

AN OVERVIEW OF CYCLING RESEARCH:

Selected Facts, Statistics, Citations and Quotations

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Reducing the risks of cycling: How do we keep cyclists safer?

(A. K. Macpherson et al., 2004)

- Children living outside urban centres have an increased risk of hospitalization because of a bicycling-related injury. However, there is a possibility that rural vs. urban cycling behaviour is different. That is, children in rural settings may use cycling more for transport than for recreation (thereby travelling longer distances). Hospitalization criteria, road conditions, helmet awareness/use/legislation all potentially can help explain the result, **but individual level data is needed to explain this finding.**

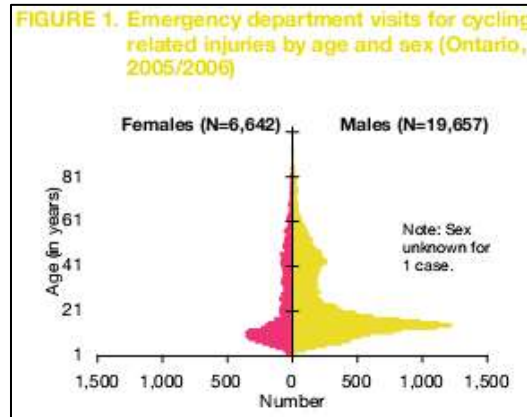
(Francis & Justason, 2010)

- “Historically, most fatal accidents have occurred in clear, dry, and daylight conditions in the spring or summer months.”

(Nicaj et al., 2009)

- While bicyclist injuries declined between 1996 and 2003, fatalities remained steady.
- Nearly all bicyclist fatalities (92%) occurred as a result of crashes with motor vehicles.
 - Most crashes (89%) occurred at or near intersections.
 - Although they make up only 5–17% of vehicles on NYC roadways, large vehicles (trucks, buses) accounted for almost one third (32%) of fatalities.
 - Nearly all (94%) fatalities involved poor driving or bicycle riding practices, particularly driver inattention and disregarding traffic signals and signs.
 - Although there are many more miles of local roads, more than half of fatal crashes occurred on arterial (large, four lane) roads (53%).
 - 7% of fatal crashes occurred on limited access highways, where bicycling is prohibited
- Bicycle lanes and properly used bicycle equipment may reduce the risk of fatalities.
 - Only one fatal crash with a motor vehicle occurred when a bicyclist was in a marked bicycle lane.
 - Nearly all bicyclists who died (97%) were not wearing a helmet.
 - Most fatal crashes (74%) involved a head injury.
- Men and children face particular challenges.
 - Most bicyclists who died were male (91%), and men aged 45–54 had the highest death rate (8.3 per million) per age group.
 - Among children aged 5–14, the death rate for boys was more than five times higher than for girls; Queens had the highest child bicyclist death rate of the five boroughs (3.2 child deaths per million, compared to 2.1 child deaths per million citywide).

(Ontario Injury Prevention Resource Centre, 2009)



“For emergency department visits, peaks in the numbers of cycling injuries were seen in males and females 10- 14 year olds followed by 15-19 year olds and 5-9 year olds (Figure 1).”

- Falling or being thrown from a pedal cycle was the most common type of injury, representing 64% of all Ontarians hospitalized with a cycling injury, *followed by a collision with a motor vehicle, which accounted for close to 20% of all cycling injury hospitalizations.*
- For emergency department visits and hospitalizations, the most common injuries were those to the upper limb, followed by the head, and lower limb, for each of emergency department visits and hospitalizations respectively (Figure 2). More specifically, open wound of the head was the most common injury seen in emergency departments followed by fracture of forearm and fracture of shoulder/upper arm. For hospitalizations, fracture of the forearm, fracture of lower leg and intracranial injury were most common.

Sharing Road Space (Granville, Rait, Barber, & Laird, 2001)

- There is awareness of special road provision being accorded to cyclists but a general lack of awareness regarding the operation, purpose and regulations surrounding different types of provision.

Attention and expectation problems in bicycle-car collisions (Räsänen & Summala, 1998)

- The most frequent accident type among collisions between cyclists and cars at bicycle crossings was a driver turning right and a bicycle coming from the driver’s right along a cycle track.

(Canadian Institute for Health Information, 2003)(i) – Injury Hospitalizations among Children/Youth in Ontario, 2001-2002

- Leading cause: Falls (41%)
- MVCs: (16%)
- Pedal Cycling: 6%
 - Comprise 11% and 12% in male children between ages of 5-9 and 10-14, respectively

(Canadian Institute for Health Information, 2004) – Sports and Recreational Injury Hospitalizations in Ontario, 2002-2003

- In fiscal 2002–2003 there were 6,113 sports and recreation related injury hospitalizations in Ontario, comprising 9% of the province’s injury hospitalizations.
- Figure 1 illustrates that the leading cause of sports and recreational injury hospitalization was cycling (21%),
 - For cycling injuries, the average length of stay in hospitals 4.3 days
- Half of all sports and recreation related hospitalizations were persons under the age of twenty, with a pronounced peak of 1,140 (19%) in the 10-14 year age group
- Cycling was the top cause of injury across all regions (ranging from 16% for the North region to 32% for Toronto).

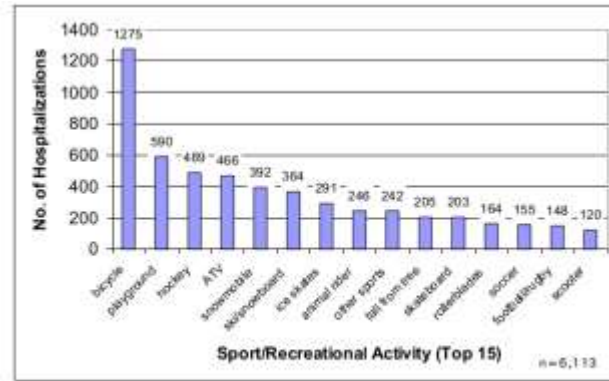


Figure 1. Number of Hospitalizations by Type of Sports and Recreational Activity (Top 15), Ontario, 2002–2003

(Hoffman, Lambert, Peck, & Mayberry, 2010) – Bicycle Commuter Injury Prevention

- Approximately 20% of bicycle commuters experienced a traumatic event and 5% required medical attention during 1 year of commuting. Traumatic events were not related to rider demographics, safety practices, or experience levels. These results imply that injury prevention should focus on improving the safety of the bicycle commuting environment.
 - Toronto has 3x injury rate compared to North American average:
 - On using 1,196 of the Toronto commuters, researchers reported an injury rate of 18.6 per 100,000 miles commuted. In contrast, the North American survey described an injury rate of just 6.0 per 100,000 miles commuted.
 - ...nearly 20% of commuters experiencing a traumatic event during the yearlong study period.

(Komanoff, 1999) – Killed by Automobile – Death in the Streets in NYC 1994-1997

- More pedestrians/cyclists are killed in NYC than drivers
 - Combined pedestrian and cyclist fatalities averaged 255 per year and were remarkably constant over the four years, with a standard deviation of only 12. The average exceeds by 25 percent the annual average of approximately 200 motor vehicle users who died in crashes in New York City during the same period.

Drivers and Vehicles: Summary

- Younger drivers — ages 19-34 — caused 485, or almost half (48 percent) of the 1,020 pedestrian and cyclist deaths in NYC during 1994-97, although they accounted for only one-quarter (25 percent) of the city’s population. Adjusted for population, people age 19-34 were 4 times more likely to kill with an automobile than were NYC dwellers 60 or over
- Only 7 drivers who killed were ticketed for violations that specifically endanger pedestrians and cyclists, such as violating right-of-way in crosswalk, unsafe backing, unsafe opening of a

car door, and driving on the sidewalk. This pattern strongly suggests a marked lack of interest, on the part of police officers, in the rights of pedestrians and cyclists.

- ...driver strictly or largely culpable, 74 percent; driver partly culpable, 16 percent; driver not culpable, 10 percent.
- For the 820 fatalities in which the identity of the driver was established, 747, or 91 percent, of the drivers were men
- Death by automobile, in New York City, is largely a matter of one group of people — young men — killing two other groups: older men, and women of all ages.

Ten Key Findings:

- 2) *New Yorkers age 65 and older were more than twice as likely to be killed by an automobile as to be murdered during 1994-97*
- 3) *...drivers were at least partly culpable in 90 percent of fatalities (pedestrian fatalities)*
- 4) *The most frequent causes of fatalities were vehicles turning into pedestrians in crosswalks, followed by speeding, and driving through a red light or stop sign.*
- 9) *DWI is now a relatively small subset of a larger class of dangerous and aggressive driving, which is routinely ignored in law enforcement and media campaigns.*
- 10) *Drivers were summonsed for moving violations in only 16 percent of pedestrian and bicyclist fatalities during 1994-97; police cited only 7 drivers, or less than 1 percent of those who killed pedestrians, for violating laws specific to pedestrian safety.*

Driver Culpability

- had the driver chosen to walk, cycle, or take the subway, he would have posed little or no danger to anyone. But the driver has chosen to drive, and must accept the responsibility that comes with this choice

Top Causes of Pedestrian and Cyclist Fatalities, 1997 (189 Cases)

Cause Code	Proximate Cause	No.	Per-cent*
104	Driver turned into ped in x-walk	33	17%
103	Speeding	21	11%
102	Drove through red light or stop sign	19	10%
202	Insuff. driver caution in ped area	19	10%
301	No pedestrian forewarn / driver r-o-w	15	8%
105	Driver struck pedestrian in crosswalk	14	7%

Percents are relative to 189 cases with known cause. Case numbers and percents reflect double-counting of cases with multiple cause (31 cases have two causes, 6 have three). Causes are explained in text.

- The only one of the common causes listed above that is ever mentioned in public discourse is speeding; and even for this well-known and well-understood variety of driver violence, actual enforcement (as opposed to hollow rhetoric) is extremely rare

Driver Violations

- Only seven drivers were summonsed for violating traffic laws that specifically protect pedestrians, such as disregarding right-of-way (see note to next table), even though our analysis of the reports indicates that many fatalities arise directly from such violations.

Killer Vehicles

Vehicle Class in Pedestrian and Cyclist Fatalities (1994-97)

Vehicle Class	No. Cases	Adj. #1	Per-cent	Adj. #2	Per 10 ³ Miles	Risk Ratio
Car (incl SUV)	572	640	68%	689	1.36	.80
Truck	221	247	26%	266	3.21	1.90
Light Truck	139	155	16%	167	3.49	2.07
Heavy Truck	82	92	10%	99	2.83	1.67
Bus	49	49	5%	53	8.80	5.21
Motorcycle	11	11	1%	12	?	?
Unknown	94	NA	NA	NA	NA	NA
Total	947	947	NA	1020	1.69	1.00

The 22 truck fatalities of unknown type were prorated here between light and heavy. The 94 fatalities by unknown vehicle were apportioned to cars and trucks (but not buses or motorcycles) in Adjustment #1. Percents are calculated on these fatalities. All class fatalities were then increased by 7.7 percent to capture 73 fatalities not in database (Adjustment #2). Per-mile figures exclude highway driving. Risk ratio is relative to total except motorcycles. Bicycles, not included here, killed five pedestrians during 1994-97.⁷

(Komanoff & Smith, 2000) – The Only Good Cyclist

- ...drivers were highly culpable in 30 (out of 53) cases, partly culpable in 11 cases, and not culpable in 12 cases. Driver misconduct was thus the principal cause in 57% (30 out of 53) of the cases and a contributory factor in 78% (30 plus 11, or 41, out of 53).
- If we had considered drunken driving or unlicensed driving as highly culpable ipso facto, then drivers would be highly culpable in 35 cases, partly culpable in 10 cases, and not culpable in 8 cases, establishing driver misconduct as the principal cause in 66% (35 out of 53) of the cases and a contributory factor in 85% (35 plus 10, or 45, out of 53).
- The leading categories of driver misconduct leading to bicyclist fatalities, together accounting for the deaths of 33 cyclists, were:
 - Driver passing cyclist unsafely or aggressively (12 cases out of 53, or 23%; becomes 15 cases, or 28%, if 3 “dooring” fatalities are included here (see discussion on p. 8)
 - Driver turned into cyclist’s path (8 cases out of 53, or 15%)
 - Driver speeding (7 1/2 cases out of 53, or 14%)
 - Driver ran red light or stop sign (5 1/2 cases out of 53, or 10%)
- Remaining 8 cases in which driver misconduct contributed to fatal crash:
 - Dooring (3 cases)
 - Wrong-way driving (1)
 - Driver’s failure to exercise due caution (4)

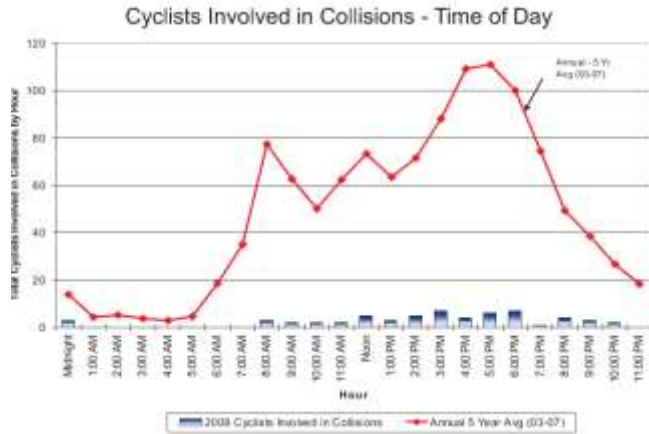
(Nicaj et al., 2009) – Bicyclist Fatalities in NYC: 1996-2005

- “Consistent with findings in other settings, we found that a large proportion of crashes occur at intersections and on multilane roads and disproportionately involve large vehicles, suggesting that when road users compete for space in a crowded road environment, characterized by restricted space, intersecting paths, and reduced visibility, the likelihood of a crash increases.”
- “We found only one death in a bicycle lane in the ten-year study period, underscoring the benefit that dedicated road space for bicyclists can promise.”

(Toronto Traffic Safety Unit, 2008) – **Cyclist collision Summary**

Year	Fatal	Injured	No Injury	Total
2003	1	1,022	174	1,197
2004	3	1,015	158	1,176
2005	3	1,021	163	1,187
2006	3	954	141	1,098
2007	3	1,019	149	1,171
2008	0	50	9	59
Total	13	5,081	794	5,888

Injury Severity	2008	5 Year Avg (03-07)
No Injury	9	158
Minimal	28	546
Minor	21	417
Major	1	42
Fatal	0	3
Total	59	1,165



Age Group	2008				5 Year Avg (03-07)
	Fatal	Injured	No Injury	Total	
0-4 yrs	0	0	0	0	29
5-14 yrs	0	1	0	1	113
15-19 yrs	0	4	0	4	110
20-24 yrs	0	3	1	4	127
25-34 yrs	0	8	2	10	231
35-44 yrs	0	13	2	15	234
45-54 yrs	0	14	1	15	149
55-64 yrs	0	6	1	7	71
65+ yrs	0	1	0	1	45
Unknown or Blank	0	0	2	2	56
Total	0	50	9	59	1,165

Cyclist Collision Rate - Toronto compared to other Canadian Cities*

City	Population	Total Collisions	Collision Rate / 100,000 Population	Cyclist Collisions	Cyclist Collision Rate / 100,000 Population
Toronto	2,607,637	53,255	2,042	1,165	45
Montreal	1,854,442	36,797	1,984	NA	NA
Calgary	1,019,942	38,619	3,786	259	25
Ottawa	870,800	12,987	1,491	287	33
Edmonton	741,028	26,066	3,518	199	27
Winnipeg	665,028	14,726	2,214	230	35
Vancouver	578,041	2,637	456	229	40
Hamilton	504,559	3,356	665	156	31

(Shah, Sinclair, Smith, & Xiang, 2007) - **Pediatric hospitalizations for bicycle-related injuries**

- Children and adolescents aged 20 years and younger comprise more than half of the estimated 85 million bicycle riders in the USA. (Of all recreational sports, bicycle-related injuries are the leading cause of emergency department visits for children.
 - ...more than 500 000 bicycle-related injuries treated in emergency departments each year from 1990 to 2004, and, in 2003, 68% of these injury episodes involved children.

Bicycles are connected to more childhood injuries than any other consumer product, except the automobile.

- ...national database analyses have failed to examine detailed patient characteristics, have concentrated only on head injuries, or have used broad age groups.
- Our study of a large, inpatient sample supported previous research indicating that more than 70% of bicycle-related injuries occurred in males. In part, male predominance among US bicycle riders explains this. We identified children aged 10–13 years as having the highest rate of hospitalization for bicycle-related injuries. Data from both the National Electronic Injury Surveillance System and the National Center for Health Statistics have identified the same high-risk group for bicycle-related injuries.
- This discrepancy implies that motor vehicles may be linked to the more severe bicycle-related injuries, which comprise a larger portion of inpatient admissions.
 - In addition, our research relied on external cause of injury codes to identify hospitalizations related to bicycle events. We could not identify cases that were not coded for a bicycle-related injury. Therefore, national estimates of hospitalizations for bicycle-related injuries may be under-reported in this study.
- In 2003, an estimated 10 700 children were hospitalized for a bicycle-related injury in the USA. Inpatient charges totaled nearly \$200 million with a mean charge of \$18654 per hospitalization. The national rate was 12.7 hospitalizations per 100000 children.
- Conclusion: Pediatric bicycle-related hospitalizations are a significant public health problem. The morbidity and mortality among children and the economic costs to society are large.

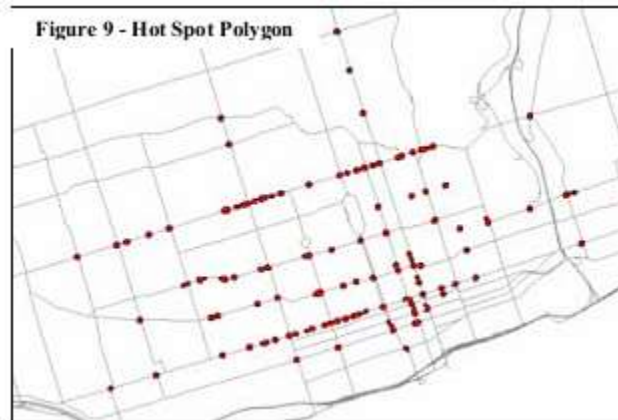
() - BicycleMotor-Vehicle Collision Study

- The frequency of bicycle collisions appears to correlate with traffic volume and bicycling activity patterns.
- Collisions occurred most frequently in summer, and in central parts of the city, where bicycle use is most common.
- Collisions were concentrated mainly on arterial roads, particularly the central east-west routes. The vast majority of collisions happened in dry weather conditions. Most occurred in daylight, particularly during rush hours, especially the evening peak, between 3 p.m. and 7 p.m.

(Guarino, Du, & Kutna, 2004) - Bicycle-Motor Vehicle Collision Locations in the City of Toronto

- ...Our density analysis resulted in the identification of 93 'hot spot' areas where accidents were occurring more frequently.
- In 1999 the City of Toronto conducted a survey to measure the state of cycling in the city and to provide a benchmark for cycling behaviour and attitudes.
 - ...cycling is a significant activity in the city with approximately sixty percent of households owning a bicycle and approximately forty eight percent of the population over 15 participating in either recreational or utilitarian cycling.

- According to the City of Toronto's Bike Plan, cyclists are only involved in two percent of all reported vehicle collisions, however they account for seven percent of injuries and five percent of fatalities.
- In the downtown core there are 6.4 collisions per km², and when the entire city is considered, the density drops to 1.9 collisions per km²
- When analyzed by month, the distribution of collisions is skewed with collisions occurring more frequently during the summer months (June to September). Nearly 60% of all reported collisions occurred during the period from June to September.
- The time of day in which collisions occur also exhibited a strong skewness with collisions occurring most frequently during the evening rush hour between 3 and 7 pm.
- A turning action seems to be one of the most common factors in the collisions under consideration with 82.7% of collisions being angle, side wipe, and turning movement.
- The resulting shape file consisted of 337 polygons and after some cleaning of the data and removal of extraneous polygons the final result was 93 hot spots (Figure 9). As this layer did not contain any information regarding the accidents in these locations, some further processing was required.



(ScienceDaily, 2007) - Kids' Bike Injuries Are Major Public Health Concern

- A new study conducted by researchers at the Center for Injury Research and Policy at Nationwide Children's Hospital concludes that bicycle-related injuries among children and adolescents in the U.S. may be a more significant public health concern than previously estimated.
 - The study, published in the October issue of Injury Prevention, estimates that bicycle-related injuries among children and adolescents result in nearly \$200 million in hospital inpatient charges annually.

(Transport for London, 2010) - Cycle Safety Action Plan

- The gender split of fatalities was 27% female and 73% male. While these proportions largely reflect the gender make-up of current cyclists in London (35% female, 65% male), it can be seen that men are over-represented in terms of casualties, including serious injuries and fatalities.

- Pedal cycle casualties occur most often amongst people aged between 20 and 50 years old, with 30-34 being the most common age for men, and 25-29 for women (see Appendix 4). This reflects the age distribution of cyclists in London.
 - Of the 15 cyclist fatalities that were recorded, eight of these involved a goods vehicle; a heavy goods vehicle (HGV) in six cases, and a medium goods vehicle (3.5-7.5t) in the remaining two cases.
- 18% (78) of all serious injuries to cyclists occurred when another vehicle disobeyed junction controls.
 - 5% (23) of collisions where cyclists were seriously injured occurred after the cyclist disobeyed a junction control (2007).
 - Although cyclists who disobey traffic signals are breaking the law, this type of conflict is a relatively minor contributor to cyclist fatalities and serious injuries. Public consultation on the draft version of this plan, however, revealed a widely held view that increased cyclist adherence to junction controls would significantly improve cycling safety. It will therefore be necessary to understand and address public perceptions as well as encourage cyclists to comply with junction controls.

(Wardlaw, 2002) - Assessing the actual risks faced by cyclists

Key Points

- Cycling is far safer than driving anywhere when the health benefits and reduced risk to third parties are included
- Cycling gets safer as it gets more population
- There is no known example in recent decades when an increase in cycling led to an increase in cyclist deaths

Cycling Risk:

- A British cyclist who rides for 280 hours per year (2,300 miles) will face an annual risk of death about double that of a British driver, but the risk is low at 0.0083% per year
- Scandinavian researchers^{12, 13} have identified a reliable power-law relationship between cycle flow and risk per cyclist, with an index value in the range -0.6 to -0.7. Thus if cycle flow doubles, deaths will increase by only 25-30%; the risk per cyclist will fall by 35-40%.

Canadian Institute for Health Information. Hospitalizations due to Bicycle-Related Injuries Among Children and Youth Down 15% in Five Years, Reports CIHI. Press Release. 2004
(Canadian Institute for Health Information., 2004)

- Number of Canadian children between the ages of 5 and 14 being hospitalized as a result of bicycle injuries has declined by 15% over five years
 - This was offset by an increase among those 15 and older

(Toronto Public Health, 2012) - Road to Health: Improving Walking and Cycling in Toronto

- While collision rates for pedestrians and cyclists have declined over the last decade, Toronto is still less safe for pedestrians and cyclists than other Canadian cities.
- Automobile accidents take a heavy toll on human life and health in Canada. In 2009, they resulted in over 2,000 deaths and 172,000 injuries, 11,000 of them serious injuries. Motor vehicle collisions are a leading cause of death for young people, accounting for 70% of all accidental deaths in the 15 to 24 age group.
 - In North America, individuals who walk and cycle face a higher risk of traffic injuries. Pedestrians and cyclists are more likely to be killed or injured than car and public transit users, by either per trip or per kilometre measures, in proportion to the number of pedestrians and cyclists on the road.
 - Cyclists in North America are twice as likely to be killed and eight times more likely to be seriously injured than cyclists in Germany, North American cyclists are three times as likely to be killed and 30 times as likely to suffer serious injuries than cyclists in the Netherlands.

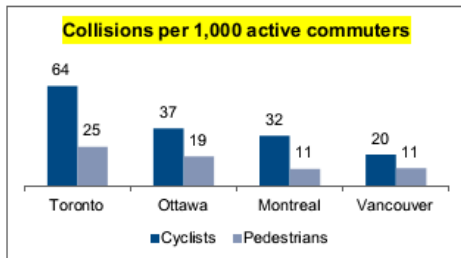


Figure 12: Active commuting collision rates in Canadian cities (per 1,000 commuters)
Data: 2006 Statistics Canada census data, City of Toronto Traffic Safety Unit 2011a, 2011b

- Pedestrians are particularly at risk, accounting for 50% of all fatalities from collisions in Toronto (Chapter 3).
- This is supported by Toronto survey data, where general safety is the number one concern about cycling in Toronto.
- These efforts are particularly important on major arterials where 69% of cyclist-vehicle collisions and 58% of pedestrian-vehicle collisions occur.
- A pedestrian is 8 times more likely to die as a result of a collision when a vehicle is going 50 km/hr than when it is going 30 km/hr.
- Less than 5% of pedestrians are likely to die as a result of a collision when it occurs at speeds below 30 km/hr; this rate rises to about 25 percent at 40 km/hr and about 85 percent at speeds of 50 km/hr.
- A review of 19 traffic-calming initiatives in four European countries found that injuries caused by collisions for all road users fell by 41-83%, while fatalities dropped by 14-85%. After 30 km/h zones were introduced in London, these zones experienced a 42% reduction in fatalities.

What are the existing attitudes of cyclists and drivers?

Sharing Road Space (Granville et al., 2001)

- “...whilst cyclists generally regard themselves as equal to other road users, this status is not assigned to them by others” Cyclists are generally not considered to deserve priority on the road

by most other road users. The exception was drivers who also cycled who showed more tolerance and sympathy towards the rights of cyclists. For non-cyclists, however, one bad experience of poor cycling behaviour often served to create a negative impression that extended towards all cyclists.

- While all respondents regard cyclists as the most vulnerable type of road user, criticism is widely levelled at cyclists for not consistently adhering to the law in terms of courteous and acceptable road behaviour. There are a number of factors cited by drivers which have impacted upon the prioritisation accorded to cyclists as road users. These factors include :
 - A lack of regard for other road users,
 - A failure to adhere to basic road safety guidelines,
 - Poor cycling behaviour,
 - Not paying road tax,
 - Not being able to keep up with other traffic and
 - Not showing courtesy to others.
- ...drivers who do not cycle tended to view cyclists as a minority group, commanding too much by way of resources but who were clearly benefiting from significant additional provision in both Aberdeen and Edinburgh...Drivers who do cycle do not hold these views and are much more tolerant and supportive of cyclists...non-cycling road users expect cyclists to be the ones to learn how to deal with other road users and so the emphasis is placed upon cyclists obtaining the relevant information to act properly, rather than drivers doing so.
- Drivers are less supportive of cycle lane provision and other aspects of provision specific to cyclists such as advanced stop lines and filter lanes...A number of factors underlie this, including the perceived dearth of cyclists in both the study cities, a lack of understanding of the rationale behind this type of provision...
- Some drivers who attempted to show cyclists greater consideration reported being harassed by other drivers.
- Drivers very rarely altered their overtaking behaviour at road narrowings to take account of the decrease in road width...between 67% and 100% of cars overtook a cyclist where the road was narrow. The percentage of cars overtaking did not vary according to the width of the running lane or the presence of a cycle lane.
- When a cyclist and a vehicle approached a pinch point from opposite directions, with no cycle bypass and no obvious priority, only one vehicle in the fifty-one cases observed waited for the cycle to pass. A cyclist holding his/her speed and line in this case faces obvious dangers.
- Many motorists have a superior attitude towards cyclists and feel that they have more right to the road, or that perhaps, due to the increased size and robustness of their vehicles, they can bully cyclists into getting their own way.

(Räsänen & Summala, 1998)

- *The most frequent accident type among collisions between cyclists and cars at bicycle crossings was a driver turning right and a bicycle coming from the driver's right along a cycle track.*
 - Cyclists' behavior was in marked contrast to that of drivers. In these cases, 68% of cyclists noticed the driver before the accident, and 92% of those who noticed believed the driver would give way as required by law.

(Komanoff, 1999) – Killed by Automobile – Death in the Streets in NYC 1994-1997

- 97 percent of cyclist-killers were men strongly suggests that driver aggression (and not just cyclist impulsiveness) plays a significant role in killing bicycle-riders in New York City.
- In three police precincts most afflicted by deadly drivers, outrage over traffic danger has long been directed against cyclists rather than drivers

(Hurt, Ouellet, & Thom, 1981) - The Hurt Report

- 6. In multiple vehicle accidents, the driver of the other vehicle violated the motorcycle right-of-way and caused the accident in two-thirds of those accidents.
- 7. The failure of motorists to detect and recognize motorcycles in traffic is the predominating cause of motorcycle accidents.

Why do people choose not to cycle?

Sharing Road Space (Granville et al., 2001)

- Over two in five (41%) leisure-cyclists and over one quarter (27%) of cycling motorists stated that one of the main problems of using a bicycle was the threat of accidents.
- The deterrents to cycling, summarised by TRL, were “time pressure, stress, aggressive driver behaviour, decline of the nuclear family, personal security fears, out of town shopping, government support for road building, car ownership and British drivers’ ‘disregard’ for the Highway Code” . The visions of, “harassed, rain-soaked, exhausted individuals negotiating hills and threatened by lorries were powerful images”.
- The media profile of cycling was found to be lower than that of the car, in that it was rarely portrayed as an everyday activity.

(Cavill & Davis, 2008b).

- The real and perceived physical danger posed by motor traffic is one of the main barriers to engaging in cycling
- It is also important to note that the actual risk remains small – amounting to one cyclist death per 33 million kilometres of cycling. It would take the average cyclist 21,000 years to cycle this distance, or, put another way, 21,000 average cyclists would have to cycle for a year before one of them was killed.
- It is more accurate to examine only the risk for distances that can be cycled and not consider the kilometres travelled on motorways, on average the “much safer” kilometres. When they adjusted the data to exclude motorway journeys, they found that the chance of being admitted to hospital following a crash is virtually equal for both modes of transport, but in terms of fatalities per billion kilometres travelled there are nearly twice as many motorists killed as cyclists.
- There is now increasing evidence for the phenomenon of ‘safety in numbers’. Studies suggest that policies leading to increases in the number of people walking or cycling appear to be effective in improving the safety of people using these modes
- The Jacobsen study concluded that: “A motorist is less likely to collide with a person walking and bicycling if more people walk or bicycle. Policies that increase the numbers of people walking and bicycling appear to be an effective route to improving their safety...”

(Royal College of Nursing, 2007)

- One of the barriers to taking up cycling is a perception of the physical danger posed by motor traffic. However, the real risks are minimal and outweighed by the health benefits by a factor of around 20 to 1 (Hillman 1992).
- Being sedentary presents a greater risk: over 50,000 people die in the UK each year from coronary heart disease related to insufficient physical activity, compared to around 100 cyclists killed on the road

(Shikaze, 2012) – Creating Bicycle-Friendly Communities

- “In a 2009 poll conducted for the Share the Road cycling coalition (STRCC), 60 percent of Ontarians said they would like to cycle more often. However, they said that the main reason they don’t is that they are “worried about safety on the road.”

(Guarino et al., 2004) - Bicycle-Motor Vehicle Collision Locations in the City of Toronto

- After commuting distance, safety is the most frequently cited reason for not using a bicycle for utilitarian purposes.

(McKeown, 2007) - Air Pollution Burden of Illness from Traffic in Toronto - Problems and Solutions

- Safety concerns are a significant barrier to engaging in walking or cycling:
 - A key barrier to engaging in physical activity involves concerns about safety and security. For example, residents will not use a cycle lane or path if they believe it is dangerous.
 - A survey shows that 82% of Canadians have expressed an interest in walking more regularly, and 66% of Canadians have indicated a desire to cycle more, however, safety concerns prevent them from becoming more active.
 - Traffic injuries and fatalities from vehicles travelling at high speeds, heavy traffic flow and a lack of separate lanes and paths are key reasons why citizens do not walk or cycle in cities
 - Sidewalks and protected areas for walking and cycling can help reduce collisions between vehicles and pedestrians and cyclists
 - Many current cyclists, and people who would like to cycle, are also concerned about breathing vehicle emissions on roads with heavy traffic. The closer one is to the tailpipe of vehicles

What about helmets & helmet legislation?

(Robinson, 2006b)

- “Random breath testing in New South Wales produces an obvious, sustained reduction in deaths. Another campaign, about the same time as the helmet law, reduced pedestrian fatalities by 34%. In Victoria, a campaign against speeding and drunk-driving reduced pedestrian deaths by 43%.” Therefore improving road safety in general can increase safety for cyclists more substantially than helmet laws.

- While helmets are shown to reduce head injuries, they also may encourage cyclists to take more risk. Among other confounders, there is no significant conclusion that can be made towards the benefits of enforcing mandatory helmet laws.

(A. Macpherson & Spinks, 2008)

- Did a systematic review to determine the effects of bicycle helmet legislation on bicycle-related head injuries and helmet use, and the occurrence of unintended adverse consequences. Of the five studies that met inclusion criteria, two studies showed statistically significant declines in head injuries following implementation of helmet legislation compared with controls. One study reported a non-statistically significant decline.

(Francis & Justason, 2010)

- “The authors, pointing out that 89% of the deaths and serious injuries recorded in their study were due to head trauma, suggested the most effective means of automatic protection was in the wearing of a bicycle helmet. Here they relied on an Australian study (Rivara, 1989 N Eng J Med) that found that riders wearing helmets had 85% less risk of head injury and 88% less risk of brain injury compared to those not wearing helmets. They advanced the view that the introduction of legislation requiring the use of protective helmets should be considered.”

(Callaway, 2009) - Bicycle helmet laws could do more harm than good

- “Helmet laws like those in effect in Australia levy a substantial cost on healthcare systems because savings from fewer head injuries pale in comparison to the costs incurred by decreases in cycling...”
 - Only under extreme, theoretical circumstances to mandatory helmet laws not end up costing the healthcare system
 - Estimated that helmet laws could cost the US \$4.8 billion/year, but assumes that benefit of cycling was \$1/km. However, as long as benefit of cycling is not zero, there will be a net cost incurred due to helmet laws
 - Helmet laws cause decrease in bike ridership from 20-40% (Robinson, 2006b)
 - Some say de Jong over-values health benefits of cycling

(Robinson, 2006a) - Bicycle Helmet Legislation - Can we reach a consensus

Helmet Law Studies

- In contrast to the 90 brain injuries >AIS2 in the Cochrane review, the helmet-law review included 10,479 head injuries severe enough to appear in hospital admissions databases.
- Yet there was little or no notice-able response in %HI to the changes in %HW, leading to serious doubts about the benefits of helmet legislation
- The obvious and sharp decline in numbers of non-head injuries (Fig. 1a) coinciding exactly with legislation can be explained by noting that numbers counted in identical pre- and post-law observational surveys declined by 36%;

- Helmet laws discouraged children (42% reduction in the first year) more than adults (29% reduction)
- However, all studies of enforced helmet legislation that measured cycle-use reported substantial declines. Thus it is possible to conclude only that helmet laws did not reduce the risk of injury per cyclist, but not whether this is due to risk compensation, reduced safety in numbers (Jacobsen, 2003;Robinson, 2005), or over-optimistic predictions of the benefits of helmets in preventing serious head injuries
- ...but other experiments showed that wearing bike helmets increased rotational accelerations (Corner et al., 1987)

Cost-benefit analyses: helmet laws

- In New Zealand, the estimated cost of helmets in the first 5 years of the law was NZ\$7.51 million, mainly for purchase of helmets, 27 times greater than the estimated reduction of NZ\$0.28 million in hospital costs (Taylor and Scuffham, 2002).
- The authors (Hendrie et al., 1999) concluded: "In monetary terms, it is unlikely that the helmet wearing legislation would have achieved net savings of any sizeable magnitude".
- Even though cycling to work was estimated to reduce mortality by 40% (Andersen et al., 2000), the two cost-benefit analyses discussed above ignored the loss of health benefits from reduced cycling.
- The above suggests that measures to improve overall road safety can be more cost effective than helmet legislation.
- Injury and fatality rates per kilometre cycled are substantially higher – more than five times for higher for fatalities – in countries where fewer people cycle. Countries with the low helmet wearing have more cyclists and lower fatality rates per cycle-km.
- McLean et al. (1997) estimated that helmets for Australian motor vehicle occupants would reduce injury costs by \$1.9 billion (over 5 years, all vehicles equipped with airbags) or \$2.2 billion (only half the fleet with airbags). This compares with \$0.78 billion to equip the entire population with helmets (20 million at \$39 each, the cost used by Hendrie et al., 1999).

General principles

- (1) Any legislation (including helmet laws) should not be enacted unless the benefits can be shown to exceed the costs.
- (2) Helmet legislation should be evaluated in terms of the effect on cycle-use, injury rates per km cycled, and changes in percentages of hospitalised cyclists with head and brain injuries (%HI).
- %HI data for cyclists should therefore be compared with the same statistics for other road users.
- (5) Surveys of cycle-use should use the same sites and observation periods and be conducted at the same time of year, ideally the year before and year after legislation,

- (7) If the benefits of helmet laws cannot be shown to exceed the costs by similar ratios to other road safety initiatives, the legislation should be repealed.

The Status Quo: Where are we now and how do we move forward?

How physically active are we?

(Cavill & Davis, 2008b).

- Up to two-thirds of men and three-quarters of women report low activity levels which substantially increase their risk of contracting up to twenty chronic diseases or conditions

(Active Living by Design,) – Primer

- Daily participation in high school physical education classes dropped from 42% in 1991 to 33% in 2005. Nationwide, 31.3% of high school students do not participate in sufficient vigorous or moderate physical activity.
- The proportion of youth who are overweight and adults who are obese has more than doubled in the last 20 years. Among children aged 2 through 19 years in 2002, 33.6% were overweight or at risk of overweight and 17.1% were overweight.
- 34% of coronary heart disease deaths can be attributed to physical inactivity; inactive adults are nearly twice as likely as those who are active to have coronary heart disease.
- An analysis of data from the 2003-04 National Health and Nutrition Examination Survey (NHANES) showed that 66.3% of adults are either overweight or obese, with 32.2% of adults qualifying as obese, or approximately 30 pounds overweight.

(City of Toronto, 2009) - Cycling Statistics

- “Toronto has seen a small, but significant increase in cycling over the past 10 years. The number of cyclists in Toronto increased 6% between 1999 and 2009 (from 48% to 54%)”
 - The census says that between 2001 and 2006, the number of people riding a bike to work in Toronto increase by over 30%
- Although cycling is most popular among younger males, 2006 Census data suggest the cycling demographic is shifting.
 - Among commuter cyclists, the increase in the number of people riding a bicycle to work was greater among females than males.
 - The greatest increases in the percentage of people riding a bicycle to work were among females aged 45 to 54 (+136.8%) and males aged 55 to 64 (+147.2%).
 - [Percentage increase in people riding a bicycle to work, by age and sex \(Toronto, 2001-2006\)](#)
- Bike mode share is reported at 1.7% in Canada (highest city, national average 1.3%), but is not a really good measure as it hides difference across the city

Table 1 - Torontonians mode of travel to work

Mode of travel	2001		2006		2001-2006
	#	%	#	%	% Change
Bicycle	14,925	1.3	19,780	1.7	+ 32.6
Walked	73,230	6.4	81,565	7.1	+ 11.4
Public transit	387,485	33.8	394,955	34.4	+ 1.9
Car, truck, van, motorcycle, taxicab as driver or passenger	663,720	57.9	644,400	56.1	- 5.2% as driver + 18.7% as passenger
Other	6,630	0.6	8,215	0.7	+16.5

- Source: Statistics Canada, 2006 Census

(Institute for Clinical Evaluative Sciences (ICES), 2007) - Neighbourhood Environments and Resources for Health Living - A Focus on Diabetes in Toronto

- ...onset of type 2 diabetes is occurring at younger and younger ages.
- ...increases in physical activity would likely offset the rise in obesity and type 2 diabetes in the general population.

(McKeown, 2007) - Air Pollution Burden of Illness from Traffic in Toronto - Problems and Solutions

- Toronto’s rate of physical activity is well below what is needed for good health. Recent studies have indicated that the Canadian population and children in particular are not as physically active as recommended by health professionals. Over 2.6% of all health care costs in Canada are spent dealing with the ill health effects of physical inactivity.
- People who live in spread-out, car-dependent neighbourhoods walk less, weigh more, and suffer from more high blood pressure, diabetes and heart problems than people who live in high density, walkable communities

(Toronto Public Health, 2012) - Road to Health: Improving Walking and Cycling in Toronto

- In Toronto, where only 42% of adults are physically active in their leisure-time. Adults in Toronto aged 20 or older have the second lowest levels of physical activity compared to adults surveyed in 35 other health units throughout Ontario.
- A startling 93% of Toronto youth are not meeting the recommended daily requirements needed to derive health benefits from physical activity
- In Toronto, over 40% of adults and 22% of adolescents are overweight or obese
- A startling 93% of Toronto youth are not meeting the recommended daily requirements needed to derive health benefits from physical activity.
- In Toronto, over 40% of adults and 22% of adolescents are overweight or obese.
- Based on the 2006 census, 7.1% of Torontonians walk to work, and 1.7% cycle to work, leading to a combined active commuting mode share of 8.8%³. The 2006 Transportation Tomorrow

Survey (TTS) indicates that 7.1% of trips for all purposes are made by walking, and 1.1% is made by cycling, leading to a combined mode share of 8.2%

- These census and TTS mode shares under-represent the importance of walking and cycling to Torontonians. First, walking and cycling trips for shopping and leisure activities are not included in the TTS, while trips for these purposes using other modes are counted.
- Among residents of some neighbourhoods in the Toronto core, over 25% of all trips are made using active transportation.
- Despite these increases, Toronto's active commuting mode shares lag behind those of many other leading North American cities (Figure 7). Of these cities, Portland has the highest mode

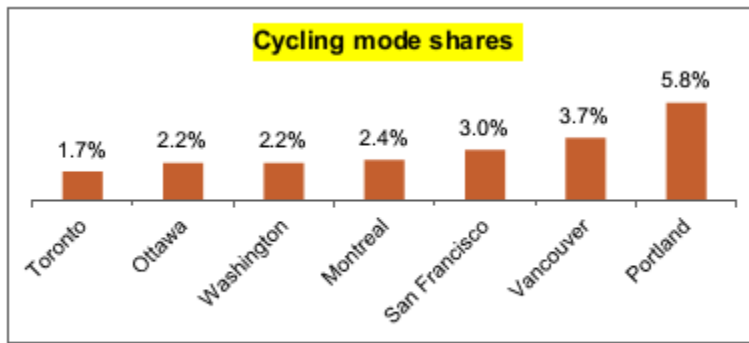


Figure 7: Active commuting mode shares of North American cities

- Data: Pucher and Buehler 2011, TransportPolitik 2011

How dependent on cars are we?

(Toronto Public Health, 2007)(McKeown, 2007) – Air Pollution Burden of Illness from Traffic

- The number of vehicles traveling into and out of the city each morning has increased by about 75% over the last two decades.
- 67% of trips into Toronto were made by single occupant vehicles. About 14% of trips were made by multiple occupant vehicles. Only 20% of trips into the city were made by public transit (including GO bus, GO train, regional bus and TTC).
- People living or working close to high-traffic areas experience more adverse effects than people who are further away from traffic sources.
- Toronto Public Health has determined that traffic pollution gives rise to about 440 premature deaths and 1,700 hospitalizations each year in Toronto.
- The study estimates that children experience more than 1,200 acute bronchitis episodes per year as a result of traffic pollution. Children are also likely to experience the majority of asthma symptom days (estimated to be about 68,000 per year)
- Traffic-related pollution... contributes to 67,000 acute respiratory symptom days, and 200,000 restricted activity days during which people spend days in bed or cut down on their usual activities.

(Active Living by Design,) – Primer

- Over the past 20 years, the amount of time Americans collectively spent in traffic increased at a rate 12 times that of the growth in population. The total number of trips taken on foot dropped by 50% over the same time period.
- One-fourth of all trips are one mile or less, but three-fourths of these short trips are made by car.
- Although almost half of all trips were less than three miles in 1990—a convenient distance for a bicycle—less than one percent were actually made by bicycle.

(Aalgaard, 2010) - Toronto Board of Trade Reminds Us We Ain't Doing So Hot

- *“Toronto’s 80-minute commute ranked last in global study” – was a study in the I-told-you-so kind of obvious*

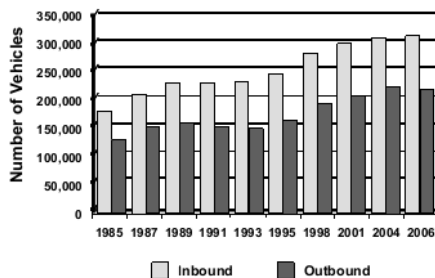
(Spears, 2010) - Toronto ranked last in survey of commuting times - thestar.com

- Even gridlocked Los Angeles is a better place for commuters than Toronto and its neighbouring municipalities
 - It takes people in Greater Toronto an average of 80 minutes to commute to work, round trip
 - That’s 24 minutes slower than Los Angeles, and the worst among 19 cities including New York, London, Chicago and Berlin.

(McKeown, 2007) - Air Pollution Burden of Illness from Traffic in Toronto - Problems and Solutions

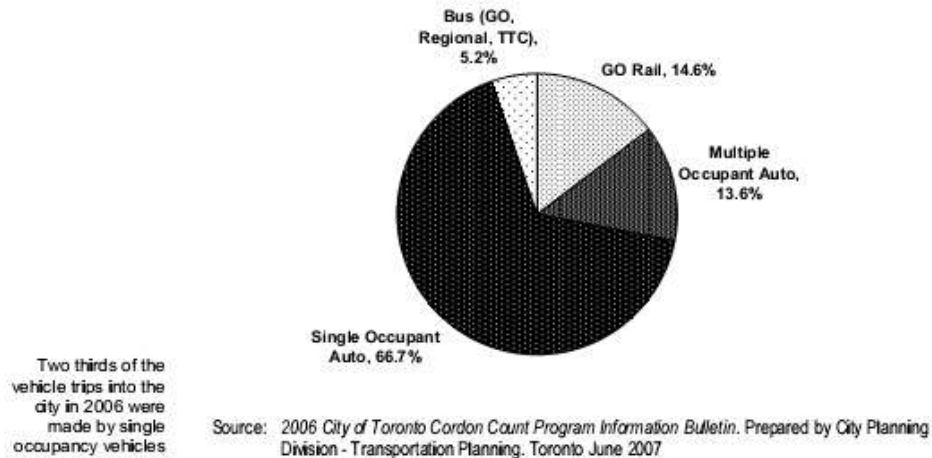
- It is of concern that pollution trends in Toronto for some key pollutants of health concern reveal little improvement in air quality over the last two decades. [...]It may be that gains in the transportation sector, such as the introduction of less polluting vehicles and improvements in fuel quality, are being off-set by the increased volume and frequency of vehicle use.
- Summary: Trend data suggest that progress is slow in improving air quality in Toronto. Gains in cleaner vehicles are being offset by increases in traffic volumes.

Figure 4. Trend in Mean Daily Number of Vehicles Entering and Exiting Toronto (6:30 a.m. – 9:30 a.m.)



Source: 2006 City of Toronto Cordon Count Program Information Bulletin. Prepared by City Planning Division - Transportation Planning, Toronto June 2007

Figure 5: Mode of Travel – Inbound Person Trips (6:30 a.m. – 9:30 a.m.) 2006



What are the health risks of inactivity?

(Canadian Association of Physicians for the Environment, 2012)

- Each additional hour spent in a car per day is associated with a 6% increase in the likelihood of obesity

How bad is air pollution?

(McGrath,)

- [...] most climate scientists and a growing number of governments are calling for carbon reductions to 80% of 1990 levels by 2050. That figure based is on the assessments published by the Intergovernmental Panel on Climate Change – the world’s preeminent scientific body tasked with evaluating the risk of climate change caused by human activity.
 - As a sector, transportation is a major contributor to the United States’ total emissions.
- By 2030, vehicle miles travelled are predicted to increase by 59%

(Canadian Association of Physicians for the Environment, 2012)

- Affects kids the most and has been shown to cause childhood asthma exacerbations
- Has been correlated with increased mortality, cardiovascular mortality and morbidity, the onset of childhood asthma, and exacerbation of respiratory symptoms in adults
- Is a major contributor to greenhouse gases that contribute to climate change

(Ontario Medical Association, 2005) – **The Illness Costs of Air Pollution**

- The OMA’s new cumulative estimate for smog-related premature mortality is 5,800 deaths annually.
- In ICAP 2005, the total hospital admissions associated with air pollution exposure is estimated at over 16,000

- In 2005, the emergency room visits associated with air pollution exposure is estimated at almost 60,000 cases
- In 2005, a total of over 29 million minor illnesses are expected to be associated with air pollution exposure. Most of these cases will be minor restricted activity days and restricted activity days.
- **Table 1**...demonstrates the substantial increase in health damages that can be expected in Ontario over the next 20 years if air quality does not improve

Table 1 – Provincial Health Damage Summary for Four Example Years

	Example Years			
	2000*	2005	2015	2026
Premature Deaths	1,925	5,829	7,436	10,061
Hospital Admissions	9,807	16,807	20,067	24,587
Emergency Room Visits	45,250	59,696	71,548	87,963
Minor Illnesses	46,445,663	29,292,100	31,962,200	38,549,300

(McKeown, 2007) - Air Pollution Burden of Illness from Traffic in Toronto - Problems and Solutions

- In 2004, Toronto Public Health (TPH) estimated that air pollution (from all sources) is responsible for about 1,700 premature deaths and 6,000 hospitalizations each year in Toronto.

Nature of Traffic-Related Pollution

- Exposure to pollutants is elevated in urban areas with high traffic volumes and heavily travelled highway corridors
- Street canyons (streets lined with tall buildings that impede the dispersion of air pollutants) and areas very close to busy roads typically have a high concentration of. These areas may also contain a high concentration of people, including pedestrians and cyclists, or people within buildings alongside the road.

Factors that Affect Exposure to Traffic Pollutants

- Driving a vehicle: Pollution levels inside vehicles during commutes tend to be higher than background levels at urban monitors.
- Work-related Exposure to Vehicle Emissions: People who work close to traffic emissions experience higher rates of cancer and respiratory and cardiac illnesses compared to less exposed workers
- Proximity to Roadways: People living close to busy roads experience increased respiratory symptoms
- Level of Physical Activity: As physical activity level increases, more air pollutants are deposited in the lungs
- Duration of Exposure: the risk of developing COPD has also been linked with long-term exposure to air pollution in a study of individuals living close to busy roads for at least five years.

- Vulnerable populations: Children are particularly vulnerable to the health impacts of traffic, as are seniors and people of all ages with underlying medical problems. Poverty is linked with increased health risk from traffic

Adverse Health Effects of Traffic Pollution

- Respiratory Effects: Living near traffic is associated with increased asthma symptoms, wheeze and chronic bronchitis, and with reduced lung function
- Cardiovascular Effects: Living near heavy traffic is associated with increased cardiac problems, including heart attacks
- Cancer: Chronic elevated exposure to vehicle emissions is linked with increased rates of lung cancer in adults and leukemia in children
- Hormonal and Reproductive Effects: Chronic exposure to heavy traffic pollution is associated with reduced fertility in men and low birth weight

(Toronto Public Health, 2012) - Road to Health: Improving Walking and Cycling in Toronto

- There is evidence that traffic-related pollutants are linked to cardiovascular disease, lung cancer, and increased risk of adverse pregnancy outcomes
- The Ontario Medical Association (2005) estimated that provincial costs associated with air pollution exposure were \$7.8 billion in 2005. In the City of Toronto, traffic-related pollution was estimated to cause 440 premature deaths, 200,000 restricted activity person-days and 1,700 hospitalizations per year in 2007. Mortality costs alone were valued at \$2.2 billion.

What is the economic cost of inactivity?

(Ontario Medical Association, 2005) – The Illness Costs of Air Pollution

Table 2 – Economic Damages for Three Example Years

	Example Years		
	2005	2015	2026
Lost Productivity	\$374,342,400	\$402,883,900	\$466,508,500
Healthcare Costs	\$506,612,700	\$571,089,400	\$701,988,500
Pain and Suffering	\$536,546,600	\$593,149,400	\$718,341,300
Loss of Life	\$6,391,700,000	\$8,279,400,000	\$11,027,400,000
Total	\$7,809,201,700	\$9,846,522,700	\$12,914,238,300

(McKeown, 2007) – Air Pollution Burden of Illness from Traffic

- Mortality-related costs associated with traffic pollution in Toronto are \$2.2 billion each year.

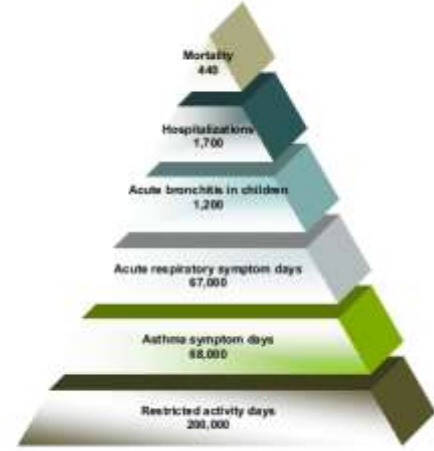
(McKeown, 2007) - Air Pollution Burden of Illness from Traffic in Toronto - Problems and Solutions

- This study estimates that mortality-related costs associated with traffic pollution in Toronto are about \$2.2 billion. A 30% reduction in vehicle emissions in Toronto is projected to save 189 lives and result in 900 million dollars in health benefits.

Table 5. Traffic-Related Morbidity and Mortality Estimates (Toronto 2004)

Health Outcome	Mean (number of occurrences per year)	95% Confidence Interval (CI)
Acute exposure mortality	257	161 - 352
Chronic exposure mortality	183	104 - 262
Elderly cardiac hospital admissions	1,595	149 - 3,032
Cardiac hospital admissions	14	7 - 20
Respiratory hospital admissions	60	20 - 100
Cardiac emergency room visits	5	0 - 15
Respiratory emergency room visits	244	60 - 449
Adult chronic bronchitis cases	190	0 - 377
Child acute bronchitis episodes	1,234	0 - 2,651
Asthma symptom days	67,912	24,918 - 110,374
Acute respiratory symptom days	66,830	60,782 - 1,355,571
Minor restricted activity days	99,182	0 - 423,332
Restricted activity days	211,674	124,654 - 298,447

Figure 7. Pyramid of Health Effects from Traffic-Related Air Pollution¹⁴: Annual illness outcomes for Toronto in 2004



(a) Numbers are rounded

- The mortality-related economic impact of traffic pollution in Toronto is about 2 billion dollars:

Table 6. Annual Economic Costs Associated with Traffic-Related Air Pollution (a)

Health Outcome	Economic Cost (billion dollars)	95% Confidence Interval (CI) (billion dollars)
Mortality	2.2	1.1 - 4.1

- A 30% reduction in vehicle emissions is projected to save about 190 lives and result in 900 million dollars in health benefits each year in Toronto

(Toronto Public Health, 2012) - Road to Health: Improving Walking and Cycling in Toronto

- A US study found that inactive individuals incur over \$600 in additional health care costs per year as compared to active individuals.
- A Canadian study calculated that physical inactivity alone is directly associated with \$1.6 billion in annual health care costs in Canada, or 1.5% of all Canadian health care costs. Each additional 10% increase in physical activity in Canada would translate to annual direct health care savings of up to \$150 million.
- The Ontario Medical Association (2005) estimated that provincial costs associated with air pollution exposure were \$7.8 billion in 2005. In the City of Toronto, traffic-related pollution was estimated to cause 440 premature deaths, 200,000 restricted activity person-days and 1,700 hospitalizations per year in 2007. Mortality costs alone were valued at \$2.2 billion.

What is the impact of weather on rates of cycling?

(Granville et al., 2001) **Sharing Road Space**

- ...there are some conflict situations which will not be created solely by the attitude or behaviour of road users. These include poor weather conditions, roads in a poor state of repair and inconsistencies in the operation of specialist provision and inconsistency in enforcement. Cyclists often thought drivers were unaware of these problems.

(J. Pucher & Buehler, 2005) **Cycling Trends and Policies in Canadian Cities**

- Poor cycling infrastructure and safety are much larger deterrents to bicycling than poor weather. The Yukon has the highest bike share of work trips (2.0%) in Canada, and the Northern Territories (1.6%) far exceed both Ontario (1.0%) and Quebec (1.2%).
- Cities across Europe that have climates very similar to Ontario cities have much higher rates of cycling than we do (Table 3). This suggests that weather plays a minor role (at most) in decisions about cycling

TABLE 3: Comparison the Percentage of People Who Bike to Work in Three Cities with Similar Weather

CITY	AVERAGE ANNUNAL TEMPERATURE	AVERAGE ANNUNAL PRECIPITATION	PECENTAGE OF PEOPLE WHO BIKE TO WORK
Amsterdam	9	800	35%
Copenhagen	5	1500	40%
Toronto	8	800	<1%

Adapted from: Bicycle Use and Safety in Paris, Boston, and Amsterdam (Transportation Quarterly, 1998)

How is our current funding?

(Alliance for Biking & Walking, 2010)

- While 10% of trips in the U.S. are by bike or foot, 13% of traffic fatalities are bicyclists and pedestrians. Biking and walking receive less than 2% of federal transportation dollars.

(Spears, 2010) - Toronto ranked last in survey of commuting times - thestar.com

- ...a plan exists to deal with transportation issues in Greater Toronto, but it exists mostly on paper:
 - “It was 80 per cent unfunded, and now with Thursday’s provincial budget, it’s 90 per cent unfunded,” said Wilding on Monday as she released the report.

(Vélo Québec, 2007) - Bikeroutes, Greenways and Bicycle Touring

- Surprisingly, authorities are often reluctant to acknowledge the legitimacy of cycling as a means of transportation. In the United States, as Andy Clarke from the League of American Bicyclists pointed out, cycling and walking account for 10% of travelling activity and 13% of road accidents, but only 2% of federal transportation funding. And the central government funds a mere 20% of development expenditures.

The Benefits of Cycling: Why should we invest?

(Northern Ireland Cycling Initiative, 2008) – **Planning for Cycling – Executive Summary**

- The overall value accrues from the unique combination of the benefits that cycling offers through:
 - improvement in general health and fitness
 - reduced pollution and the emission of CO₂
 - help in tackling congestion

(Smith Lea, 2009) - **Bike Lanes**

- Cycling is good for the Community:
 - According to the Victoria Transport Policy Institute (2004), increased non-motorized travel improves community cohesion, security and aesthetics.
 - Enrique Penalosa, the former Mayor of Bogota, Columbia who established the largest network of separated bicycle lanes in the developing world (300 kilometers), saw children as the key to good city planning: “If a city is good for children, it will be good for everybody else.” (Ode, 2004)

What are the health benefits of cycling?

(Medical News Today, 2010)

- “Children who cycle to school are more physically active and fit than those who use other modes of transport, according to new research from the official journal of the American College of Sports Medicine.”

Bicycle Almanac (Bicycle Universe,)

- **“Health benefits of cycling outweigh the risks.** "The gain of 'life years' through improved fitness among regular cyclists, and thus their increased longevity exceeds the loss of 'life years' in cycle fatalities. An analysis based on the life expectancy of each cyclist killed in road accidents using actuarial data, and the increased longevity of those engaging in exercise regimes several times a week compared with those leading relatively sedentary lives, has shown that, even in the current cycle hostile environment, the benefits in terms of life years gained, outweigh life years lost in cycling fatalities by a factor of around 20 to 1." -- Mayer Hillman, Senior Fellow Emeritus, Policy Studies Institute, and British Medical Association researcher”

(Alliance for Biking & Walking, 2010)

- “States with the lowest levels of biking and walking have higher traffic fatalities and chronic disease”

Sharing Road Space (Granville et al., 2001)

- Scotland has a long record of poor health, much of which could be reduced if people were to take more exercise. Cycling, as either a form of transport or as a leisure activity, provides a moderate level of exercise and helps to develop cardiovascular fitness.

(Hillman, 1997)

- Cyclists who cover at least 40 kilometres each week halve their risk of heart disease when compared with those who do not cycle.

(BUFA, 2009) – Cycling and health

- One rough calculation suggests that new cyclists covering short distances can reduce their risk of death (mainly due to the reduction of heart disease) by as much as 22 per cent.
- A 15-minute bike ride to and from work five times a week burns off the equivalent of 11 pounds of fat in a year.
- Cycling can have positive effects on how we feel too.
- The strength and co-ordination that regular cycling brings make injuries less likely.
- ...study found that aerobic fitness was boosted by 11 per cent after just six weeks of cycling 'short distances' four times a week.
- Cyclists and pedestrians actually absorb lower levels of pollutants from traffic fumes than car drivers.

(Canadian Association of Physicians for the Environment, 2012)

- Each kilometre walked per day decreases the risk of obesity by 4.8%
- Bike commuting can reduce the risk of premature mortality by approximately one-third
- Moderate activity (about 30 min/day, 5 days/week) has been associated with decreased rates of mortality, cardiovascular disease, diabetes, dementia, breast cancer and colon cancer
- Cyclist and pedestrians breathe less concentrated air pollution than drivers (they're farther away from the cars but they breathe fast and may inhale more)
- Despite the ill-effects of air pollution and injury, the benefits of cycling are still 7 times greater than the risks

(Cavill & Davis, 2008b).

- Benefits to health: a key motivator for cycling
 - A survey by the DfT of motorists, who had recently reduced some of their short car journeys, showed that 34% had done so to get more exercise compared to 8% who had done it to help the environment or the 2% who wanted to help reduce congestion.
 - Cycling to and from work is considered to be more acceptable and cost-effective than formal work-site exercise classes. Other advantages to employers, reported in a UK survey include improved employee morale, higher productivity and loyalty, and reduced costs associated with car parking provision. In addition, there is also evidence for reduced absenteeism among employees who are physically active on one or more days per week

(Royal College of Nursing, 2007)

- One study found that people who cycle to work experienced a 39 per cent lower rate of mortality compared with those who did not, even after adjustment for other risk factors, including leisure time physical activity (Andersen et al 2000).
- Cycling for an additional 30 minutes on most days of the week, combined with reducing calorie intake, can achieve weight loss comparable to that achieved by doing three aerobic classes a week.
- Cycling is also particularly well suited to over-weight or obese people, as approximately 70 per cent of body weight is borne by the saddle, thus providing the required cardiovascular exercise without putting excess strain on the musculoskeletal system.

(Reynolds, 2009a) - Is Bicycling Bad for Your Bones

- Various studies confirming that competitive cyclists have significantly less bone density than age-matched controls
 - Exact reasoning remains unknown
 - For recreational cyclists: not worry, training regimen is much different (no runs, no weightlifting, etc.)

(Reynolds, 2009b) - Phys Ed - Do More Bicyclists Lead to More Injuries

- Surgeons in Denver collected data from 1995-2000 and 2001-2006
 - Found that the severity of bodily damage had increased, number of chest injuries rose 15%, and abdominal injuries tripled. Length of cyclists' time in ICU grew
- "What we concluded was that a lot of these people were commuters," Dr. Kashuk said, adding, "If we keep promoting cycling without other actions to make it safer, we may face a perfect storm of injuries in the near future."
- "...the Denver study seemed to indicate that getting more people to ride meant more would be hurt.
 - But that is not necessarily so, a well-established body of counterintuitive science promises. This research, which has examined bicycle-riding patterns in the United States and in Europe, has found that in virtually every instance, when the number of riders on the road increases, the likelihood of accidents declines. This surprising result is known among its researchers as the "safety in numbers" effect, and it has been repeatedly documented."
- "How can more cyclists mean fewer accidents? "It seems unlikely that people walking or bicycling obey traffic laws more" just because more of them are on the streets, the author of the California study wrote. "Adaptation in motorist behavior seems more plausible." In other words, when more cyclists show up on the roads, car drivers become used to them and respond appropriately.
 - There is a Catch-22 in that proposition, of course, and studies like the one from Denver underscore the issue's complexity. In the early stages of increasing bike ridership, injuries may increase, as may their severity, since drivers will not yet be acclimated to the influx of two-wheeled traffic (and many of the early-adaptor riders will not be attuned to the nuances of negotiating in traffic)

- What, then, can be done? No solutions are easy, said Dr. Walter Willett, chairman of the department of nutrition at the Harvard School of Public Health and an avid cyclist who, with others in his department, is studying how best to increase bicycle safety.”
- “Finally, do not assume that, should you dutifully follow the rules, you are freed from constant vigilance. Individual driving behavior, no matter how many cyclists ride, will always remain unpredictable, if not perverse. Consider the results of a 2007 study from Britain, which found that, when cyclists skipped wearing helmets, drivers yielded more of the road to them while passing; if the cyclists did don their helmets, the drivers tended to crowd dangerously close.”
(Toronto Public Health, 2012) - Road to Health: Improving Walking and Cycling in Toronto
- One US study found that men who walk or cycle to work were half as likely to be obese (Gordon-Larsen et al. 2009). Another US study found that every additional kilometre walked per day is associated with a 4.8% reduction in obesity. In contrast, every additional hour spent in a car each day is associated with a 6% increase in the likelihood of obesity (Frank et al. 2004).
- According to Basset et al. (2008), at the population level, countries with higher rates of active transportation and transit use have lower obesity rates, as illustrated in Figure 1.

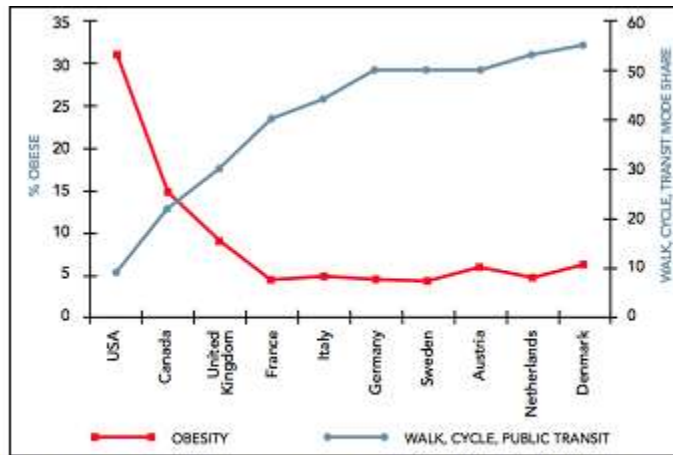


Figure 1: Population-level relationship between obesity and combined walking, cycling, and transit mode share

Source: Transport Canada (2010), data from Basset et al. (2008)

- A meta-analysis concluded that active commuting is associated with an 11% reduction in cardiovascular risk. High levels of walking for transportation have been associated with a 31% decrease in the risk of cardiovascular disease.
- Physical activity has been found to reduce the overall relative risk of colon cancer by 24%. Active commuting in particular has also been associated with significant reductions in the risk of breast cancer.
- Physical activity has also been found to reduce the symptoms of depression, anxiety and panic disorders, with beneficial effect equal to meditation or relaxation.
- Research also suggests that physical activity can improve mental health in people without specific disorders. There is evidence that increasing physical activity can improve multidimensional self-esteem (McAuley et al. 2000), improve mood, reduce stress (Fox 1999 and Taylor 2000), and enhance perceptions of happiness and satisfaction (Taylor 2000)

- In a meta-analysis of 80 large cohort studies, people who received 150 minutes of moderate to vigorous activity per week have a 14% reduction in mortality, while people who received 300 minutes of physical activity experienced a 26% reduction in mortality.
- Studies conclude that the health benefits of shifting to active transportation outweigh the health risks – by at least a 15:1 ratio.

What are the financial benefits of cycling?

Sharing Road Space (Granville et al., 2001)

- As a result of low maintenance costs and nil fuel requirements, more people can afford to cycle than to use any other transport method. Thus, cycling is seen to be a very cost efficient mode of transport for journeys of five miles or less.

(McGrath,)

- An average midsize car driven 10,000 miles in a year costs its driver about \$.76 per mile, or \$7,574 for the year. The estimate includes gasoline, oil, maintenance, tires, insurance, license, registration, taxes, depreciation, and finance charges.
 - ...“externalities,” they boost the true cost of driving a car to about \$1.20 per mile, according to one estimate.
- Gary Barnes at the University of Minnesota tallied the economic benefits of cycling to his state. In a state of about 5 million people, his conservative estimate found that Minnesota’s modest rate of bicycling – about 1.5% of adult trips and 5% of trips by children – led to fiscal benefits in excess of \$300 million per year.
- Todd Litman and the Victoria Transport Policy Institute (VTPI) in British Columbia calculate that for every mile of travel shifted from automobile to bicycle, society saves an average of 24 cents. Using VTPI’s methodology, we find that if 5% of car trips in the greater Seattle area were shifted to bicycle, the public would save an average of \$970,000 per day in automobile-related costs,

(Canadian Association of Physicians for the Environment, 2012)

- The New Zealand Transport Agency estimated in 2008 a savings of \$4.27 per km walked and \$2.14 per km cycled (NZ \$) taking into account morbidity, mortality, and health-sector costs.

(McKeown, 2007) – Air Pollution Burden of Illness from Traffic

- Implementation of comprehensive, integrated policies and programs could reduce total vehicle travel by 30 to 50%.
- A 30% reduction in motor vehicle emissions in Toronto could save nearly 200 lives and result in 900 million dollars in health benefits annually.

(Sælensminde, 2004) - Cost-benefit analyses of walking and cycling

- The benefits of investments in cycle networks are estimated to be at least 4–5 times the costs. Such investments are thus more beneficial to society than other transport investments.

(Smith Lea, 2009) - Bike Lanes

- I-CE, a Dutch bicycle planning expertise centre [...] calculated that the benefits of building bicycle lanes are 7.3 times higher than the costs

- A recent Canadian study demonstrated that [...] if everyone rode as much as they do in Victoria, B.C., which currently has the highest levels of active transportation in Canada, the benefits in terms of congestion reduction, roadway costs, pollution, safety, etc. would increase to \$7.0 billion per year (Go for Green, 2004). This study also found that proximity to recreational trails increase property values.

(Toronto Public Health, 2012) - Road to Health: Improving Walking and Cycling in Toronto

- Based on very conservative calculations, 2006 levels of walking and cycling in Toronto are estimated to prevent about 120 deaths each year. Total savings from these prevented deaths range from \$130 million to \$478 million depending on how deaths are valued.
- Achieving walking and cycling commuting mode shares of 12% and 6%, respectively, would prevent about 100 additional deaths each year, yielding additional annual benefits of \$100 million to \$400 million
- A US study found that inactive individuals incur over \$600 in additional health care costs per year as compared to active individuals.
- A Canadian study calculated that physical inactivity alone is directly associated with \$1.6 billion in annual health care costs in Canada, or 1.5% of all Canadian health care costs. Each additional 10% increase in physical activity in Canada would translate to annual direct health care savings of up to \$150 million.
- Across Canada, physical inactivity is estimated to cost \$3.7 billion in economic productivity loss, due to its role in coronary artery disease, stroke, hypertension, colon cancer, breast cancer, type II diabetes and osteoporosis. Together, inactivity and obesity are estimated to account for \$6.4 billion in lost economic output due to short- and long-term disability and premature death.
- One study modeled the air quality effects of eliminating automobile round trips of 8 km and shorter and replacing 50% of them with bicycle trips in 11 metropolitan areas in the Upper Midwestern US. They estimated net health benefits from reduced urban particulate matter (PM 2.5) and ozone to be \$3.5 billion per year.
- The Ontario Medical Association (2005) estimated that provincial costs associated with air pollution exposure were \$7.8 billion in 2005. In the City of Toronto, traffic-related pollution was estimated to cause 440 premature deaths, 200,000 restricted activity person-days and 1,700 hospitalizations per year in 2007. Mortality costs alone were valued at \$2.2 billion.
- In a review of 16 economic analyses of the health-related impact of interventions to increase walking and cycling, the median health benefit to cost ratio was 5:1. The five studies deemed highest quality by the authors yielded cost-benefit ratios from ~3:1 to ~14:1,
- These ratios increase further when also considering benefits that are not health-related. An analysis by the Sustainable Development Commission (2011) highlights benefit-cost ratios of 18:1 to 38:1 for small-scale cycling schemes using the UK NATA framework for benefit-cost analysis. Major cycling infrastructure projects are pegged at 11:1, while local highway road schemes have benefit-cost ratios of 4:1 or 5:1. The NATA framework monetizes costs and benefits related to: changes in journey time, travel costs, accidents, noise and greenhouse gas emissions.

- The high benefits to cost ratios enable the achievement of high mode shares without excessive costs. In Portland where the cycling mode share is between 3% and 7%, bike facilities comprised less than one percent of Portland’s capital expenditures for transportation from 2001 to 2007.
- ...the total expenditures on pedestrian infrastructure are undoubtedly well below the \$76 to 278 million in benefits from prevented deaths each year.
- The value of active transportation in Toronto
 - The reductions in mortality from current levels of walking and cycling in the Toronto population are worth between \$130 million and \$478 million each year. These benefits – which accrue from about 120 prevented deaths – are rarely considered in transportation planning and decision-making. How do these values compare to Toronto’s expenditures on walking and cycling?
 - Approximately \$14 million of the City’s annual capital transportation budget is dedicated to improvements in walking and cycling infrastructure – or, 5% of the total capital expenditures for Transportation Services. Over the next five years, \$9 million of the City’s capital transportation budget will be allocated to cycling infrastructure and projects each year.
- Costs of collisions, injuries, and fatalities
 - Improving safety for pedestrians and cyclists in Toronto could avoid over \$60 million in direct and indirect economic costs.
 - Across Ontario, the 2% of collisions that involve pedestrians lead to 11% of the social costs of all collisions in Ontario. Investing in safety for users of active transportation has the potential to yield disproportionate economic benefits

What are the environmental/ traffic congestion benefits of cycling?

Sharing Road Space (Granville et al., 2001)

- Cycling is environmentally friendly as the mode of transport is silent and produces no emissions. By contrast, motorised transport is noisy, while its emissions reduce air quality and add to the “greenhouse” gases contributing to global warming.
- Cycling can also reduce congestion and the journey times of other road users, particularly in urban areas. Businesses may be unwilling to be based in an area constantly beset by traffic congestion which can cause delivery and health problems and result in a negative effect on the local economy.
- When compared with previous studies, the TRL research found that, “avoiding stress and congestion, rather than getting physical exercise and saving money, now appear to be more important factors”, as to why people take up cycling.
- Noland (1996) found that for a perceived increase in safety of 10%, an increase in cycling of over 10% was observed. TRL found that, “general attitudes to cycling were positive: cycling was thought of as healthy, a way to relieve stress, and a good family activity”.

(McGrath,)

Climate Protection

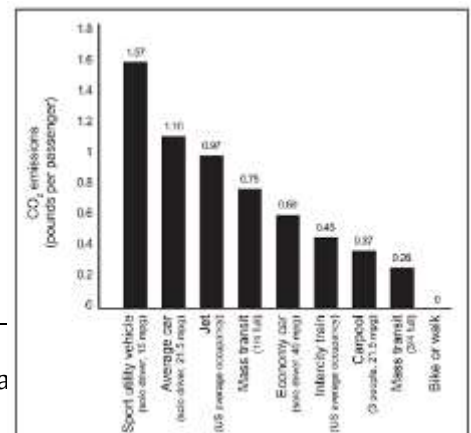


Figure 2. (Source: Sightline Institute)

- While a solo driver in an average car releases about 1.1 pounds of CO2 per mile, a bicyclist releases none. [...]Even a Toyota Prius releases about .6 pounds of CO2per mile (see Figure 2).

Improved Safety

- Increasing the number of cyclists on your streets can save lives. That is what Peter Jacobsen found in his 2003 report “Safety in Numbers”, in which he noted that “motorists adjust their behavior in the presence of people walking and bicycling,” leading to a reduction in the rate of collisions between motorists and bicyclists and walkers.
- Recent data from the Portland Office of Transportation reinforced Jacobsen’s finding: cycling rates soared since the early 1990s while the crash risk per rider dropped by about 70% (see Figure 3).

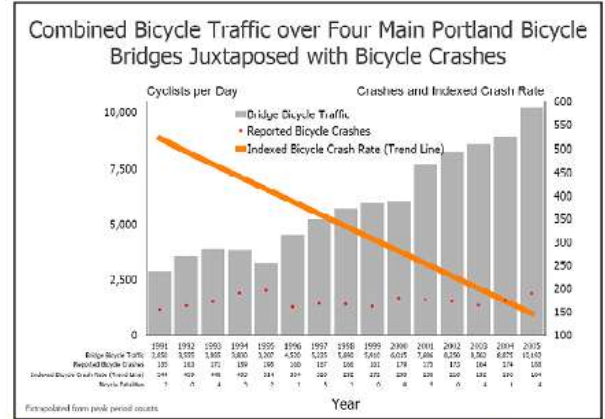


Figure 3. (Source: Portland Department of Transportation)

(Cavill & Davis, 2008b).

- Improved Air quality:
 - 24,000 vulnerable people die prematurely each year and similar numbers are admitted to hospital because of exposure to air pollution from particulates, ozone, and sulphur dioxide, most of which is related to road traffic. Air quality is often worse in more deprived areas and affects vulnerable populations more, exacerbating the symptoms of people with asthma, for example
 - It is often assumed that cyclists (and pedestrians) are exposed to higher air pollution levels than motor vehicle occupants because they are physically unprotected, [...]However, in slow moving traffic, typical of rush-hour traffic, car occupants can be exposed to higher pollutant levels
 - “Cars offer little or no protection against the pollutants generated by vehicle traffic. Road users can be exposed to significantly elevated levels of pollutants as they are, in effect, travelling in a ‘tunnel’ of pollution.
 - Car drivers also suffer up to two to three times greater exposure to pollution than pedestrians in slow moving traffic
- Danger:
 - It has been observed that the greater the motor traffic volumes the lower the levels of non-traffic street activity. This is not surprising since more motor vehicles means more noise and air pollution, and greater perceived risk for those on foot and travelling by bike,
 - A review of 250 20mph zones in England, Wales and Scotland found that crashes involving cyclists had fallen by 29%. In addition, crashes at relatively low speeds (20mph) tend towards less severe injuries and few deaths in contrast to those occurring at speeds of 30mph and above.
- Increased play and activity opportunities for children:
 - The Department of Health recommends that all young people should participate in physical activity of at least moderate intensity for one hour per day [...]. 40% of boys and 60% of girls do not undertake this on most days of the week.

- Some of the reduction in activity levels in recent years has come about because of an increasingly hostile traffic environment, which has contributed to a strong decline in child cycling
- “Children’s need for safe access to a diverse outdoor environment on the front street and opportunities for extending their free range mobility along footpath networks and traffic calmed roads, needs to be incorporated in the estate design and management process.”
- “The sad reality is that most streets are now linear car parks with a central race track.”

(Toronto Public Health, 2012) - Road to Health: Improving Walking and Cycling in Toronto

- Transportation system benefits:

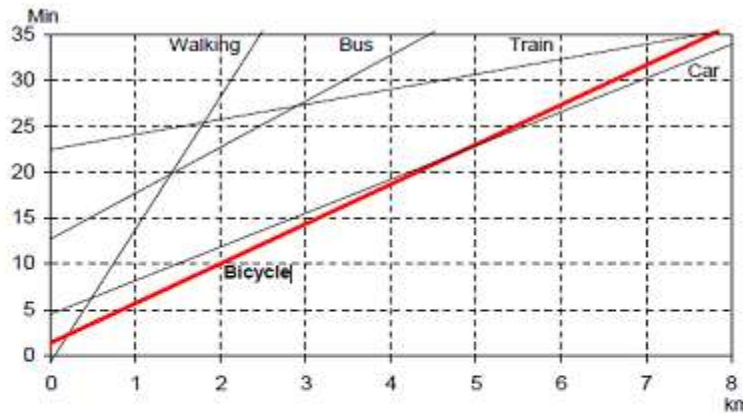


Figure 4: Comparing the speed of different travel modes for different trip distances*

Source: Dekoster and Schollaert (1999)

*The modes depicted in the figure do not all start at 0 minutes because of the time required at the "start-up" of some of the modes. For example, train trips require ~22 minutes to arrive at the station, purchase a ticket and board the train. Alternatively, there is no "start-up time" for walking, which starts at 0.

- Investing in active transportation and public transport can also help to reduce congestion, reduce delays from collisions, reduce the unreliability of travel time, reduce fuel and transport costs and improve residents’ ability to access facilities and services.
 - Seventy percent of Toronto commuters use cars, fuelling consistent traffic congestion in and around the city and metro area. An Organization for Economic Co-operation and Development report estimated that traffic jams cost Toronto \$3.3 billion per year.
 - In the Board’s Scorecard on Prosperity, Toronto was ranked last for commute times and 1th of 23 global cities on transportation.
 - The strain on Toronto’s transportation systems will only increase, as population and employment in the Greater Toronto and Hamilton Area are expected to grow by 50% between 2001 and 2031
- Social, economic and environmental benefits:
 - Active transportation as an alternative to car travel is associated with a number of social benefits, including increased social interaction, social networks and social capital
 - Increasing the mode share of walking and cycling may also contribute to reduced crime.

- Improving the walking environment can increase economic value of local properties. Homes within walking distance of schools, parks and shopping sell for more in the United States.
- ...increases in sale and rental prices of both residential and commercial properties.
- In Toronto, only 66% of adults report a strong sense of belonging to their local community.
- There are also ways in which active transportation generates “net” economic benefits – economic activity that would not have otherwise occurred. For example, cycling expenditures are more likely to remain within the local economy rather than going almost directly to companies out of the city or province (as do expenditures on gasoline).
- Cortright (2007) concludes that Portland keeps \$800 million that would drain out-of-town if local residents drove cars at the same rate as an average U.S. city. By spending less money on gasoline, a higher proportion of Portlanders’ expenditures on goods and services are likely to remain in the local economy.
- Research indicates that investments in cycling infrastructure generate more jobs per dollar spent than investments in road-only infrastructure. Cycling projects create a total of 11.4 local jobs for each \$1 million spent. Pedestrian-only projects create about 10 jobs per \$1 million and road-only projects create 9.6 jobs per \$1 million.
- Investing in active transportation may be a particularly cost-effective way of reducing greenhouse gas emissions. The Intergovernmental Panel on Climate Change (IPCC) suggests that packages of walkways, bikeways and bus/rapid transit could reduce greenhouse gas emissions from light-duty vehicles by 25% at a cost of only US\$33 per tonne of CO₂ equivalent. By comparison, the IPCC estimates that reductions from high-efficiency vehicles would cost less than US\$110 per tonne of CO₂ equivalent.

Best Practices: What policies make a difference?

National – What we’ve discovered and/or implemented

(Canadian Association of Physicians for the Environment, 2012)

How do we make it easier and more convenient for more of us to cardio-commute more often?

- Bike lanes, bike routes, well-lit streets, parks and low-cost recreation facilities
- Traffic calming measures like speed limits <30kph, road humps, pedestrian crossings
- Neighbourhoods with high “walkability” measurements, such as nearby shops, public transit, sidewalks, and fewer single-family homes
- High street connectivity like the classic grid pattern where streets cross at right angles and form small blocks and numerous intersections
- Increased residential and employment density
- Better public transport
- Attractive street and neighbourhood design
- Support from schools and neighbourhood design
- Support from schools and work places, walking school bus programs, available bike racks, change rooms and showers

- Car congestion fees and expensive parking spots

Toronto/Ontario

Ontario Highway Traffic Act (Ontario Highway Traffic Act,)

- \$80 fine for failing to wear helmet on bike (under 18 yrs)
- \$110 fine if carry passenger under 16 is not wearing helmet
- \$110 fine for riding in or along a crosswalk
- \$110 for failing to stop as a cyclist

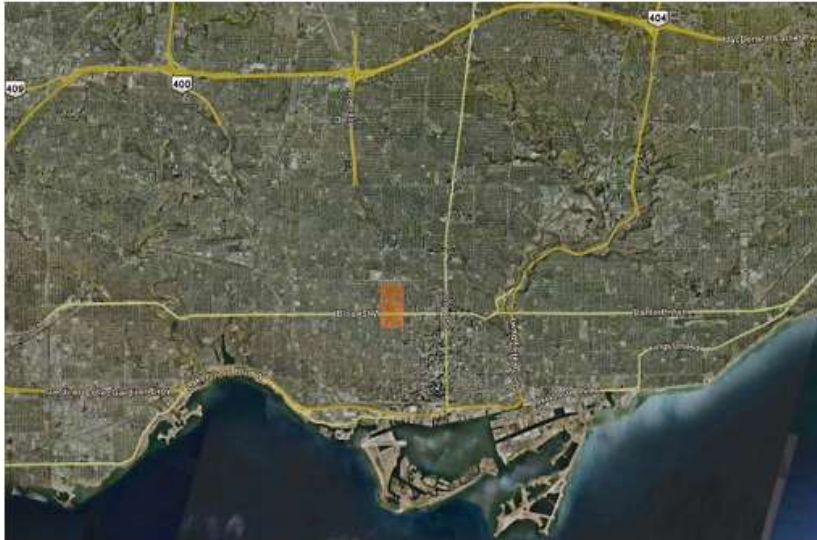
(Clean Air Partnership, 2009) - Bike Lanes, On-Street Parking and Business

- Only 10% of patrons drive to the Bloor Annex neighbourhood;
- Patrons arriving by foot and bicycle visit the most often and spend the most money per month
- There are more merchants who believe that a bike lane or widened sidewalk would increase business than merchants who think those changes would reduce business;
- Patrons would prefer a bike lane to widened sidewalks at a ratio of almost four to one;

(Institute for Clinical Evaluative Sciences (ICES), 2007) - Neighbourhood Environments and Resources for Health Living - A Focus on Diabetes in Toronto

- Outlying areas of Toronto [...] were built largely after the Second World War. Compared to more central parts of the city, these outlying neighbourhoods were more sparsely populated, had poorer access to public transit and retail services, and had higher rates of car ownership. Residents in these areas also reported relatively fewer walking, bicycling and public transit trips per day
- In contrast, the south central part of Toronto and the downtown core had low diabetes rates. Neighbourhoods in south central Toronto were built largely in the pre-war era. [...] characterized by a high population density, mixed residential and commercial land use, dense road and public transit networks and lower rates of car ownership. South central Toronto also had a relatively high number of bicycle lanes. Residents in these areas reported relatively more walking, bicycling and transit trips per day.
- This relationship between low activity-friendliness and high diabetes rates was strongest in “high-risk” neighbourhoods (i.e., those characterized by lower income levels and higher proportions of visible minority residents).
- **Dr. Cavacuiti's Notes:**
- Key Finding: Multiple Risks
 - Many neighbourhoods with high diabetes rates and low AFI also have high proportions of low income and visible minority populations
- Key Finding #3:

- Areas of the city with the highest diabetes rates have among the lowest rates of walking or biking and transit use
- They also score low on our measure of activity
- Key Finding #1:
 - Diabetes rates are the highest in areas that have: lower income levels, a higher proportion of visible minorities, high immigration rates
- Key Finding: Multiple Risks
 - High diabetes areas tend to be outside of downtown and have generally worse: access to resources & activity levels
 - Neighbourhoods are affected differently:
 - Downtown high risk areas have lower diabetes rates than expected
- Wealthy areas have low diabetes rates, no matter their access to resources or activity friendliness.
- ... only 18% of cyclists reported feeling comfortable biking on major roads without bike lanes, whereas 53% reported feeling comfortable cycling on major roads with bike lanes



Map 1. The Bloor Annex neighbourhood (highlighted in orange) within the larger Toronto context

(Source data: Google Earth.)

- Overall, walkers visit the area most often, with 84% visiting more than 5 times per month; followed by bicyclists, 72% of whom visit more than 5 times per month

(Clean Air Partnership, 2010) - New research finds strong support on Bloor Street to remove on-street parking for bike lanes

- 4 out of 5 people surveyed do not usually drive to the area
- Merchants overestimated the percentage of people who drive to Bloor West Village and yet more than half believed that reducing onstreet parking by 50% and adding a bike lane or widening sidewalks would either increase or have no impact on their daily number of customers.

- People who arrive by transit, foot, and bike visit more often and spend more money than those who drive
- People who preferred to see street use reallocated for widened sidewalks or a bike lane were significantly more likely to spend more than \$100 per month than those who preferred no change.
- The majority of people surveyed (58%) preferred to see street use reallocated for widened sidewalks or a bike lane, even if on-street parking is reduced by 50%

(Dotan, 2009) - The Revolution Will Not Be Motorized

“...every single bike lane is a fight right now, as is every pedestrianization initiative and almost every shift towards public transit. We are told we need to prioritize, pick the one or two projects that matter most, and then justify those to everyone with a car and a (mistaken) belief that businesses benefit more from vehicular traffic than that which arrives on foot.”

(HKPR District Health Unit & Health for Life, 2007) - Active Communities Charter

- Work towards building active communities based on following values: *Quality of Life, Health, Accessibility, Inclusion, Community Safety, Community Cohesion and Vitality, & Environmental Sustainability*

(McKeown, 2007) - Air Pollution Burden of Illness from Traffic in Toronto - Problems and Solutions

- Taken together, implementation of comprehensive, integrated policies and programs are expected to reduce total vehicle travel by 30 to 50% in a given community, compared with current planning and pricing practices.

Intervention Studies Related to Reducing Traffic

- During the 1996 Summer Olympic Games in Atlanta, Georgia, a strategy for minimizing road traffic congestion was implemented. An ecological study comparing the 17 days of the Olympic Games to a baseline period of the 4 weeks prior to and following the Olympic Games was conducted (Friedman et al. 2001).
 - The results demonstrate a significant decrease in the number of asthma acute care events (by 42%) in children between the ages of 1 and 16 during this time. Air quality improved with a decrease in peak daily ozone and carbon monoxide by 28% and 19% respectively.
- Studying the effects of relocating individuals from more to less polluted areas also presents a unique opportunity to demonstrate the associated health benefits. Over the duration of a 10-year prospective study of respiratory health and air pollution in children in Southern California, 110 participants moved to a new place of residence.

- Subjects who had moved to communities of lower PM₁₀ showed increased lung function while those who moved to areas of higher PM₁₀ showed decreased lung function (Avol et al. 2001).
- In 2003 the London Congestion Charging Scheme (CCS) was implemented in an effort to reduce traffic density in London, UK.
 - A recent review of the impact of this scheme analysed traffic data and emissions modelling (Beevers and Carslaw. 2005). There was a 12% reduction in both NO₂ and PM₁₀ emissions at the time of the study, and even greater reductions are likely with expansion of the program.
- Overall: Intervention studies provide compelling evidence that reducing vehicle emissions improves health outcomes:
 - An analysis of the impact of air pollution on quality-adjusted life expectancy in Canada reports that a reduction of 1µg/m³ in sulphate air pollution would yield a mean annual increase in quality-adjusted life years of 20,960, a very substantial positive impact (Coyle et al. 2003). It is clear that reducing vehicle emissions will have a significant impact on improved health outcomes. There is an urgent need to implement plans and policies that will work towards mitigating these adverse effects.

Sustainable Transportation Approach

- Implementation of a sustainable transportation system typically focuses on enhancements to transit services, urban form, and behaviour shifts towards becoming more physically active and driving less

Figure 8. Hierarchy of Transportation Users (In Descending Order of Priority)



Source: World Health Organization. 2006. *Promoting Physical Activity and Active Living in Urban Environments*.

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- ...higher density cities spend the least on providing mobility infrastructure for their residents when trips are being made using predominantly public transport, walking and cycling. The proportion of community income used on transportation rises from less than 6% in densely populated cities where most trips are made by walking, cycling and public transit, to 12% in cities where the car is relied upon almost exclusively for transportation.

- Investments that support active transportation result in important social benefits, including better social cohesion, neighbourhood vitalization, and sense of community
 - Some research findings suggest that where safe opportunities exist to walk and cycle, low-income Canadians are more likely to make use of cycling and walking. Therefore, investments that support active transportation result in important social benefits.
- As urban density increases, walking, cycling, and use of transit increases while car travel declines
- Health Promotion Initiative: *The Walking Strategy*
 - The main theme of the strategy is “putting pedestrians first” in future city building. The Walking Strategy will call for a change in mindset from a transportation system designed principally for automobiles to one that places pedestrians at the top of the transportation hierarchy.
- Prepare a Sustainable Transportation Implementation Strategy, drawing from and integrating existing policies and plans (e.g. Official Plan, Bike Plan, Transit City Plan, TTC Ridership Growth Strategy, Walking Strategy)

(Toronto Coalition for Active Transportation, 2008a) - Benchmarking Toronto Bicycle Environment

- When we compare the supply of on-street bike facilities to the total amount of land available in Toronto, we see that very little land is devoted to bike infrastructure – just 0.3 km per km². In comparison, we see as much as 3.4 km in Copenhagen, and about 1.0 km in New York City.

(Toronto Coalition for Active Transportation, 2008b) - Pedaling into High Gear: Lessons from Bike Summit

Complete Streets

- If a municipality can adopt a Complete Streets policy, all the other work involved with creating a bike-friendly city will follow
- In Seattle, where a Complete Streets policy exists, when it's time to reconstruct a street that's in the Bike Plan, the City hosts a complete streets meeting, bringing together various municipal departments like transportation, forestry, signals, utilities, parking, and others. If the route is in the Bike Plan then the bike lane project happens – there is no further debate or opportunity to defer work. Under this system, installing bicycle infrastructure becomes much more routine so that a public debate is not needed for every bike lane installation.

(Ward 20 Cycling Committee, 2010) - List of Priorities

Door Zones

According to the City's Toronto Bicycle/Motor-Vehicle Collision Study (2003): "in the central area of the city, the most frequent type of collision [between bicycles and



motor vehicles] involved a motorist opening their door and striking a cyclist."

Bike Boxes

Bike boxes are marked spaces at intersections that indicate dedicated areas where cyclists can wait when stopped at an intersection (for an example, see the illustration below). Bike boxes can serve a variety of purposes. They can facilitate left hand turns and improve the visibility of cyclists.



Bike boxes could also be used to facilitate "two-point left turns" or "indirect left turns" as in the example pictured below.



Markings through Intersections



Increases cyclist visibility, creates more space for them on the road and through intersections

Protected Bike Lanes



Increases safety, quickest way to implement is to install inexpensive and removable plastic bollards (shown)

(Toronto Public Health, 2012) - Road to Health: Improving Walking and Cycling in Toronto

- The state of active transportation in Toronto:
 - Surveys suggest that official mode shares understate the number of Torontonians for whom walking and cycling are important modes of transportation
 - About 55% of all trips in Toronto are less than 7 km, and are therefore very conducive to cycling. Over 20% of all trips are under 2 km and therefore very walkable.
 - Of relevance to Toronto, cycling is almost as fast as driving for trips of 7 km in urban areas, and walking is generally as fast as driving for trips of 500 m and less.
- Improving active transportation in Toronto:
 - In Toronto's re-developing areas, walking and cycling can be supported through mixed use, higher density development with high route connectivity.
- Transportation and public health have historically been addressed separately by planners and policymakers in Canada. However, it is now recognized that current land use planning and automobile-oriented transportation systems are closely linked to Canadians' low levels of daily physical activity
- Active transportation as a source of physical activity:
 - People who commute by active modes (e.g. walking or biking) get more physical activity than those who commute by inactive modes (e.g. driving).
 - Research indicates that it is also easier to maintain physical activity levels through activities that are incorporated into daily life – such as walking, cycling or using stairs – than through activities that require a gym or recreation centre. “Lifestyle” physical activity interventions that are not “facility-dependent” are more likely to produce longer-term increases in activity levels.
- Active transportation and equity in Toronto:
- Safe walking and cycling opportunities can reduce inequality by enabling individuals without motor vehicles to more easily access goods and services. In Canada, older adults, children, and low-income families are less likely to own cars, and are therefore most likely to benefit from improvements to alternative modes of transportation. Active transportation can also reduce health inequality by improving access to health services and increasing physical activity.
- First, walkable and bikeable neighbourhoods in the former City of Toronto tend to be the least affordable for those with low incomes.
- Second, low-income families often live in high-rise neighbourhoods in Toronto's suburbs. These neighbourhoods are characterized by wide roads, long city blocks, segregated land uses, and clusters of high rise apartment buildings. They frequently feature limited pedestrian and bicycle infrastructure and few public gathering places. Many residents feel uncomfortable walking in their neighbourhood at night.

- The positive association between income and pedestrian safety has been recorded in many American cities. In Montreal, twice as many young cyclists and almost four times as many young pedestrians require medical interventions in the poorest areas than in the wealthiest areas.
- Young and elderly people using active transportation also appear more vulnerable to collisions and fatalities in Toronto:
- Separation from traffic:
 - Cycling and walking are safer and more enjoyable if cyclists and pedestrians are well separated from traffic for the entire length of their journey. The extent and continuity of sidewalks are associated with increased walking and reduced pedestrian-vehicle collisions.
 - Bicycle facilities that separate cyclists from motor vehicle traffic are strongly associated with increased levels of cycling, and reduced crashes and injuries. In the City of Portland, the 210% increase in cycling from 1991 to 2004 is linked to two key factors: the quality of cycling facilities; and the completeness of the bikeway network, including clear connections and near-continuous service. Where the bikeway network was not well connected and not of the highest quality, bicycle use essentially remained at the levels that existed prior to network expansion.
 - As of 2010, Toronto had 17 km of bicycle lanes per 100,000 residents. Montreal and Vancouver had 28 and 38, respectively.
 - Toronto's bike lanes were described as "poor" by 54% of Torontonians and 64% of Toronto cyclists. Over 70% of Torontonians – those who already cycle for transportation and those who do not – reported that separating bike lanes from traffic would most improve cycling in Toronto.
 - Improvements to cycling facilities are also needed to reduce the 30% of Toronto collisions that involve sideswiping, car doors, and rear-ending.
 - Based on surveys, separated bike lanes are viewed as being equally desirable as off-street paths, a testament to their perceived safety.
 - In New York City, the installation of cycle tracks decreased injuries to cyclists and pedestrians by 57% and 29%, respectively.
 - Studies in London found that new cycle tracks decreased the rate of bicycling crashes and increased the number of cyclists on the roadway by 58% over 3.5 years
- Re-allocating space from motor vehicles to active transportation:
 - According to City of Toronto Transportation Services, there are few remaining opportunities to accommodate bicycle lanes on Toronto roadways without reducing traffic capacity or on-street parking. Consequently, in both the downtown and the suburbs, safe cycling facilities will likely require the reallocation of roadway space from on-street parking or motor-vehicle traffic to cyclists.
 - In a study of 62 roadway reallocation projects in eleven countries, 51 of the 62 cases showed a traffic decrease as the overall result, with 11% reductions on average.
 - In New York City, a bold program to reallocate space has transformed Times Square and Herald Square into pedestrian plazas. The change has increased the number of

pedestrians by 11% in Times Square and has decreased injuries to motorists and passengers by 63% in the project area. It has also reduced traffic congestion in the area and increased travel speed along most routes. Finally, the scheme has broad public support; 74% of New York residents agreed that Times Square has improved dramatically as a result of the change.

- In Bloor West Village, nearly half (48%) of those who usually drive to the neighbourhood reported that they would prefer a more pedestrian- or cyclist-oriented street, even if it meant removing on-street parking
- Almost 75% of business owners and managers thought that their business would improve or stay the same with these changes.
- Traffic signal phases:
 - Bicycle phases: A study in Davis, California, found that bicycle phases dramatically reduced automobile bicycle collisions. There were 10 collisions near a focus intersection in the 35 months before the installations of a bicycle phase; in the 35 months following installation there were no collisions at this same intersection.
- Bicycle boxes: In Portland, observations revealed an improvement in motorists yielding to cyclists at bike box locations. Most cyclists report feeling safer with bike boxes. The majority of motorists in Portland also reported that bike boxes made driving safer.
- Making active transportation more attractive
 - Route quality and speed:
 - 39% of Torontonians who do not ride in the winter reported that they would ride more often with safer, cleared bike lanes and paths
 - Pavement quality is very important to cyclists' rating of road segments. The number of cyclists on a path in London doubled after the path was resurfaced
 - Winter reductions in cycling may be countered by snow clearing and sanding or salting of ice along cycling routes, dedicated bike lanes, bike-friendly transit, and education about how to ride safely in inclement weather.
 - Transit integration:
 - All aspects of the Greater Toronto Area's transportation system will face increasing stress as 100,000 people move to the area each year. Avoiding doomsday predictions of total gridlock in the City of Toronto will require significant investments in regional transit, active transportation, and modal integration.
 - Between 1985 and 2006, the number of inbound vehicle trips between 6:30 and 9:30am increased by 75%, and outbound vehicle trips increased by 79%. Many of these vehicle trips are too long to be made by walking or cycling alone, but could effectively be replaced by active transportation in combination with transit.
 - Research supports the possibility of increasing walking-transit trips through targeted investment in the comfort and convenience of these integrated trips.

- Almost all transit users in Toronto walk to and from transit (92%), so it is critical that Toronto ensure safe and convenient pedestrian access to transit.
- Marketing programs:
 - Because of their relatively minimal cost, marketing programs are extremely cost-effective, particularly at the city- or community-level.
- Education programs:
 - In both Germany and the Netherlands, curriculum-based education on safe walking and cycling encourages habitual and safe active transportation in the next generation of citizens
- Enabling active transportation through land-use planning
 - One study found that urban sites with small blocks and extensive sidewalk systems had, on average, three times the pedestrian volumes of suburban sites with long blocks and short, incomplete sidewalk systems. The Transportation Research Board (2009) concluded that doubling residential density reduces household vehicle miles traveled (VMT) by 5-12% in the US. When combined with mixed-use developments and improvements to public transit and employment concentration, VMT reductions reach 25%
 - There is also evidence that street-level urban design significantly increases levels of walking and cycling.
- Making active transportation more accessible
 - Walking and cycling facilities for vulnerable users:
 - Interventions that increase the year-round safety and convenience of walking, cycling and transit use tend to support non-drivers and economically disadvantaged people. Unfortunately, as discussed in Chapter 4, Toronto's current active transportation patterns and facilities appear to create transportation and health inequalities. Young pedestrians in Toronto appear particularly likely to be hit by motor vehicles, while elderly pedestrians are particularly at risk of being killed. Toronto's low-income neighbourhoods may also have lower levels of walkability and bikeability.
 - Traffic calming strategies are particularly valuable for the elderly, for children and for other vulnerable users.
 - Affordable housing in vibrant communities:
 - These trends are apparent in Toronto, where many low-income families often live in the outer areas where active transportation is least feasible
 - Toronto could make a special effort to increase the supply of affordable housing in neighbourhoods with high destination accessibility. Increasing the supply of affordable housing in walkable and bikeable locations may help to address health disparities (Chapter 4).
 - Culturally competent community-based programs:

- In a survey conducted by the Community Cycling Centre in Portland, 60% of respondents expressed concern about the cost of a bicycle, indicating that such an expense would be outside their means.
- Implementing coordinated packages of actions:
 - A coordinated package of complementary infrastructure measures, programs, and policies may enhance the impact of any intervention that is a component of that package.
- Setting goals:
 - Developing quantitative goals that are supported by Council, by City staff, and by community stakeholders have helped other cities increase their effectiveness in promoting safe walking and cycling.
 - Chicago's goals are to increase bicycle use so that 5% of all trips less than 8 km are by bicycle;
 - New York City's goal is to reduce traffic fatalities by 50% by 2030
 - Calgary's goal is to increase the downtown walking mode share to 11% and the downtown cycling mode share to 4% by 2020
- Developing plans, policies and standards
 - For example, the City of Toronto could proactively identify opportunities for pedestrian and cyclist facilities as part of every road reconstruction or resurfacing project. Every "secondary land use plan" is an opportunity to specifically address the needs of pedestrians, cyclists, and users of all ages and abilities. As of 2006, few Toronto secondary plans addressed active transportation.
- Collecting better information:
- Data on walking and cycling in Toronto is severely limited by the Transportation Tomorrow Survey's exclusion of walking trips other than to work or to school.

Other Provinces/Territories

(Vélo Québec, 2007) - Bikeroutes, Greenways and Bicycle Touring

- "If you build it, they will come." The famous quote from the Kevin Costner movie *Field of Dreams*:
 - In France, the numbers show that cycling is more popular among those who live within five kilometres of a greenway and that greenway users are four times more likely to use their bikes for transportation.
- In Quebec, 16% of all cycling is for commuting or transportation purposes. This represents 330 million kilometres a year, which translates into savings of some 30 million litres of gas and 76,000 tonnes of CO₂. [...] Overlooked in environmental rhetoric until as recently as 10 or 15 years ago, bicycles now figure [prominently in most sustainable development initiatives.
- Bikeways that are designed primarily for tourism purposes are often used by locals as well. For example, the Ontario Waterfront Trail has become an important link between a series of

riverfront communities. In the past 10 years, the incidence of practical cycling on the trail has risen from 14% to 24%.

- *“When a town’s population grows from 10,000 to 200,000 in a manner of days during peak tourist seasons, bicycles are instrumental in helping to stave off traffic congestion. France’s Ile de Re, for example, has 50,000 beds and 20,000 bikes for rent. About half of the visitors to the island opt to cycle during their stay.”*

Challenges and Rewards

1. Perception: The first is recognition as an accepted form of routine transportation
2. Funding: Acknowledging the legitimacy of cycling is not enough – it has to be backed by a solid financial commitment to its development
3. Intermodality: With respect to the issue of the overall role of greenways in transportation, Nicolas Mercat pointed out that traffic at a train station increases significantly when it has direct access to a bikeway. Cycling being three times faster than walking, direct access to a bikeway can multiply by nine the distance people are willing to ride to get to the station.
4. Promotion: A growing section of the working population is more likely to consider cycling as a commuting option. They require incentives, facilities and encouragement to seal the deal
 - a. ...160 million Americans who have cycled no longer engage in the activity, in particular because they do not feel safe in traffic

International – What have other countries been doing?

USA

(Nica et al., 2009)

- Infrastructure:
 - Complete 200 miles of bicycle facilities (paths, lanes and routes) over the next three years on NYC streets.
 - Focus on introducing new bicycle paths and improving and maintaining existing ones.
 - Conduct a pilot program of easily identified green-colored lanes to reinforce on-street striped lanes.
 - Install chevron markings, bicycle logos, and special signs for bicycle routes designed to improve how bicyclists and motorists share the road.
 - Accelerate the placement of outside bicycle parking racks citywide.
 - Conduct follow up analyses to better ascertain locations which have disproportionately high fatalities or injuries in relation to exposure. Study these locations for possible safety improvements.
 - Aggressively pursue grant funding for new greenway construction. Upgrade and improve existing greenway infrastructure within City parks.
- Legislation:

- Support state legislation requiring large vehicles to be equipped with cross over mirrors. These mirrors, commonly seen on school buses, increase a vehicle operator's ability to see in front of the vehicle.
- Support legislation to increase the fine for motor vehicles that park in bicycle lanes within city parks.
- Explore the utility of legislation as a means to increase helmet use.
- Improve Data Collection:
- One of the limitations of this study was the incomplete or inconsistent data on bicyclist fatalities and injuries. To improve data collection the City will take the following steps:
 - Train health care providers to better document contributing factors in medical records
 - Submit a proposal to the NYS Department of Motor Vehicles to modify the recording of bicycle crash information on the police accident form. Such a change may lead to improved, more standard documentation of bicycle crash information

(Active Living by Design,)

- Evidence is mounting that automobile-oriented land use policies reduce transportation choice, adversely affect air quality and safety, and discourage physical activity.
- Most communities are designed to favor one mode of travel – the automobile. Building roads, schools, shopping centers and other places of interest only for convenient access by cars often keeps people from safely walking or biking around town.
- How land-use patterns can encourage physical activity:
 - Transit use and walking increase with density and more integrated land uses.
 - Integrated land use can increase the number and percentage of walking and biking trips.
 - Averaging across 11 studies, residents of high walkable neighborhoods reported more than twice as many walking trips per week as residents of low walkable neighborhoods (3.1 daily trips vs. 1.4).
 - Residents in a highly walkable neighborhood engage in about 70 more minutes per week of moderate and vigorous physical activity than residents in a low-walkability neighborhood.
 - Forty-three percent of people with safe places to walk within ten minutes of home met recommended activity levels, while just 27% of those without safe places to walk were active enough to benefit their health.
 - An 11-year study [...] in Seattle [...]found that people increased trips by transit, bicycling and walking as a result of moving into more walkable neighborhoods.
 - A national study of 448 metropolitan counties found that people living in sprawling, low-density counties walk less, weigh more and are more likely to be obese or have hypertension than people living in more compact counties.
- Current land-use plans increase automobile dependency, and resultantly:
 - Between 1982 and 1997, urban land density in the U.S. dropped by more than 20% [...] Population grew 17% while the amount of urbanized land increased 47% and vehicle miles traveled increased 55%.
 - Average urban land densities are roughly one-tenth what they were before motorized transportation.
 - The number of walking trips children take to school declined 60% since 1977.
 - Less than 15% of students between ages of five and 15 walk to or from school and 1% bike, compared to 48% of students walking and biking to school in 1969.

(McGrath,)

- Governments and citizen groups seeking to promote bicycle transportation in the United States traditionally have employed what are known as the “Five E’s”: engineering, education, enforcement, evaluation and planning, and encouragement.
 - *“In the following sections we will review evidence supporting a few of E’s, including engineering, education and encouragement, and also an important variable that is not currently counted among the Five E’s: land use.”*

Engineering (bike lanes, parking)

- Nelson and Allen’s aptly-name study *If You Build Them, Commuters Will Use Them*. The authors found that every new mile of bikeway per 100,000 people is associated with a .069 percent increase in bicycle commuting. More recent investigations by Dill and Carr and Barnes strengthen the case that bike lanes lead to more people riding more often.
- Conversely, it appears that the installation of new automobile capacity can depress walking, biking, and transit rates.
- Bicycle lanes have benefits beyond merely stimulating riding. They contribute to more traffic flow, are liked by cyclists, and create a safer riding environment.

Education (cycling classes, motorist awareness programs) and Encouragement (events, promotion campaigns)

- The State of Washington’s Commute Trip Reduction (CTR) program [...] requires large employers to develop and implement a program to encourage employees to choose modes of travel other than the single-occupant motor vehicle.
 - In workplaces with over 100 full-time employees, one person is designated as an “employee transportation coordinator”: He or she distributes informational material about transportation options and company-led incentives for non-single occupant vehicle commuting.

Land Use

- Density – or the number of people or jobs in a given area – is a key determinant of driving and bicycling rates. The denser a city, the less its residents tend to drive and the more they tend to walk, bike, or use transit.

(League of American Bicyclists, 2007) - **March/April 2007. League of American Bicyclists**

- Bicycle-friendly communities edition
 - Judged based on the 5 E’s: Engineering, Education, Encouragement, Enforcement, Evaluation & Planning
 - Given one of four ratings: platinum, gold, silver, bronze
- Single Platinum: Davis, CA
 - Education:
 - “City residents voted to get rid of public school buses many years ago, so many children walk or bike to school. There is a comprehensive local bike map with

tips and resources on the back, and the university offers BikeEd courses and has League cycling Instructors on staff.”

- Encouragement:
 - Bicycle volumes are so high on campus that there is a car lockdown during class changes
 - Bicycling is so core to this community’s identity that the city’s logo is a bike
 - In the process of establishing a west coast bicycle museum
 - Davis has had a city/university bike map in one integration or another since the 1970s
 - Map is updated every few years, contains routing/distance/travel time on one side, and bike-ed info on the back
 - Map is free, and distributed through the city, university and local bike shops
- Enforcement:
 - The community lowered the fines for cycling offences to encourage police officer to increase enforcement. The local police officers give away blinking rear lights to people who don’t have them.
- Engineering:
 - Davis has bike lanes on approximate 95 percent of all its arterials and collectors
 - Has 27 grade separations for bicycles and pedestrians
 - Invested heavily in cycling before it was common to do so – they had identified the “quality of life” issues even before they were a part of national dialogue
- Evaluation:
 - There are more bikes in Davis than there are cars, and 17% of trips are by bike
 - The only US community that has two full-time bike coordinators, staff, and two bike advisory committees
 - They had developed their own guidelines before any national guidelines existed (California Dept of Transportation later based their guidelines loosely off of Davis)

(Active Living by Design,) – Primer

Mixed Land Use and Opportunities for Physical Activity

- For trips less than one mile, mixed-use communities generate up to four times as many walking trips per week as low-walkability neighborhoods.
- Residents in a highly walkable neighborhood engage in about 70 more minutes per week of moderate and vigorous physical activity than residents in a low-walkability neighborhood.

Transportation Policies Make a Difference

- People who report having access to walking/jogging trails are 55% more likely to be physically active.

- Walking trips increase with good connectivity of the street network, a greater number of intersections and blocks, and streets with low speeds that are narrow and visually interesting.

The Impact of Accessible Parks, Trails and Greenways

- In a survey of U.S. adults, people with access to neighborhood parks were nearly twice as likely to be active as those without access.
- Greenways have contributed the most to community quality of life through health and fitness, followed by access to natural areas and recreation, land use patterns, pride in the community and community identity.
- Walking trails may be beneficial in promoting physical activity among women and people in lower socioeconomic groups.
- Greenways can have positive effects on cities by protecting open space, attracting investment, revitalizing cities, reducing personal stress and protecting the environment.

England/UK

Sharing Road Space (Granville et al., 2001)

- In the words of TRL (1997), “the implication would seem to be that informational strategies alone are insufficient to change behaviour significantly”.
- Thus, to effectively encourage greater incidence of cycling, a three pronged strategy should be implemented:
 - supplying information to the individual and society promoting the benefits of cycling and
 - informing them on the costs of other forms of transport, plus a change in the attitudes other road users have towards cyclists;
 - encouraging employers, colleges and other organisations to make it easier for people to cycle while giving cycling equal status with the car;
 - making cycling safer, therefore reducing the biggest perceived deterrents to uptake

(Ogilvie, Egan, Hamilton, & Petticrew, 2004)

- “We found some evidence that targeted behaviour change programmes can change the behaviour of motivated subgroups, resulting (in the largest study, TravelSmart) in a shift of around 5% of all trips at a population level.”
 - *These programmes aimed to change people’s travel behaviour by offering an intervention only to a motivated subgroup of the population or by offering information and advice tailored to people’s particular requirements, or both*
 - Volunteers participating in trials experienced short term improvements in certain measures of health or fitness after taking up active commuting. Single studies of commuter subsidies and a new train station have also shown positive shifts of 1% and 5% of trips, respectively.
- “The balance of best available evidence about agents of change, publicity campaigns, engineering measures, and charging road users suggests that they have not been effective...”

(McGrath,)

How much change is possible?

- In a 2001 report, Roger Mackett of the U.K.'s Centre for Transport Studies found that in the urban areas he studied in England, about 7% of automobile trips could be shifted to walking or biking through infrastructure improvements and social marketing. Litman and VTPI found that even more change is possible. They estimate that percentage of trips taken by bike or on foot could be increased to 10-35% if infrastructure improvements and social marketing is combined with market reforms such as accurate pricing parking for cars.

(Cavill & Davis, 2008b).

- A Norwegian study of pedestrian and cycling track networks in three cities reported that the net benefit/cost ratio for each was: 4.09 in Hokksund; 14.34 in Hamer; and 2.94 in Trondheim. The author concluded that: "The investment in walking and cycle track networks in the three Norwegian cities appear to be highly beneficial to society."
 - An important point, longer term, is that a shift towards streets where a 'critical mass' of cyclists and pedestrians were allocated a more equitable portion of road space would lead to lower motor traffic speeds and volumes, and a reduction in the risks to cyclists per kilometre travelled
- Case study: Odense
 - 35 million new trips by bicycle (or 25,000 new cycling trips per day)
 - A 20% increase in cycling, which now accounts for a share of 25% of urban trips
 - More than half of the new trips being substitutes for trips that would have been undertaken by car
 - A 20% reduction in road traffic injuries involving cyclists, in spite of the overall increase in cycling
 - 500 years of lifetime added to the total lifetime of the citizens of Odense, corresponding to five months longer life for males
 - A 20% mortality reduction among those aged 15-49
 - A DKK 33 million saving (€4.5 million) resulting from the health gains achieved through the project.
- Case study: York City Council priorities
 - Over time, this has led to a reduction in road casualties well above the national average. The priorities are set out below:
 - 1. Pedestrians
 - 2. People with disabilities
 - 3. Cyclists
- The hierarchy reviews and challenges a widely held – if generally unconscious – bias towards car travellers in transport planning practice.

(Cavill & Davis, 2008a)

- Case studies (PCTs promoting cycling):
 - Liverpool PCT is one of the few to employ a full-time cycling officer to promote cycling and coordinate a programme of led rides for priority target groups.
 - Nottingham: developing an innovative approach to promoting cycling through working with NHS Health Trainers, who will be encouraged to offer cycling as a core part of their public health work alongside issues such as smoking prevention and promotion of healthy eating.

- Bolton: working closely with cycling and mental health charities to offer ten week led ride programmes to mental health service users. The programme offers the opportunity for participants to rediscover the joy of cycling and the benefits to their mental wellbeing in a safe and supportive environment.
- Northamptonshire: The “Easy Rider” programme will offer guided leisure cycling rides, access to cycles at low or no cost, and transport for cycles to safe places to ride.

(Northern Ireland Cycling Initiative, 2008) – Planning for Cycling

- The Atkins report also considered there “to be a poor understanding of the links between interventions and outcomes, particularly for public transport, walking, cycling etc.”
 - We conclude that a lack of evidence is hindering both the effective planning for cycling and could be a cause of weaker political will.
- According to national data, the majority of adults agree that everyone should be encouraged to cycle to assist their health (87%), help the environment (79%) and ease congestion (73%). Around 37% of people agree that that they could easily walk or cycle on journeys they currently make by car. Further there is public support for taking measures to improve conditions for cyclists. Just over two-thirds (68%) of respondents agree that 'cyclists should be given more priority', while only 11% felt that 'cycle lanes on roads simply reduce space'
- It is important to note that the greatest impact that cycling has is on the health benefits of additional cyclists.
- Unless planners and developers are aware of the full economic benefits it is difficult to ensure that the costs and benefits of cycling investment will be considered fairly.

(The Times, 2012) - The Times Cities fit for Cycling manifesto

The Times is committed to achieving its eight point manifesto calling for cities to be made fit for cyclists.

1. Lorries entering a city centre should be required by law to fit sensors, audible turning alarms, extra mirrors and safety bars to stop cyclists being thrown under the wheels.
2. The 500 most dangerous road junctions must be identified, redesigned or fitted with priority traffic lights for cyclists and Trixi mirrors that allow lorry drivers to see cyclists on their near-side.
3. A national audit of cycling to find out how many people cycle in Britain and how cyclists are killed or injured should be held to underpin effective cycle safety.
4. Two per cent of the Highways Agency budget should be earmarked for next generation cycle routes, providing £100 million a year towards world-class cycling infrastructure. Each year cities should be graded on the quality of cycling provision.
5. The training of cyclists and drivers must improve and cycle safety should become a core part of the driving test.
6. 20mph should become the default speed limit in residential areas where there are no cycle lanes.
7. Businesses should be invited to sponsor cycleways and cycling super-highways, mirroring the Barclays-backed bicycle hire scheme in London.

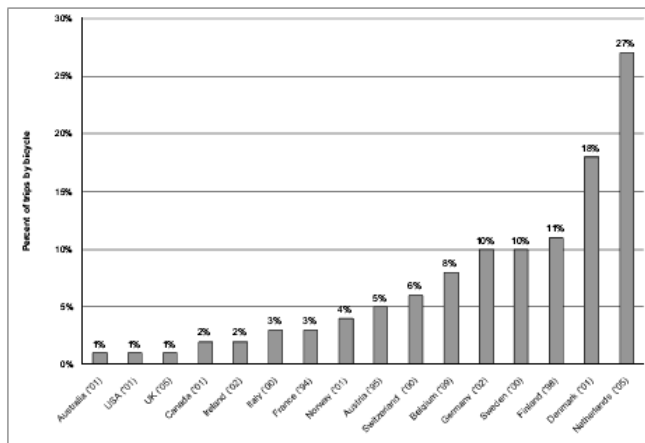
8. Every city, even those without an elected mayor, should appoint a cycling commissioner to push home reforms.

Other Europe

(Francis & Justason, 2010)

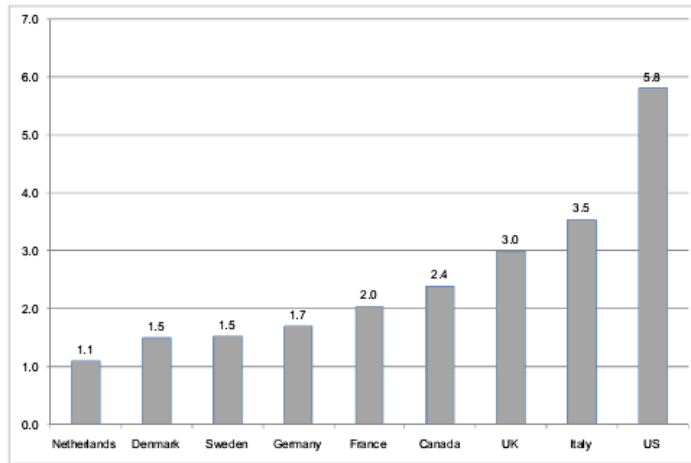
- “With the agency in place, British Columbia looked to Sweden for a model. Sweden had a 35 year history of injury prevention programs and in that time has reduced injury deaths to half the Canadian rate. The Swedish model is based on a three-pronged approach: injury surveillance and prevention research; providing a safer environment for children through legislation and regulation; and (coalitions to promote) a broad-based safety awareness and education campaign.”
- Major Recommendations:
 - Mandatory Helmet Legislations (Enacted in 1996)
 - Education and Awareness Programs in Conjunction with Helmet Legislation
 - Include focus on safety and protection of pedestrians from cyclists
 - Stress that many injuries are due to inattention or negligence
 - Include dangers of stereo headphone use while cycling
 - Visibility of cyclists at night/low-light situations
 - Specific focus on truck driver trainings + truck mirror configurations
 - Reserved bike lanes
 - Laws enforcing property owners to maintain clear sight lines at sidewalks/driveways
 - Determine age at which children are mature enough to understand rules to follow rules → therefore can traverse busy traffic conditions, etc.
 - Conduct pilot study over several years, investigating all motor vehicle bicycle-related accidents with a view to developing a better understanding of their causation → this will allow you to be in a better position to develop safe driving and safe cycling programs and educational materials

(J. Pucher & Buelher, 2007) – **World Transport Policy and Practice**
Introduction



● **Figure 1: Bicycle share of trips in Europe, North America (Percent of total trips by bicycle)**

- Only about a fourth of bike trips in these three countries are for purely recreational purposes, compared to three three-fourths of bike trips in the USA (U.S. Department of Transportation, 2003).
- Women make 45% of all bike trips in Denmark, 49% in Germany, and 55% in the Netherlands.
- Children and adolescents have the highest rates of cycling in almost every country.
- Finally, rates of cycling are similar among different income classes in these three countries, with the number of bike trips per day falling only slightly with increasing income. In short, cycling in the Netherlands, Denmark, and Germany is for women as well as men, all age groups, all income classes, and all trip purposes.
- The phenomenon of ‘safety in numbers’ has been consistently found to hold over time and across cities and countries.



- **Figure 3: Bicycling fatality rate in European countries, Canada and the US (2002)**
- On the contrary, in the Netherlands, with the safest cycling of any country, less than one percent of adult cyclists wear helmets, and even among children, only 3-5% wear helmets (Dutch Bicycling Council, 2006; Netherlands Ministry of Transport, 2006).

Amsterdam, Netherlands

- By comparison, car use is difficult in the central city. There are few car parking spaces, and many cul-de-sacs and one way streets hinder car travel.
- Fifty percent of Amsterdam’s inhabitants made daily use of their bikes (City of Amsterdam, 2003a). Over 85% of Amsterdam’s residents rode their bike at least once a week in 2003.
- First, the affluent cycle more than the poor in Amsterdam.
- Bike planners in Amsterdam speculate that lower income groups see the car as an important status symbol, while they view the bicycle as a “poor man’s” vehicle. Consequently, they prefer to drive instead of cycle.
- Recent immigrants and their children also cycle less than the average resident of Amsterdam.
- Finally in 1978, a newly elected city council focused on bicycling as an integral tool for solving the city’s transport problems.
- Amsterdam is used for all trip purposes: for 34% of work trips, 33% of shopping trips and 27% of leisure trips in 2003.

- Dutch traffic laws protect young cyclists and put the responsibility for an accident on the car driver.
- Amsterdam had about 775 km of traffic calmed streets in 2000.
- During peak hours on workdays, up to 10,000 bikes were parked at Amsterdam Central Station in 2006.
- The bike rental fee is included in the price of the car parking ticket.
- Similar to Germany, Dutch school children go through bicycle training in school.
 - Bicycles are made available to schools by the city government for free so that children who do not own a bicycle can learn at school how to cycle safely in Amsterdam.

Groningen, Netherlands

- The compactness of Groningen is not an accident but resulted from strict land use plans that limited the type of sprawled, low-density development that would have greatly increased trip distances and required more car use.
- For local trips within Groningen, the bike share of trips is 59%.
- It is now possible to cycle from several outlying residential areas directly to the city centre without having to stop at even one traffic signal, greatly speeding up bike travel between outlying residential areas and work, shopping, and the university in the centre.



Traffic signal enabling four-way all-green crossing for cyclists in Groningen, avoiding all possible conflicts with turning cars

Source: Peter Berkeley

- There are separate traffic signals for cyclists, and cyclists usually get advance green lights.
- Cyclists are also allowed to make right turns at intersections when the traffic signal is red, while car drivers cannot.
- Cyclists are permitted to make right or left turns at many intersections where they are - prohibited for cars. That gives cyclists greater flexibility in the routing of their travel.
- Cyclists and pedestrians have absolute priority in the city centre

- Much of Groningen's city centre is off limits to cars. It is not possible for cars to pass through the city centre from one end to the other.
 - Speed limits are reduced to 30km/hr or less.
- The main way that Groningen promotes cycling is not through any special marketing gimmicks but rather by providing superb cycling facilities and restrictions on car travel.

Copenhagen, Denmark

- Indeed, a third of Copenhagen's road transport budget is earmarked for cycling facilities and programs
- The city's focus now is on improving safety at intersections, since that is where most serious crashes occur. Increasingly, the city is installing advance stop lines for cyclists, priority traffic signals, and bright blue marking of bike lanes crossing roads.
- Copenhagen bike planners have a strong preference for separate paths over on-street lanes on major roads.



Green wave for cyclists on this major street in Copenhagen, synchronized at 20km/hr. Note the specially protected path, with a curb separating the path from the lanes for motor vehicles.

Source: Niels Jensen, City of Copenhagen

- Another innovative program in Copenhagen is the Bicycle Account, a bi-annual survey of cyclists (City of Copenhagen, 2004 and 2006). Every two years cyclists themselves evaluate the actual performance of the bicycling system in the city, and provide suggestions for its improvement.

Odense, Denmark

- Since 43% of children reach school by bike. Recently, Odense introduced the world's first interactive cycling trainer for children to help them improve their cycling skills in traffic (www.b-game.dk/demo.php).



Green wave for cyclists in Odense, with bright green lights flashing on bollards just to the right of the lane to indicate correct cycling speed to achieve all green lights at intersections

Source: Troels Andersen, City of Odense

-
- Finally, bike lanes and paths are promptly cleared of ice and snow with a special vehicle that sprays a salt solution onto the riding surface. That facilitates winter cycling.
- There are no direct routes for cars to pass through Odense's city centre from one side to the other. In effect, that restricts traffic to vehicles with destinations in the city centre instead of just passing through
- Above all, cyclists strongly endorsed priority traffic signals for cyclists at intersections and synchronised green wave lights adjusted to cyclist speeds; improved and better maintained surfaces of the existing cycle paths and lanes; and expanded and improved bike parking facilities.

Berlin, Germany

- *Germany is especially interesting for this examination of cycling policies precisely because the country does not have a long tradition of cycling, certainly nothing even approaching the bicycling culture of the Netherlands. Moreover, Germany has a much higher level of car ownership and use than the Netherlands and Denmark*
 - *Germany is home to some of the world's most important car manufacturers (Volkswagen, Daimler-Benz, Audi, Porsche, BMW), which together represent a very strong lobby for highways and cars.*
- Today's share of all trips made by bike is 10%, which can be considered high given the cold winters, the automobile oriented transport policies implemented in the past, and the population size of the city.

- The main driving forces for promoting bicycling in Berlin were environmental pollution and air quality considerations, but also the city's worsening financial crises. Promoting bicycling and expanding cycling infrastructure is relatively cheap compared to building roads or rail transport infrastructure.



- *Most residential neighbourhoods in Berlin are traffic calmed in this way, providing ideal conditions for cycling. Indeed, 72% of all streets are traffic calmed, with speed limits of 30km/hr or less. Cyclists and pedestrians have as much right to use these streets as motorists.*
- In 2000, the city established a dedicated annual funding source for bicycling infrastructure by introducing a special bicycling budget of €1.5 million per year. In 2006 the bike budget increased to €2.5 million per year and is expected to increase even further to €3 million in 2008.
- As in most German cities, school children have to take part in cycling training and pass a test with real police between 3rd and 4th grade.
- Separate facilities for bikes are only deemed necessary at roads with a speed limit of 50km/h or more and with automobile traffic volume of at least 10,000 cars per day. Overall, more than half of all heavily trafficked roads in Berlin have bike facilities (750km out of 1450km).

Muenster, Germany

- Perhaps even more important, police ticket motorists who endanger bicyclists or otherwise disobey traffic laws intended to promote pedestrian and cyclist safety.
- 12 streets are officially designated as bicycling streets (Fahrradstrassen), where the entire width of the street is intended for cycling, but where motor vehicles are usually permitted provide they travel at cyclist speeds and do not endanger cyclists,
- Of particular note is the famous bike/walk Promenade, a 4.5-km car-free beltway that encircles the old town of the city and serves as connector and distributor for 16 bike paths radiating outward toward the suburbs and 26 routes leading to the city centre and Cathedral Square



• Typical traffic signal in Muenster, where cyclists usually get an advance green light ahead of motorists

• Source: Peter Berkeley

- Many non-arterial residential streets - especially in new residential areas - are yet further traffic calmed, with speed limits of 7 km/hr. They are designated as “Spielstrassen” (play streets), which are equivalent to the Dutch “Woonerf” and the British “Home Zone.” Traffic signs clearly notify motorists that they must share the street with pedestrians, cyclists, and playing children, who have traffic priority over cars on such streets.
- Many intersections also have advance stop positions for cyclists, in front of waiting cars, thus giving them a head start in crossing the intersection, increasing both the speed and safety of cycling.
- ...car travel is often detoured by artificial dead-ends and deliberate street blockages of various sorts, reducing the speed and convenience of car travel.
- It is not possible for cars to pass from one end of the city to the other through the town centre. That forces car traffic to take circumferential routes and helps mitigate the congestion, environmental, and safety problems that the additional through-traffic would cause in the city centre.
 - New car parks have been built near the edge of the city centre, with motorists encouraged to park their cars there and then to walk, bike, or take a bus to the centre.
 - On-street parking is usually restricted in duration and its price rises sharply with proximity to the city centre. The restricted supply and high price of parking obviously discourage car use and increase the relative convenience of cycling.
- Cycling promotion initiatives in Muenster:
 - Annual bicycling festivals that promote the environmental advantages of bicycling
 - Annual awards to firms that do the most to increase bicycling among their employees

- the bicycle was chosen as the official symbol of the city during the celebrations marking 1200 year anniversary of the founding of Muenster in 793
- Bicycling is the dominant transport mode for women as well as men and among all age groups, professions, and income classes.

Conclusions and Policy Implications

- Bicycling is the dominant transport mode for women as well as men and among all age groups, professions, and income classes.
- Europe’s best bicycling cities strive constantly to make things even better for cyclists and thus to raise yet further their already very impressive cycling levels.
- ” At least one advantage of its financial distress is the stark realisation that cycling is the most economical mode of transport, in addition to being environmentally and socially sustainable.”

Table 1: Traditional measures used in virtually all Dutch, Danish, and German cities to promote cycling

Extensive systems of separate cycling facilities
• Well maintained, fully integrated paths and lanes
• Connected off-street short-cuts, such as mid-block connections, and passages through dead ends for cars
Intersection modifications and priority traffic signals
• Advance green lights for cyclists
• Advanced cyclist waiting positions (ahead of cars) fed by special bike lanes facilitate safer and quicker crossings and turns
Traffic calming
• Traffic calming of residential neighborhoods via speed limit (30km/h) and physical infrastructure deterrents for cars
• "Home Zones" with 5 km/h speed limit, where cars must yield to pedestrians and cyclists using the road
Bike parking
• Large supply of good bike parking throughout the city
Coordination with public transport
• Extensive bike parking at metro, suburban, and regional train stations
• Bike rentals at train stations
Traffic education and training
• Comprehensive cycling training courses for school children
• Special cycling training test tracks for children
• Stringent training of motorists to respect pedestrians and cyclists
Traffic laws
• Special legal protection for children and elderly cyclists
• Strict enforcement of cyclist rights by police and courts

Source: Information provided directly to authors by bicycling coordinators in the Netherlands, Denmark, and Germany.

(Wardlaw, 2002) - Assessing the actual risks faced by cyclists

- A cycling culture exists in France. There is mutual respect and toleration between cyclists and drivers. Perceived danger when cycling is low, since drivers may be relied on to compensate near cyclists.

Asia

(Cherry, 2007) - Electric Bike Use in China and Their Impacts on the Environment, Safety, Mobility and Accessibility

- The National Road Transportation Law classifies electric bikes as “bicycles” that can operate in the bicycle lane and is not subject to laws governing other motorized modes, such as license, insurance and helmet requirements. The General Technical Standards limits size and speed so that electric bikes can operate safely in the bicycle lane. These standards are poorly enforced and most SSEBs do not adhere to the maximum weight or speed requirements. A recent movement among the industry has been to reclassify electric bikes as Light Electric Vehicles (LEV), which will give them more latitude to develop larger and faster two and four wheeled vehicles.
- Many cities are facing difficult policy decision related to electric bike regulation. Several cities, including Beijing, Guangzhou and Fuzhou have or are attempting electric bike bans. Many policy makers feel that electric bikes are too fast to safely operate in the bicycle lane and too slow to safely operate in traffic lane.
 - “Also to the extent that they displace car trips, they improve the safety of the transportation system in Chinese cities.”
- ...if an electric bike user would otherwise choose a car; there could be net environmental and mobility advantages in choosing an electric bike as an alternative. If they would otherwise choose a bicycle, then electric bike use could result in net environmental advantages, but mobility disadvantages.
- In Shanghai and Kunming, electric bike users take more trips and travel farther than users
- Lead pollution is the most problematic environmental problem with electric bikes. They use approximately one battery set every 10,000 kilometres.

Table 4: Lifecycle Environmental Impact Per Passenger Kilometer Traveled^d

	Energy Use (kWh/100 pax- km)	CO ₂ (g/pax- km)	SO ₂ (g/pax- km)	PM (g/pax- km)	CO (g/pax- km)	HC (g/pax- km)	NOX (g/pax- km)	Pb ^b (g/pax- km)
Car ^c	140	306	0.689	0.277	10.06	1.67	1.32	0.299
Bus	13.06	48.4	0.022	0.065	0.159	0.015	0.270	0.005
Bicycle	4.88	4.70	0.014	0.059	Unkn	Unkn	Unkn	0.000
BSEB	6.12	22.08	0.123	0.125	Unkn	Unkn	0.027 ^d	0.710
SSEB	8.42	30.44	0.164	0.175	Unkn	Unkn	0.020 ^d	1.013

^a Assuming lifespan of 1,000,000 km, 20,000 km, and 50,000 km and average load factors of 50 pax, 1 pax, and 1 pax for bus, bicycle and electric bike, respectively.
^b Assuming one battery every 10,000 km for electric bikes and one battery every 3 years or 250,000 kilometers for buses.
 Note: some fields are Unknown (Unkn) because data are not available for the emission of these pollutants from production processes and/or power plant emissions
^c Sullivan et al. 1998-LCA of Generic US Car
^d Only Use phase emission rate, no production processes included
 Note: some fields are Unknown (Unkn) because data are not available for the emission of these pollutants from production processes and/or power plant emissions

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