LITERATURE REVIEW

1. A conceptual framework for road safety and mobility applied to cycling safety
Scientific literature lacks a model which combines exposure to risk, risk, and the relationship between them. This paper presents a conceptual road safety framework comprising mutually interacting factors for exposure to risk resulting from travel behaviour (volumes, modal split, and distribution of traffic over time and space) and for risk (crash and injury risk). The framework’s three determinants for travel behaviour are locations of activities; resistances (generalized transport costs); needs, opportunities, and abilities. Crash and injury risks are modelled by the three ‘safety pillars’: infrastructure, road users and the vehicles they use. Creating a link in the framework between risk and exposure is important because of the ‘non-linear relationship’ between them, i.e. risk tends to decrease as exposure increases. Furthermore, ‘perceived’ risk (a type of travel resistance) plays a role in mode choice, i.e. the perception that a certain type of vehicle is unsafe can be a deterrent to its use. This paper uses theories to explain how the elements in the model interact. Cycling is an area where governments typically have goals for both mobility and safety. To exemplify application of the model, the paper uses the framework to link research on cycling (safety) to land use and infrastructure. The model’s value lies in its ability to identify potential consequences of measures and policies for both exposure and risk. This is important from a scientific perspective and for policy makers who often have objectives for both mobility and safety. (Science direct)

2. Assessment of the effectiveness of narrow separators on cycle lanes
Axel Wilke, Judith Aussendorf
IPENZ Transportation Group Conference Dunedin, 2013
Road authorities desire to better provide for existing people cycling, and to encourage more people who wish to cycle but are discouraged due to safety concerns. There is widespread acknowledgement (supported by a substantial body of research) that providing increased physical separation between motor vehicle and bicycle space will help address these concerns and lead to an increase in cycling. A wide variety of physical devices and delineators are available to provide separation. This research covers on-road trials of a 100 mm wide raised bicycle lane separator in Christchurch. ViaStrada was commissioned by VicRoads to design the
empirical study, and evaluate and report on the findings. Christchurch City Council provided site support and Canterbury University helped to analyse the results. Separators were placed in two locations where motorists were commonly encroaching into exclusive bicycle lanes. Road user behaviour was observed before and after installation, and qualitative feedback was also sought from site users. The results show a significant effect on motor vehicle encroachments following installation, particularly when separators were supplemented by vertical posts. Very positive feedback was also received from existing cyclists. Some recommendations for best practice guidance on the most appropriate treatment locations and layouts are also suggested. (Scholar)

3. Bicycle guidelines and crash rates on cycle tracks in the United States
   Anne C. Lusk, Patrick Morency, Luis F. Miranda-Moreno, Walter C. Willett, Jack T. Dennerlein
   We studied state-adopted bicycle guidelines to determine whether cycle tracks (physically separated, bicycle-exclusive paths adjacent to sidewalks) were recommended, whether they were built, and their crash rate. We analyzed and compared US bicycle facility guidelines published between 1972 and 1999. We identified 19 cycle tracks in the United States and collected extensive data on cycle track design, usage, and crash history from local communities. We used bicycle counts and crash data to estimate crash rates. A bicycle facility guideline written in 1972 endorsed cycle tracks but American Association of State Highway and Transportation Officials (AASHTO) guidelines (1974–1999) discouraged or did not include cycle tracks and did not cite research about crash rates on cycle tracks. For the 19 US cycle tracks we examined, the overall crash rate was 2.3 (95% confidence interval = 1.7, 3.0) per 1 million bicycle kilometers. AASHTO bicycle guidelines are not explicitly based on rigorous or up-to-date research. Our results show that the risk of bicycle–vehicle crashes is lower on US cycle tracks than published crashes rates on roadways. This study and previous investigations support building cycle tracks.
   http://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2012.301043

4. Bicycle infrastructure: can good design encourage cycling?
   Angela Hull & Craig O'Holleran
   This research posits the question that good design of the bicycle infrastructure in a city will encourage more people to cycle. Research is carried out to compare the cycle infrastructure in selected European cities against an adapted Level of Service concept using accompanied ride-alongs. The literature review on the factors that encourage/dissuade cycle use suggests that it is the potential rider’s perceptions on the safety of cycling in their neighbourhood that is the deciding feature. Moreover, the literature review showed that contextual factors such as whether the actual infrastructure meets the needs of different cyclists are relatively under-researched. Six case study cities were selected (Edinburgh, Cambridge, Amsterdam, Rotterdam, The Hague, Utrecht) and compared on a range of factors by the riders including the coherence, directness, attractiveness, safety and comfort of the network. A cycle infrastructure scoring system was derived from the cycling research literature and the research was carried out by the researcher, an experienced cyclist, accompanied by an inexperienced cyclist. Using this research, the article makes several recommendations for improving and enhancing existing cycle infrastructure provision. (Taylor & Francis)

5. Bicycle transportation issues: describing the attitudes and opinions of cyclists in Austin, Texas
   Justin William Marlin
   Texas State University, An Applied Research Project, Degree of Masters of Public Administration, 2008
   Bicycling is an underutilized and marginalized mode of transportation. The neglect of bicycle funding and infrastructure has led to an increasingly unsafe environment for cyclists. Cities are on the forefront of addressing cycling issues and are most likely to encounter and ultimately have to fix the problems facing cyclists. The lack of cycling facilities is a serious issue, but expanding opportunities for cyclists produces many benefits not only for individuals but society as a whole. Austin Texas has been designated a Silver level bicycle friendly city with a favourable bicycling environment when compared to other U.S. cities. Therefore this study describes the attitudes and opinions of cyclists in Austin, Texas regarding the effectiveness of the city of Austin in addressing factors important to increasing bicycle transportation options. Bicycling issues identified through a literature review resulted in a set of categories that formed the basis of a survey. The survey was distributed electronically to cyclists throughout Austin. But as the results of this study highlight, in the eyes of its own cyclists, Austin still has a lot of work to do to make cycling a more viable transportation option. Cyclists are most
concerned about Austin’s improvement in the following areas: bicycle lanes and paths, connecting existing bicycle facilities and bicycles with public transportation, traffic enforcement of motorists, cyclist education, large-scale land use, and finally commuting and utilitarian cycling. In addition to discussing the problems associated with the afore mentioned categories, recommendations for overcoming these barriers will be provided. Addressing these issues has the greatest potential for making a safer and more convenient bicycling environment, thus improving bicycle transportation options for Austinites. https://ecommons.txstate.edu/bitstream/handle/10877/3436/fulltext.pdf?sequence=1

6. Design options to reduce turning motor vehicle conflicts with bicyclists and pedestrians at intersections
Rogers, William
RiP Project 40212, 2015
More than 4,000 pedestrians and 700 bicyclists were killed in collisions with motor vehicles in the United States in 2012. Each year, many more pedestrians and bicyclists have their jobs, financial security, and physical capabilities changed permanently as a result of non-fatal crashes. The most common location for these collisions is at intersections. By way of example, a nine-year analysis of bicycle crash types in Cambridge, MA showed that over 60% of bicycle/motor vehicle crashes occurred at intersections. In addition, 56% of pedestrian crashes in Alameda County, CA occurred at or within 50 feet of an intersection. Signalized intersections are particularly important locations for safety improvements: an extensive pedestrian safety analysis in New York City found that nearly half (47%) of pedestrian fatalities and severe injuries occurred at signalized intersections. Improving bicycle facilities at intersections is clearly a critical safety topic, and several common types of bicycle crashes have been identified in previous studies. Of particular concern for bicyclist safety at intersections is the conflict between bicyclists traveling straight and automobiles from the opposite direction turning left across the path of bicyclists. In addition, there are often conflicts between bicyclists traveling straight and automobiles from the same direction turning right across the path of bicyclists. A third common type of bicycle crash involves motorists emerging from side streets and driveways (which are a kind of minor intersection) and not yielding to through-moving cyclists. There are also several common types of pedestrian crashes. These often occur at intersections that involve automobiles turning left and striking pedestrians in the far crosswalk and automobiles turning right and striking pedestrians in the near or far crosswalk. This includes situations where drivers are allowed to make a right turn on red. Despite the widespread acknowledgment of these problems, transportation engineers and planners still lack definitive guidance on which types of designs have the greatest safety benefits. For example, current design practices commonly drop bicycle pavement markings and signs at intersections, providing little or no positioning guidance for motorists or bicyclists. Meanwhile, some more recent guidance suggests options such as dashing or coloring through the intersection. Some intersections fail to provide crosswalks or pedestrian signals, leaving motorists and pedestrians to rely on their best guess as to what the other user will do. In addition to these ambiguous situations, there are a number of design choices that may directly impact pedestrian or bicycle safety: pedestrian signal phases may be shortened to their minimum required length, turning radii may be increased, or right-turn-on-red may be allowed in order to allow more automobiles to pass through the intersection, making it more difficult to cross the street as a pedestrian. These changes are often made without the most effective consideration of pedestrian safety. There is no comprehensive approach to indicate what designs provide the most effective approach or the most appropriate situation in which each should be applied. The primary guidance documents for practitioners, including the American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities (2012), AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities (2004), NACTO Urban Bikeway Design Guide (2011), Highway Capacity Manual (2010), Highway Safety Manual (2010), and Manual on Uniform Traffic Control Devices (2009), do not provide sufficient information about the strategies that are most effective in specific circumstances. Engineering judgment will still be needed in many cases, but better guidance for applying typical and innovative intersection design treatments will help improve pedestrian and bicycle safety. The objective of this research is to develop guidance for intersection design that minimizes the risk of motor-vehicle turning conflicts with pedestrians and bicyclists. The following tasks are expected: (1) identify typical and innovative design treatments to improve the safety of bicyclists and pedestrians at signalized intersections; (2) identify prevalent motor vehicle/bicycle and motor vehicle/pedestrian crash types at signalized intersections and identify specific differences in different settings (urban, suburban, rural); (3) conduct conflict studies at intersection approaches with and without the following design elements:
for bicycles, standard bicycle lanes; marked/dashed bike lane/bike travel path through intersections; colored pavement for bike travel paths through intersections; bike boxes; bicycle signal-heads with accompanying bicycle-specific signal phasing; physical separation of bicycle facilities; and exclusive right-turn lanes for automobiles; for pedestrians, pedestrian signals with and without leading pedestrian intervals; curb extensions; reduced curb radius; prohibit right-turn-on-red; and pedestrian crossing islands; (4) document safety impacts of various design treatments observed; and (5) a practitioner's reference for effective accommodation of bicycles and pedestrians at intersections. This reference will synthesize existing information in the common manuals mentioned above and add relevant results from research providing practitioners with documentation to improve designs of intersections for multiple users. A key outcome of this research is the ability to determine those intersection designs that provide the most effective means of improving bicycle safety for specific situations and environments. Note that the conflict studies will not be expected to produce crash modification factors (CMFs) since it is unlikely that there will be sufficient data to draw strong conclusions. However, the conflict studies will provide a basis for future data collection and more rigorous studies that produce CMFs. (TRID)

7. **Influence of bike lane buffer types on perceived comfort and safety of bicyclists and potential bicyclists**
   McNeil, Nathan, Monsere, Christopher M, Dill, Jennifer
   Transportation Research Record: Journal of the Transportation Research Board, No. 2520, pp.132-142
   Buffered and protected bike lanes are increasingly recognized as a valuable tool in enticing potential or wary cyclists to use a bicycle for transportation. These facilities—which provide extra space and (in the case of protected bike lanes) physical separation from motor vehicles—have been studied and are preferred by many bicyclists over traditional bike lanes. There has been little research, however, on the difference between buffer types and how they affect people’s sense of the safety and comfort of bicycling. This paper uses data from surveys collected for a multicity study of newly constructed protected bike lanes to examine the influence of various hypothetical and actual buffered bike lane designs (both with and without physical protection) from the perspective of current bicyclists (n = 1,111) and of residents living near the new facilities (n = 2,283) who could be potential bicyclists. Findings suggest that striped or painted buffers offer some level of increased comfort, whereas buffers with some sort of physical protection, even protection as minimal as a plastic flexpost, yield significant increases in perceived comfort for potential cyclists with safety concerns (the interested but concerned). Of residents living near recently built protected bike lanes, 71% of all residents and 88% of the interested but concerned indicated that they would be more likely to ride a bicycle if motor vehicles and bicycles were physically separated by a barrier. (TRID)

8. **“Bicycles may use full lane” signage communicates U.S. roadway rules and increases perception of safety**
   George Hess, M. Nils Peterson
   PLoS ONE, 2015, Vol.10, No. 8
   Many global challenges, including obesity, health care costs, and climate change, could be addressed in part by increasing the use of bicycles for transportation. Concern about the safety of bicycling on roadways is frequently cited as a deterrent to increasing bicycle use in the USA. The use of effective signage along roadways might help alleviate these concerns by increasing knowledge about the rights and duties of bicyclists and motorists, ideally reducing crashes. We administered a web-based survey, using Twitter for recruitment, to examine how well three US traffic control devices communicated the message that bicyclists are permitted in the center of the travel lane and do not have to “get out of the way” to allow motorists to pass without changing lanes: “Bicycles May Use Full Lane” and “Share the Road” signage, and Shared Lane Markings on the pavement. Each was compared to an unsigned roadway. We also asked respondents whether it was safe for a bicyclist to occupy the center of the travel lane. “Bicycles May Use Full Lane” signage was the most consistently comprehended device for communicating the message that bicyclists may occupy the travel lane and also increased perceptions of safety. “Share the Road” signage did not increase comprehension or perceptions of safety. Shared Lane Markings fell somewhere between. “Bicycles May Use Full Lane” signage showed notable increases in comprehension among novice bicyclists and private motor vehicle commuters, critical target audiences for efforts to promote bicycling in the USA. Although limited in scope, our survey results are indicative and suggest that Departments of Transportation consider replacing “Share the Road” with “Bicycles May Use Full Lane” signage, possibly combined with Shared Lane Markings, if the
intent is to increase awareness of roadway rights and responsibilities. Further evaluation through virtual reality simulations and on-road experiments is merited.
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0136973

9. Operational analysis of shared lane markings and green bike lanes on roadways with speeds greater than 35 mph
Sando T & Hunter W
Florida Department of Transportation Research Centre, 2014
This study analysed the effectiveness of shared lane markings (sharrows), wide curb lanes, standard and buffered bike lanes, and green bike lanes in improving operations of bicycle facilities. Three measures of effectiveness were used in this study: lateral separation between the motor vehicle and bicyclist, the distance of bicyclists to the curb or edge of pavement, and the yielding behaviour of drivers and cyclists at merge points. Also, motor vehicle speeds before, while, and after passing bicyclists were analysed. Except for the Bridge of Lions site, the before-and-after data indicate that installation of sharrows led to an increase in lateral separation between motor vehicles and bicyclists. At Riverside Drive, the separation increased by 0.67 feet, while at the North 56th Street site, an increase of 2.55 feet was observed after installing sharrows and increasing the outside lane width. Data also suggested a significant improvement in lateral separation of 0.86 feet at Sunset Drive, which was widened to create a wider outside lane (but had no shared lane markings), and Bailey Road, where a marked buffer between the travel lane and bike lane resulted in an increase in separation between motor vehicles and bicyclists of 0.72 feet. It was also observed that bicyclists rode further from the curb/edge of pavement for the after-period compared to the before-period for Riverside Drive, Bridge of Lions, North 56th Street, and Sunset Drive. P-values less than 0.05 were observed for these five sites suggesting that the treatments were effective in moving bicyclists further from the curb/edge of pavement. Data also indicates that drivers slow down as they pass bicyclists on non-limited access roadways (before speed of 32.02 mph to 29.97 mph while-passing) and then increase their speeds after overtaking the bicyclists (30.80 mph while-passing to 32.82 mph after-passing). The difference between the speeds before-passing and while-passing, and while-passing and after-passing, were both significant with a p-value less than 0.000. However, when the before-passing (32.02 mph) and after-passing (32.54 mph), excluding while-passing speeds, were analysed, no significant difference was found (p-value = 0.110). For limited access facilities, the difference between the overtaking driver’s speed before-passing (37.35 mph) and while-passing (34.93 mph) the bicyclists was significant with a p-value of 0.000. However, the difference between motor vehicle speeds while-passing bicyclists (34.94 mph) and after-passing (35.48 mph) was not significant (p-value = 0.150). Contrary to the non-limited access streets, the difference between vehicle speeds before- (37.33 mph) and after-passing (35.48 mph) was significant for the limited access facilities (p-value =0.017).
(Google Scholar)

10. 5 of the greatest dangers facing cyclists in London
Andreas, 12/08/2014 in Safe cycling in London
London Cyclist, 2014
http://www.londoncyclist.co.uk/5-greatest-dangers-facing-cyclists-london/