EVIDENCE DEMONSTRATING THE EFFICIENCY, SAFETY & ECONOMIC BENEFITS OF LOWER MAXIMUM SPEED LIMITS IN ASHLAND, OREGON

Abstract

Lower maximum speeds will reduce deaths, injuries, and pollution and will lead to increased bicycling and walking with their associated health benefits. Ashland households, taken as a whole, that chose to shift from driving to walking or bicycling, will save more than $1 million per year.

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We recommend that the City Council:

i. Direct the Public Works Department to pursue reducing maximum speeds within the City to the maximum extent allowed by Oregon Revised Statute 810.180, and
ii. Request that the Southern Oregon legislative delegation ensure that Ashland is included among the jurisdictions which would be empowered, as Portland currently is, to set speed limits on roadways under the City's jurisdiction pursuant to a reintroduced HB 4103 (2020 legislative number).

Below, we outline empirical evidence showing a 5mph speed reduction promotes significant improvements not only in transportation system safety, but efficiency as well — including the counterintuitive result of reduced traffic congestion. We also show that such change would require minimal initial investment and generate substantial economic returns.

The contributors of this report are indebted to the original research and writing undertaken by Steve and Michelle Porter of Bend Economic Research. Their work is reproduced here with permission. The Ashland specific analysis has been added but the bulk of the report is credited to Steve and Michelle who we wish to publicly thank for their contribution to the safety, welfare, and health of all Oregonians and the planet earth.

This report denotes the original research by utilizing a vertical line adjacent to sections written by Steve and Michelle Porter (see first two paragraphs, above). Where the word "Ashland" has been substituted for the word "Bend" or numbers changed to reflect figures for Ashland instead of Bend but the balance of the section is otherwise consistent with the original text the vertical line is retained (as in the first paragraph).

SUMMARY

It is tempting to dismiss the difference between 25mph and 20mph speed limits as marginal and unimportant. However, volumes of data indicate the contrary, showing that dramatic social and economic gains follow from that 5mph reduction.

For one, **significant improvements in transportation system safety occur**. When 20mph speed limits are installed in urban and residential streets, citywide risks of serious injury and fatality among pedestrians and cyclists drop by 40% and 30%, respectively. These and similar effects elevate both actual and perceived safety levels for all transportation system users.

With those changes in safety levels, modal substitution rates increase. Data show that as speed limits approximate 20mph, a "tipping point" is reached where widespread adoption of non-vehicle transport occurs. This has a profound effect on vehicle miles traveled (VMT) in 20mph systems. A decrease in Ashland's speed limits from 25 to 20mph would be expected to reduce VMTs by about 5%, or almost 3 million miles annually.

It is estimated that $764,212 in annual savings would result from reduced traffic collisions in Ashland under a reduced maximum speed limit system. Other economic consequences include reduced fuel usage and pollution levels. Slower traffic speeds, lower VMTs, and increased rates of walking and cycling improve public health and generate economic gains. Reduced annual fuel consumption would be anticipated with saving to Ashland's households of $305,554 per year. Additionally, reduced climate inducing CO_2 emissions would fall by 1,070 metric tons.

It is clear that a reduced maximum speed limit system would quickly pay for itself since implementation costs are estimated at about $100,000.

All told, if Ashland were to make a commitment to slower maximum speed limits in a manner consistent with Oregon Revised Statute 810.180 and enforce those speed limits adequately, it would stand to generate annual economic savings of more than $1 million – for a one-time implementation cost of approximately $100,000.

The following report details empirical research and calculations supporting each point in the above summary. Naturally, all findings are subject to certain data limitations and may be revised in the event additional information becomes available. This report accordingly may be best viewed as preliminary; nevertheless, reasonable professional care has been taken to ensure accuracy and, where applicable, conservatism in estimation.

INTRODUCTION

Over the last few decades, hundreds of municipalities, encompassing tens of millions of residents in North America and Europe, have adopted 20mph speed limits. Cities including Washington, D.C., New York City, Seattle, and, as of April 2018, Portland, Oregon,[1] are among them, as are smaller towns, with populations similar to Ashland's.[2]

These cities form natural laboratories for assessing the policy. Substantial quantitative research has taken place across them to evaluate traffic mortality rates, pollution levels, and transportation system throughput, among many other variables. There is accordingly a wealth of " real-world" empirical evidence drawn from locales that have made 20mph their system-wide default speed limits.[3]

"Reductions in vehicle travel speeds can be achieved through lowered speed limits, police enforcement of speed limits, and associated public information. More long-lasting speed reductions in neighborhoods where vehicles and pedestrians commonly share the roadway can be achieved through engineering approaches generally known as *traffic calming*. Countermeasures include road humps, roundabouts, other horizontal traffic deflections (e.g., chicanes), and increased use of stop signs. Comprehensive community-based speed reduction programs, combining public information and education, enforcement, and roadway engineering are recommended."[4]

The evidence shows that all participants in a transportation system are benefited by reduced speed limits, and, of equal importance, no participants are made materially worse off. Such findings demonstrate a high level of efficiency associated with implementation of 20mph default speed limits: the transportation system is made unambiguously better in a 20mph regime since no one must incur losses in order to confer benefits on others.

[1] New York City was the first U.S. city to adopt a 20mph program, which it did according to a zoning approach in which certain zones adhere to the 20mph standard while others do not. Under this approach, traffic deaths fell for three consecutive years, declining by approximately 23% in total. Portland's implementation of the 20mph program reduces speed limits on "non-arterial residential streets, which comprise about 70 percent of the city's street grid." New signs were posted citywide in April 2018.

Lazo, L., "As Traffic Deaths Soar, Cities Pursue Lower Speeds to Eliminate Fatalities," *The Washington Post* (February 25, 2017).

Nius, E., "Portland City Council Approves 20 mph Speed Limit on Residential Streets," *The Oregonian* (January 18, 2018).

Seattle Department of Transportation Website, "20 MPH Zones" (accessed May 2018).

[2] 20mph is the default speed limit in most European towns, as well as many towns in the UK, encompassing all population sizes.

[3] In the context of Ashland, the terms "system-wide" and "default" are meant to refer to the majority of roads in Ashland currently designated with 25mph speed limits, in a manner consistent with Oregon Revised Statute 810.180: "A road authority may establish by ordinance a designated speed for a highway under the jurisdiction of the road authority that is five miles per hour lower than the statutory speed," subject to certain considerations and limitations. Roughly 184.7 lane-miles in Ashland are estimated to be immediately eligible for 20mph limits.

[4] W.A. Leaf and D.F. Preusser, Literature Review on Vehicle Travel Speeds and Pedestrian Injuries Among Selected Racial/Ethnic Groups, October, 1999 https://one.nhtsa.gov/people/injury/research/pub/hs809012.html

Findings associated with 20mph speed limits will be thematically presented as follows: 1) Safety; 2) Traffic Congestion; 3) Fuel Consumption; 4) Carbon Emissions; 5) Road Capacity and Infrastructure Spending; and 6) Public Health. Where sufficient data are available, the economic implications of transition to 20mph speed limits will be evaluated within each of these areas. Finally, conclusions following from these analyses will be presented.[5]

DISCUSSION

1. Improved Safety for All Transportation System Participants

Improved safety outcomes extend from automobile drivers and their passengers to pedestrians, cyclists, and residents in 20mph systems, affecting essentially all those using the transportation system and living or working near it. These benefits derive from reduced traffic collisions, diminished severity of crashes, and decreases in non-traffic crime levels. Each element is addressed in turn, and a detailed evaluation of collision reduction is provided.

The most salient gauge of transportation system safety is found in the quantity of traffic collisions that occur. An ideal system would generate zero collisions and feature safeguards such that, if one were to transpire, it would be of the least serious type. A statistical relationship has been observed between traffic speed changes and corollary changes in the number of crashes. It shows that a decrease in average traffic speed from 25mph to 20mph (which represents a 20% reduction in speed) is associated with:

- a 45% decline in fatal collisions;
- a nearly 30% decrease in collisions resulting in serious injury; and
- a 20% reduction in collisions resulting in minor injury.[6]

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[5] In general, the analysis of social and economic effects relating to 20mph speed limits evaluated in this report can be thought of as reflecting an "average" level of implementation, including placement of 20mph signage along with some measures of public education, enforcement, and traffic calming. "Average" implementation reflects the typical level of signage and ancillary supportive policies adopted by localities moving to 20mph speed limits.

[6] It can be noted, as a logical matter, that actual traffic speeds need not necessarily change just because posted speed limits change. While this is true, it has been empirically observed that 1) a proportion of traffic does adhere to posted limits; 2) a portion of traffic that does not adhere to posted limits tends to "anchor" its speeding against the posted limit (e.g., these speeders will exceed whatever the limit is by X mph); and 3) when posted traffic speed limits change, the average traffic speed changes along with it, in the range of nearly 100% of the change (i.e., if the speed limit declines 5mph, then so will the average traffic speed decline 5mph) to 25% of the change. Due to non-linearity and feedback effects, even 25% of a 5mph decline in average speeds (i.e., a 1.25mph reduction) that brings traffic closer to 20mph can have profound safety and efficiency consequences. When enforcement or traffic calming is added alongside speed limit reductions, compliance is further enhanced.

Elvik, R., "The Power Model of the Relationship Between Speed and Road Safety: Update and New Analyses," Institute of Transport Economics, Norwegian Centre for Transport Research (2009).

"Vision Zero: How Safer Streets in New York City Can Save More Than 100 Lives a Year," Drum Major Institute for Public Policy and Transportation Alternatives (June 2011).

Standalone empirical observations (detailed below) that relate to cities adopting 20mph speed limits corroborate these findings. A 20mph default speed limit brings transportation systems closer to a collision-free ideal.

In addition to reduced collision counts, the severity of any collisions that do occur also declines, with a disproportionately large decrease in the worst types of automobile accidents that result in death or serious injury.[7] This favorable redistribution occurs because of the non-linear relationship between speed and crash severity.[8] As speeds approximate 20mph, mortality and injury risks dramatically decrease in collisions, an effect that will be detailed below. In summary, at lower speeds, drivers have more time to react to events precipitating possible collisions, improving odds of avoiding accidents, and the harm of any crash that does happen is reduced.[9]

This section will focus on statistics showing the level of safety improvement in 20mph systems as reflected by crash counts and severity. These numbers are among the most reliably tallied and studied quantitative elements of transportation systems and therefore provide a useful starting point for understanding the safety implications of 20mph speed limits.[10] They are not, however, comprehensive.

Notwithstanding the limitations of traffic collision and mortality statistics in reflecting safety gains associated with 20mph systems, representative statistics are outlined below showing traffic safety improvements that

[7] Sammer, G. and F. Wernsperger, "Results of the Scientific Investigation Accompanying the Pilot Trial of 30 kph Limit in Side Streets and 50 kph Limit in Priority Streets," The 23rd European Transport Forum: Proceeding of Seminar G: Traffic Management and Road Safety (September 1995).

[8] Grundy, C., et al., "Effect of 20mph Traffic Speed Zones on Road Injuries in London, 1986-2006: Controlled Interrupted Time Series Analysis," *British Medical Journal*, Vol. 339 (2009).

[9] Two empirical studies observe a "spillover effect" where reduced speed limits on targeted roads lead to reductions in speeding on roads with unaltered speed limits. This implies broader life-saving implications for 20mph speed limit systems than those reflected in analyses solely addressing collisions on 20mph streets and, indeed, evidence shows that, once 20mph speed limits are established on a critical mass of streets, fatalities on non-20mph streets fall by an average of 8%, up to 11.5%. (Archer, J., et al., "The Impact of Lowered Speed Limits in Urban and Metropolitan Areas," Monash University Accident Research Centre (2008). Grundy, C., et al., "Effect of 20mph Traffic Speed Zones on Road Injuries in London, 1986-2006: Controlled Interrupted Time Series Analysis," *British Medical Journal*, Vol. 339 (2009).)

[10] Statistics in this section derive from numerous studies that reflect findings from New York City and the UK, where the most empirical work has been done to evaluate 20mph speed limit safety. Importantly, these regions all reduced speed limits to 20mph from 30mph, rather than from 25mph as would be done in Ashland. This has the logical effect of causing reported statistics to likely overstate the level of collision and mortality reductions that would be observed in Ashland following 20mph implementation. These figures nevertheless provide important reference points relating to 20mph speed limit safety and, in all events, provide useful directional evidence showing the relationship between 20mph speed limits and road collisions, deaths and serious injuries.

have occurred upon adoption of 20mph speed limits. As applicable, discussions of specific factors underpinning these reductions and implications for Ashland are provided.[11]

Pedestrians

Pedestrian involvement in killed-or-seriously-injured collisions ("KSI collisions") has been shown to decrease by 39% to 50% in 20mph systems.

The fatality risks to pedestrians decline as speed limits fall toward the 20mph mark because of the non-linear relationship between pedestrian risk and vehicle speed in collisions. This speed-safety link is illustrated in Figure 1, originally published in the "Cities Safer by Design" manual of the World Resources Institute, based on OECD research. A clear inflection point can be found when vehicle speeds exceed 20mph, shown on the graphic at 30kph. (Since the graphic derives from research conducted in OECD countries, it uses the international standard kilometers per hour ("kph") instead of mph; a speed of 30kph is approximately equal to 20mph, a speed of 40kph is approximately equal to 25mph, and a speed of 50kph is approximately equal to 30mph.)

The implications of non-linearity in pedestrian mortality risk vis-a-vis automotive speed are striking. It has been found that a pedestrian in contact with a vehicle traveling 30mph is *eight times more likely to die* than in a collision with a vehicle traveling 20mph.[12] Across speeds ranging from 25mph to 20mph, it is shown that each 1mph difference in vehicle speed reduces fatality risk by about 6%, such that a pedestrian's fatality risk *doubles*

[11] The following studies are cited in this section:

Webster, D. and A. Mackie, "Review of 20mph Zones in London Boroughs," Transport Research Laboratory (2003).

Sammer, G. and F. Wernsperger, "Results of the Scientific Investigation Accompanying the Pilot Trial of 30 kph Limit in Side Streets and 50 kph Limit in Priority Streets," The 23rd European Transport Forum: Proceeding of Seminar G: Traffic Management and Road Safety (September 1995).

Department for Transport, "Interim Evaluation of the Implementation of 20mph Speed Limits in Portsmouth" (2010).

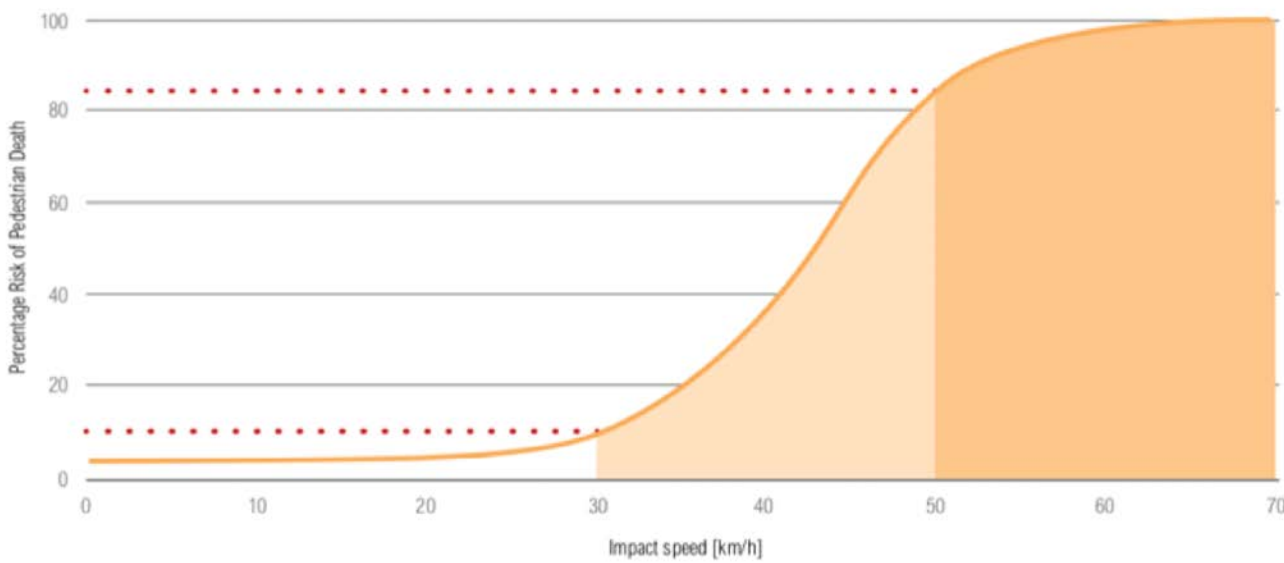
"Road Safety Factsheet: 20mph Zones and Speed Limits Factsheet," Royal Society for the Prevention of Accidents (November 2017).

Department for Transport Traffic Advisory Leaflet 9/99 (June 1999), "20 mph Speed Limits and Zones."

New York City Department of Transportation Website: "Motorists & Parking, Neighborhood Slow Zones" (accessed June 2018).

[12] "Vehicle Speed and Pedestrian Age Determine Crash Outcomes," ***Status Report*** (Insurance Institute for Highway Safety/Highway Loss Data Institute), Vol. 35, No. 5 (May 2000).

Figure 1



Note: The above figure shows the relationship between pedestrian fatalities and vehicle impact speed published by the OECD (2006). Some recent studies show a similar relationship, but account for sample bias to find slightly lower risks in the 40 to 50 km/hr range. (Rosen & Sander 2009, Tefft 2011, Richards 2010, Hannawald and Kauer 2004) There are not, however, studies from low- and middle-income countries where things like vehicle type, emergency response time and other characteristics may influence this relationship. In any case, there is clear evidence to support policies and practices that lower vehicle speeds to 30 km/hr where pedestrians are commonly present, and no more than 50 km/hr on non-grade separated streets.

with an impact speed increase from 20mph to 25mph. Seemingly marginal reductions in traffic speeds within the crucial speed range of 20mph to 25mph have robust impacts on pedestrian mortality.[13]

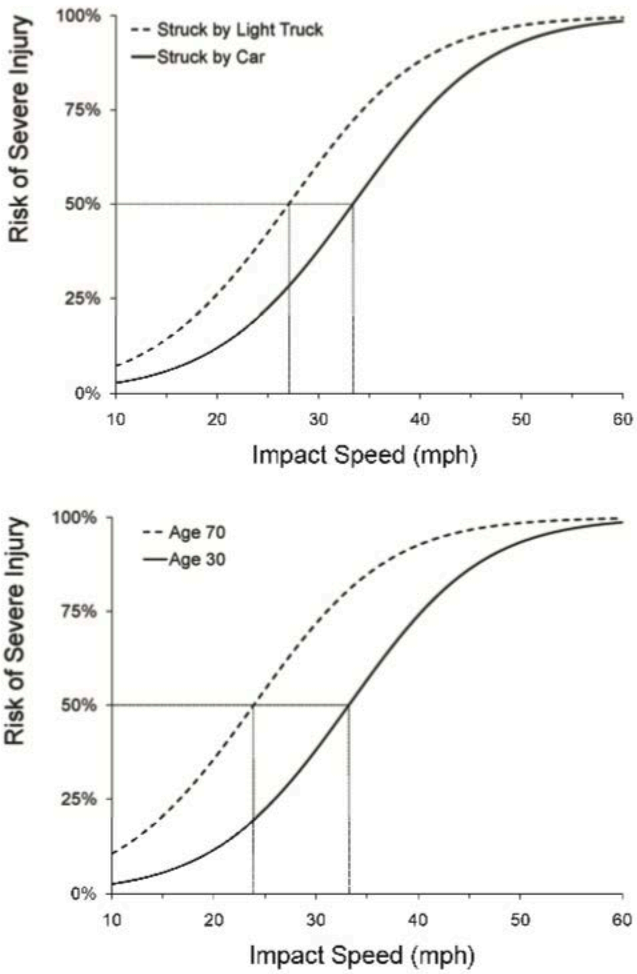
Beyond fatalities, severe injuries among pedestrians also are substantially mitigated with 20mph speed limits. And, as with fatality risk, a non-linear relationship between injury risk and automotive speed is observed, with a critical inflection point in the slope occurring around 20mph. Figure 2 shows two representations of empirical data, both of which illustrate pedestrians' risk of severe injury plotted against vehicle speed. The top graphic highlights the significance of vehicle type, showing that light trucks (including pickups and SUVs) are more inimical to pedestrians than passenger cars since trucks tend to knock down and then run over victims, while cars tend to roll victims over the windshield, the former being much more damaging to a human body. The second graphic highlights the significance of pedestrian age, showing that the elderly are particularly endangered in collisions.[14]

[13] Barrios, L., "Killing Speed," Injury Prevention, Vol. 6 (2000).

Tefft, B., "Impact of Speed and a Pedestrian's Risk of Severe Injury or Death," ***AAA Foundation for Traffic Safety*** (September 2011).

[14] Tefft, B., "Impact of Speed and a Pedestrian's Risk of Severe Injury or Death," ***AAA Foundation for Traffic Safety*** (September 2011).

Figure 2



These findings are emphasized here because both have critical importance for Ashland. In the first instance, Ashland traffic is heavily populated by light trucks and SUVs, consistent with broader trends in the U.S. [15] In the second instance, Ashland's elderly population is large and growing, owing to Ashland's prominence as a retirement destination. Ashland's senior citizen population increased 29.5% from 2010 to 2019, [16] now comprising 22% of the populace. The over-65 population in Jackson County is forecast to grow to almost 30% of the population by 2035 and 37% by 2065 compared to 20.1% in 2015. [17] This places special duty on Ashland's transportation system to meet the safety needs of this cohort of users. For these reasons, emphasis should be placed on these vehicle-type and age-related findings, and additional consideration should be given to the severity of light truck collisions involving the elderly, mortality and injury statistics for which are not available.

The foregoing logic and empirical results are distilled into summarized findings of a review conducted by the U.S. Department of Transportation into the nexus between traffic speed and pedestrian risk, regardless of vehicle type or pedestrian age. As illustrated in Figure 3, a critical threshold of traffic speed is found at 20mph, a speed above which is found a surge in pedestrian fatality and injury.[18]

Figure 3

[15] Carey, N., "Trucks, SUVs Shine in Mixed January Sales, Cars Less So," *Reuters* (February 1, 2018).

[16] U.S. Census Quick-Facts (accessed 12/7/2020)

https://en.wikipedia.org/wiki/Ashland,_Oregon#Demographics

[17] https://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1005&context=opfp (accessed 11/25/2020)

[18] "Literature Review on Vehicle Travel Speeds and Pedestrian Injuries," U.S. Department of Transportation, National Highway Traffic Safety Administration (October 1999).

Vehicle travel speed and pedestrian injury severity.
(Florida, 1993-1996; pedestrians in single-vehicle crashes)

Injury Severity	Travel Speed (Officer Estimates) 1-20 mph	21-25 mph	26-30 mph	31-35 mph	36-45 mph	46+ mph	Total
Fatal (K) injury	1.1%	3.7%	6.1%	12.5%	22.4%	36.1%	6.5%
Incapacitating (A)	19.4%	32.0%	35.9%	39.3%	40.2%	33.7%	27.0%
Nonincapacitating (B)	43.8%	41.2%	36.8%	31.6%	24.7%	20.5%	38.8%
Possible inj (C) or none	35.6%	23.0%	21.2%	16.6%	12.7%	9.7%	27.7%
Total frequency	13,368	1,925	2,873	2,188	2,493	906	23,753

An acute relationship between pedestrian well-being and traffic speed is well established. At speeds above 20mph, collision incidence rates are higher and those collisions result in worse and more likely fatal injuries. Research conducted in connection with pedestrian risk of mortality and severe injury therefore emphasizes the importance of keeping pedestrian activity removed from high-speed traffic (i.e., traffic traveling much above 20mph), and the most straightforward way of separating pedestrians from high-speed traffic is by reducing traffic speeds to acceptably safe levels (i.e., approximately 20mph) on residential and urban roads.[19]

Children

Children are especially susceptible to roadway injury and death, in part because of their smaller stature and in part because of their undeveloped physiology. It has been demonstrated that children do not perceive approaching vehicles or process that information in the same manner as adults, so they tend to misjudge traffic and be struck by automobiles. Crucially, it has been found that children cannot reliably detect an automobile approaching at speeds over 25mph, with better perceptivity at lower speeds.[20]

This fact, on its own, argues strongly in favor of system-wide 20mph speed limits, particularly in Ashland, where more than 3% of the population is under 5 years old, and 16.1% is under 18 years old.[21]

Consistent with these observations, empirical studies have found that 20mph speed limits are associated with dramatic reductions in child KSI collisions, with observed declines in the range of 45% to 67%.

Bicy*clists*

The rate of bicyclist involvement in KSI collisions decreases 29% to 50% with 20mph speed limits.

[19] Tefft, B., "Impact of Speed and a Pedestrian's Risk of Severe Injury or Death," *AAA Foundation for Traffic Safety* (September 2011).

[20] Wann, J., et al., "Reduced Sensitivity to Visual Looming Inflates the Risk Posed by Speeding Vehicles When Children Try to Cross the Road," *Physiological Science*, Vol. 22, No. 4 (2011).

[21] United States Census Bureau, "Ashland, Oregon QuickFacts" (accessed June 2018).

Drivers

Depending on the particulars of 20mph speed limit implementation, reductions in vehicular crashes of any type range from 15% to 50%. Additionally, collisions in which drivers are killed or seriously injured decrease in the range of 31% to 57%. Elderly driver injuries decline by approximately 50%.

Passengers

Passengers in automobiles are similarly benefited. A reduction in passenger deaths of 31% has been found in 20mph systems, and elderly passenger injuries have been shown to decline by 40%.

Motorcyclists

Motorcyclists experience 68% to 79% declines in casualties.

Economic Implications of Reduced Collisions

It is manifest that a human life defies economic valuation. Human health and well-being are similarly incalculable in worth. From a moral perspective, it may be stated that the loss of a single human life or the erosion of one person's well-being due to traffic accident outweighs any financial consideration; if a life can be saved through improved traffic management and planning, it should be done without resorting to amoral and base cost-benefit analysis of the type that assumes a human's death can somehow be compensated by fast enough traffic flows.

Notwithstanding these views, in the interest of completeness, it is appropriate to mention research that has estimated the economic costs associated with traffic collisions. Fatal crashes result in approximately $1.4 million in economic costs each, and crashes involving serious injury cost roughly $1.0 million per injured survivor. Medical costs and lost productivity comprise the majority of these financial losses, with additional contributions to cost coming from property damage and traffic congestion. Collisions in which only property damage occurs (i.e., those with no fatalities or injuries) carry an average cost of roughly $3,900 each.[22]

Applied to Ashland's traffic collision statistics, these economic values can be used to estimate costs that would be saved through implementation of 20mph speed limits. Over this approximate five-year span, the fatal collisions carried an imposed cost of $3.3 million; major injury collisions cost approximately $1 million. Conservatively, assuming zero medical or lost productivity costs for Level C injury collisions and property-damage collisions, costs of remaining traffic collisions equaled about $10 million.[23] Total calculated costs are therefore approximately $14.4 million, or about $2.9 million per year.

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[22] Blincoe, L., et al., "The Economic and Societal Impact of Motor Vehicle Crashes," U.S. Department of Transportation, National Highway Traffic Safety Administration, DOT HS 812013 (May 2015 (Revised)).

[23] Level B and Level C injuries may well implicate medical attention and productivity losses. Level B injuries are "visible injuries" that include those "evident to observers at the scene of the crash" such as "a visible lump, abrasions, cuts, bruises, minor lacerations, etc."

Were Ashland to achieve average collision reductions via implementation of 20mph speed limits, it would be expected to experience total economic savings of approximately $0.76 million annually.[24] The particulars of those savings are as follows.

First, Ashland would experience a reduction in fatal injuries of roughly 45% (from two every five years to one during a five-year period). This would save approximately one life every five years and reduce economic losses by about $1.5 million during a five-year period ($298,620 annually).

Second, collisions generating Level A injuries would be expected to decrease by about 30% (from 11 to 7.7 over five years), resulting in saved costs of $317,460 ($63,492 annually).

Third, remaining collisions would be anticipated to decline in incidence by about 20% (i.e, from (95+255+355) = 705 to 564), reducing economic losses by slightly more than $2 million ($402,000 annually).[25] These calculations are summarized in Table 1.[26]

The City of Ashland's geographic information system (GIS) accident data shows 1,064 compared to the ODOT statistics, as used in Table 1, of 718. Importantly, the City's GIS data shows that 14% of all accidents involved a pedestrian or a person riding a bicycle.

Level C injuries "include momentary unconsciousness, complaint of pain, limping, nausea, etc." U.S. Department of Transportation, Federal Highway Administration, "KABCO Injury Classification Scale and Definitions" https://safety.fhwa.dot.gov/hsip/spm/conversion_tbl/pdfs/kabco_ctable_by_state.pdf (accessed November 25, 2020).

[24] Importantly, this analysis assumes that "but-for" collisions (i.e., collisions that will occur in the future if not for speed limit interventions) will not increase over time; any increase in but-for collision incidence would cause life and financial savings associated with 20mph speed limits to increase proportionately.

[25] Many of these collisions are subject to self-reporting and do not generate police involvement. It is likely the actual counts of such collisions exceed reported numbers, and it may be further speculated that a share of these unreported crashes is attributable to speed-related factors.

[26] Due to safety spillover effects from 20mph to non-20mph roads, safety-related network effects associated with modal substitution, and reduced VMTs, reductions in fatalities, injuries, and non-injury collisions would not occur solely on 20mph speed limit streets. On the basis of statistical evidence, it would be expected that essentially all KSI collisions on urban local roads would be eliminated, with smaller percentage reductions along collector and minor arterial streets.

Table 1.
Ashland Estimated Collision Savings with 20 MPH Speed Limits

	Baseline 1 (A) [27]	20 MPH Estimate (2) (B)	Reduction (C) (A - B)	$ Loss per Collision (D)	Estimated Annual Savings (C) X (D) / 5
Fatal Injury Collisions	2	1.1	0.9	$1,659,000	$298,620
Class A Injury Collisions	11	7.7	3.5	$96,000	$63,492
Class B Injury Collisions	95	74.1	20.9	$27,800	$105,640
Minor Injury Collisions	255	204.0	51.0	$22,800	$232,560
Property Damage	355	284.0	71.0	$4,500	$63,900
TOTAL	718	570.9			$764,212

Notes:

(1) Baseline values reflect 5-year totals 2015 through 2019
(2) Column (B) calculated as (Column (A) x (1 – 0.45)) for Fatal Injury Collisions; (Column (A) X (1 – 0.3) for level A injury Collisions; and (Column (A) X (1 – 0.2) for all other injury types

2. Reduced Traffic Congestion

When system-wide speed limits are reduced to 20mph, the speed reductions are associated with decreases in traffic congestion, rather than increases. This effect stems from two parallel mechanisms. The first relates to increased uptake of walking or cycling, which results in the removal of cars from roads. The second relates to the improved utilization of roadway resources when drivers operate at lower speeds. These two processes play a role in explaining how vehicle travel times in Ashland would be negligibly - if at all - changed with 20mph speed limits.

Increased Walking and Cycling Decrease Traffic Congestion

When additional people walk or cycle for transport, those people undertake a simple substitution – walk or cycle rather than drive – and thereby reduce vehicle miles traveled in the transportation system. Owing to this

[27] ODOT Crash Data Statistics, https://zigzag.odot.state.or.us/uniquesig08615cf883bed667d26bcec3a7dc5c6b/uniquesig0/SecurezigzagPortalHomePage/ for "all roads in Ashland" (accessed 12/07/2020),

substitution effect, the removal of cars and VMT from the transportation system is directly reflected by increases in walking and biking, growth in which has been observed at rates up to 36% following implementation of 20mph speed limits.[28]

Such large increases in non-automotive modalities, and attendant decreases in vehicular roadway demand, accumulate over time through a positive feedback loop. First, reduced automotive traffic speed limits induce more people to walk or cycle because lower speed limits improve the real and perceived levels of safety for non-automotive transportation. Since the propensity of residents to walk or cycle, rather than drive, is based upon factors of "safety, perceptions of safety, the condition of the surfaces and the overall appearance of the…environment,"[29] as actual and perceived safety increase – in lockstep with reductions in speed limits – more people forgo car travel, thus freeing up roadway resources and reducing congestion.[30]

Second, as additional commuters take to sidewalks and bike lanes, safety levels for pedestrians and cyclists rise further. This is because, as pedestrian and cycling activity increase, drivers become more attuned to their presence, and danger levels fall. Empirical studies show the "likelihood that a given person walking or bicycling will be struck by a motorist varies inversely with the amount of walking or bicycling," as shown in Figure 4.[31]

[28] Bristol City Council, "Monitoring Report: 20mph Speed Limit Pilot Areas" (2012).

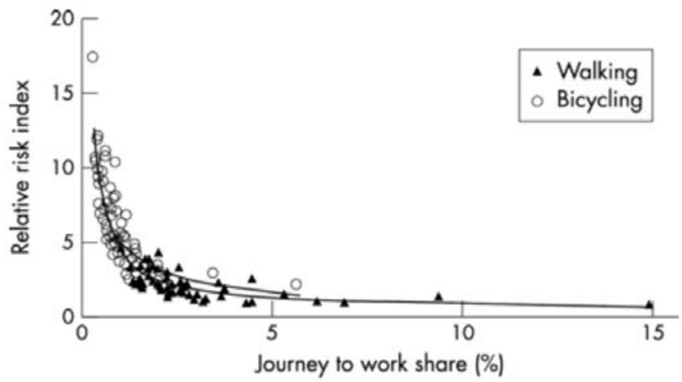
This increase in walking and cycling occurred in connection with implementation of 20mph speed limits and development of additional walking and cycling infrastructure like construction of additional sidewalks. Hence, it has not been determined to what extent the modal substitution can be attributed to speed limit changes. It will be discussed shortly, however, that such increase is consistent with the economics of network effects and empirical observations regarding pedestrian and cyclist safety.

[29] Tovar, M. and Kilbane-Dawe, "Effects of 20mph Zones on Cycling and Walking Behaviours in London," Par Hill Research Ltd. (2013).

[30] From an economic perspective, in addition to a shift in relative safety levels, a 20mph regime also induces walking and cycling uptake because it alters the opportunity costs associated with driving relative to walking or cycling. This is because a lower speed limit network reduces the average speed differential between driving and non-driving modes.

[31] Jacobsen, P., "Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling," ***Injury Prevention***, Vol. 9 (2003).

Figure 4



That is, as more people walk and cycle, the safer it becomes for everyone to walk and cycle, exhibiting a phenomenon known as "network effects" (i.e., the value of walking or cycling increases for all pedestrians and cyclists as each incremental person substitutes from driving to a non-driving mode).[32] This follow-on improvement in real and perceived safety for pedestrians and cyclists induces yet more uptake, which engenders additional network effect benefits, causing traffic levels and congestion to fall further.[33] Crucially, walking and cycling complement each other, with higher rates of either walking or cycling leading to reduced risk for both pedestrians and cyclists.[34]

As summarized by researchers in the U.K.:

> A 20 mph speed limit, properly enforced, would go a long way to removing the present deterrents to cycling. There would be gains both to the cyclists who now brave the present unsatisfactory conditions and to would-be cyclists, now frustrated, who would feel enabled to join them…[and] other road users would gain from reduced congestion.[35]

Consistent with these modal substitution mechanisms, empirical evidence shows reductions in vehicle transport are substantial upon 20mph adoption. Following reduction of road speed limits to 20mph, system

[32] Liebowtiz, S.J. and S. Margolis, "Network Externalities (Effects),"

[33] "Vision Zero: How Safer Streets in New York City Can Save More Than 100 Lives a Year," Drum Major Institute for Public Policy and Transportation Alternatives (June 2011).

[34] "The statistics show that bike riders actually protect pedestrians by altering the behavior of drivers." Sadik-Khan, J. ***Streetfight***, Viking (2016).

[35] Plowden, S. and M. Hillman, ***Speed Control and Transport Policy***, Policy Studies Institute (1996), Ch. 10.

traffic volumes were observed in one empirical study to decrease, on net, by an average of 15% across 250 measured locales.[36]

A separate analysis of traffic volume responses to the implementation of 20mph speed limits found that net system traffic volumes decreased in the range of 5.3% to 13.4%, depending upon particulars of the implementation such as the extent of 20mph speed limit deployment (i.e., system-wide, resulting in greater traffic decreases, versus zoned), enforcement levels, and other contemporaneous traffic calming measures.[37] Importantly, for reasons including network effects associated with non-driving modes and other time-dependent feedback mechanisms, these traffic reduction levels may be best viewed as short-run consequences, with larger reductions likely over longer intervals when follow-on effects have fully matured.[38]

Quantification of Expected VMT Reductions in Ashland with 20mph Speed Limits

These findings provide useful reference for understanding the directional relationship between speed limits and VMTs as well as the general magnitude of VMT responsiveness to implementation of 20mph speed limits. They can accordingly be used to estimate the effects a 20mph speed limits would have on traffic volume in Ashland. Care must be taken, however, in applying the empirical findings' results to Ashland because, in the 20mph speed limit areas subjected to empirical study of traffic volume change, all underwent speed limit reductions from 30mph to 20mph (i.e., a 10mph reduction) and therefore twice the reduction applicable to the instant analysis. Translating the findings to Ashland's circumstances requires consideration of several observations, each of which is discussed below.

First, it is significant that the speed limit reduction from 30mph to 20mph encompasses the speed limit reduction applicable to Ashland (i.e., 25mph to 20mph). The experience of these converted 30mph zones is relevant and enables an initial estimate to be made of VMT responsiveness in Ashland as follows. The

[36] This net reduction figure accounts for route displacement effects. The majority of traffic was found not to circumvent the lower speed limit zones; rather, the traffic simply disappeared, a concept that is sometimes referred to as "reduced demand." The levels of traffic volume reduction are highly variable region to region and appear to depend principally upon the level of commitment made to a 20mph regime: generally, the greater the adoption rate (i.e., closer to system-wide rather than on a zone-by-zone basis, more enforcement and greater implementation of other traffic calming measures, the greater the reduction in traffic volumes). This finding is entirely consistent with the economics of induced demand and the law of demand. (See: Department for Transport Traffic Advisory Leaflet 9/99 (June 1999), "20 mph Speed Limits and Zones.")

[37] Steer Davies Gleave, "Research into the Impacts of 20mph Speed Limits and Zones, (November 2014).

[38] Research relating to VMT responses to road infrastructure changes show that full demand responses tend to mature after approximately three years, while most traffic reduction research evaluates shorter-term responses, often of just one year.

Noland, Robert B. and Lewison L. Lem, "A Review of the Evidence for Induced Travel and Changes in Transportation and Environmental Policy in the US and the UK," *Transportation Research Part D*, 7 (2002).

Litman, Todd, "Generated Traffic and Induced Travel: Implications for Transport Planning," Victoria Transportation Policy Institute (April 17, 2017).

approximate midpoint of observed traffic volume reductions is 10% (i.e. 5.3% to 15%), implying an average 1% traffic volume reduction per 1mph of speed limit reduction within the 30mph to 20mph range. This suggests that a 5mph speed limit reduction would be met with approximately 5% of VMT decline; such level of response might well be expected in Ashland.

Second, it is pertinent to ask whether the relationship between speed reduction and VMT response within the 30mph to 20mph range is linear (i.e., 1% VMT reduction per 1mph speed reduction across the whole range) or whether there are reasons why VMT responsiveness might increase or decrease across the range in non-linear fashion. The mechanism underpinning VMT reduction is modal substitution, and modal substitution rates are modulated by actual safety and perceived safety. Therefore, it is appropriate to evaluate how safety levels vary across the speed ranges of 1) 30mph to 20mph; 2) 30mph to 25mph; and 3) 25mph to 20mph to ascertain whether there is evidence of any safety tipping point within these speed ranges that would serve to generate large modal substitution increases at a certain speed but not above it. If so, that would provide evidence that, above a certain speed limit range, modal substitution rates would be low and, below a certain speed limit range, substitution would higher - i.e., it would indicate a non-linear relationship between speed reduction and VMT response. On this basis, the evidence would show whether a 1% VMT reduction per 1mph of speed limit decrease across the 25mph to 20mph range is likely accurate or too high or too low.

In this connection, several statistical observations are helpful in illustrating relative risk levels across the three speed limit intervals:

> 1) half of pedestrian deaths and 80% of pedestrian serious injuries occur at traffic speeds of 30mph or lower, indicating that speeds up to 30mph retain significant risk levels;
> 2) only rare instances of fatality or serious injury are observed at speeds 20mph or lower, with just five percent of pedestrian collisions at 20mph resulting in death, indicating that speeds at or below 20mph provide low risk levels and that it is within the range of 30mph to 20mph where a crucial speed/safety step-change occurs; and
> 3) as speeds decline from 25mph to 20mph, risk of pedestrian death in a collision falls by 50% and, as speeds approximate 20mph, pedestrian and cyclist mortality risks stabilize at a low level (i.e., large safety gains occur as speeds fall from 25mph to 20mph and additional large gains are not realized below 20mph), demonstrating significant risks remain in play at speeds 25mph and higher and those risks dramatically fall as 20mph speeds are approximated.[39]

[39] Dorling, D., "20mph Speed Limits for Cars in Residential Areas, by Shops and Schools," Nine Local Actions to Reduce Health Inequalities, University of Oxford.

"Vehicle Speed and Pedestrian Age Determine Crash Outcomes," ***Status Report*** (Insurance Institute for Highway Safety/Highway Loss Data Institute), Vol. 35, No. 5 (May 2000).

Barrios, L., "Killing Speed," Injury Prevention, Vol. 6 (2000).

Accordingly, while it is true that every 1mph speed reduction in the 30mph to 20mph speed range is important for health and safety reasons, there is evidence of a tipping point in safety implications at speeds approximating 20mph. It is not until traffic speeds decline to 20mph that safety levels for pedestrians and cyclists stabilize at low levels. It is at this speed limit where perceived and actual safety become sufficient to provoke widespread modal substitution for transportation. In sum, the statistics imply a clustering of perceived and actual safety below 25mph and around the 20mph mark, which, given the importance of actual and perceived safety in motivating modal substitution, indicates responsiveness of VMT reduction to speed limit reduction would be greatest within the 25mph to 20mph speed range.[40] Speed declines from 30mph to 25mph would elicit smaller modal substitution effects since high risk levels remain in this range. This implies that a non-linear VMT reduction relationship with speed decrease exists and that above-average VMT responsiveness occurs within the 25mph to 20mph speed range. A 5% VMT reduction expectation in Ashland is conservative.

Third, it is shown that network effects apply to pedestrian and cyclist safety in transportation systems. Network effects generate pedestrian and cyclist safety value in increasing total quantities as more people switch from vehicles to non-vehicle modalities.[41] The lowest risk levels for pedestrians and cyclists occur when large numbers of people walk or cycle rather than drive. This relationship implies a non-linear link between vehicle speed limits and the quantum of network effect benefits since speed limit reductions generate modal substitution. Modal substitution in turn triggers network effect benefits that further reduce pedestrian and cyclist risk to engender more modal substitution.[42] Network effect benefits thus lag and compound other factors provoking modal substitution, so a concentration of VMT reduction as speed limits approach 20mph is consistent with the economics of network effects.[43] Modal substitution owing to network effects would exhibit non-linear growth as speed limits decrease, and VMT declines would accordingly accelerate as speed limits approach 20mph. Again, on this basis, a 5% VMT reduction expectation in Ashland is conservative.

Consistent with these considerations, it can be stated that, while a 5% VMT reduction in Ashland following adoption of 20mph speeds is a meaningful reference expectation, it may well be understated due to existence of modal substitution tipping point and accelerated network effects occurring around, but not much above,

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Tefft, B., "Impact of Speed and a Pedestrian's Risk of Severe Injury or Death," ***AAA Foundation for Traffic Safety*** (September 2011).

Speck, J., ***Walkable City***, North Point Press (2012).

[40] Tovar, M. and Kilbane-Dawe, "Effects of 20mph Zones on Cycling and Walking Behaviours in London," Par Hill Research Ltd. (2013).

[41] Jacobsen, P., "Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling," ***Injury Prevention***, Vol. 9 (2003).

[42]" Vision Zero: How Safer Streets in New York City Can Save More Than 100 Lives a Year," Drum Major Institute for Public Policy and Transportation Alternatives (June 2011).

[43] Sadik-Khan, J. ***Streetfight***, Viking (2016).

20mph speed limits. Ashland could experience VMT decreases in excess of 5% upon adoption and enforcement of 20mph speeds, and thus encounter corresponding reductions in congestion.[44]

Data from Portland, Oregon provides an important insight into the community's response to slower maximum speeds. Bicycle volume increased by approximately 6.4 percent between 2010 and 2011 on Portland streets where speeds were reduced from 25 to 20 MPH. Within the same timeframe, 61 percent more bicycles were counted at 11 locations on newly developed neighborhood greenways.[45]

Portland has demonstrated the efficacy of "all ages and abilities" networks. Their success is shown in Figure 5. Increased density of bicycle boulevards (shown in green) between 2000 and 2010 coincides with a more than 5 percent increase in bicycle mode share. Clearly, separated in roadway bicycle facilities also played a significant role in the growth of bicycle use. Consideration of those types of improvements in Ashland will occur as a part of the City's update of the Transportation System Plan (schedule to begin in 2021).

Improved Utilization of Roadway Resources Improves Traffic Flow

The second factor that causes reduced traffic congestion in a 20mph speed limit network relates to roadway utilization efficiency. Automobiles can make better use of road supply at lower speed limits in urban and residential areas due to reduced spacing, improved filtering, and decreased collisions.

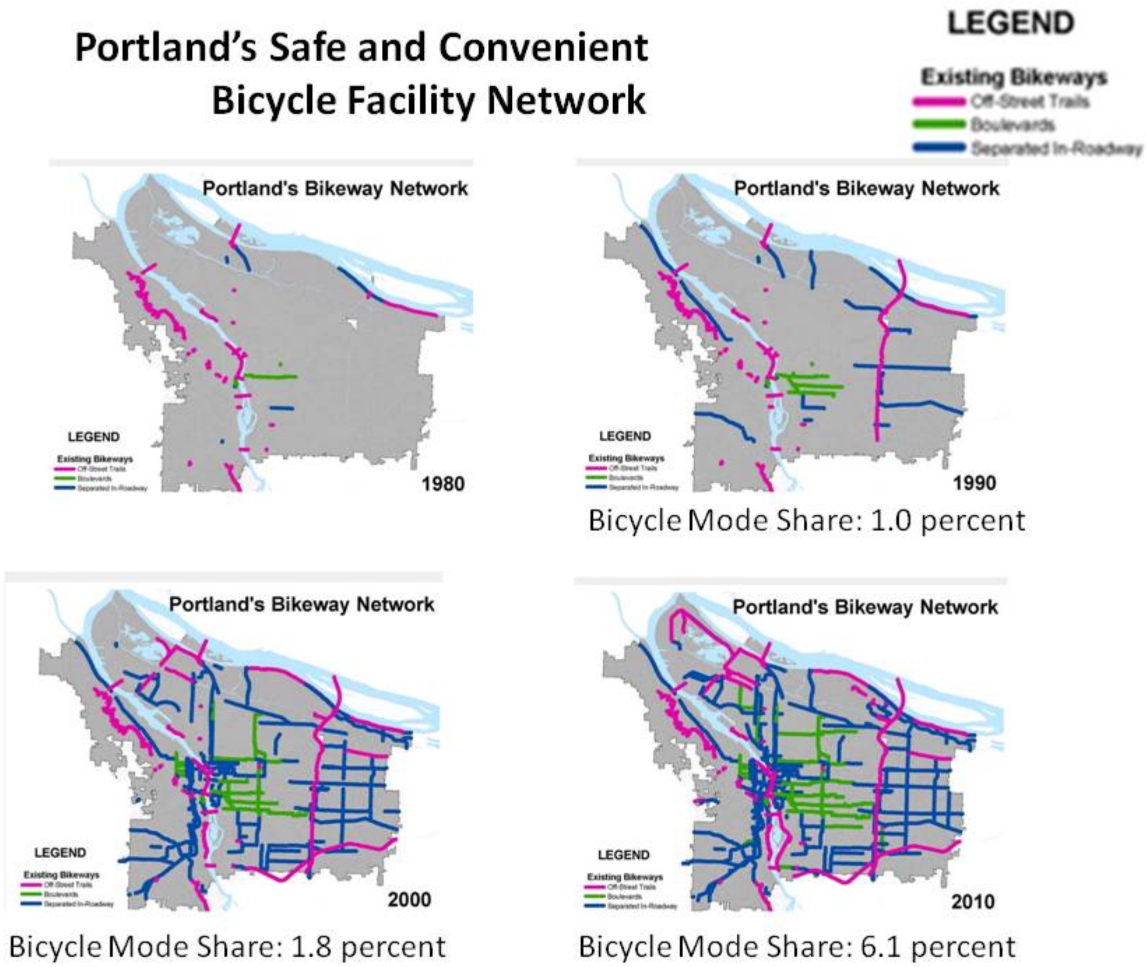
Reduced Spacing

As speed limits decline, cars traveling in the same lane require less "shy-distance" between them. Also known as "reduced spacing," densification of cars safely occurs when braking distances needed by automobiles contract. Because cars require less distance to come to a stop at lower speeds, they can leave less empty space between them (i.e., they can follow one another more closely) without increased risk of collision.

[44] A 5% VMT reduction value may further be considered conservative when applied to prospective 20mph implementation in Ashland because the availability and affordability of e-bikes continue to grow as the technology diffuses along a typical path of adoption. For trip durations of up to several miles, particularly in urban and suburban settings, e-bikes are particularly good substitutes for automobiles, but their safety profile generally equates to that of traditional bicycles and so increased adoption would be influenced by safety factors modulating modal substitution from vehicles to cycles. Most empirical evidence relating to substitution effects and VMT responses to 20mph limits pre-dates the current level of e-bike availability. This new technology factor implies greater modal substitution and VMT reductions in present and future 20mph applications.

[45] Neighborhood Greenways, Portland Bureau of Transportation, Neighborhood Greenways 101, https://www.portlandoregon.gov/transportation/article/554110
Portland Bicycle Counts Report, 2011, Portland Bureau of Transportation, February 2012; https://www.portlandoregon.gov/transportation/article/386265
Neighborhood Greenways Assessment Report, Portland Bureau of Transportation, 2015; https://www.portlandoregon.gov/transportation/article/735768

Figure 5



Portland's goal is to have 25 percent of commute trips made by bicycle in 2035.[46]

Automotive braking distance requirements (and thus safe shy-distance intervals) follow an exponential expansion with respect to speed, so even a small reduction in traffic speeds can generate large roadway space savings.[47] As illustration, the distance required for a vehicle to stop when traveling 20mph is roughly 14 meters.

[46] Portland Transportation System Plan, Policy 9.49.f, page 27; https://www.portland.gov/sites/default/files/2020-05/chapter2.tsp_.03.06.2020.pdf

[47] Litman, T., "Whose Roads? Evaluating Bicyclists 'and Pedestrians 'Right to Use Public Roadways," Victoria Transport Policy Institute (December 2013).

At 25mph, the requirement is 26 meters, nearly double the lower speed's stopping distance, despite the seemingly marginal 5mph speed difference.[48]

Reduced spacing leads to transportation system efficiency gains since it enables a safe increase of traffic density on the road (i.e., there is less "dead space" between each car in the system) during peak traffic times. This allows the system to accommodate more cars simultaneously. Significantly, this does not increase congestion; rather, cars are able to move at least as smoothly as at higher speeds, but simply with less empty space separating them. By eliminating unused lane miles, existing roadway resources are used more efficiently. On the basis of observing that braking distance and shy-distance intervals fall by nearly 50% in the 25mph to 20mph range, it can be generally stated that a speed limit reduction to 20mph significantly increases effective road capacity.[49]

Improved Filtering

Filtering is the process by which cars exiting one road merge into the traffic flow on another. When long traffic queues form, that is symptomatic of poor filtering efficiency. Such inefficiency often can be linked to a large speed differential between the stopped/merging traffic and the higher-speed oncoming traffic. As the speed of oncoming traffic increases, the difficulty of merging grows because the required "buffer" distance for safe maneuvering becomes greater; merging traffic requires more room to achieve the target speed.[50]

When speed limits are lower, the required buffer distance for safely merging into moving traffic falls. Long traffic queues are less likely to form and, if they do, are more quickly dissipated. This improves system-wide traffic flow and throughput, and reduces congestion, as road resources are more efficiently utilized. By way of demonstration, a reduction in traffic congestion of 10% was observed at systemically important (and typically congested) traffic interchanges in Sao Paulo, Brazil, in the first month following implementation of reduced speed limits.[51]

These insights are particularly pertinent along North Main.

[48] "Cities Safer by Design," World Resources Institute, graphic entitled "Higher Vehicle Speeds Require Longer Stopping Times" (2015). Stopping distance totals reflect reaction distance and braking distance.

[49] Duany, A., et al., ***Suburban Nation***, North Point Press (2000).

[50] Archer, J., et al., "The Impact of Lowered Speed Limits in Urban and Metropolitan Areas," Monash University Accident Research Centre (2008).

[51] "Numeros de Acidentes Cai 30% Apo Novos Limites na Marginais," ***O Estadoa de Sao Paulo*** (August 29, 2015).

<u>Decreased Collisions</u>

Significant reductions in traffic collisions are associated with 20mph speed limits. As collisions and attendant roadway obstructions are reduced, traffic congestion falls and travel time reliability improves since fewer crashes cause less traffic backup.[52]

Collisions that stop traffic have sweeping consequences for transportation system efficiency, with effects reverberating through the system.[53] Consider, for instance, the unused roadway just ahead of an accident that stops traffic and the blockages that occur on nearby roads as a traffic stall ripples outward. These are inefficiencies in transportation systems wrought by avoidable collisions. By reducing crashes, 20mph speed limits inoculate against an important cause of congestion.

Collectively, reduced spacing, improved filtering, and decreased collisions enhance road resource utilization and traffic flow, increase vehicle throughput, reduce traffic congestion, and benefit drive-time reliability.

Decreased Speed Limits Do Not Materially Affect Travel Times

Intuition may suggest that lower speed limits significantly increase travel times; however, both empirical evidence and computer simulation models disprove this, particularly as relates to a change from 25mph to 20mph speed limits in residential and urban areas, as will be discussed in detail.

As a prefatory matter, it is necessary to focus discussion only on those vehicle trips that would have any possibility of experiencing meaningful travel time increases - i.e., relatively short trips. Long vehicle trips would be logically unaffected by urban/residential speed limit changes. A 100-mile trip comprised of, say, 2 miles on residential roads and 98 miles on freeways would register no consequential travel time change under urban/residential 20mph speed limits; any time penalty incurred on residential roadway would represent a minuscule fraction of total travel time and thus be indiscernible against the whole.

Conversely, short trips predominantly traversing urban/residential 20mph candidate streets would potentially be subject to appreciable travel time increases. Generalized across a transportation system, it can be stated that, the shorter the trip, the greater the proportion of total travel on urban/residential areas. And, the greater the proportion of travel on urban/residential roads, the better the prospects for meaningfully longer travel

[52] Blincoe, L., et al., "The Economic and Societal Impact of Motor Vehicle Crashes," U.S. Department of Transportation, National Highway Traffic Safety Administration, DOT HS 812013 (May 2015 (Revised)).

[53] Archer, J., et al., "The Impact of Lowered Speed Limits in Urban and Metropolitan Areas," Monash University Accident Research Centre (2008).

times. For this reason, analysis will be circumscribed to travel time changes on trips of 3 miles or fewer. Such circumscription is not overly restrictive, as trips 3 miles or less account for over 40% of all vehicular trips.[54]

Focusing analysis on this short-trip genus of vehicle travel, it has been shown that, for trips within urban and residential areas, travel time delays do not derive from posted speed limits. Instead, the primary generators of "delay" are intersections, traffic queues, and unilateral braking for cornering and turns. While turning speeds are unaltered by traffic speed limits, both intersection efficiency and traffic queuing are beneficially affected by 20mph speed limits (owing to reduced spacing, improved filtering, and decreased collisions).

Additional studies quantifying changes in travel duration due to speed limit changes find that reducing speed limits by approximately 5mph has essentially no effect on travel times. An analysis conducted in Australia determined that a 10kph (i.e., 6.2mph) speed limit reduction was associated with travel time increases of 3 percent in the short-term, and, following behavioral adaptation, 0.6 percent in the long-term.[55] Confirming this conclusion, it has been separately found that speed limit reductions in the range of 5mph increase travel times by about 1 percent.[56]

It is possible to estimate travel time impacts in Ashland using these findings. If an average speed of travel of 15mph (accounting for intersections, traffic, etc.) on vehicle trips occurring exclusively within urban/residential areas is achieved, then 1-mile, 2-mile, and 3-mile journeys would exhibit travel times of 4 minutes, 8 minutes, and 12 minutes, respectively.[57] Conservatively using the short-term travel time increase estimate of 3 percent, those travel times would increase by 7 seconds, 14 seconds, and 22 seconds, respectively, in a 20mph system. Since over 40% of vehicle trips cover 3 miles or fewer - and since it is shorter trips most likely to occur on urban/residential roads - a substantial share of all trips in targeted 20mph areas would experience travel time increases of well less than a minute.[58]

Two other empirical studies' findings corroborate these calculations. One shows that a 10kph (i.e., 6.2mph) speed limit reduction is associated with an increased average travel time of less than 26 seconds per trip (or

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[54] Federal Highway Association 2009 National Household Travel Survey, "Vehicle Trips, Number of Vehicle Trips by Trip Distance Including Trips 2 Miles or Less."

[55] SMEC Australia and R.J. Nairn and Partners, "Effects of Urban Speed Management on Travel Time: Simulation of the Effects of Maximum Cruise Speed Changes in Melbourne," Federal Office of Road Safety (1999).

[56] Horeau, E. and S. Newstead, "An Evaluation of the Default 50km/h Speed Limit in Victoria," MUARC Report No. 261, Monash University Accident Research Centre (2006).

[57] This 15mph average speed is obtained using the Google Maps "Directions" feature for automobile travel around residential and urban portions of Ashland. Across a variety of routes, Google Maps indicates average travel times of 4 minutes per mile (i.e., 15mph).

[58] Federal Highway Association 2009 National Household Travel Survey, "Vehicle Trips, Number of Vehicle Trips by Trip Distance Including Trips 2 Miles or Less."

about 21 seconds, adjusted for a 5mph speed limit decrease) - roughly the calculated change for a 3-mile trip.[59] The second study finds that a 5kph (i.e., 3.1mph) speed limit reduction is associated with about 10 seconds longer travel time per mile (i.e., about 16 seconds per mile, adjusted for a 5mph speed limit decrease).[60] Both studies confirm that travel times in Ashland would change by well less than one minute per trip, or in the range of 3%, on vehicle travel occurring exclusively within urban/residential areas. And travel times would change by an even lower percentage on trip routes combining urban/residential and non-urban/residential streets. These calculations in all cases show maximum travel time increases since they do not account for VMT reductions generated by 20mph speed limits.[61]

Accordingly, there is reason to believe average vehicle travel times in Ashland would likely be materially unaffected, or at worst minimally and insignificantly increased, and perhaps even minimally reduced. To the extent there would be any travel time increases, they would be vanishingly small and measured in seconds.[62]

[59] Haworth, N., et al., "Evaluation of a 50km/h Default Urban Speed Limit for Australia," National Road Transport Commission, Melbourne (2001).

[60] Robertson, S. and H. Ward, "Valuation of Non-Accident Impacts of Speed," MASTER Working Paper R 1.2.2, VTT Communities and Infrastructure (1998).

[61] The difference between the short-term 3% and long-term 0.6% travel time increases reported by one study is explained by behavioral adaptation, which would include things such as modal substitution generating VMT reductions. Using the estimated 0.6% travel time increase generates expected travel time changes that do account for some measure of VMT response. For 1-mile, 2-mile, and 3-mile trips, a 0.6% travel time change translates to a 1.4 second, 2.9 second, and 4.3 second travel time increases, respectively.

[62] It may be perceived that increased drive times displace working hours and diminish earnings, leading to economic loss. Statistics showing concurrent increases in commute times and working hours in the U.S. belie this view. Work is not a substitute of driving. Also, the average American conducts 3.61 hours of work or working-related activities each day, leaving 20.39 hours of non-working time into which commuting time increases measured in seconds could be easily absorbed with ***de minimis*** economic impact. (See: U.S. Department of Labor, Bureau of Labor Statistics "American Time Use Survey - 2016 Results." Saad, L., "The '40-Hour Workweek Is Actually Longer - by Seven Hours," ***Gallup*** (August 29, 2014). Ingraham, C., "The Astonishing Human Potential Wasted on Commutes," ***Washington Post*** (February 25, 2016).)

3. Decreased System-Wide Fuel Consumption

Two distinct lines of inquiry must be addressed to understand the implications of 20mph speed limits on system-wide fuel consumption. The first is the extent to which the speed limit reduces or increases driving overall; and the second is the extent to which fuel consumption among cars in the road system is increased or reduced with lower speed limits.

On net, it is found that, while the fuel consumption among cars in the road system is not materially impacted by lower speed limits, reduced traffic in the transportation system reduces system-wide fuel usage. Overall fuel usage declines in 20mph speed limit networks.

Reduced Traffic Levels Generate Lower Fuel Consumption

When system-wide 20mph speed limits are adopted, modal substitution draws people out of automotive transport and into walking, cycling, and mass transit alternatives. This reduces individual automobile usage and decreases system-wide fuel requirements.

The directional effect of reduced automobile usage and attendant reduced VMTs is unambiguous: under a 20mph speed limit regime, the substitution effect places downward pressure on system-wide fuel usage. In the broadest sense, reduced VMTs would be expected to shrink fuel consumption by an amount roughly proportionate to the VMT reduction.[63] This framework will be used later to quantify the economic implications of reduced fuel usage.

Remaining Traffic's Fuel Consumption Is Not Materially Altered

With respect to vehicles that do traverse a 20mph roadway system versus a 25mph system, two offsetting factors affect how much fuel those automobiles use. The first relates to the energy costs of acceleration, and the second pertains to the relative fuel efficiencies of different cruising speeds. In general, these factors offset, resulting in no material difference in fuel usage rates between automobiles in a 20mph transportation system versus a 25mph network.[64] Nonetheless, some empirical studies have found substantial gains in fuel efficiency among vehicles in 20mph speed limit networks as a by-product of reduced speed limits - i.e., improved driver behavior. Each point is addressed below.

At lower speed limits, automobiles use less energy to reach a road's cruising speed. This is because the energy required to achieve a given speed is proportional to the square of that speed. That is, a non-linear relationship

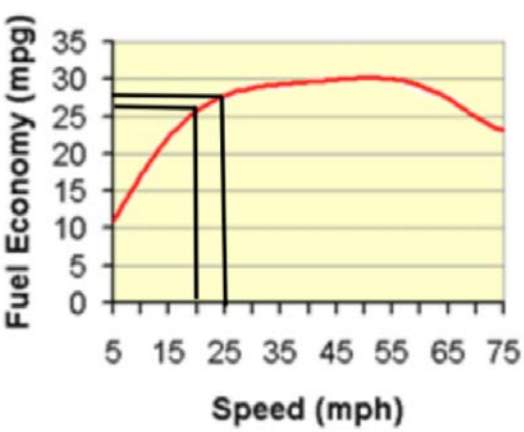
[63] Naturally, factors other than VMTs bear on fuel consumption reductions; fuel consumption could decrease by more or less than the decrease in VMTs because not all vehicle types consume fuel at similar rates, and there may be a systematic bias that favors modal substitution for certain types of vehicles. Driving style of modal switchers also bears on the analysis, as do the particulars of transportation system design.

[64] "An Evaluation of the Estimated Impacts on Vehicle Emissions of a 20mph Speed Restriction in Central London," Transport and Environmental Analysis Group, Centre for Transport Studies, Imperial College London (April 2013).

between target speed and fuel consumption is realized during acceleration; as the target speed increases, fuel usage grows exponentially. As such, the energy required to attain 30mph or 25mph dwarfs that to achieve 20mph, and repeated acceleration to these higher speeds reduces fuel efficiency relative to a 20mph system.[65]

On the other hand, most automobiles maximize their cruising fuel efficiency at speeds greater than 20mph. It is observed that fuel efficiency for most automobiles peaks at cruising speeds of approximately 55mph, with efficiency penalties associated with higher and lower cruising speeds. There is a cruising-speed fuel efficiency loss associated with a 20mph speed limits relative to 25mph limits. The efficiency difference between 20mph and 25mph cruising speeds is nevertheless small, having been calculated as a roughly 8% difference in fuel economy levels once cruising speed has been attained (that is, ignoring the effects of reaching the higher speeds).[66] Figure 5, from fueleconomy.gov, illustrates the relative insensitivity of fuel efficiency to cruising speed levels above 20mph, and the difference between fuel efficiency levels at 20mph versus 25mph (vertical and horizontal black lines have been added for clarity). The effect is relatively small and, importantly, only a small share of any urban/residential trip occurs at cruising speed.[67]

Figure 5



Since acceleration and cruising speed factors are directionally offsetting, and since myriad other particulars must be known to determine which factor dominates in a given setting,[68] the result of any generalized analysis is that, within a speed limit range of approximately 20mph to 25mph, there is no material difference in fuel economy among vehicles in a transportation system.

It is nonetheless worth noting that driving style has substantial bearing on fuel usage, and driving style has been shown to change in response to speed limits. Whether a driver operates a vehicle conservatively or aggressively has dramatic implications for fuel usage since aggressive driving tends to be marked by rapid speed

[65] "An Evaluation of the Estimated Impacts on Vehicle Emissions of a 20mph Speed Restriction in Central London," Transport and Environmental Analysis Group, Centre for Transport Studies, Imperial College London (April 2013).

[66] The Automobile Association calculates that the percentage difference in fuel economy between a cruising speed of 20mph and 30mph is about 8.5%. "20mph Roads and CO2 Emissions," The Automobile Association website (accessed May 2018).

[67] Archer, J., et al., "The Impact of Lowered Speed Limits in Urban and Metropolitan Areas," Monash University Accident Research Centre (2008).

[68] These include the types of automobiles used in the affected transportation system, prevailing driving styles, particulars of road and intersection design, the typical trip lengths of users of the road system, etc.

changes that demand higher fuel usage.[69] Fuel consumption among aggressive drivers has been shown to be as much as *four times* that of non-aggressive drivers.[70] In addition, a single aggressive driver can cause other drivers to operate their vehicles less efficiently by setting off ripple effects that reduce overall traffic smoothness. It has been shown that, with 20mph speed limits, reports of aggressive driving behaviors decline 40%,[71] so it would be expected that reduced aggressiveness in 20mph systems would benefit overall fuel efficiency as a by-product of reduced speed limits.

Indeed, in at least two instances of empirical study, the foregoing logic manifested quantitatively in measured driver behaviors and fuel usage. Upon the introduction of 30kph (i.e., 20mph) speed limit zones in Germany, it was observed that gear change events (a proxy measure for acceleration and cruising speed values) and braking events declined by 12% and 14%, respectively. Since reductions in gear changes and braking collectively reflect smoother driving patterns, the behavioral changes resulted in a measured 12% reduction in fuel usage among drivers.[72] In a second study of urban traffic, it was found that "reduced speeds and more even driving have resulted in 26% reduction in fuel consumption."[73]

These findings are echoed in a Department for Transport circular which states the following:

> There may also be environmental benefits [associated with 20mph speed limits] as, generally, driving more slowly at a steady pace will save fuel and reduce pollution, unless an unnecessarily low gear is used.[74]

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[69]" An Evaluation of the Estimated Impacts on Vehicle Emissions of a 20mph Speed Restriction in Central London," Transport and Environmental Analysis Group, Centre for Transport Studies, Imperial College London (April 2013).

[70] Archer, J., et al., "The Impact of Lowered Speed Limits in Urban and Metropolitan Areas," Monash University Accident Research Centre (2008).

[71] Department for Transport, "Interim Evaluation of the Implementation of 20mph Speed Limits in Portsmouth" (2010).

[72] Hass-Klau, Carmen, *An Illustrated Guide to Traffic Calming* (1990).

[73] Mitchell, P., "Speed and Road Traffic Noise: The Role that Lower Speeds Could Play in Cutting Noise from Traffic," A Report Commissioned by the UK Noise Association (December 2009).

Van Beek, W., et al., "The Effects of Speed Measures on Air Pollution and Traffic Safety," Proceedings of the European Transport Conference (2007).

[74] Department for Transport, "Setting Local Speed Limits," Department for Transport Circular (January 2013).

The U.S. Department of Transportation Federal Highway Administration concurs: "Slower moving vehicles make less noise and, generally, emit fewer pollutants…fuel consumption reductions of 10 to 12 percent have been reported." See: Federal Highway Administration Course on Bicycle and Pedestrian Transportation, Lesson 11, "Traffic Calming."

In sum, since there are reasons why a 20mph speed limit regime would not necessarily result in improved fuel economy per mile driven, the most conservative argument is that there would not be meaningful change in drivers' fuel usage in a 20mph regime. Nonetheless, at least two empirical studies showing enhanced fuel economy per mile driven in reduced-speed networks highlight the possibility of diminished fuel usage per vehicle mile in 20mph systems, particularly when driver behavior improves.[75]

Economic Implications of Reduced Fuel Consumption

The absence of any substantive change in fuel economy per vehicle mile driven, accompanied by a reduction in system-wide VMTs due to modal substitution, implies a system-wide reduction in fuel utilization with 20mph speed limits. Considering the extent of traffic volume reductions observed in regions adopting 20mph speed limits, potential fuel savings can be sizable.[76]

It is possible to define the approximate fuel savings and attendant financial savings this effect would generate in Ashland. The Oregon Department of Transportation estimates that citywide annual VMT in 2019 was 58,987,174 miles. Shifts in mode of travel with slower maximum speeds would reduce this total by 2,949,359 miles per year. Using the U.S. fleet fuel economy of 25 miles to the gallon allows for the calculation of the gallons of gasoline that would <u>not</u> be consumed with slower maximum speeds, 117,974 gallons per year. Multiplying the estimated fuel savings by the current cost of gasoline, $2.59 yields a total annual economic saving of $305,554.

These calculations are summarized in Table 2.

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[75] It has also been shown that, in 20mph systems, traffic idling at intersections can be reduced as a result of improved filtering. Since idling for 10 seconds or longer is associated with fuel wasting, improved junction filtering would be expected to limit idling times and thus reduce fuel consumption.

Gaines, L., et al., "Which Is Greener: Idle, or Stop and Restart? Comparing Fuel Use and Emissions for Short Passenger Car Stops," U.S. Department of Energy, Argonne National Laboratory (2012).

[76] Department for Transport Traffic Advisory Leaflet 9/99 (June 1999), "20 mph Speed Limits and Zones."

Steer Davies Gleave, "Research into the Impacts of 20mph Speed Limits and Zones, (November 2014).

Table 2

Estimate of Annual Fuel Savings with Slower Maximum Speeds		
	Baseline (G)	Slower Maximum Speed Estimate (H)
A. VMT within City per year (2019)[77]	58,987,174	56,037,815
B. U.S. Fleet Fuel Economy (miles per gallon)[78]	25	25
C. Estimated Fuel Consumption by Residents (in town) (A/B)	2,359,487	2,241,513
D. Savings in gallons (w/ slower maximum speeds) (G - H)		117,974
E. Estimated Cost per gallon (regular gasoline)[79]		$2.59
F. Savings from slower maximum speeds (D*E)		$305,554

[77] Oregon Department of Transportation, 2019 Estimate, per Stu Green

[78] Highlights of the Automotive Trends Report, US EPA, https://www.epa.gov/automotive-trends/highlights-automotive-trends-report#:~:text=Figure%20ES%2D1.&text=Fuel%20economy%20increased%20by%200.2,0.4%20mpg%20to%2025.5%20mpg (accessed 11/25/2020)

[79] AAA; https://gasprices.aaa.com/?state=OR (accessed 12/26/2020)

4. Lowered Carbon Emissions

Significant decreases in carbon emissions are registered in areas with 20mph speed limits. Since fewer vehicle miles are traveled in 20mph systems, corresponding reductions in pollution are realized. Additionally, among residual VMTs, lower speeds tend to be associated with reduced noise pollution and particulate matter dispersion from vehicle tires, clutches, and brakes.

Lower Carbon Emissions from Fewer Vehicle Miles Traveled
"Modal substitution causes more users of the transportation system to walk or cycle when 20mph speed limits are enacted, thereby reducing VMTs. Fuel consumption commensurately declines and, in turn, pollution levels diminish, both with respect to carbon-dioxide ("CO_2") and particulate matter.[80]

Carbon-Dioxide
One important measure of a transportation system's air pollution is the quantity of CO_2 greenhouse gas it emits. Generally, CO_2 emissions decline linearly with VMT reductions. Thus, were Ashland's VMTs to decline in a manner consistent with empirically studied 20mph networks, Ashland's automobile fleet would be expected to emit about 5% fewer tons of CO2.

A general estimate of potential tons of CO_2 reduction can be given through the following analysis. The Oregon Department of Transportation, in 2019, estimated that total vehicle miles of travel (VMT) within the City of Ashland totaled 58,987,174 miles. By lowering the maximum speeds in the City, VMT is expected to decline by 5% or by almost 3 million miles. Using the US fleet fuel economy of 25 miles per gallon allows the computation of the estimated savings, measured in gallons per year; 117,974 gallons/year. Each gallon of gasoline produces 20 pounds of carbon dioxide (CO_2)[81] meaning the City's residents, by choosing to walk or bicycle rather than drive, can reduce CO_2 emissions by 2,359,487 pounds or 1,070 metric tons per year.

These calculations are shown in Table 3.

Economic Implications of Reduced Carbon-Dioxide Emissions

According to research published in 2015, each metric ton of CO_2 generated by emissions carries an economic damages value (often referred to as "social cost") of approximately $220.[82] The Environmental Protection

[80] In addition to this effect, reductions in aggressive driving reduce CO2 emissions since aggressive drivers generate approximately four times the CO2 output of non-aggressive drivers.

Archer, J., et al., "The Impact of Lowered Speed Limits in Urban and Metropolitan Areas," Monash University Accident Research Centre (2008).

[81] https://www.fueleconomy.gov/feg/contentincludes/co2_inc.htm#:~:text=It%20seems%20impossible%20that%20a,the%20carbon%20and%20hydrogen%20separate

[82] Moore, F. and D. Diaz, "Temperature Impacts on Economic Growth Warrant Stringent Mitigation Policy," ***Nature Climate Change***, Vol. 5 (2015).

Than, K., "Estimated Social Cost of Climate Change Not Accurate, Stanford Scientists Say," ***Stanford News*** (January 12, 2015).

Agency, on the other hand, estimated the social cost of a metric ton of CO2 in 2015 to be about $36.[83] Other estimates peg costs in the middle of this range.[84] Without taking a position on the merits and limitations of any particular approach or set of assumptions used in valuing CO_2 social costs, for purposes of this analysis, an approximate midpoint of $125 in estimated social costs per metric ton of CO_2 emissions will be used. A reduction in emissions of 1,070 metric tons would equate to $133,750 of annual savings in implied damages. These calculations are shown in Table 3.

Table 3

Estimate of Annual CO_2 emission reduction with 20MPH Speed Limits	
A. VMT in Ashland per year (2019) [85]	58,987,174
B. VMT with Reduced Maximum Speeds (A - (A - .05)	56,037,815
C. Difference in citywide VMT (A - B)	2,949,359
D. Average assumed fuel economy (miles per gallon) [86]	25.0
E. Savings measured in gallons of fuel by lowering the maximum speeds (C / D)	117,974
F. CO_2 emissions in pounds per gallon of gasoline	20
G. CO2 emissions savings by lowering the maximum speeds (E * F)	2,259,487
H. CO2 Reductions (measured in metric tons) (G / 2205)	1,070
I. Estimated social cost of CO_2 per metric ton	$125
J. Estimated social benefit from reducing CO2 emissions (H * I)	$133,758

Micro-plastics & Other Non-exhaust Traffic-related Particulate Matter

Another measure of environmental pollution can be found in plastics dispersed into the environment as a consequence of the mechanical abrasion (i.e., wearing down) associated with car tires. Plastics pollution increases as a function of VMTs, and research indicates that "wear and tear from tires significantly contributes to the flow of (micro-)plastics into the environment."

[83] The EPA currently estimates the social cost of carbon to be around $1. There appears to be zero economic merit to this figure and it is accordingly ignored here.

Archived Environmental Protection Agency Website, "The Social Cost of Carbon: Estimating the Benefits of Reducing Greenhouse Gas Emissions" https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html (accessed June 2018).

[84] Harvey, C., "Should the Social Cost of Carbon Be Higher?" *Scientific American* (November 2017).

[85] Oregon Department of Transportation, 2019 (per Stu Green)
[86] Highlights of the Automotive Trends Report, US EPA, https://www.epa.gov/automotive-trends/highlights-automotive-trends-report#:~:text=Figure%20ES%2D1.&text=Fuel%20economy%20increased%20by%200.2,0.4%20mpg%20to%2025.5%20mpg (accessed 11/25/2020)

> The relative contribution of tire wear and tear to the total global amount of plastics ending up in our oceans is estimated to be 5-10%. In air, 3-7% of the particulate matter (PM2.5) is estimated to consist of tire wear and tear.[87]

Aside from micro-plastics, other non-exhaust traffic-related particulate matter generation comprises an important component of traffic environmental impact. "Non-exhaust particles can be generated either from non-exhaust sources such as brake, tire, clutch and road surface wear or already exist in the form of deposited material at the roadside and become resuspended due to traffic-induced turbulence." Within urban and suburban settings, higher VMTs correspond with higher non-exhaust particulate matter levels.[88]

Thus, both micro-plastics generation and particulate matter pollution would be expected to decline as a result of lower VMTs brought on by 20mph speeds.

Lower Speeds and Smoother Traffic Generate Less Particulate Matter

As traffic speeds increase and as traffic patterns become more interrupted (i.e., marked by "stop-and-go" driving), the levels of particulate matter generated by non-exhaust traffic-induced factors, such as tires and brakes, increases. Accordingly, lower average traffic speeds and smoother traffic flows associated with a 20mph system would contribute to reductions in plastics pollution and particulate matter dispersion.

Since 20mph speed limit networks are associated with lower traffic speeds, reduced gear shifts, less braking events, and lower levels of aggressive driving behavior, reduced total particulate matter and lower tire wear levels would tend to be associated with 20mph systems.[89] Indeed, tire-related pollution depends upon speed and driving style (i.e., faster and more aggressive driving generate greater pollution),[90] while the direct generators of particulate matter pollution are braking events and gear shifts.[91]

[87] Kole, P., et al., "Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment," *International Journal of Environmental Research and Public Health*, Vol. 14, No. 10 (2017).

[88] Grigoratos, T. and G. Martini, "Brake Wear Particle Emissions: A Review," *Environmental Science and Pollution Research International*, Vol. 22 (2015).

[89] Hass-Klau, Carmen, *An Illustrated Guide to Traffic Calming* (1990).

Department for Transport, "Interim Evaluation of the Implementation of 20mph Speed Limits in Portsmouth" (2010).

[90] Kole, P., et al., "Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment," *International Journal of Environmental Research and Public Health*, Vol. 14, No. 10 (2017).

[91] Grigoratos, T. and G. Martini, "Brake Wear Particle Emissions: A Review," *Environmental Science and Pollution Research International*, Vol. 22 (2015).

5. Decreased Road Capacity Requirements & Saved Infrastructure Expenses

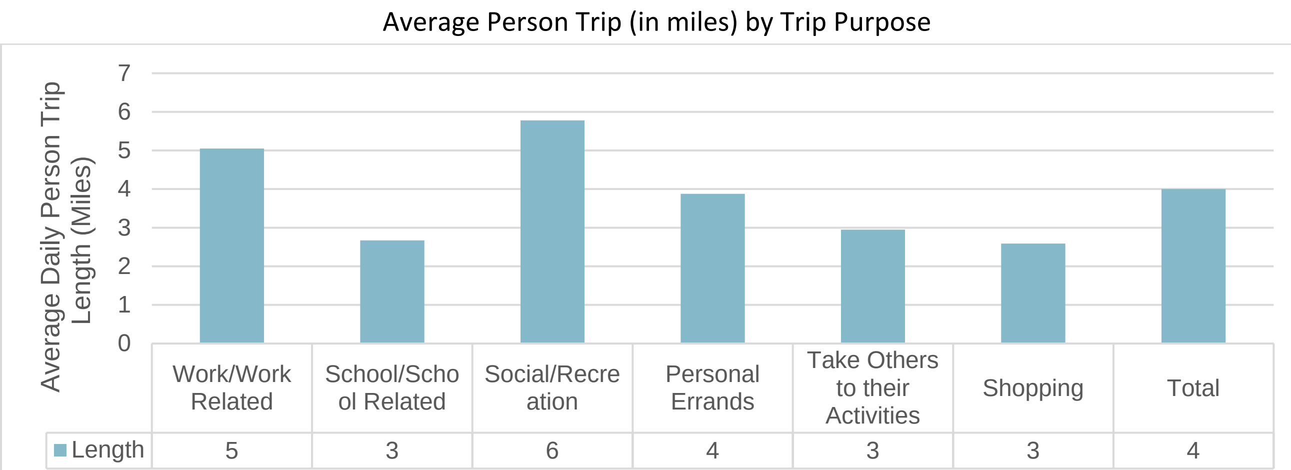
There are two means by which a 20mph speed limit system decreases vehicular roadway capacity demands. The first is reduced overall VMTs, and the second is enhanced efficiency of roadway space utilization, particularly during peak travel times. Both factors imply savings on infrastructure costs. Those savings far outweigh costs of implementing 20mph speed limits in Ashland.[92]

20mph Speed Limits Reduce Road Capacity Needs

With lower VMTs, consumption of roadway capacity by vehicles declines, freeing roadway resources. This reduction in VMTs is not realized uniformly across a transportation system; rather, network "bottlenecks" tend to experience the greatest traffic reductions. This is due to the mechanics of how modal substitution occurs in a 20mph system.[93]

To illustrate how bottlenecks recognize disproportionately large volume relief, it is instructive to consider typical vehicular trip distances. Nationally, 20% of all vehicular trips are not more than 1 mile in distance, while 32% of trips cover 2 miles or less, and 42% are capped at 3 miles.[94] Similarly, the Rogue Valley Metropolitan Organization's (MPO) data shows that, regardless of trip purpose, trips within the MPO are short, as illustrated in Figure 6.

Figure 6



[92] To the extent VMT reductions enable reduced or even slowed construction of new road lane-miles, future structural maintenance costs would be reduced, with potential implications for City budgeting.

[93] Cass, N. and J. Faulconbridge, "Commuting Practices: New Insights into Modal Shift from Theories of Social Practice," *Transport Policy*, Vol. 45 (2016).

[94] Federal Highway Association 2009 National Household Travel Survey, "Vehicle Trips, Number of Vehicle Trips by Trip Distance Including Trips 2 Miles or Less."

Thus, a substantial portion of traffic derives from "short-trip" travel. And, in centralized transportation system networks, short vehicle trips comprise a large share of bottleneck traffic (since centralized nodes are where vehicles become funneled and where bottlenecks subsequently occur). Substitution from driving to walking or cycling is most likely to occur when the total distance traveled is lowest, so it follows that shorter trips contributing 40% or more to bottleneck congestion experience the highest rates of modal substitution.[95] Modal substitution thus generates a disproportionately large relief of traffic demand at the points most typically identified as bottlenecks and candidates for roadway expansion.

Superior junction filtering and vehicle spacing in 20mph systems also reduce road supply needs during peak travel hours since vehicular traffic on the roads makes better use of the available space. This effect frees more roadway capacity, particularly at intersections beleaguered by long queues and wait times (i.e., bottlenecks). Traffic throughput efficiency with respect to road supply thereby increases, further reducing perceived needs for additional lane-miles.

Through these two complementary mechanisms, existing vehicular roadway infrastructure can accommodate population growth, a consideration of significance in Ashland given anticipated future population gains.[96] A corollary of this increased effective capacity is that construction of fewer additional lane-miles would be implicated, saving Ashland funds on roadway expansion and future maintenance costs.[97]

Cost of Implementing 20mph Speed Limits Is Low

It is possible to estimate costs that would be incurred by the City of Ashland if 20mph speed limits are adopted by considering the experience of Portland, Oregon, in its rollout of 20mph speed limits, which took effect April 1, 2018.[98] Since both Ashland and Portland are cities in Oregon (and thereby have identical state-level traffic

[95] Around 74% of all bike trips in the U.S. and over 93% of walking trips cover 3 miles or less. At distances above 3 miles, trip shares for both cycling and walking fall precipitously, suggesting it is at around the 3-mile threshold that modal substitution effects would largely diminish. Longer trips would more likely use roadways outside a city's urban/suburban transportation system, including freeways, and would thus contribute less to bottleneck congestion per VMT.

U.S. Department of Transportation, Federal Highway Administration, 2009 National Household Travel Survey (data extraction tool accessed June 2018).

[96] "Jackson County and Ashland Population Forecast, Planning Commission Presentation, https://www.ashland.or.us/SIB/files/2019-09_24_Population_Forecast_PRES.pdf (September 26, 2019).

[97] In addition to lower lane-mile requirements, reduced parking capacity would be implicated by VMT reductions, thus reducing space, cost and upkeep requirements for new vehicle parking spots. The cost of a new parking space in a structured parking garage is approximately $15,000.

Flusche, D., et al., "The Bottom Line: How Bicycle and Pedestrian Projects Offer Economic Benefits to Communities," Pedestrian and Bicycle Information Center Webinar Presentation (May 7, 2013).

[98] The City of Portland, Portland Bureau of Transportation Website "Residential Speed Limit Reduction" (accessed June 2018).

laws), and since both cities would utilize the same legislative path for adopting 20mph speed limits, it follows that Portland's project costs can inform expectations of cost in Ashland.

Portland's transportation system encompasses approximately 4,842 lane-miles,[99] of which roughly 3,000 lane-miles received 20mph speed limit designations.[100] Encompassed in the rollout was the installation of about 2,000 new speed limit signs around the city,[101] an undertaking with costs pegged at $300,000.[102]

Scaling down the project cost to Ashland's size entails consideration of Ashland's lane-miles most likely to be subject to 20mph speed limits and then applying a pro-rata cost figure to those lane-miles. Ashland has approximately 218 lane-miles of roadway, with 185 that are posted at 25mph and have average daily traffic (ADT) volumes under 2,000 and could be immediate candidates for 20mph speed limits.[103] Accordingly, Ashland's 20mph rollout would encompass about 6.2% of Portland's affected lane-mileage (i.e., 185 / 3,000). Assuming Ashland would install new speed limit signs at the same rate and cost as Portland, then Ashland's estimated cost of new signage would run to approximately $18,500.

However, the particular state statute that applies to Ashland, ORS 810.180(10), requires not only that the street have fewer than 2,000 ADT but also that 85% of the motorists drive the particular roadway at less than 30mph.

> ORS 810.189(10): "The highway is located in a residence district.
> (b)The statutory speed may be overridden by a designated speed only if:
>> (A)The road authority determines that the highway has an average volume of fewer than 2,000 motor vehicles per day, more than 85 percent of which are traveling less than 30 miles per hour; and
>> (B)There is a traffic control device on the highway that indicates the presence of pedestrians or bicyclists.
>
> (c)The road authority shall post a sign giving notice of the designated speed at each end of the portion of highway where the designated speed is imposed and at such other places on the highway as may be necessary to inform the public. The designated speed shall be effective when signs giving notice of the designated speed are posted.

[99] The City of Portland, Portland Bureau of Transportation Website "How Portland's Streets Are Maintained and Repaired" (accessed June 2018).

[100] Friedman, G., "3,000 Miles of Portland Streets May Get Slower Speed Limits Under New Bill," ***The Oregonian*** (April 24, 2017).

The City of Portland, Portland Bureau of Transportation Website "Residential Speed Limit Reduction" (accessed June 2018).

[101] The City of Portland, Portland Bureau of Transportation Website "Residential Speed Limit Reduction" (accessed June 2018).

[102] Njus, E., "Portland City Council Approves 20 mph Speed Limit on Residential Streets," ***The Oregonian*** (January 18, 2018).

[103] GIS analysis using data provided by the Ashland Public Works Department, November, 2020

Consequently, Ashland may need to conduct speed studies and post additional signs than Portland. With that in mind, it is estimated that the City’s cost to reduce maximum speeds could total as much as $100,000.

6. Improved Public Health

The public health consequences of 20mph speed limits are far-reaching and implicate many facets of life. Since it is unlikely any review can comprehensively capture the benefits society realizes with slower traffic speeds and lower driving levels, this section is not intended to be categorical in coverage. Rather, it briefly surveys certain empirical findings relevant to Ashland's potential adoption of 20mph speed limits, focusing on traffic collisions, pollution, and the obesity and diabetes health epidemics.[104]

Notwithstanding the limited coverage of public health effects discussed in this report, the substantial breadth of public health impacts brought about with 20mph speed limits is notable. In summary of the widespread value of 20mph speed limits on public health, one University of Oxford researcher states:

> …when asked what single policy I would suggest [to improve public health], I always reply '20mph' or, if I'm being a little more verbose: 'twenty's plenty.' This normally elicits some surprise. The person I am speaking to usually expects me to suggest reducing poverty by reducing unnecessary privileges for the rich, narrowing economic inequalities, raising social mobility, or improving health services or education; not simply slowing cars down. All those other things are very laudable, but if you want to do just one thing, then the thing you can actually do, the one thing that has now been done in over one hundred local authorities…, the thing that makes a difference that you can feel, see and measure straight away, is to stick a sign that says 20mph [on posts] where you live. And, fortunately, it is now (almost) as easy as that.[105]

Fewer Collisions Improve Health and Make Health Outcomes More Equitable

Overwhelming empirical evidence, some of which is outlined earlier in this report, chronicles the power of 20mph speed limits to reduce both the quantity and severity of traffic collisions. Drivers, passengers, motorcyclists, pedestrians, cyclists, and children realize significant safety and health gains. A review of 20mph speed limit regimes published in the *Journal of Public Health* concludes that: "Twenty mile per hour zones and limits are effective means of improving public health via reduced accidents and injuries."[106] More evidence will not be presented here to elaborate on this point, but volumes remain available to testify to the significance of 20mph speed limits in securing public well-being.

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[104] Other areas of public health that are not addressed, but which have been found to benefit from reduced traffic speeds/levels or from increased non-automotive transport levels include social health, mental health, and depression. See, for instance: Leyden, K., "Social Capital and the Built Environment: The Importance of Walkable Neighborhoods," ***American Journal of Public Health***, Vol. 93, No. 9 (2003).

[105] Dorling, D., "20mph Speed Limits for Cars in Residential Areas, by Shops and Schools," Nine Local Actions to Reduce Health Inequalities, University of Oxford.

[106] Cairns, J., et al., "Go Slow: An Umbrella Review of the Effects of 20mph Zones and Limits on Health and Health Inequalities," ***Journal of Public Health***, Vol. 37, No. 3 (2015).

A related point, and one that has not yet been addressed in this report, relates to questions of socioeconomic equity in the public health implications of 20mph speed limits. It has been found that traffic collisions are disproportionately damaging for those with lower incomes and less education. One's chances of being killed or seriously injured in traffic crashes rise as one's salary or education level falls, with low-income pedestrians *twice as likely to be killed* as higher-income pedestrians.[107] Traffic accidents accordingly represent a significant source of social inequality and, by extension, show that traffic speed limits above 20mph are a forceful promoter of inequity in a transportation system.[108]

While the economics are complex and will only be mentioned in brief here, it is generally the case that the lower a person's income and education, the more likely that person is to lack health insurance. In the event emergency care is required, the individual will either accumulate paralyzing medical debt, or, owing to an inability to pay medical costs, effectively receive "charity care" funded by outside money.[109] Hence, the long-run personal economic implications of traffic collisions inequitably bear on those with lower incomes, and public funds are disproportionately funneled into the treatment of injuries generated by traffic collisions.[110] In Ashland, this issue is acute, since it is estimated that almost 10% of the population under 65 years old lacks health insurance.[111] Speed limits of 20mph help pare this root of social inequality by cutting traffic collisions and injuries - especially among groups that simultaneously carry both the greatest injury risk and the lowest health insurance coverage - while also helping improve the financial efficiency of local health care provision.[112]

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[107] Harper, S., "Trends in Socioeconomic Inequalities in Motor Vehicle Accident Deaths in the United States, 1995-2010," ***American Journal of Epidemiology***, Vol. 182, No. 7 (2015).

Morency, P., "Neighborhood Social Inequalities in Road Traffic Injuries: The Influence of Traffic Volume and Road Design," ***American Journal of Public Health***, Vol 106, No. 2 (2012).

Maciag, M., "America's Poor Neighborhoods Plagued by Pedestrian Deaths," Governing Research Report (August 2014).

[108] Dorling, D., "20mph Speed Limits for Cars in Residential Areas, by Shops and Schools," Nine Local Actions to Reduce Health Inequalities, University of Oxford.

[109] "Key Facts about the Uninsured," Henry J. Kaiser Family Foundation (September 19, 2017).

[110] Lam, B., "Who Pays Hospital Bills When Patients Can't?" ***The Atlantic*** (October 13, 2015).

"A Floor-and-Trade Proposal to Improve the Delivery of Charity-Care Services by U.S. Nonprofit Hospitals," The Hamilton Project, The Brookings Institution, Policy Brief 2015-07 (2015).

[111] United States Census Bureau, "Ashland, Oregon QuickFacts" (accessed December 8, 2020).

[112] St. Charles Health System, Inc. is a not-for-profit Oregon corporation and provides a financial assistance program for those unable to pay for the cost of their care, a practice sometimes referred to as "charity care" in the U.S. healthcare system.

Oregon Health Authority, Division of Health Policy & Analytics, Office of Health Analytics "Oregon Acute Care Hospitals Financial and Utilization Trends, 4th Quarter 2016," (June 2017).

Lower Pollution Levels Enhance Public Health and Reduce Medical Costs

Earlier in this report the influence of traffic speed and traffic volume on various pollutants was described. Levels of CO_2, micro-plastics, particulates, and road noise decline in response to slower traffic and lower VMTs. The consequences of reduced pollution on future environmental remediation costs and on resident life quality were also mentioned. Unstated were the profound human health consequences of air and noise pollution and the salutary public health effects of reducing those pollutants.

Traffic-related air pollution has been shown as a statistically significant predictor of an array of health maladies, including childhood asthma,[113] cardiovascular risk,[114] as well as inflammation and cancer,[115] and links to pregnancy disorders have also been suggested.[116] Traffic noise, for its part, has been found to contribute to hypertension, heart attack risk, childhood cognitive impairment, and sleeping disorders.[117]

While quantifying the financial consequences of improving public health levels by reducing air and noise pollution will not be attempted, it is clear that the directional relationship between pollution and costs associated with disease and mortality is positive, and it is further apparent that the magnitude of pollution-related healthcare costs is quite high. Even modest pollution reductions would substantially improve public health outcomes and reduce overall medical costs borne by Ashland's residents and health care providers.

[113] Khreis, H. and MJ Nieuwenhuijsen, "Traffic-Related Air Pollution and Childhood Asthma: Recent Advances and Remaining Gaps in the Exposure Assessment Methods," *International Journal of Environmental Research and Public Health*, Vol. 14, No. 3 (2017).

[114] Nawrot, T., "The Detrimental Health Effects of Traffic-Related Air Pollution," *American Journal of Respiratory and Critical Care Medicine*, Vol. 179, No. 7 (2009).

[115] Krzyzanowski, M., B. Kuna-Dibbert and J. Schneider (Eds.), "Health Effects of Transport-Related Air Pollution," World Health Organization (2005).

[116] Raz, R., et al., "Traffic-Related Air Pollution and Autism Spectrum Disorder: A Population-Based Nested Case-Control Study in Israel," *American Journal of Epidemiology*, Vol. 187, No. 4 (2018).

Krzyzanowski, M., B. Kuna-Dibbert and J. Schneider (Eds.), "Health Effects of Transport-Related Air Pollution," World Health Organization (2005).

[117] Pignier, N., "The Impact of Traffic Noise on Economy and Environment: A Short Literature Study," KTH Royal Institute of Technology (2015).

Increased Walking and Cycling Reduce Incidence of Obesity and Diabetes

Obesity and diabetes constitute two of the most significant health epidemics facing American society. They afflict tens of millions of people and generate hundreds of billions of dollars in medical expenses nationally.[118]

Within Jackson County, Oregon, approximately 25% of adults are obese.[119]

Obesity and diabetes are linked to sedentary lifestyle factors and can be prevented and managed with physical activity. An increase in activity reduces risk of onset and intensification.[120] Owing to the simple relationship between physical movement and affliction with obesity or diabetes, it follows that modal substitution from driving to walking or cycling would reduce the severity and affliction rates of obesity and diabetes in the community by replacing a sedentary activity, driving, with non-sedentary ones, walking and cycling, in people's routines.

As with the inequitable socioeconomic profile of traffic collisions, obesity and diabetes express a similarly steep relationship across the socioeconomic gradient. Both diseases show strong inverse relationships with income and education level. As income and education levels decline, obesity and diabetes rates increase.[121] Transportation systems that discourage modal substitution into walking and cycling due to unsafe speed limits accordingly impart disproportionately large harms on those people at the lowest socioeconomic status levels. This is because those with less income and education tend to be simultaneously those most at risk for injury or fatality while walking (and thus most discouraged from it) and those whose statistical health profiles could most benefit from walking.[122] Addressing equitability effects in a transportation system requires consideration of this factor.

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[118] "Adult Obesity Causes & Consequences," Centers for Disease Control and Prevention Website (accessed June 2018).

Petersen, M., "Economic Cost of Diabetes in the U.S. in 2012," ***Diabetes Care***, Vo. 36 (2013).

[119] "Open Data Network,
https://www.opendatanetwork.com/entity/0500000US41029/Jackson_County_OR/health.health_behaviors.adult_obesity_value?year=2015
(accessed December 8, 2020)

[120] "Obesity Prevention Source," Harvard T.H. Chan School of Public Health (accessed June 2018).

[121] Ogden, C., et al., "Prevalence of Obesity Among Adults, by Household Income and Education - United States, 2011-2014," ***MMWR Morbidity and Mortality Weekly Report (CDC)***, Vol. 66, No. 50 (2017).

Rabi, D., et al., "Association of Socio-Economic Status with Diabetes Prevalence and Utilization of Diabetes Care Services," ***BMC Health Services Research***, Vol. 6 (2006).

[122] Morency, P., "Neighborhood Social Inequalities in Road Traffic Injuries: The Influence of Traffic Volume and Road Design," ***American Journal of Public Health***, Vol 106, No. 2 (2012).

Beyond 20mph speed limits' modal substitution effects, lower speed limits also can encourage incremental walking trips made solely for exercise or pleasure among those in the lowest income brackets. This effect would generate advantageous health results. Institution of 20mph speed limits would reduce pedestrian risks and remove an impediment to increased physical activity for those most at risk for obesity and diabetes.

CONCLUSION

Before enumerating specific findings of this report, one foundational conclusion must be emphasized. Adoption of 20mph speed limits in a transportation system is an important, and perhaps necessary, step toward enhancing that system's safety, efficiency, reliability, and equitability. It is not, however, a standalone cure for all transportation system problems, and information outlined in this report should not be mistaken for suggesting 20mph speed limits are a panacea. Two points illustrate why.

First, the breadth of success in improving safety and generating economic gains associated with 20mph speed limits is modulated by the particulars of its implementation. The greater a commitment to public education, police enforcement of speeds, and installation of complementary traffic calming measures, the greater the traffic speed and traffic volume responses will be, and hence the greater the safety and economic gains will be. It is true that simply replacing speed limit signs has been shown to produce improvements, and those "sign-only" benefits are a good first step. Yet, the full array of social and economic returns will not be realized without supplemental initiatives like education, enforcement, and calming. Thus, any contemplation of adopting 20mph speed limits also implies adoption of some level of complementary policies to support that speed limit change. Indeed, this report reflects an "average" implementation of 20mph speed limits, involving more than changing signs but less than large-scale reconfiguration of roadways to calm traffic as some cities have done. Greater results than those calculated here could be obtained with an above-average commitment to implementation and complementary policies.

Second, even with a "full" implementation of 20mph limits and supportive ancillary measures, a transportation system will still be susceptible to traffic deaths and injuries, system bottlenecks, fuel and resource wasting, travel time variability, and inequitable distributions of the system's benefits and costs. Accordingly, while 20mph speed limits and complementary measures are crucial to improving a transportation system, additional policies to promote safety and social efficiency are required to fully address transportation system needs. The findings of this report should not be mistaken to suggest that 20mph speed limits are a cure-all; they are not. They are important, and they are socially and economically compelling, but they are not, on their own, sufficient.

Finally, Ashland's major roadways, even where there are bike lanes, are fundamentally dangerous except for those few people (the Brave and the Fearless) who have the knowledge and skills to "ride in traffic". Few citizens can or do ride in traffic. However, improvements to the transportation system that match bicycle facility design, as described by the National Association of City Transportation Officials[123], to the skill and knowledge level of "all ages and abilities" will allow everyone to ride everywhere in safety; just as motorists can now do. The required improvements are beyond the scope of this paper but should be identified, funded, designed and constructed as a part of the City's upcoming update of its Transportation System Plan.

[123] National Association of City Transportation Officials, Designing for All Ages and Abilities, December 2017, https://nacto.org/wp-content/uploads/2017/12/NACTO_Designing-for-All-Ages-Abilities.pdf

Stepped-up traffic enforcement, broader use of neighborhood traffic calming measures, and improvements/construction of bicycle and pedestrian facilities have a cost. These costs are not considered in the estimated $100,000 price tag to lower maximum speeds consistent with the requirements of ORS 810.180.

Having addressed theses critical points, we now outline effects that can be reasonably expected to result from Ashland's adoption of 20mph system-wide speed limits:

1. Dramatic reductions in traffic collisions of all types are associated with 20mph speed limit systems. Fatal and KSI collisions exhibit especially large decreases. In addition to saving lives from premature death and debilitating injury, 20mph speed limits in Ashland would be associated with economic savings in the range of $0.76 million per year.

2. Traffic congestion levels would be expected to decrease in Ashland following adoption of 20mph speed limits as a consequence of modal substitution and improved utilization of roadway resources. Total annual VMT reductions in the range of 5% would be expected.

3. Vehicular travel times would be either slightly reduced or unaffected by implementation of 20mph speed limits.

4. Declines in VMT and increases in modal substitution result in system-wide fuel consumption decreases. The decline in motor fuel consumption would generate financial savings for Ashland residents of about $305,554 per year.

5. Traffic-related pollution is a function of the volume and speed of motorized vehicles. Important environmental benefits, including reduced CO_2, particulate matter, and noise pollution result from slower speeds and reduced VMT. The estimated benefit of CO_2 reductions, 1,070 metric tons, are worth $133,758.

6. Reductions in traffic speed and volume diminish road wear.

7. The cost of implementing 20mph speed limits in Ashland is low, estimated to be in the range of $100,000.

8. Public health levels increase as VMTs decline and modal substitution occurs, which would benefit all residents of Ashland and enhance efficiency of local health care.

9. A 20mph speed limit system is more socially equitable than a 25mph system, and 20mph speed limits would improve social equitability in Ashland.

Thank you for your consideration of this important transportation policy change.

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Steve is a recognized authority on economic analysis and valuation. He has provided expert testimony in high-stakes commercial litigation on topics including economics, valuation, statistics, econometrics, market definition, consumer choice, business strategy, and pricing, among others. He has consulted with Fortune 500 corporations on intellectual property licensing, asset transactions, and valuation issues, and he has conducted economic impact analyses, including work performed on behalf of the Los Angeles Superior Court. His articles have published in the *Journal of Legal Economics*, *les Nouvelles*, the *Patent, Trademark & Copyright Journal*, the *Journal of the Patent and Trademark Office Society*, and *Intellectual Asset Management*, among others. He also is co-author of *IP Strategy, Valuation, and Damages* (LexisNexis), a treatise on intellectual property economics. Steve has been an invited speaker before the Chicago Bar Association, the Attorney General's Office of the State of Arizona, and various law firms and corporations, where he has lectured on topics ranging from economic analysis and valuation to econometrics and game theory, and he has been quoted by and featured in the editorials section of the *Wall Street Journal*. Steve is a recipient of the William J. McKinstry Award in economics, the *Wall Street Journal* Scholar Award, the Micronomics Economic Research Award, and the IE Fund Leadership Scholar Award. He has served as a teaching assistant in economics at the Dolibois European Center in Luxembourg, an ad-hoc referee for the *Journal of Forensic Economics*, and as Co-Chair and an Executive Committee Member of Young Professionals Advisory Council at the Farmer School of Business. Steve graduated *summa cum laude* and with University Honors from Miami University in Oxford, Ohio, completing dual majors in economics and marketing. He was granted his MBA, with honors by the Dean and Board of Academic Affairs, from IE Business School in Madrid, Spain, graduating 5th in a class of more than 400. Steve holds the Series 65 securities license.

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