recommended to obtain more precise estimates of the costs of inactivity in New Zealand, it is considered that the values presented in this report are a sound interim estimate for inclusion in the EEM2.

# 1 Introduction

There is a growing awareness that traditional economic evaluation methods tend to undervalue the wider public health benefits provided by active transport modes, which include walking, cycling, and their variants, such as skates and scooters. The objective of this project is to determine the monetary value of the health benefits of active transport modes, in order to include it in cost-benefit analyses for transport and other government sectors.

In transport cost-benefit analysis, the Land Transport NZ *Economic evaluation manual* (EEM2, 2005) currently values these health benefits at 40 c/km (for new pedestrians only) and 16 c/km for existing and new cyclists. Recent research commissioned by Land Transport NZ (BECA 2007) reassessed the benefits associated with moving a person from inactive to active health status in terms of willingness-to-pay (WTP) for disability adjusted life years (DALYs), health sector resource costs, and lost output resource costs. In the BECA report, benefits were then evaluated at 80 c/km for walking and 40 c/km for cycling, with a cap on the annual health benefits of $1,000 per user. Note: The cap on benefits applied in this study does not imply that there are no health benefits for a person after reaching the active status – it was applied because the methodology divided $1000 by the distance a person needed to travel by active mode per year to achieve active status.

This report builds on previous research by conducting a more detailed investigation into the specific health benefits derived from increased physical activity and transport choice factors. It considers the following key areas:

- reduced disease states and health impairment
- increased life expectancy
- increased productivity.

We conducted a comprehensive review of the valuation of health benefits of active modes in other countries, and designed several methodologies for arriving at a per-kilometre (km) value in New Zealand.

## 1.1 Limitations of this research

This project was limited by several factors:

- A lack of recent and New Zealand-specific health and physical activity data – the most recent research on disability adjusted life years (DALYs, defined in section 3) is from 1996.
- Data on New Zealanders' physical activity is primarily taken from self-reported surveys, which are less robust than other studies.
- Disaggregated health sector costs were not available for each ailment identified.

The lack of specific data limited the methodological approaches available to value the health benefits of active transport modes. Nonetheless, for the purposes of determining a per-km value that can be easily incorporated into the EEM2, the data used in this report is considered to be sufficient.

We acknowledge that the goal of assessing population level health impacts in terms of a monetary value per person-km will always be beset with difficulties because of the large number of assumptions involved – both at the level of the valuation and at the level of predicting future use of a transportation project. We have laid out our assumptions as clearly as possible throughout the report. With respect to transportation cost-benefit analysis, this valuation of the health benefits of active transport is considered to be as robust as any currently applied in comparable countries.

The project does not attain the level of robustness that might be expected of an epidemiological research study into the health burden of inactivity. For this reason, it may be inappropriate to apply these values in policy contexts other than transportation cost-benefit analysis. We recommend areas for further research in section 8.3.

# 2 Background

A review of public agency websites and documents in Organisation for Economic Co-operation and Development (OECD) member countries confirmed that there is broad international consensus that increased use of active transport modes can have significant public health, environmental and economic benefits. However, the review of overseas transport funding practices identified few established approaches to valuing these health benefits. This is likely due to the fact that many countries (including France, Germany, Australia, Canada and the United States) do not require cost-benefit analysis (CBA) for funding or prioritisation of active mode transport projects. The United Kingdom is the only other country that has an established procedure for assigning health and other benefits of active modes into standard transport CBA. New Zealand has therefore been a leader in incorporating the benefits of active modes into transport CBA procedures.

One probable reason that a CBA of active transport is not widely employed is because the benefits are difficult to measure through traditional transport economic analysis. From an early stage in the preparation of this report, it was apparent that many of the social and psychological benefits associated with the use of active modes are difficult to quantify and contextually sensitive. For this reason, one of our key focuses became the identification of areas for further research and data collection (both local and otherwise). These areas are summarised in section 8.3.

## 2.1 Key transport policies

Key transport strategies and policies related to the delivery of New Zealand's land transport system in relation to active modes are outlined in the following publications:

- *New Zealand transport strategy* (MoT 2002)
- *Sustainable transport* (MoT 2007b)
- *Getting there: On foot, by cycle* (MoT 2005)
- *Programme funding manual* (Land Transport NZ 2007)
- *Economic evaluation manual: Vol. 2* (Land Transport NZ 2005).

The ***New Zealand Transport Strategy*** (NZTS) aims to integrate public health objectives and transport investment, acknowledging the role of active transport modes in protecting and promoting public health through increasing physical activity and reducing air pollution.

***Sustainable transport*** (MoT 2007b) is the government discussion paper and update of the NZTS. It sets specific targets for increased active mode share, citing public health benefits as one of the key objectives of the updated strategy. The strategy states that road users will be expected to face the full costs of their transport choices, including carbon charges, by 2040, but that public transport and active modes may be eligible for subsidies owing to their health benefits, as well as environmental and congestion reduction benefits (p. 12).

***Getting there: On foot, by cycle*** (MoT 2005) discusses the walking and cycling component of the NZTS in more detail. It articulates the government's vision for increasing population health through increased active mode use.

***The Land Transport NZ Programme funding manual*** (PFM) lays out the policy, rules and procedures that road controlling authorities and regional councils must satisfy to be eligible for financial assistance from the National Land Transport Programme (NLTP) administered by Land Transport NZ.

Economic efficiency evaluation procedures are one of three standard assessment criteria described in the PFM, and the detailed procedures for conducting a cost-benefit analysis (CBA) are contained in Land Transport NZ's ***Economic evaluation manual: Vol 2*** (EEM2).

These documents emphasise the wide range of benefits delivered by increased use of active modes, including public health, environmental, social and economic. The challenge to funding bodies, such as the NZ Transport Agency, is to develop robust relationships that link the macro-economic benefits of active transport to the micro-economic analysis associated with individual transport projects. The economic evaluation of active modes, as currently described in the EEM2, is discussed in more detail in the next section.

## 2.2 Current economic evaluation of active transport modes

The economic efficiency of all transport projects is currently evaluated as only one part of a broader assessment and evaluation process, which is outlined in the *Programme funding manual* (Land Transport NZ, 2007). NLTP funding is allocated to proposed activities within activity classes. Pedestrian and cycle projects fall under activity class 8 (Use of the land transport system), which also covers travel demand management, community programmes and advertising, and rail and sea freight operations. (Other active modes, such as skates and scooters, are specifically not covered by the EEM2 at this time.) High-level trade-offs between funding for different modes are made between activity classes, and then within an activity class, projects are evaluated and prioritised.

The standard assessment criteria for proposed projects are as follows:

- *the seriousness and urgency of the transport issue or problem addressed, taking account of relevant strategies and regional and local priorities*
- *the effectiveness of the proposed activity in dealing with the issue or problem*
- *the economic efficiency of the proposed activity*
- *and in exceptional circumstances additional factors specific to the proposed activity and relevant to determining its overall priority.* (Land Transport NZ 2007, 6–5).

The specific procedures required to undertake the economic efficiency evaluation of walking and cycling are laid out in EEM2.

EEM2 notes that cycle and pedestrian facilities are non-market goods, making it difficult to ascribe an economic value to their benefits. Either 'stated preference' or 'revealed preference' methods have therefore been used to value social and economic benefits. The benefits of walking and cycling projects that are recognised in EEM2 are listed in the table on the next page. Not all of the benefits enumerated are given explicit values in EEM2. Sub-components of benefits are listed in the second column, and where values are given in EEM2, they have been listed in the third column.

**Table 2.1 Benefits of active transport modes as currently treated in EEM**

| Benefit | Breakdown of benefit elements | Current value |
|---|---|---|
| Motorised traffic reduction | Perceived Vehicle Operating Costs (VOC) and travel time savings for people who change modes | Variable: The congestion reduction benefits of a walking or cycling project result from the number of private vehicle trips that are replaced by walking or cycling. This depends on location and time of day. There is no congestion-reduction benefit in places or at times when there is no congestion. |
| | Resource cost corrections for unperceived VOC | |
| | Travel time and VOC savings for other road users | |
| Accident costs | New pedestrians | 4 c/km (included in composite value) |
| | All cyclists | 0 c/km, neutral benefit |
| Health benefits | New pedestrians | 40 c/km (included in composite value) |
| | All cyclists | 16 c/km (included in composite value) |
| User cost savings | Based on the amount of modal change | These are generally zero for times other than peak periods and are included in the overall perceived value of modal change. |
| Environmental benefits (monetised and non-monetised impacts) | Congestion reduction, vehicle emissions | 10 c/km (included in composite value) |
| Community liveability | Benefits resulting from new or improved pedestrian or cycle facilities are proportional to the change in average distance to such a facility from residences in the community – will only be significant if a network of facilities is provided. | No given value |
| Consumer travel options | Mentioned, but not given an explicit value | No given value |

The gap analysis of current economic evaluation of active transport modes identified benefits that should be considered, but are not currently included. These are shown in table 2.2.

**Table 2.2 Benefits not considered in current EEM for active transport modes**

| Benefits not considered | Explanation |
|---|---|
| Health benefits | Not recognised for existing pedestrians. |
| | Other active mode users (skates and scooters). |
| Parking cost savings | The cost of parking is not currently included in the vehicle operating costs (VOC). Whether a car park is paid for by the user or not, it has a value that should be considered as a benefit when the user changes mode and no longer requires the car park. |
| Exercise time savings | By commuting by active mode, already active new users may save time that they currently use to exercise. This should be valued at the same level as non-market values of travel times used elsewhere in the EEM. |
| Noise reduction | Reduction of traffic noise associated with mode change is not currently considered for active modes. Road evaluations can incorporate the hedonic pricing[a] of traffic noise impacts. |
| Productivity | If robust evidence can establish a relationship between active mode use and increased work productivity, this benefit should be measured as increased output (e.g. fewer sick days). |

a) A hedonic model of prices is one that decomposes the price of an item into separate components (internal and external) that make up its price. In this case it may include noise impacts on property values, different aspects of human health, and/or willingness-to-pay surveys.

It should be mentioned that health disbenefits, including increased risk of obesity and road accidents, could be included in the CBA of road projects when they result in increased motor vehicle use.

## 2.3 Active mode trends and travel patterns

The World Health Organization (WHO) recommends that journeys of less than 5 kilometres (km) be viewed as appropriate for active transport modes (WHO 2004). The New Zealand strategy, *Getting there*, suggests that destinations within a 7 km radius could be reached by bicycle, and within 2 km by walking, based on research by Burke and Browne (2007).

The Auckland Regional Transport Authority (ARTA) estimates that approximately 43 percent of peak morning trips are less than 5 km, and that approximately 67 percent of these are currently undertaken by car (ARTA 2007). Thus, if the more conservative WHO recommendations are adopted, at least 28 percent (more than 1 in 4) of all Auckland area peak-hour trips are a suitable distance to shift to active modes.

Active transport mode share rates remain low in New Zealand; approximately 9 percent of adults commute to work by active transport modes (Statistics New Zealand 2007) and 32 percent of children walk or cycle to school (Schofield et al. 2008). The graph on the next page (Figure 1) shows that only Wellington and Nelson increased or sustained active mode share between 1996 and 2006. Further research is required to explain the strong performance in these two regions, the results of which may help guide active encouragement efforts in other regions.

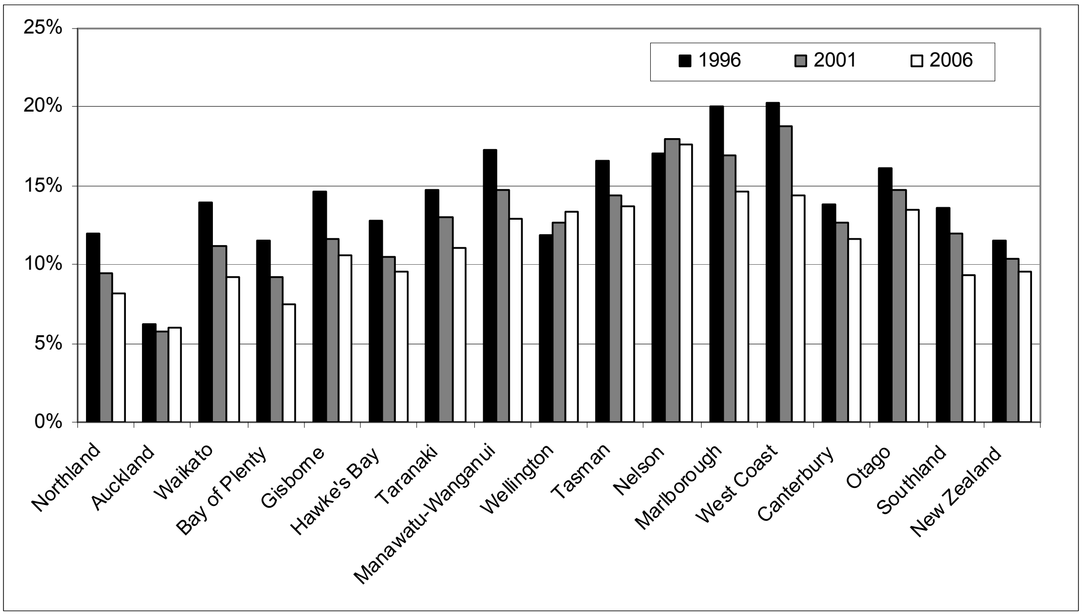


**Figure 2.1 Regional trends in census active mode share 1996–2006 (15+ age)**

Every 5 years, Statistics New Zealand collects survey data on travel-to-work mode share in the census. Adjusted to include only people travelling to work by car, public transport or active modes, Figure 1 indicates that Auckland had the lowest active mode share of any region in 2006. Auckland's active mode share (5.9 percent) is particularly low in comparison to Wellington (13.4 percent). Auckland also has a much smaller percentage of households that do not own a car (7 percent) compared to Wellington (11.3 percent), despite having similar median household incomes. While some of this may be attributable to demographic factors, it is likely that historical land use policies and investment priorities have contributed to the particularly low uptake of active modes in Auckland, given that its topography and climate is at least as cycle-friendly as Wellington's.

# 3 Health linkages to physical activity

This section summarises research on the health effects of increased physical activity.

Internationally it is estimated that non-communicable chronic diseases account for 60 percent of all deaths and 47 percent of the global burden of disease, and these are projected to increase to 73 percent and 60 percent respectively by 2020 (WHO 2004). The recommended level of moderate-intensity physical activity engagement to help prevent or minimise the effects of a multitude of non-communicable diseases is the accumulation, on at least 5 days per week, of at least

- 30 minutes per day for adults
- 60 minutes per day for those under the age of 20 years (Department of Health Physical Activity Health Improvement and Promotion 2004; Sport & Recreation New Zealand 2003).

This is the current definition for being classified as sufficiently active for health benefits; below this threshold, people are classed as having insufficient activity. (A further subclass of insufficiently active people are those who get no activity at all, and are classed as being sedentary).

Although people in developed, urbanised countries such as New Zealand may participate in leisure-time physical activity, these populations are still considered to be largely inactive because of their generally sedentary lifestyles and reliance on labour-saving devices and transport choices. According to a recent nationwide health survey, only 50.5 percent of New Zealand adults are regarded as sufficiently active for health benefits (MoH 2008). Indeed, Ministry of Health (2001) data shows that physical inactivity is the second leading risk factor of 'disability adjusted life years' (DALYs – this concept is explained further below) in New Zealand, with 7 percent of DALYs being attributable to inactivity.

Active transportation contributes to overall physical activity because it requires the movement of large muscle groups to walk, cycle, or otherwise exert oneself to get from place to place (Department of Health Physical Activity Health Improvement and Promotion 2004). Active transport modes should thus be viewed as a promising means of habitually accumulating physical activity at the population level. As well as understanding that active transportation can make an important contribution to overall physical activity accumulation, it is important to understand the heath associations between overall physical activity and specific diseases. Therefore this section of the report:

- examines the evidence linking specific health conditions and level of physical activity
- identifies the prevalence and economic impact of these health conditions within the New Zealand context
- investigates the contribution that active transport modes can make towards physical activity budgets.

**YLL, YLD and DALYs**

In studies of population health, it has traditionally been difficult to monitor any health outcomes other than mortality reduction, because the latter is much easier to observe and quantify than reduced quality of life.

In *The burden of disease and injury in New Zealand* (2001) the Ministry of Health uses a generalised concept of 'years of life lost' (YLL) and extends it to 'years of healthy life lost'. This a health gap measure that incorporates both loss of life years and loss of quality of life by assigning values (disability weights) based on social preferences for these states of being. It measures the burden of disease and injury, both fatal and non-fatal. Extending YLL in this way requires that non-fatal health states be quantified in terms of 'years lost to (severity adjusted) disability' (YLD), which can then be added to 'years lost to premature mortality' (YLL) to yield an integrated unit of health – the 'disability adjusted life year', or DALY. Thus, one DALY represents the loss of one year of healthy life.

We use the New Zealand-specific data on YLL, YLD and DALYs in this report to help us quantify the health impacts of inactivity.

# 3.1 Physical disease states

This section considers the disease states and impairments for which increased physical activity may deliver benefits. Improvements in life expectancy associated with increased physical activity are likely to reflect the impact of reduced risk factors and are not considered separately in this section.

## 3.1.1 Cardiovascular disease

Cardiovascular disease (CVD) includes coronary heart disease and stroke. Insufficient accumulation of physical activity is a risk factor for CVD (Department of Health Physical Activity Health Improvement and Promotion 2004; Ezzati et al. 2002). Cohort studies have identified that people who accumulate higher amounts of total physical activity (even at lighter intensities and/or for shorter durations) show a CVD risk reduction irrespective of whether other risk factors are present (Hardman 2001; Lee et al. 2001; Sesso et al. 2000). When the relationship between physical activity engagement and CVD disease is isolated, relative risk reductions for CVD that can be attributed to physical activity are between 20 percent and 35 percent (Macera et al. 2003).

Active transportation has been shown to influence some CVD risk factors such as hypertension, overweight/obesity, and high triglycerides. Research has shown that people who walked to work, when compared to those who took motorised transport, were more likely to have normal blood pressure (Hayashi et al. 1999; Hu et al. 2002), body mass (Hu et al. 2002; Wagner et al. 2001), and blood lipid profiles (Hu et al. 2001).

Within the New Zealand context, CVD has a substantial profile in the burden-of-disease data and accounts for the largest share of DALYs (24 percent), with more males (31 per 1000) being affected than females (19 per 1000) (Ministry of Health 2001). People of Maori ethnicity have higher DALYs attributed to CVD in comparison to the non-Maori population.

## 3.1.2 Cancer

Longitudinal data suggests that regular physical activity has a protective effect against some cancers. The evidence is strongest for colon and rectal cancers, with some support existing for breast, endometrial, lung, and pancreatic cancers (World Cancer Research Fund & American Institute for Cancer Research 2007). Furthermore, there is strong evidence that physical activity can help reduce obesity (Department of Health Physical Activity Health Improvement and Promotion 2004), which is in itself is a risk factor for numerous cancers (World Cancer Research Fund & American Institute for Cancer Research 2007).

When the effect of physical activity on site-specific cancers is assessed, the reduction in relative risk for cancer in people who are sufficiently active, compared with those who are inactive, is:

- colon cancer – 30–40 percent
- breast cancer – 20–30 percent
- lung cancer – 20 percent (although these figures may also be influenced by tobacco smoking) (Lee 2003).

Further research is needed to develop relative risk reduction profiles for other cancers.

Specific to active transport and cancer, a case-controlled study conducted with Chinese adults showed that the risk of colon cancer was significantly reduced in those who engaged in active transport compared with those who commuted by motorised modes and accumulated the same level of physical activity through recreation. In other words, active transport was found to be more effective in reducing risk than recreational activity. The effect was more pronounced for those who had been commuting by active modes for longer durations (>35 years) (Hou et al. 2004).

In New Zealand, the health impact of cancer is substantial, with the prevalence rate from all cancers being 23 people per 1000 and the total attributable DALYs being 20 percent (MoH 2001). As with the CVD burden-of-disease data, people of Maori descent are more likely to have higher DALYs attributable to cancer when compared with non-Maori.

### 3.1.3 Type 2 diabetes

Physical inactivity is a major risk factor for type 2 diabetes (Department of Health Physical Activity Health Improvement and Promotion 2004; Kriska 2003), with longitudinal data showing that the chance of developing this disease is reduced by 33–50 percent in people who are sufficiently physically active (Lynch et al. 1996; Manson et al. 1992). This relationship holds true for people who only engage in walking (Hu et al. 1999) or cycling (Young et al. 1993).

One study of the relationship between active transportation and type 2 diabetes followed 14,290 Finnish adults for 12 years. Those who engaged in moderate to high levels of occupational, active transportation or leisure-time physical activity showed a reduced risk of developing type 2 diabetes when compared to the general population (Hu et al. 2003).

In New Zealand, the burden of disease from diabetes (both types 1 and 2) is grouped together under endocrine diseases, and the DALYs lost to these is estimated to be 5 percent, with a prevalence rate of 6 people per 1000 (MoH 2001). When Maori and non-Maori are compared, DALYs attributable to type 2 diabetes are highest in the Maori population. It is also likely that the number of DALYs lost to type 2 diabetes is underestimated, as research suggests that half of the population in New Zealand who have type 2 diabetes are undiagnosed with the condition (MoH 2003a).

### 3.1.4 Obesity

Obesity has been identified as an epidemic throughout developed and developing countries. A World Health Organization report estimates that globally, approximately 1.6 billion adults are overweight and 400 million are obese, and this is projected to increase to 2.3 billion and 700 million respectively by 2015 (WHO 2006).

In New Zealand, approximately

- 21 percent of children are overweight
- 10 percent of children are obese (MoH 2003b)
- 32 percent of adults are overweight
- 21 percent of adults are obese (MoH 2004a).

Although obesity is not directly responsible for mortality, it is recognised as a risk factor for numerous conditions, including all-cause mortality, CVD, some cancers, musculoskeletal conditions and poor mental health (Department of Health Physical Activity Health Improvement and Promotion 2004).

Physical activity engagement is a key preventive tool in maintaining a balance between energy intake and expenditure. Low population levels of participation in physical activity are a significant factor in the sharp increase in rates of obesity shown around the world (Department of Health Physical Activity Health Improvement and Promotion 2004). Furthermore, for people who are overweight or obese, engaging in physical activity can provide important risk reductions across numerous chronic conditions (Grundy et al. 1999). Those who walk or cycle to work (Badland and Schofield 2008) or school (Gordon-Larsen et al. 2005) are more likely to be of normal body mass index (a measure of obesity) when compared to those who commute by motorised transport.

In addition, Frank, Andresen and Schmidt (2004) reported that each additional hour per day spent commuting by car was associated with a 6 percent increase in the odds of becoming obese. Conversely, each additional kilometre walked per day showed a 4.8 percent reduction in the odds of becoming obese. Neighbourhood walkability[1] (i.e. the degree to which neighbourhood design supports walking) had a negative relationship with body size; a 5 percent increase in neighbourhood walkability was associated with a 32.1 percent increase in active transport modes and a 0.23 point reduction in body mass index (BMI) in US adults (Frank et al. 2006).

This data indicates a strong relationship between urban design, obesity, and travel mode opportunities. Although promotional approaches have had some success at increasing physical activity – for example, encouraging children to walk or bicycle to school, walking and cycling promotional campaigns, prescriptions for walking written by doctors or nurses for sedentary patients (green prescriptions), and walking groups for at-risk people – they do not have a significant impact without environmental intervention. In recognition of the need for supportive environments, Sallis et al. (1998) recommend that:

> *Environmental interventions should be put in place before educational interventions are attempted. Health promotion programmes sometimes encourage impossible or unrealistic behaviours. For example, media campaigns that encourage people to walk in their neighbourhoods may be irrelevant to people in low-income neighbourhoods with poorly maintained sidewalks, parks controlled by drug dealers, no free recreational programs, and limited transportation to activity programmes in other locations. Such campaigns can be seen as blaming the victim of an unfortunate environment and fail to change behaviour. First, policies should be adopted to reduce crime and provide opportunities for safe recreation and active living. Then, educational programmes are more likely to be effective. Effectiveness of programmatic approaches could be increased if accompanied by changes to the physical environment.*

No evidence exists regarding the DALYs lost from obesity in New Zealand, because obesity is considered a risk factor for other diseases, such as CVD, certain cancers, and type 2 diabetes, rather than as a risk factor for mortality. In other words, no ones dies of obesity, but they are likely to develop other life-threatening disease because of it. However, there is a significant financial burden from obesity; WHO estimates the cost of obesity to be 2–7 percent of annual health budgets, which would be approximately $303 million per annum in New Zealand (MoH 2004b).

1 Neighbourhood walkability is defined on an index as a composite measure of the built environment by summing z scores for intersection density, residential density, retail floor area ratio, and mixed land use for each mesh block. These variables are usually assessed using Geographical Information Systems (GIS) procedures (Frank et al. 2006).

### 3.1.5 Musculoskeletal conditions

'Musculoskeletal' is a broad term that encompasses osteoporosis, osteoarthritis and lower back pain. These conditions can cause severe disability and loss of everyday functionality (Department of Health Physical Activity Health Improvement and Promotion 2004). Specific types of physical activity can benefit these conditions. Weight-bearing physical activities that cause bone stress (e.g. walking and running) can increase bone mineral density during adolescence, and in later life, these activities have been shown to be important in delaying the progression of osteoporosis. Furthermore, physical activity engagement can help improve balance and improve muscle mass in older adults, and therefore reduce the risk of falls and associated fractures (Snow et al. 2000). In the case of osteoarthritis, no evidence exists regarding the prevention of osteoarthritis through regular physical activity engagement.

A high proportion of the population will experience lower back pain at some stage of life, and research suggests that in the UK alone, 150 million days per annum are lost from work because of lower back pain (Clinical Standards Advisory Group 1994). A weak association exists between physical activity and prevention of lower back pain (Vuori 2001). People who experience lower back pain can benefit from moderate-intensity aerobic activities, such as walking.

To the best of our knowledge, no studies exist that explore the relationship between active transportation and musculoskeletal variables. Further research would thus be required to establish the relationship between active transport modes and the incidence of musculoskeletal conditions, in order to quantify the benefits that could be realised. For this reason, we have not included musculoskeletal conditions in the benefits of active modes.

### 3.1.6 Infectious diseases

Little is known about the relationship between physical activity and exposure to infectious diseases. Evidence suggests that physical activity may enhance some immune functions and depress others. For example, physical activity prevents stress-induced suppression of the immune system, and thereby assists with preventing infectious disease (Fleshner 2005). However, other research has shown that vigorously intense activities may exacerbate infectious disease episodes by depressing the immune system and increasing the susceptibility to these diseases (Halvorsen and Endsjø 1993).

We are unaware of any research that has specifically examined the relationship between active transportation and infectious diseases, or associations with exposure to infectious diseases when engaged in physical activity. For these reasons, we have not included infectious diseases in the potential health benefits of active modes.

### 3.1.7 Respiratory diseases

Chronic respiratory diseases are long-term conditions affecting the airways and lung structure. Being physically active does not influence the risk of these conditions, but it can play an important role in maintaining lung health and therefore preventing these diseases. The primary risk factors for chronic respiratory conditions are tobacco smoking, indoor and outdoor air pollution, allergens, and occupational risks (WHO 2007). Chronic obstructive pulmonary disease (COPD) and asthma are common chronic respiratory complaints. Although physical activity does not have a role in the prevention of these conditions, one major review article concluded that suitable physical activity programmes can improve the health and fitness of those with COPD, but do not affect quality of life or long-term prognosis (Chavannes et al. 2002). Another review assessed the relationship between asthma and physical activity. Within the asthmatic population, habitual physical activity increased overall fitness levels and reduced lung capacity during mild- and moderate-intensity exercise. As with the COPD review, physical activity programmes improved overall cardiopulmonary fitness in asthmatic patients, but did not affect their quality of life (Ram et al. 2005).

Chronic respiratory diseases account for 9 percent of DALYs lost and have a prevalence rate of 12 people per 1000 in New Zealand. Based on these figures, morbidity and mortality from chronic respiratory diseases accounts for the sixth largest share of DALYs lost by the New Zealand population. Furthermore, Maori are more likely to be affected by these diseases than non-Maori. In the case of COPD, one prospective[2] study has shown a 46 percent reduction in the risk of hospital admissions of those with COPD who maintain a high level of physical activity engagement (Garcia-Aymerich et al. 2003).

Acute respiratory infections have a different relationship to physical activity engagement. With regard to upper respiratory tract infections (URTI), such as the common cold and influenza, a 12-month prospective study conducted with older adults (aged 66–84) demonstrated a negative correlation between the incidence of URTI and moderate physical activity engagement (Kostka et al. 2000). This research suggests that being physically active reduces the severity of URTIs. A randomised controlled study of women (mean age 35 years) demonstrated that those who participated in moderate physical activity experienced 5.1 +/- 1.2 days per year with an URTI, compared with 10.8 +/- 2.3 days in sedentary women (Nieman et al. 1990). A reduction in the severity of URTIs will probably have implications for absenteeism.

The research on respiratory diseases is not conclusive enough at this stage to include it in the benefits of active transport modes. However, it is plausible that increased physical activity could reduce some of the morbidity and health sector costs related to COPD and URTI, and therefore, this is recommended as an area for further research.

# 3.2 Other health impairments

## 3.2.1 Mental health

Regular participation in physical activity appears to provide preventive and therapeutic effects for a range of mental illnesses. Research has shown that physical activity is an effective tool in preventing (Camacho et al. 1991) and treating depression (Lawlor and Hopker 2001), which is the most common form of mental illness in New Zealand. Other research has shown that physical activity has positive effects on anxiety, stress, phobias, panic disorders and schizophrenia (Department of Health Physical Activity Health Improvement and Promotion 2004).

In the case of mental well-being, physical activity plays an important role in enhancing perceptions of happiness and satisfaction (Taylor 2000), self-worth and motivation (Fox 2000), coping with stress (Stephens 1988), social interactions (Taylor 2000), and sleep patterns (Kubitz et al. 1996). Although Sturm and Cohen (2004) found no relationship between urban sprawl (which is positively associated with car use) and mental health outcomes, other research has shown that urban sprawl can lead to social isolation, which can increase rates of depression (Champion 1990). To our knowledge, no study has looked specifically at the relationship between active transportation and mental health.

Mental illnesses, such as depression, anxiety, stress, schizophrenia and bi-polar disorders, are widespread in New Zealand. Approximately 47 percent of New Zealanders will experience a mental illness and/or addiction at some time in their lives, and one out of five people are affected by mental

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2 A prospective study is one in which the subjects are identified and then followed forward in time.

illness each year (Oakely Browne et al. 2006). New Zealand burden-of-disease data show the DALYs attributable to mental illnesses are 12 percent and the rate is 17 people per 1000. Differences exist across gender, with the rate being higher in females (21 per 1000) when compared with males (14 per 1000) (MoH 2001).

Dunn, Trivedi and O'Neal's 2001 review showed that maintaining physical activity over the course of a person's lifespan can reduce the relative risk of depression by 22 percent. However, further studies are needed to develop the evidence base across a range of mental illnesses.

Thus, the relationship between depression and physical activity is robust enough to include a reduction of YLD in the benefits of active modes.

### 3.2.2 Impact of travel mode-related stress

The literature indicates correlations between choice of travel mode and stress levels. Several studies have found that commuters travelling by car experience elevated stress levels, when compared to their baseline stress levels and the stress experienced by commuters by other travel modes (Bellet et al. 1969; Robinson 1991; Simonson et al. 1968). Much of this stress may be attributable to factors outside the driver's control, such as traffic delays, unpredictable behaviour of other drivers, driving-related anxiety, and time pressures (Evans and Carrere 1991; Novaco et al. 1979; Schaeffer et al. 1988; Stokols et al. 1978; White and Rotton 1998). In particular, exposure to traffic congestion has been positively associated with elevated blood pressure (Stokols et al. 1978), absenteeism (Novaco, Stokols, and Milanesi, 1991), hospitalisation rates (Stokols and Novaco 1981), and presenteeism (self-reported lack of engagement at work) (Schaeffer et al. 1988). Prolonged exposure to elevated stress levels has negative consequences for occupational performance (Cohen 1980; Barling et al. 1995), including increased absenteeism (Knox, 1961; Novaco et al. 1991), reduced job satisfaction (Koslowsky et al. 1995), and decreased task motivation (Schaeffer et al. 1988; Stokols et al. 1978; White and Rotton 1998).

Although some people find that time spent driving can alleviate stress (Kluger 1998), commuting by automobile generally appears to be more stressful than travelling by other modes (Frank et al. 2006; Koslowsky and Krauz 1993). Surveys by Gatersleben and Uzzell (2007) and O'Regan (2003) demonstrated correlative linkages between commute mode and stress levels; those who walked or cycled reported lower levels of stress than those who commuted by other modes. White and Rotton (1998) identified increased stress amongst car commuters as compared to those travelling by bus.

Conversely, a recent Canadian survey (Turcotte 2006) found that public transport commuters were less likely to enjoy commuting when compared to car drivers, but this appears to reflect time exposure. The survey found that 'Dislike' rates increased with commute duration and with city size. The greater dislike of commuting by transit travellers and residents of large cities can be explained by their longer average commute duration and increased need to transfer. After accounting for these factors, the researcher found no statistically significant difference between transit and automobile commuters, while people who cycled or walked to work were most likely to enjoy their commute. Overall, Turcotte found that people who engaged in active transport were most likely to report the lowest levels of commuting stress.

A caveat of these findings is that these data are cross-sectional rather than longitudinal, and thereby do not establish the direction of causality between the attributes being analysed. Compounding this is the lack of national data regarding costs associated with stress, and the differences in levels of stress that are experienced between various travel modes. We consider it premature to attribute health benefits from reduced stress from active travel modes, although we believe they are likely. The potential economic costs of stress would appear sufficient to justify local research into the relationships between mode choice and stress.

### 3.2.3 Productivity

Productivity represents an aggregated measure of economic output as a function of input. In terms of this report, productivity is used to describe the productive capacity of human resources (i.e. employees) measured in terms of both the quantity and quality of their output. This section investigates the potential for increased physical activity to catalyse improvements in workplace productivity.

Mills et al. (2007) conducted a before-and-after intervention-control study, and ascertained that a multi-faceted individualised workplace health programme focusing on wellness (including the promotion of physical activity) generated both

- a reduction in health risk factors (0.45) and absenteeism (4.3 days per year)
- an improvement on the work performance scale (0.79, 10.4 percent productivity performance) per employee.

Similarly, Pronk et al. (2004) conducted a cross-sectional study that examined the relationship between self-reported workplace productivity (presenteeism) with overall physical activity in US workers. Job performance was positively associated with moderate- and vigorous-intensity physical activity engagement, and perceived work quality was positively linked to moderate-intensity physical activity engagement. However, this study could not determine causality, or the active transport contribution to overall physical activity engagement.

Specific to active transport, a Scottish study focused on the effects of increasing walking and cycling commuting rates to and from work (Mutrie et al. 2002). The randomised study controlled trial used a ‘stages of change’ approach and tailored resources according to individual profiles (n=295 employees). Each person in the intervention group received a pack containing interactive print materials, and information regarding local commute routes and safety. The intervention group was nearly twice as likely to walk to work (OR=1.93), but no changes were shown in cycling behaviour. One year later, 25 percent of the intervention group were still walking to work. A sub-study using objective monitoring (pedometers and heart-rate monitors) revealed that the average commute times for active transporters was 25 minutes, and the mean MET value[3] was 4.8 for walking and 7.0 for cycling. With regards to productivity, those who walked to work were also more likely to report improved mental health scores than the control group, but these differences were not statistically significant. Similar relationships were also shown in an earlier Finnish study (Vuori et al. 1994).

Little research appears to have been conducted into potential relationships between physical activity and job satisfaction. Self-report surveys conducted in Dublin indicated a high correlation between travel mode and measures of job satisfaction, although these results are difficult to validate and generalise to local conditions. It remains unknown how active transport engagement may influence job satisfaction.

3 MET (metabolic equivalent unit) is a measure that expresses the ratio of the associated metabolic rate for the specific activity divided by the resting metabolic rate that is used in physical activity research (see Ainsworth et al. 1993). It allows us to compare the relative intensity of different transport modes.

### 3.2.4 Injury risk

One of the major barriers to active transport is perceived danger from motor vehicle collisions (Pucher and Dijkstra 2000), and the relationship is even more pronounced when cycling for transport is isolated (Pucher and Buehler 2008). Not only is this perception present in adults when considering their own travel behaviour, but also when they are selecting their child's commute mode (Hinckson et al. 2008). In contrast, a recent New Zealand study showed that the injury risk for children walking or cycling to school was relatively low (10.3 and 46.1 injuries per million trips, respectively) when compared to injuries in other settings. An automobile was involved in 40 percent of all school travel injuries, and the most severe injuries occurred while the child was travelling by motor vehicle (Schofield et al. 2008). Other New Zealand studies have shown that injuries with a motor vehicle as the mechanism were responsible for 15 percent ($11.3 million) of all hospitalisation costs and 9 percent (n=160,000) of all hospitalisation rates in 2000–2003. Furthermore, 27 percent (n=882) of all injury-related deaths in 2000–2001 were associated with a motor vehicle collision (Stephenson et al. 2005). The aggregated data did not allow for accidents associated with active transport modes to be independently analysed. The logical conclusion that can be drawn from these studies is that a modal shift to active transport will reduce traffic injuries because of the reduced number of collisions with motor vehicles.

Other research has shown that the presence of more pedestrians and cyclists on the street has an inverse association with risk of motor vehicle collision. This suggests that motorists become increasingly aware and drive more cautiously when there are higher levels of pedestrian activity, a phenomenon referred to as 'safety in numbers' (Jacobsen 2003). This trend was shown in Australia when cycling data were examined. The study concluded that if the cycling rate doubled, the injury risk per kilometre would reduce by 34 percent. Alternatively, if Australian cycling rates halved, the injury risk per cycling-kilometre would be predicted to increase by 52 percent (Robinson 2005). Turner et al. (2006) found a noticeable 'safety in numbers' effect in New Zealand, which is consistent with overseas research. This research indicates the potential for an additional 'safety in numbers' benefit that could be incorporated into the assessment of the economic benefits associated with policy and planning decisions that increase total active transport activity in an area.

The injury-risk evidence cited above has two implications for the health benefits associated with active modes:

- The evidence confirms that the negative impact of active-mode injury risk does not outweigh the health benefits of increased activity, particularly when compared to private vehicle travel.
- Increasing the numbers of cyclists and pedestrians on the road can have a positive impact in terms of reducing the frequency of active-mode injuries per capita. An injury-reduction benefit could therefore be attributed to projects that increase the number of walkers and cyclists on the road. However, injury-reduction benefits are not in the scope of the health benefits determined in this report. Valuation of an injury-reduction benefit is recommended as an area for further research.

### 3.2.5 Air pollution exposure

Vehicle emissions are a substantial contributor to air pollution in urban environments and it is estimated that motorised vehicles contribute 80 percent of air pollution in these settings (WHO 2005).

There are two ways in which air pollution health impacts can be understood with regard to active transport modes:

- as a direct impact (cost or benefit) for active-mode users who are exposed to higher or lower levels of pollution

- as a population-wide health benefit of reduced emissions, as fewer vehicles are used in urban areas if there is a modal shift to active modes.

The former impact is directly relevant to the health benefits valuation undertaken in this report, while the latter should be included in the environmental benefit of active modes (air pollution reduction).

Travelling by active transport modes can reduce motorised traffic congestion and vehicle emissions by reducing total vehicle travel (Department of the Environment and Heritage 2004). Typically, people travelling in cars and buses are exposed to higher levels of air pollution than people engaging in active transport (Kaur et al. 2007). This is because the air intakes of vehicles lie directly in the path of emissions from surrounding vehicles, and those who travel by motorised modes are also subject to the emissions from their own vehicles.

Although this is the case, it is important to note that pedestrian air pollution exposure is still higher than ambient air samples (Gulliver and Briggs 2007), and the World Health Organization recognises that although active commuting delivers health benefits, active transport conducted in close proximity to motorised vehicles can have serious adverse health consequences from air pollution exposure, including CVD and respiratory diseases (WHO 2005). Furthermore, although active commuters are exposed to lower air pollution concentrations than people in vehicles, the journey-time exposure can contribute disproportionately to their total exposure. For example, a small Dutch study (n=8) demonstrated that cyclists breathed 2.3 times as much as car drivers during commuting, and during this period they inhaled similar levels of carbon monoxide, but significantly higher amounts of nitrogen dioxide, when commute distances were equated (van Wijnen et al. 1995).

Other factors that may influence air pollution exposure for those who engage in active transport include frequency and duration of stopping at traffic intersections, proximity of travel route to motorised traffic, temperature, wind speed, and travel through ‘street canyon’ environments (Kaur et al. 2007). If active transport routes are located away from major roadways (for example, if there is a network of footpaths and paths on side streets and through parks) air pollution exposure for this population can be minimised. Residents of more walkable neighbourhoods are also less likely to be exposed to air pollution. A 5 percent increase in neighbourhood walkability was associated with 5.6 percent reduction in oxide of nitrogen grams and 5.5 percent fewer volatile organic compound grams emitted (Frank, Sallis et al. 2006).

However, there are only limited population-level studies focused on transport-related air pollution, and it appears to be premature to make conclusive statements about exposure extremes experienced by sub-groups (WHO 2005). At this point, there is insufficient evidence to be able to establish air pollution exposure by travel mode, and we recommend that longitudinal research be undertaken in the local context to establish the level of exposure to emissions for active-mode users.

European data suggest that the burden of disease attributable to air pollution from motorised traffic may be at least the same amount as that caused by road accidents (Kunzli et al. 2000). Based on this assumption, it has been estimated that 500 deaths per year in New Zealand are directly attributable to traffic-related air pollution (Fisher et. al. 2007). Given the relationship between vehicle emissions and health, air pollution reduction benefits can be calculated for the portion of active-mode trips that entail a reduction in motor vehicle trips (mode shift). Because this is not a direct benefit relative to users of active modes, this impact should be valued and included in the environmental or population-wide benefits.

## 3.3 Summary

Taken together, there is a body of research demonstrating that physical activity reduces the risk of numerous chronic health conditions. Specific evidence exists for the protective effect of active transport engagement on CVD, certain cancers and obesity, all of which are serious health concerns in New Zealand.

There is insufficient research to determine with confidence the associations between active transport and the other chronic conditions investigated in this report. For example, physical activity engagement is associated with improved workplace productivity, but no research has specifically looked at workplace productivity and commuting behaviours.

Neighbourhood design is likely to influence travel choices and opportunities, and there is strong evidence that residents of communities that support walking and cycling have better health profiles than those of less walkable neighbourhoods. Also, while the risk of injury is higher for people who walk or cycle, motor vehicles are the mechanisms for the majority of the accidents. It is likely that if there is a modal shift to active transport, there will be a reduction in traffic injuries because of the phenomenon of ‘safety in numbers’, and the lower number of motor vehicles on the streets. Air pollution will also improve if a modal shift occurs, and this benefit should be taken into account in the economic evaluation process.

The literature review identified four diseases for which there is robust evidence of reduced risk resulting from increased physical activity (including active transport):

- cardiovascular disease (CVD)
- cancer (breast, colon, lung)
- type 2 diabetes
- depression.

The following table summarises these diseases (as well as all-cause mortality) and their relationship to inactivity in terms of relative risk reduction. The relative risk reductions (RRR) cited in the literature review have been transformed to represent the relative risk (RR) of insufficient activity compared to sufficient activity; i.e. the ratio of the risk (or rate) of a disease amongst those exposed to a given risk factor (insufficient physical activity) to that amongst those who are not exposed to that risk factor (MoH 2001). The RR is used to help calculate the costs of inactivity in section 5. Additionally, the burden of each disease in terms of New Zealand DALYs is included in the table.

**Table 3.1 Diseases with an evidence-supported link to inactivity, relative risk reduction if sufficiently active, relative risk and NZ-specific DALYs attributable**

| Factor | | RRR[a] of activity (cited in text) | Source | RR[b] of inactivity *1/(1-RRR)* | NZ DALYs attributable (MoH 2001) |
|---|---|---|---|---|---|
| All-cause mortality | | 55% | Bijnen et al. 1999; Erikssen et al. 1998 | 2.22 | n/a |
| CVD | | 20–35% | Macera et al. 2003 | 1.25–1.54 | 24% |
| Cancer (all) | | | Lee 2003 | | 20% |
| | Colon | 30–40% | | 1.43–1.67 | 3.2% |
| | Breast | 20–30% | | 1.25–1.43 | 2.4% |
| | Lung | 10–20% | | 1.11–1.25 | 2.9% |
| Type 2 diabetes | | 33–50% | Lynch et al. 1996; Manson et al. 1992 | 1.49–2 | 5% (All endocrine conditions) |
| Depression | | 22% | Dunn et al. 2001 | 1.28 | 3.6% (All mental illnesses) |

a) The relative risk reduction is relative to mortality in all disease states except depression, in which case it is incidence.

b) Relative risk

# 4 Active transport characteristics

This section of the report identifies the characteristics of active transport modes that will be used to calculate the value of health benefits that can be attributed to active-mode projects.

## 4.1 Physical activity accumulation through active transport modes

Physical activity is defined as any bodily movement produced by skeletal muscles that results in an expenditure of energy, with occupational, recreational, transportation, and household activities all contributing to overall physical activity engagement. As mentioned previously, active transport contributes to overall physical activity by the use of large muscle groups to walk, cycle, or similarly exert oneself to get from place to place (Department of Health Physical Activity Health Improvement and Promotion 2004).

Accordingly, the evidence of health benefits resulting from general moderate physical activity can also be fully attributed to active modes of transportation. Moreover, as outlined in section 3, studies that focused specifically on active transportation found that many of the health outcomes associated with being physically active were more pronounced in those who engaged in active transport when compared to those who participated only in leisure-time physical activity (Andersen et al. 2000; Hayashi et al. 1999; Hou et al. 2004; Hu et al. 2001; Hu et al. 2002; Wagner et al. 2001). This may be because active transport involves regular travel to a specific destination with two journeys for each trip (arrival and departure). The additional purpose of the activity, namely travel, may lead participants to engage in it more regularly than they would in purely leisure-time activity.

Active transport thus provides a valuable opportunity to accumulate physical activity. We therefore consider that the risk reduction factors listed in table 3.1 have robust links to active transport modes, and we use these in determining the value of health benefits that can be attributed to active mode transport projects.

## 4.2 Time, distance and frequency of active-mode trips

The New Zealand Household Travel Survey is an ongoing survey of household travel conducted for the Ministry of Transport. Each year, people in over 2000 households throughout New Zealand are invited to participate in the survey by recording all their travel over a 2-day period. The 2003–2006 data (MoT 2008) was drawn from 12,700 people in 5,650 households, collected between March 2003 and June 2006. From this data, we were able to determine the average time per day that each age group spent cycling and walking for transport. Other active modes have not previously been surveyed in the New Zealand context.

### 4.2.1 Cycling

Table 4.1 displays the times per day that respondents spent cycling. The mean and median figures demonstrate that, among those who cycled for transport during the 2-day survey period, their average daily cycling met (or was very close to meeting) the recommended 30 minutes of moderate-intensity physical activity per day for adults.

**Table 4.1 Time per day spent cycling for those who reported cycling**

| Age | Minutes per day spent cycling | | | | | |
|---|---|---|---|---|---|---|
| | 10th percentile | 25th percentile | *Median* | 75th percentile | 90th percentile | **Mean** |
| 15–24 years | 9 | 10 | *26* | 35 | 85 | **34** |
| 25–34 years | 20 | 20 | *29* | 49 | 75 | **39** |
| 35–44 years | 10 | 30 | *40* | 70 | 108 | **58** |
| 45–54 years | 10 | 20 | *30* | 62 | 119 | **50** |
| 55+ years | 10 | 14 | *36* | 55 | 84 | **41** |
| Total population | 10 | 19 | *30* | 49 | 78 | **39** |

For most age groups, less than 10 percent of trips were under 10 minutes, and a slight majority of people who cycled for transport did so for more than 30 minutes per day. Assuming an average speed of 20 km/hour, the average cycle trip distance and frequency would be 5–6 km for 2 trips, or 3–3.5 km for 3 trips. Note that although the speeds and distances are likely to be less for children (although not in intensity or MET values), the benefit for children should not be less, as it is the intensity and time spent cycling that is important.

### 4.2.2 Walking

Table 4.2 shows that the median for each age group is lower than the mean. That is, while the mean suggests that on average, those who walk for transport meet the recommended minimum daily threshold (for 20+ years of age), the lower median suggests that most people walk less than 30 minutes, but there are some who walk a good deal longer than that. The median is greater than 20 minutes per day for each age group, suggesting that those who walk are nevertheless close to achieving the minimum recommended daily activity from walking.

**Table 4.2 Time per day spent walking for those who reported walking**

| Age | Minutes per day spent walking | | | | | |
|---|---|---|---|---|---|---|
| | 10th percentile | 25th percentile | *Median* | 75th percentile | 90th percentile | **Mean** |
| 15–24 years | 6 | 13 | *25* | 45 | 70 | **35** |
| 25–34 years | 5 | 10 | *25* | 45 | 76 | **35** |
| 35–44 years | 4 | 10 | *21* | 45 | 74 | **33** |
| 45–54 years | 4 | 10 | *23* | 40 | 65 | **32** |
| 55–64 years | 4 | 10 | *23* | 42 | 65 | **32** |
| 65–74 years | 7 | 10 | *25* | 45 | 69 | **34** |
| 75+ years | 8 | 15 | *29* | 45 | 71 | **37** |

Assuming a walking speed of 5 km/hour, the average daily walking distance would be 2–2.5 km, which would support an average trip distance of 1.2 km for 2 trips per day.

## 4.3 Intensity

The *Compendium of physical activities* (Ainsworth et al. 1993) classifies the intensity of activities as multiples of one MET, or the ratio of the associated metabolic rate for the specific activity divided by the resting metabolic rate. This allows us to compare the relative intensity of different transport modes.

**Table 4.3 MET values for transport-related activity (adapted from Ainsworth et al. 2003)**

| Activity | | MET |
|---|---|---|
| Inactivity | Sitting quietly (riding in a car) | 1 |
| Transportation | Driving automobile or light truck | 2 |
| Bicycling | <16 kph (to work, leisure, general) | 4 |
| | 16–19 kph (leisure, slow light effort) | 6 |
| | 19–22.5 kph (leisure, moderate effort) | 8 |
| | 22.5–25.6 kph (leisure fast, racing, vigorous effort) | 10 |
| Walking | 5 kph (level, moderate pace, for pleasure, work break) | 3.5 |
| | 6 kph (brisk pace or uphill, to work or class) | 4 |
| Jogging | General | 7 |
| Running | 10 kph | 10 |
| Small-wheeled recreational devices | Skateboarding | 5 |
| | Roller skating | 7 |
| | Walking with wheeled luggage | n/a |

As mentioned in section 3.2.3, a Scottish active transport study using objective monitoring (pedometers and heart-rate monitors) found that the average commute time for adults was 25 minutes and the mean MET value was 4.8 for walking and 7.0 for cycling (Mutrie et al. 2002). Adopting these MET values for commuter travel would produce an approximate 1:1.45 ratio of the intensity of walking to cycling. However, children and older people may walk at a reduced average speed (and therefore intensity). We therefore assume an average speed of 5 km/h with corresponding MET intensity of 3.5 for walking, and an average speed of 20 km/h and corresponding MET intensity of 7.0 for cycling. We assume a MET value of 5 for skateboarding, and 7 for roller skating.

Therefore, the intensity factors of different active modes are as follows:

- 1 minute of walking is equivalent to .7 minutes of skateboarding.
- 1 minute of walking is equivalent to 0.5 minutes of cycling or roller skating.

This time equivalency is accepted in health research, and means that only 15 minutes of cycling or roller skating is necessary to obtain moderately active status health benefits. Skateboarding for 21 minutes per day is sufficient to obtain health benefits.

## 4.4 Mode-specific factors

The travel survey data on walking and cycling leads to two well-founded conclusions:

- A very small proportion of the population currently walk or cycle for transport reasons (less than 10 percent), and this proportion has been decreasing steadily for well over a decade (MoT 2008).
- When people do walk and cycle for transport they are, on average, active enough (or nearly), to meet the recommended daily minimum of 30 minutes of activity.

This further supports the conclusion that active transportation presents a good opportunity to accumulate physical activity. Thus there is significant scope to maintain and increase moderate activity levels in the New Zealand population by investing in projects that will maintain and increase the mode share of active modes.

Cycling and roller skating for transport could potentially have greater health benefits over shorter times, because they are twice as intense as walking when measured using MET values. Moreover, the Household Travel Survey shows that people who cycle spend more time cycling per day, on average, than those who walk. Skateboarding is more intense, on average, than walking, but less intense than cycling and roller skating. Lack of data prevents us from drawing general conclusions about its potential for health benefits as a mode of transportation beyond assigning a health value to the kilometres travelled.

Despite its lower intensity, walking is an option that is easier and more accessible for a larger proportion of the population. Most people, except infants and people with severe disabilities, can walk. Indeed, it is the most basic form of human transport. No equipment is needed, and it is therefore the most affordable of all forms of transport. It is part of many other activities and provides access and connections for other transport modes. Walking thus has broader potential than cycling for moderate health benefits across all demographics of society.

Network-wide improvements will be necessary to make walking a more pleasant and enjoyable form of transportation for more trips, and thus increase the average daily time people spend walking, as well as greatly increase the number of people who walk for transportation.

# 5 Valuing the health benefits of physical activity

## 5.1 Principles and limitations

The following principles and limitations have guided the development of a methodology for calculating a value of the health benefits of cycling and walking projects for this report. It should be noted that the methods employed herein have been specifically designed for inclusion in the EEM2, and may not be appropriate for other research or application.

### 5.1.1 Based on available evidence

The physical activity and health literature review in section 3 identified the best and most applicable peer-reviewed studies to establish the relationship between active transport modes and specific, quantifiable health benefits. Because the body of knowledge on population health and physical activity is evolving rapidly, older studies and previous attempts to value the health benefits of active modes have not necessarily been a complete indication of their impact. This study has stopped short of including some plausible benefits, such as workplace productivity and reduced exposure to air pollution, owing to insufficient evidence of magnitude. In this respect, the values calculated in this section may be considered a conservative estimate of the total costs of insufficient inactivity.

### 5.1.2 Simple, clear and easy to use

This report was commissioned specifically to determine a per-km value of the health benefits of active transport modes, aggregated across the population in a way that could be easily incorporated into the EEM2. Given the limited scope of this report and the need to integrate with the existing transport economic evaluation framework, we have found it necessary to trade off the precision of the method with simplicity of use. It must be stressed that the methods employed to calculate the costs attributable to inactivity are not to the standard of precision that would be expected of an epidemiological study seeking to quantify these costs. This report has been limited by time frames, access to data, and the practicality of integration into the current EEM framework. Nevertheless, it is considered that the methods here provide a realistic, if broadly brushed, understanding of the health benefits that can be achieved through active transport projects, especially as compared to methods and values used overseas.

### 5.1.3 Application of the 'rule of half'

The 'rule of half' is usually applied to new-user benefits of travel demand management (TDM) initiatives that affect the price of a transport service (see section 3.2 of EEM2). In other words, only half of the usual benefits are counted for new users. This is applied in accordance with the microeconomic theory of consumer surplus, which holds that when a change in price induces new users, surplus benefits are perceived as a declining line (along the fixed demand curve) from full benefits to zero. The area of benefit is thus the full benefits divided by two (as it would be to calculate the area of a triangle as opposed to a square). The rule of half cannot apply in the same way to the health benefits perceived by new cyclists and walkers, precisely because the full health benefits are realised by those who are newly active, rather than existing users who are already active. Not all new users will perceive full health benefits, but the application of benefits to insufficiently active people will already be included in the per-km value based on the distribution of activity levels amongst the general population. In this way, full benefits are allocated to those who were previously inactive, while only marginal benefits are perceived by those who are already active. However, the rule of half may be used to apportion benefits to existing cyclists and pedestrians, to account for health benefits perceived by those users who would have changed modes had there been no intervention.

### 5.1.4 Discounting health benefits and value of life in the future

Economists Herman Daly (1991) and Kenneth Arrow (1995) have argued against the policy of discounting the value of human health, happiness and future life years, on the basis that they are not economic resources that could earn a return on investment. Also, the benefits (including health) of transportation projects are already discounted at a rate of 10 percent during the economic efficiency evaluation, so to discount the value of health benefits at the valuation stage would amount to double discounting. Therefore, we have not discounted the value of YLL, YLD, DALY or VoSL (value of a statistical life) in calculating the annual health benefit per previously inactive person. This approach is consistent with the majority of the methodologies reviewed in section 5.2.

### 5.1.5 Value of a Statistical Life (VoSL)

VoSL is used to monetise the value of a human life, and is based on the concept of willingness-to-pay. It is a standard measure that is applied in nearly every methodology reviewed in the next section, though the value varies among countries. The VoSL that is often applied in New Zealand was first established in a household survey by Miller and Guria (1991). It is updated regularly to reflect inflation, using the consumer price index (CPI). In an update of the social cost of road crashes, the Ministry of Transport (2007a) published the base VoSL as $3.19 million per fatality. The social cost per road fatality is $3.21 million – higher than the VoSL – which reflects additional costs such as property damage, medical and legal costs, and temporary loss of output (MoT 2007a), and is used to value the benefits of safety improvements to the transport network. In this report, we have employed the base VoSL in June 2007 values – $3.19 million – as a measure of willingness-to-pay for additional years of life. This value is highly comparable to the VoSL employed in the WHO Health Economic Assessment Tool (HEAT, described further in the next section.) The HEAT tool uses a standard VoSL of €1.5 million, which is approximately equivalent to NZ$3.17 million[4].

## 5.2 Literature review

The literature review revealed a number of different approaches to valuing health benefits as part of a comprehensive CBA of active transport mode facilities. The different assumptions and values used in each of the following methodologies is summarised in table 5.1.

- **Saelensminde (2004)** presents a CBA of walking and cycling track networks in three Norwegian cities, incorporating the benefits of reduced insecurity and improved fitness, in addition to the reduced external and internal costs of mode shift from private cars to walking and cycling. The health benefit components include the reduced risk of mortality, health care costs, treatment costs and potential productivity for 4 ailments (covering 5 types of cancer, high blood pressure, type 2 diabetes and musculoskeletal ailments) and additional welfare loss (at 60 percent of total costs) due to inactivity. In order to 'not over-estimate' potential benefits, they assume that only 50 percent of new cyclists or pedestrians using a given network will experience improved health benefits. The rationale for this figure (rather than a lower figure) is not explicitly explained.

4 This was calculated using the exchange rate on 30 July 2008. Note that despite fluctuations, the exchange rate between the Euro and NZ$ has been consistently close to this for the last few years.

- In a report for the European Regional Office of the World Health Organization, **Cavill et al. (2007)** review recent approaches to CBA of transport-related physical activity and provide a detailed methodology for assessing cycle-only projects in a European context. This methodology relies upon the relative risk for all-cause mortality for adult commuter cyclists, based on the findings of the Copenhagen Centre for Prospective Population Studies (Andersen et al. 2000), and the statistical value of a life (VoSL) to determine the benefits for additional cyclists. This method assumes a linear dose-response[5] relationship with no threshold, but accounts for the proportion of newly active cyclists and a factor of activity substitution. A method to determine the benefits of walking or other active modes has not yet been developed.
- In the UK, the **Department for Transport (2007)** uses a methodology based on the UK proportion of deaths due to three diseases that can be prevented by increased physical activity – coronary heart disease (CHD), stroke and colon cancer – to evaluate the physical fitness benefits of walking and cycling projects. The annual value per additional cyclist or pedestrian is calculated as the product of

  a) the number of preventable deaths per person

  b) the cost per death (using the UK VoSL).

  This method assumes that all new pedestrians and cyclists will receive the annual benefit.
- **BECA (2007)** reviews the health benefits of walking and cycling for Land Transport NZ and determined a value of 40 c/km travelled by a new cyclist and 80 c/km travelled by a new pedestrian, with an annual benefit cap of $1000 per person. The methodology employed uses the number of 1996 DALYs lost due to inactivity (7 percent) for people aged 16–64. This number is divided by the 1996 estimated number of people aged over 15 who were classified as inactive (1.24 million) to obtain a ratio of DALYs per inactive person. Using a VoSL of $3.05 million, the undiscounted annual value of a DALY is $73,000. Health sector costs and lost resource output per inactive person are also calculated, to arrive at an annual benefit of $3000 per newly active user. This annual benefit is divided by 3 to reflect the assumption that inactive users of a facility will be in the same proportion as in the general population (1:3). The amount of annual walking and cycling required to achieve active status is divided by the annual benefit of $1000 to find the per-km value. However, while the researchers state that 625 km of healthy walking is required to achieve health benefits, they divide by twice that number (1250) to arrive at the 80 c/km figure. No rationale is given in the report for dividing by twice the number of km required to reach active status. The effect of this is to halve the benefit for both walking and cycling instead of what the method otherwise suggests it should be – i.e. $1.60/km for new walkers and 80 c/km for new cyclists.
- **Stokes et al. (2007)** value the health benefits of additional walking that will be induced by a new light-rail project in Charlotte, North Carolina. In a very different approach, they focus uniquely on the costs of obesity, valued at the average extra annual health care costs faced by obese people. Additionally, they include average annual willingness-to-pay (WTP) for weight-reduction programmes. They use research on increased walking achieved by those using a commuter rail system in the US, and likely prevalence of obesity amongst projected light-rail users, to calculate

5 The dose-response curve represents the relationship between the amount of exposure (dose) to a variable, in this case physical activity, and the resulting changes in body function or health (response). A linear curve assumes equivalent benefits at any dose.

the number of people using the light rail who will walk enough as a result of the project to reduce their BMI.

- Most recently, **Boarnet et al. (2008)** examined the magnitude of health benefits from urban design characteristics that encourage walking. The value of health benefits are based on reduced risk of mortality due to CHD found in a longitudinal study of men aged 35 to 57 years. This method uses a threshold of approximately 30 minutes, but assumes graduated distribution of additional walking necessary to reach the threshold.

**Table 5.1 Summary of methodologies and assumptions from literature review**

| Study | Diseases considered | Mortality/ morbidity | Additional costs included | Monetary value assigned | Threshold, dose response, or other |
|---|---|---|---|---|---|
| **Saelensminde (2004)** | · Cancer (5 types)<br>· High blood pressure<br>· Type 2 diabetes<br>· Musculoskeletal ailments | *Mortality + morbidity*<br>(Social costs of health care, treatment, lost productivity) | · Health care costs<br>· Treatment costs<br>· Potential productivity lost<br>· Welfare loss (60% of all other costs) | Social costs of 4 diseases from NCNPA 2000 (cited in Saelensminde 2004). | Annual user benefit applied directly to 50% of new walkers and cyclists |
| **Cavill et al. (2007)** | · All-cause mortality (adults) | *Mortality only*<br>Reduced risk of all-cause mortality (0.72) | n/a | VoSL<br>(undiscounted)<br>*€0.81/km cycling only* | *Linear dose response* |
| **UK DfT (2007)** | · CVD<br>· Colon cancer | *Mortality only*<br>Number of preventable deaths<br>(ERR x 0.09 x deaths due to diseases considered) | n/a | VoSL<br>(undiscounted)<br>*0.00001 x VoSL* | Annual user benefit applied directly to each additional walker and cyclist |
| **BECA (2007)** | · DALYs due to inactivity (only including ages 15–65) | *Mortality + morbidity*<br>1996 DALYs due to inactivity (0.07 of all DALYs) | · Health sector costs<br>· Lost resource output | VoSL<br>Undiscounted to value DALYs but discounted to attribute annual value | *Linear dose response capped at 30 min per day* |
| **Stokes et al. (2007)** | · Obesity | *Morbidity only*<br>Increase in individual yearly medical costs associated with obesity | · WTP for weight-reduction programmes | · Average annual medical costs<br>· WTP for weight-reduction programmes | Annual user benefit applied to proportion of projected light-rail users who are obese |
| **Boaranet et al. (2008)** | · CHD<br>· Sudden death<br>· All-cause mortality | *Mortality only* | n/a | VoSL<br>(undiscounted)<br>Two different values used (low and high)<br>*Total project benefits only calculated* | Annual user benefit (lives saved) based on users who walk enough to move from the first to second tertile of physical activity |

## 5.3 Costs of inactivity

For the purposes of this valuation, sufficient activity for adults to receive health benefits has been defined as the accumulation of at least 30 minutes per day of moderate-intensity physical activity engagement on at least five days per week (Department of Health Physical Activity Health Improvement and Promotion 2004; Sport and Recreation New Zealand 2003). The classifications of 'insufficient activity' and 'sedentary' fall below these thresholds. All of the studies we reviewed varied slightly in their definitions, so it is unlikely that these classifications were identical in all cases. However, the literature review concluded that the excess relative risk (ERR) was associated with insufficient activity (i.e. less than 30 minutes, 5 days per week.) The health literature review established the following evidenced-based relationships between specific diseases and insufficient physical activity. (Low and high values are given when the studies provided a range of relative risk reduction.)

**Table 5.2 Diseases and ERR of insufficient physical inactivity**

| Source | Disease | ERR[a] attributable to insufficient physical activity | |
|---|---|---|---|
| | | Low | High |
| Macera et al. 2003 | CVD | 0.25 | 0.54 |
| Lee 2003 | Colon cancer | 0.43 | 0.67 |
| | Breast cancer | 0.25 | 0.43 |
| | Lung cancer | 0.11 | 0.25 |
| Lynch et al. 1996; Manson et al. 1992 | Type 2 diabetes | 0.49 | 1.00 |
| Dunn et al. 2001 | Depression | 0.28 | |

a) Excess relative risk is (RR-1). These have been calculated using the RRR and RR values listed in table 3.1. The excess relative risk values are relative to mortality for all diseases except depression, in which case, it refers to excess risk of incidence.

The excess relative risk (ERR) is used to attribute health costs to inactivity by employing the population attributable risk fraction (PAF). PAF can be understood as the difference in the incidence (or mortality) rate of a specified disease between the total population and those not exposed to a given risk factor for the disease (MoH, 2001). The PAF can be expressed as:

$$PAF = Pe(ERR) / Pe(ERR) + 1$$

where Pe = Prevalence of exposure to a given risk factor.

### 5.3.1 Mortality and morbidity costs: Willingness-to-pay

As mentioned earlier, mortality costs are easier to quantify than those of morbidity, and for this reason, several of the robust approaches outlined above limit their quantification of benefits to those of reduced mortality. There are, however, benefits evident beyond increased life expectancy, including reduction in years lost to disability and health sector costs. Sufficient evidence is available to use New Zealand YLD to estimate these costs. Low and high scenarios of ERR are employed to determine a range of potential benefits with regard to mortality.

Many of the methodologies we reviewed used a local value of a statistical life (VoSL) as an indication of willingness-to-pay (WTP), but they took quite different approaches to estimating an annualised value. The UK 2007 approach used the annual mortality rate attributable to inactivity for the inactive population and multiplied that fraction by the VoSL to estimate the annual value of someone becoming active. The BECA 2007 approach annualised the value using the VoSL (based on average age of the population and average life expectancy), and then applied that value to the number of DALYs attributable to inactivity to estimate the annual cost of mortality and morbidity. This cost was then divided by the inactive population to estimate the annual value of an insufficiently active person becoming active.

This latter approach seems to have a more logical basis, because it is linked to annualised values of remaining life. However, it also relies on DALYs, and the only DALY data for New Zealand dates to 1996 (MoH, 2001), which we considered to be less reliable considering the increases in inactivity levels and chronic diseases since 1996. We therefore decided to use both approaches to see what the results yielded.

In both methodologies, the New Zealand 2007 VoSL (used for transport purposes) was used to determine the WTP for increased life expectancy and reduced disability.

#### 5.3.1.1 Methodology A: Mortality ratio

The first methodology we employed uses two different data sets to account for the costs of mortality and of morbidity:

1. Mortality ratio uses 2004 deaths.
2. YLD ratio uses 1996 YLD.

**Mortality ratio:**

1. To calculate the costs of mortality associated with insufficient physical activity, the 2004 number of deaths[6] for each disease was multiplied by the PAF (using high and low estimates of ERR of insufficient activity) to determine high and low numbers of deaths associated with inactivity.
2. The deaths (high and low) associated with inactivity were divided by the estimated adult population of New Zealand in 2004[7], to obtain a low and high per-capita mortality ratio associated with insufficient physical activity.
3. The mortality ratios were multiplied by the 2007 VoSL to obtain the annual value of a person being physically active: $1,862–$3,427.

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6 Death data is taken from http://www.nzhis.govt.nz/moh.nsf/indexns/stats for the year 2004. This data only assigns death to one cause and does not allow co-morbidities to be captured.

7 Adult population is the total population excluding ages 0–14, estimated by Statistics New Zealand for the June quarter 2004 (Statistics New Zealand).

**Table 5.3 Mortality ratio and per-capita annual values of physical activity**

| **2004** | | **ERR (from table 5.2)** | | **PAF** | | | **Attributable deaths** | |
|---|---|---|---|---|---|---|---|---|
| | | | | *Pe(ERR)/Pe(ERR) + 1* | | | *PAF x total deaths* | |
| | Total deaths[a] | Low | High | Pe[b] | PAF Low | PAF High | Low | High |
| CVD | 10644 | 0.25 | 0.54 | 0.45 | 0.10 | 0.20 | 1085 | 2091 |
| Colon cancer | 1173 | 0.43 | 0.67 | 0.45 | 0.16 | 0.23 | 191 | 273 |
| Breast cancer | 646 | 0.25 | 0.43 | 0.45 | 0.10 | 0.16 | 66 | 105 |
| Lung cancer | 1555 | 0.11 | 0.25 | 0.45 | 0.05 | 0.10 | 75 | 159 |
| Type 2 diabetes | 843 | 0.49 | 1.00 | 0.45 | 0.18 | 0.31 | 154 | 263 |
| **Total annual attributable deaths** | | | | | | | **1571** | **2891** |
| Total of all causes | 28636 | | | | | *Percentage of total deaths* | *5.5%* | *10.1%* |
| | | | | | | Adult pop. NZ 2004 | 2690250 | |
| | | | | | | **Per capita annual mortality rate associated with inactivity** *Total annual attributable deaths/adult population (2004)* | **0.0006** | **0.0011** |
| 2007 VoSL $3,190,000 | *VoSL x mortality rate = per-capita annual value (2007) of physical activity in relation to mortality* | | | | | | Low *$1,862* | High *$3,427* |

a) Death data is taken from http://www.nzhis.govt.nz/moh.nsf/indexns/stats for the year 2004. This data only assigns death to one cause and does not allow co-morbidities to be captured.

b) Pe stands for prevalence of exposure to the risk factor, in this case, inactivity. The Pe has been sourced from the 2003 Obstacles to Action (OTA) survey to reflect levels at 2004.

### YLD ratio:

Years lost to disability (YLD) are used to estimate the costs of morbidity. YLD figures for New Zealand are only available for 1996, and it was estimated in *The burden of disease and injury in New Zealand* (MoH 2001) that 7 percent of DALYs were attributable to inactivity in that year. While DALY is not a perfect proxy for YLD, it is the best estimate available. We therefore applied 7 percent to the total YLD to estimate the number attributable to inactivity. We did not exclude YLD of children aged 0–14, because the PAF employed in the *Burden of disease* would have already accounted for age in determining the PAF of 7 percent. The YLD attributable to inactivity would be experienced by adults; therefore we divided the YLD attributable to inactivity by the estimated population who were more than 14 years old in 1996 (Statistics NZ 2007) to obtain the per-capita annual YLD attributable to inactivity (see table 5.4). We could only estimate one value, rather than both a high and a low, as there was only one PAF given in the *Burden of disease*.

**Table 5.4 Per-capita YLD attributable to inactivity, and per-capita annual value**

| 1996 | PAF 7.0% (MoH 2001) |
|---|---|
| YLD total | 214846 |
| YLD due to inactivity | 15039 |
| Adult population in 1996[a] | 2690250 |
| Per-capita YLD | 0.0056 |
| ***YLD due to inactivity/1996 adult population*** | |
| YLD value based on VoSL $76,316 | $427 |

a) Taken from the 1996 Census, Statistics New Zealand – excludes ages 0–14.

The estimate of the annual mortality and morbidity values (in 2007 dollars) of a person being physically active are given in table 5.5.

**Table 5.5 Per-capita annual morbidity and mortality values using the 2004 mortality ratio and 1996 YLD ratio**

| 2007 | Low | High |
|---|---|---|
| Mortality | $1,862 | $3,427 |
| Morbidity (YLD) | $427 | $427 |
| Total morbidity + mortality | $2,289 | $3,854 |

#### 5.3.1.2 Methodology B: DALYs

Our second methodology used DALYs associated with inactivity and the undiscounted VoSL to determine mortality and morbidity costs.

1. DALYs include a standardised value in terms of years lost for both mortality and morbidity. The PAF for inactivity in *The burden of disease and injury in New Zealand* (MoH 2001) is 7 percent of total DALYs.
2. The high and low DALYs due to inactivity were divided by the estimated adult inactive population in 1996 to determine the annual ratio of DALY per inactive person.
3. This ratio was multiplied by the undiscounted annual value of a DALY[8] to produce the per-capita annual benefit of physical activity.

8 To calculate the annual value of a DALY, we took the average life expectancy (84.8 years) minus the average age (43 years) to get 41.8 years. We then divided the VOSL by 41.8.

**Table 5.6 Per-capita annual value (morbidity and mortality) using DALYs**

| **1996** | |
|---|---|
| Total DALYs[a] | 563184 |
| PAF inactivity | 7% |
| DALYs attributable to inactivity | 39423 |
| Adult inactive population | 1120275 |
| Ratio of DALYs attributable to inactivity per inactive adult | 0.0352 |
| WTP DALY | $76,316 |
| **Annual value** | **$2,686** |

a) We used total DALYs for all age groups, as the PAF of 7% applies to total DALYs and already excludes children (MoH 2001).

**Table 5.7 Comparison of values for methodology A & B**

| **2007** | **Low** | **High** |
|---|---|---|
| A. Mortality ratio and YLD | $2,289 | $3,854 |
| B. DALYs | $2,686 | |
| Average of A & B | ***$2,488*** | ***$3,270*** |

## 5.3.2 Other costs

### 5.3.2.1 Health sector costs

Specific disease-related health sector costs were not available from the Ministry of Health, and we therefore had to develop a reliable method of estimating costs. BECA (2007) calculated health sector costs associated with inactivity by dividing the total health sector cost for 1996 ($7,440 million) by the total YLD in 1996 (215,000 YLD), to assign a value of health expenditure per YLD ($30,200). Assuming that 7 percent of total YLDs in 1996 (15,200 YLDs) were due to inactivity, and multiplying that by the associated health expenditure per YLD, BECA estimated the total health sector costs due to inactivity in 1996 ($714 million) divided by the total inactive population for that year (1.24 million), and used the CPI index to calculate the 2006 real value. The value associated with YLD due to inactivity was very close to 10 percent of total health sector costs in 1996 (BECA 2007). We used a similar approximation, but instead of ratio of DALYs we used the high and low percentages of deaths associated with inactivity, which are comparable to the final ratios used by BECA.

1. The 2004 high and low proportions of health care costs related to physical inactivity (5.5 percent and 10 percent respectively) are based on the high and low proportions of deaths associated with inactivity in the same year (see table 5.3). Note that these are lower and similar to the value of 10 percent calculated by BECA for 1996, and therefore are probably conservative.

2. Total health sector costs (including private expenditure) in 2004 are estimated to be $12,680,845,000 (MoH 2007). High and low costs associated with inactivity are assumed to be the high and low percentages of deaths associated with inactivity in 2004.
3. We divided the 2004 total health sector costs associated with inactivity by the inactive population for that year (estimated in the 2003 OTA survey to be 45.5 percent). It should be noted that the costs and benefits of physical activity have some lag time, and the health sector costs of inactivity in 2004 may be more appropriately associated with inactivity levels in previous years, which were lower than current levels. Thus, using the current percentage of inactivity may underestimate the actual health costs per inactive person.

**Table 5.8 Per-capita health sector costs (public and private) attributable to inactivity**

| | Low | High |
|---|---|---|
| **2004 total health sector costs (public & private)** | 5.5% | 10.1% |
| | **$12,680,845,000** | |
| | $697,446,475 | $1,280,765,345 |
| Inactive adults in 2004 | 1210613 | |
| 2004 per-capita health sector costs | ***$576*** | ***$1,058*** |
| 2007 values (CPI calculator) | $624 | $1,147 |

The significant weakness with this approach is that it is a crude estimate that does not consider the diverse costs associated with treating different ailments. However, there are several reasons why the final values may be considered plausible estimates. First, the health sector costs of obesity alone are estimated to be between 2–7 percent of the annual health budget, and this does not include private expenditure. Furthermore, studies have shown that on average, obese people spend three times more on out-of-pocket annual health care costs than non-obese people (Stokes 2007). There is a high correlation between obesity and insufficient activity levels, but the costs associated with inactivity are not limited to those of obesity. CVD is responsible for the largest portion of DALYs, and evidence has demonstrated a strong link to inactivity. Moreover, depression is the single largest cause of YLD in New Zealand, and has significant treatment costs that may be avoided by engaging in sufficient activity. For these reasons, 5.5–10 percent is not an unreasonable estimation of health sector costs that are attributable to inactivity.

#### 5.3.2.2 Productivity costs

Productivity costs have not been incorporated because the evidence between active transport modes and reduced sick days and other measures of productivity was simply not robust enough. This is an area recommended for further research in the New Zealand context.

### 5.3.3 Total value of health benefits

**Table 5.9 Total annual value of health benefits**

| 2007 values | Low | High | *Mean* |
|---|---|---|---|
| Morbidity + mortality attributable to inactivity | $2,488 | $3,270 | |
| Health sector (public and private) costs per inactive adult | $624 | $1,147 | |
| **Total** | **$3,112** | **$4,417** | ***$3,765*** |

## 5.4 Applying the weighted per-km value of health benefits

Cavill et al. (2007) cite evidence of a curvilinear dose-response relationship between activity and health benefits, in which benefits are much greater for small increments of additional activity when it is first taken up. In the Health Economic Assessment Tool (HEAT) for cycling developed for the World Health Organization, Cavill et al. employ a linear dose-response curve (more conservative than curvilinear because it assumes lower benefits for the first kms travelled) and do not limit the benefits at a threshold.

The 2006/2007 New Zealand Health Survey (NZHS) showed that:

- half (50.5 percent) of all adults (aged 15+) reported that they were regularly physically active, meaning they had done at least 30 minutes of physical activity per day on 5 or more days in the previous week
- one in 7 adults (15.0 percent) were sedentary, reporting less than 30 minutes of physical activity per week
- from 2002/03 to 2006/07, there was an increase in sedentary behaviour for both men and women (MoH 2008).

**Table 5.10 Breakdown of activity levels in the New Zealand population (MoH 2008)**

| Activity status | Prevalence (NZ adults) |
|---|---|
| Sedentary | 15% |
| Insufficiently active | 34.5% |
| Sufficiently active | 50.5% |

The survey data from the NZHS has been used for modelling the per-km weighted health benefits. Table 5.11 displays the annual health benefit per person from walking, distributed across the activity groups, with a weighting that accounts for the prevalence in the total population, as well as the magnitude of the health benefit. Benefit weights are attributed according to the magnitude of relative risk reduction between activity level groups (adapted from Andersen et al. 2000). The values are then divided by the number of kilometres across which health benefits could be obtained. This method thus applies a linear dose response benefit that is unique to each activity level group.

### 5.4.1 Activity classifications

- Sedentary – Shifting the sedentary group into some moderate physical activity has the greatest gains in terms of reduced mortality and morbidity (Andersen et al. 2000); therefore, this is given a magnitude weighting of 1. Because their usual activity level is zero, they can receive full annual benefits by becoming moderately active (e.g. walking at 5 km per hour) for 30 minutes, 5 days per week. This is an average annual walking distance of 625 km.
- Insufficiently active – This group can receive most of the health benefits of increased activity, although they already engage in some moderate activity and therefore on average only need to engage in 20 minutes of additional activity per day to reach sufficiently active status. They have

been given a weighting of 0.859. It has been assumed that benefits can be achieved over an annual 450 km, or approximately 20 minutes of additional activity per day for 5 days per week.

- Sufficiently active — This group is already sufficiently active, but may receive benefits both in terms of continued health benefits and by a transportation project that encourages them to stay active. Tobias and Roberts (2001) suggested, in a New Zealand-specific research paper, that public health interventions aimed at keeping active people active are likely to be more effective than those aimed at people who are sedentary. Therefore, benefits have been assigned to this group at a weighting of 0.15.

### 5.4.2 Applying the benefits of walking, cyling and skateboarding

**Table 5.11 Per-km weighted health benefits of walking**

| **Walking** | | *Benefit weight* | | | **Weighted sum = annual benefit per person** |
|---|---|---|---|---|---|
| | | 1 | 0.85 | 0.15 | |
| | | *Activity status* | | | |
| | | Sedentary | Inactive | Active | |
| Scenario of annual health benefits | | *Prevalence* | | | |
| | | 15.0% | 34.5% | 50.5% | |
| Low | $3,112 | $467 | $913 | $236 | $1,615 |
| Mean | $3,765 | $565 | $1,104 | $285 | $1,954 |
| High | $4,417 | $663 | $1,295 | $335 | $2,292 |
| | | *Km over which benefits are received* | | | ***Weighted per-km benefit*** |
| | | *625* | *450* | *312* | |
| Low | | $0.75 | $2.03 | $0.76 | $3.53 |
| Mean | | $0.90 | $2.45 | $0.91 | $4.27 |
| High | | $1.06 | $2.88 | $1.07 | $5.01 |

We assumed that cycling has:

- an average speed of 20 km/h i.e. is 4 times faster than walking, and therefore carries ¼ of the benefit on a per-km basis
- a MET intensity double that of walking i.e. people only need to be active for half the amount of time to receive the same benefits.

Therefore, cycling should carry half the benefit per km of walking (¼ x 2 = ½). In other words, the physical health benefits per minute for cycling are, on average, twice those of walking, so only half the time is required to achieve benefits. Since cyclists travel much faster than pedestrians, the per-km value is lower than that of walking.

9 The 0.85 weighting is taken from the approximate difference in risk reduction between the sedentary and next-last active group in Andersen et al. 2000.

**Table 5.12 Per-km weighted health benefits of cycling**

| **Cycling** | | *Benefit weight* | | | **Weighted sum = annual benefit per person** |
|---|---|---|---|---|---|
| | | 1 | 0.85 | 0.15 | |
| | | *Activity status* | | | |
| Scenario of annual health benefits | | Sedentary | Inactive | Active | |
| | | *Prevalence* | | | |
| | | 15.0% | 34.5% | 50.5% | |
| Low | $3,112 | $467 | $913 | $236 | $1,615 |
| Mean | $3,765 | $565 | $1,104 | $285 | $1,954 |
| High | $4,417 | $663 | $1,295 | $335 | $2,292 |
| | | *Km over which benefits are received* | | | ***Weighted per-km benefit*** |
| | | *1250* | *900* | *624* | |
| Low | | $0.37 | $1.01 | $0.38 | $1.77 |
| Mean | | $0.45 | $1.23 | $0.46 | $2.14 |
| High | | $0.53 | $1.44 | $0.54 | $2.51 |

Tables 5.11 and 5.12 thus distribute the benefits of walking and cycling across the general population, using the low, median and high values for the annual benefit and weighted per-km benefits.

We assumed that skateboarding has:

- an average speed of 10 km/h (2 times faster than walking, therefore ½ of its per-km benefit)
- a MET intensity 1.4 greater than walking (i.e. people only need to be active for 0.7 of the time of walking to receive the same health benefits).

Therefore, skateboarding should carry roughly 0.67 the benefit per km of walking. In other words, the physical health benefits per minute for skateboarding are greater than those of walking, so less time is required to achieve benefits. Since skateboarders travel faster than pedestrians, the per-km value is lower than that of walking.

**Table 5.13 Per-km weighted health benefits of skateboarding**

| **Skateboarding** | | *Benefit weight* | | | **Weighted sum = annual benefit per person** |
|---|---|---|---|---|---|
| | | 1 | 0.85 | 0.15 | |
| | | *Activity status* | | | |
| Scenario of annual health benefits | | Sedentary | Inactive | Active | |
| | | *Prevalence* | | | |
| | | 15.0% | 34.5% | 50.5% | |
| Low | $3,112 | $467 | $913 | $236 | $1,615 |
| Mean | $3,765 | $565 | $1,104 | $285 | $1,954 |
| High | $4,417 | $663 | $1,295 | $335 | $2,292 |
| | | *Km over which benefits are received* | | | ***Weighted per-km benefit*** |
| | | *910* | *682* | *455* | |
| Low | | $0.51 | $1.34 | $0.52 | $2.37 |
| Mean | | $0.62 | $1.62 | $0.63 | $2.86 |
| High | | $0.73 | $1.90 | $0.74 | $3.36 |

The per-km values for roller skating are the same as those for walking – the average roller-skating speed is 10 km/h, which is twice as fast as walking, and its average MET intensity is 7, which is twice that of walking.

This approach does not account for activity substitution, as there is no conclusive evidence to guide us on a likely proportion of activity substitution. In this case, rather than risk under-estimating the benefits with a conservative assumption, we will assume that there is no activity substitution in the lower two segments, and that all activity generated by an active transport project will be new activity.

For the active population, then, using active transport modes would provide an opportunity to reduce the time they spend on recreational physical activities because of the increased activity earned while travelling to and from work. However, this would depend on their motivation for undertaking non-transport-based physical activities. To our knowledge, no time preference surveys have been undertaken in a New Zealand setting, so we have not considered this in the benefits of active transport modes. Future research in this area could determine the value of time savings and the likely number of the population who would benefit from this. Given the importance of time travel savings in road projects, the time savings of active transport modes could significantly increase the health benefits per km for already active or vigorously active people.

The health benefit values of these active transport modes are summarised in table 5.14. The final per-km values may be rounded at this level, or rounded after the total benefits for a given project have been calculated.

**Table 5.14 Summary of health benefits for active transport modes**

| Scenario | Annual benefit | Per km walking | Per km cycling | Per km skateboarding | Per km roller skating |
|---|---|---|---|---|---|
| Low | $3,112 | $3.53 | $1.77 | $2.37 | $3.53 |
| Medium | $3,765 | $4.27 | $2.14 | $2.86 | $4.27 |
| High | $4,417 | $5.01 | $2.51 | $3.36 | $5.01 |

It should be noted that the low value for cycling is very similar to the values proposed by the World Health Organization (Cavill et al. 2007). That method used a VoSL of €1.5 million (very close to the 2007 VoSL in New Zealand, taking into account a currency conversion rate of 0.48), and calculated a per-km benefit of €0.81. In NZ$ this would be approximately $1.70[10]. Moreover, it is likely that the median and high values are sound estimates, as Cavill et al. only account for mortality costs (all-cause mortality), and exclude morbidity and health-sector costs from the benefit.

### 5.4.3 Who should benefits apply to?

#### 5.4.3.1 Children

In the BECA 2007 report, children aged 15 and under were not considered in determining the burden of inactivity – only DALYs from ages 16–64 were used. We have also chosen to exclude children from the valuation in order to use consistent health data sets. The relative risk reductions cited in the literature review only apply to adults, and likewise, deaths and DALYs lost to inactivity are highly likely to only affect adults. However, the benefits for adults may be applied to children for the following reasons:

- Children are among the most frequent users of active modes.
- Children require twice as much activity as adults in order to obtain optimal health benefits.
- Research has demonstrated that:
  - the percentage of children who are sedentary is increasing
  - childhood obesity is increasing
  - obese children are significantly more likely to be obese as adults and suffer from the associated health problems.

Thus, from a public health point of view, there are significant benefits to reducing or reversing the rise in childhood obesity, which will require reducing the percentage of children who are sedentary. The weighted per-km benefit can thus apply to children as well as adult users, because the benefits will ultimately be realised in their adult years.

#### 5.4.3.2 Existing walkers and cyclists

Health benefits for existing pedestrians are not currently considered in the EEM methodology, although existing cyclists receive full benefits. As this discrepancy in the treatment of existing walkers and cyclists seems illogical, BECA (2007) recommends that neither existing pedestrians nor cyclists should

10 This is calculated using the exchange rate as of 31 July 2008. Despite fluctuations in exchange rates, the relationship of the NZ$ to the Euro has been stable at around 0.5 for several years.

receive health benefits. We agree that the current approach is inconsistent, but strongly recommend that benefits should be counted for both existing pedestrians and cyclists, in accordance with the rule of half, for several reasons:

- The New Zealand Household Travel Survey Data indicates that on a nationwide level, commuting by active transport mode has been consistently declining and mode share by private vehicle has been consistently increasing (MoT 2008).
- As well as this, levels of insufficient activity and obesity in the population are increasing.
- Therefore, investment in new cycling and walking infrastructure may work to reduce the number of current active transport users who switch to inactive modes at a later point, and thus realise health benefits that would otherwise be lost.

Indeed, New Zealand research has suggested that interventions aimed at keeping active people active are likely to be more effective than those aimed at sedentary people (Tobias and Roberts 2001). By applying the rule of half, marginal benefits can be accounted for all users, including those who would not have continued with active transport without the intervention.

### 5.4.4 Economic evaluation period

The evaluation period describes the length of time over which projects are evaluated. The Treasury recommends a default value of 20 years, which is determined in consideration of the economic life of the asset (NZ Treasury 2007). The economic efficiency evaluation procedures in the EEM2 currently use a 25-year evaluation period (Land Transport NZ 2005).

In the UK, a standard evaluation period of 30 years, with allowance for longer evaluation periods, is used (HM Treasury 2006). The Department for Transport uses a 60-year evaluation period for the three case studies discussed in their guidance note in the appraisal of walking and cycling schemes (DfT 2007).

Increasing the evaluation period from 25 to 60 years has the effect of increasing the total benefits.

Active-mode health benefits accrue over time and may be realised after several decades, unlike other benefits of transport projects (such as time travel savings). Thus it may not be possible to take into account their full benefits if the evaluation period is only 25 years. We recommend that the evaluation period be reconsidered with respect to the unique nature of the health benefits of active transport modes.

# 6 Draft EEM text

Regular moderate physical activity reduces the risk of numerous chronic health conditions. Active transport contributes to overall physical activity by the movement of large muscle groups being employed to walk, cycle, or similarly exert oneself to get from place to place. Accordingly, the health benefits resulting from general physical activity can be fully attributed to active modes of transport. Specific evidence exists for the protective effect of active transport on cardiovascular disease, certain cancers, obesity, type 2 diabetes and depression, all of which are serious health concerns in New Zealand.

There is a significant range in the level of health benefits that can be ascribed to walking and cycling. Research commissioned to investigate the value of health benefits in New Zealand has established the following per-km values, which are comparable to those applied overseas, particularly those used by the World Health Organization to evaluate the health benefits of cycling projects. These values, which include the costs of morbidity and mortality attributable to inactivity, in addition to associated public and private health sector costs, are as follows:

- per km walking – $4.27
- per km cycling – $2.14.

Note: There may be additional benefits due to reduced air pollution exposure and productivity gains that have not been included in these values. The above values are thus subject to further revision as new information becomes available.

The values above already account for incidences of inactivity in the general population, and can be fully applied to all new pedestrians and cyclists. Furthermore, half benefits should be applied to existing cyclists and pedestrians, to account for the benefits of some current users (who might otherwise reduce their active transport engagement) continuing to walk or cycle because of an active transport mode project. Higher values may be appropriate if the expected users of a given project are at higher risk for inactivity than the general population.

# 7 Conclusions

Cost-benefit analysis of active transport (walking and cycling) projects is not currently widespread. Nevertheless, a consensus exists among experts in many OECD countries that significant public health benefits can be realised through greater use of active transport modes. A significant and growing body of evidence links insufficient physical activity to a number of medical problems. The evidence is strongest for chronic diseases, especially CVD, cancer (colon, breast and lung), type 2 diabetes and depression; these were thus the initial basis for an estimate of the benefits that can be realised in New Zealand through the increased use of active transport modes.

Attributing monetary values to these benefits is an extremely complex and problematic task, and a wide variety of approaches and assumptions have been employed in other countries. In most of the literature we reviewed, benefits were estimated and calculated as part of a research study, rather than as an applied process to be employed in the evaluation and prioritisation of proposed projects. One exception to this is the WHO Health Economic Assessment Tool for cycling. However, the health data used for this tool was limited to all-cause mortality specifically for cyclists. For this reason, there was no single 'best practice' example of methodologies that could be easily adopted into the New Zealand context for both walking and cycling. Elements of several methodologies were integrated and applied to estimate a value per km that could be easily incorporated into the existing economic evaluation methods. Mortality, morbidity and health-sector costs were all included in the total annual benefits that could be realised by an inactive person becoming physically active. These benefits were weighted and distributed across the average physical activity profile of the population to produce three scenarios of an annual benefit per person. This report focuses primarily on cycling and walking, but its findings may also be applied to other active modes, such as skates, skateboarding and scooters.

As shown in the summary of health benefits for active transport modes (table 5.14), the per-km benefits are as follows:

**Table 7.1. Per-kilometre benefits of active transport modes**

| Scenario | Annual benefit | Per km walking | Per km cycling | Per km skateboarding | Per km roller skating |
|---|---|---|---|---|---|
| Low | $3,112 | $3.53 | $1.77 | $2.37 | $3.53 |
| Medium | $3,765 | $4.27 | $2.14 | $2.86 | $4.27 |
| High | $4,417 | $5.01 | $2.51 | $3.36 | $5.01 |

The resulting range of values is considered to be a robust reflection of potential health benefits that can be achieved through transport projects that increase participation in active modes. This report favours the adoption of the medium value. Furthermore, it is recommended that half benefits be applied to existing cyclists and pedestrians, because without infrastructure interventions, levels of active-mode users tend to decrease over time.

# 8 Recommendations and possible extensions

## 8.1 Data

New data sets will be available from the Ministry of Health and Sport & Recreation New Zealand (SPARC) within the next year. Once these data sets are available, the values determined in this report should be updated accordingly.

## 8.2 Relevance to other modes

The objective of this research is to inform transport investment decisions related to active transport modes. It is noted, however, that many of the recommendations relating to health benefits and economic evaluation procedures are likely to extend to passenger transport (PT) projects.

In terms of health benefits, recent research by Besser and Dannenberg (2005) into commuters in the US revealed that passenger transport users experienced, on average, an additional 19 minutes of exercise per day than those who used motor vehicles. Results from the Auckland Regional Transport Authorities' surveys of Northern Busway patrons corroborate these results, indicating that the average passenger travels an additional 1.3 km by active transport mode per day (ARTA 2007). This equates to 19 minutes of additional walking per day, assuming an average walking speed of 4 km/h. These results indicate it would be reasonable to extend considerations of health benefits to some new users of PT projects.

Finally, the corollary of valuing the benefits of active transport modes and passenger transport is assessing the health consequences associated with increased use of private vehicles. This recognises that investment in roading infrastructure may catalyse reductions in the use of alternative modes, thereby adversely affecting the physical activity levels of users. Movement in this direction would require incorporating multi-modal modelling into evaluations of road projects to ascertain their impacts on the uptake of alternative modes. It seems inconsistent to consider the positive health impacts of active modes without also accounting for negative health impacts when evaluating road projects that facilitate increased use of private vehicles.

## 8.3 Further research

Areas for further research were identified as follows, in order of relative priority:

1. Develop models that predict how specific changes to walking and cycling conditions, and specific education and promotion programmes, affect active transport engagement in a particular situation, with special attention to changes in physical activity and fitness by the people who are most at risk of sedentary living.
2. Valuation of potential injury and accident reduction benefits that would result from increased volumes of active transport mode users.
3. Ascertain the air pollution exposure for people using active modes in various rural and urban New Zealand locations, also relative to other modes, and provide guidance for developing non-motorised facility networks that minimise exposure to air pollution.
4. Establish a quantifiable relationship between active transport modes and the incidence or treatment of musculoskeletal conditions, in order to quantify the benefits that could be realised from increased use of active modes.

5. Establish a causal relationship between increased physical activity and a reduction in morbidity and health sector costs related to COPD and URTI (respiratory diseases).
6. Investigate the relationships between physical activity, mental health and human happiness.
7. Establish the relationship between active transport mode use and increased workplace productivity, measured as reduced absenteeism or presenteeism through longitudinal studies.
8. Investigate the stress people experience from various transport modes, as well as the health impacts of stress.
9. Develop better tools for quantifying and monetising the impact that improved walking and cycling facilities may have on indirect health benefits, such as increased community cohesion (positive social interactions among people in a community), improved transportation affordability (which can reduce emotional stress), and improved access to medical services.

One longitudinal study following users of active transport modes may be sufficient to obtain enough data to create a more complete methodological approach to valuing the benefits of active transport mode participation in New Zealand.

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# Appendix: Abbreviations and acronyms

Some abbreviations and acronyms are listed here for quick reference.

| | |
|---|---|
| AADT | Annual Average Daily Traffic volume |
| ADT | Average Daily Traffic |
| ARTA | Auckland Regional Transport Authority |
| BCR | Benefit-Cost Ratio |
| CBA | Cost-Benefit Analysis |
| CVD | Cardiovascular disease |
| DALY | Disability Adjusted Life Year |
| EEM2 | *Economic evaluation manual* Volume 2 |
| ERR | Excess Relative Risk |
| HEAT | Health Economic Assessment Tool (WHO) |
| Land Transport NZ | Land Transport New Zealand (from 2004) |
| LTSA | Land Transport Safety Authority |
| MET | Metabolic Equivalent Unit |
| MoH | Ministry of Health |
| MoT | Ministry of Transport |
| NLTP | National Land Transport Programme |
| NZTS | New Zealand Transport Strategy |
| OECD | Organisation of Economic Cooperation and Development |
| OTA | Obstacles to Action survey |
| PAF | Population Attributable Risk Fraction |
| PFM | *Programme funding manual* |
| RR | Relative Risk |
| RRR | Relative Risk Reduction |
| YLD | Years Lost to Disability |
| YLL | Years of Life Lost |
| VKT | Vehicle Kilometres Travelled |
| VOC | Vehicle Operating Costs |
| VoSL | Value of a Statistical Life |
| WHO | World Health Organization |
| WTP | Willingness-To-Pay |