Cycling and Road Lighting: A Review

**Abstract**

Evidence shows that darkness discourages people from cycling. This is due to a higher perceived danger of cyclists at night from motorised traffic and personal security, which disproportionately affect women, the elderly, and disadvantaged groups. This paper provides a review on the scientific literature that intersects between cycling and road lighting to better understand the relationship between both terms. We used a hybrid systematic and snowballing method. 52 studies on several disciplines such as engineering, transport, road safety, and public health were reviewed. The literature suggests that… Gaps in the literature are…

**Keywords**

Cycling; road lighting; road safety; personal security; inequalities

# Introduction

Benefits of cycling are well established in the literature. Cycling improves physical, mental, and social health; reduces pollution, carbon emissions, and congestion; and it is more inclusive than private motorised modes, reducing inequalities (references needed). For this reason, cycling is being encouraged. Yet, most people keep choosing to drive to cycle.

One of the main determinants of cycling is fear of motorised vehicles (reference needed). Many studies have explored to what extent safe cycling infrastructure affects cycling (add brief conclusions of these studies here). However, less investigated have been other micro-built environmental factors such as road lighting, which may have a strong influence on people’s fear when cycling.

Previous academic literature reviews have touched on elements of the relationship between cycling and lighting. For example, S. Fotios and Castleton (2017) reviewed suggested interventions to enable cycling lighting to contribute to the safety of cyclists in the UK. Reynolds et al. (2009) reviewed the impact of transport infrastructure, including street lighting, on cycling collisions. However, to the best of our knowledge, no academic paper has reviewed the international literature available on the intersection between both terms, cycling and road lighting. This paper aims to fill this gap in the literature.

The review is guided by the following questions:

1. To what extent does darkness influence cycling behaviour?
2. To what extent does darkness increase the risk of road collision among cyclists?
3. To what extent does darkness increase the risk of being a victim of crime among cyclists?
4. Is the association between cycling and darkness the same between different groups?
5. What type of road lighting is the most suitable for cycling to increase and be safer?

We focus on road and/or ambient lighting, excluding studies on lighting equipment for cyclists, such as reflective clothing or bicycle-mounted lights.

The review is organized as follows. Section 2 describes the method. Section 3 presents the findings of the papers reviewed. Section 4 critically analyses the findings and identifies gaps in the literature. Section 5 closes the work with the conclusions.

# Method

We used a hybrid systematic and snowballing method. First, we searched in the SCOPUS electronic databased (on 15 November 2022) for studies investigating the relationship between cycling and road lighting. The query string used for the search was as follows:

*(bicycl\* OR bik\* OR cycling OR cyclist\* OR “cycle hire”) AND (“city light\*” OR “public light\*” OR “road light\*” OR “street light\*” or “city illumination” OR “public illumination” OR “road illumination” OR “street illumination” OR “city lamp\*” OR “public lamp\*” OR “road lamp\*” OR “street lamp\*” OR “lamp post\*” OR “light post\*” OR “light pole\*”)*

This search, based on the content of the title, abstract, and keywords, resulted in 262 records. After screening abstracts and full text, 46 studies were selected. We excluded papers that did not focus on cycling and road lighting (many studies mentioned cycling and lighting in passing but not as the topic of the paper).

In the second stage, we checked the references from the studies selected (i.e. snowball technique), and after screening abstracts and full texts, 11 additional papers were selected. In total, 57 were reviewed. A flow chart of included studies is shown in Figure 1.

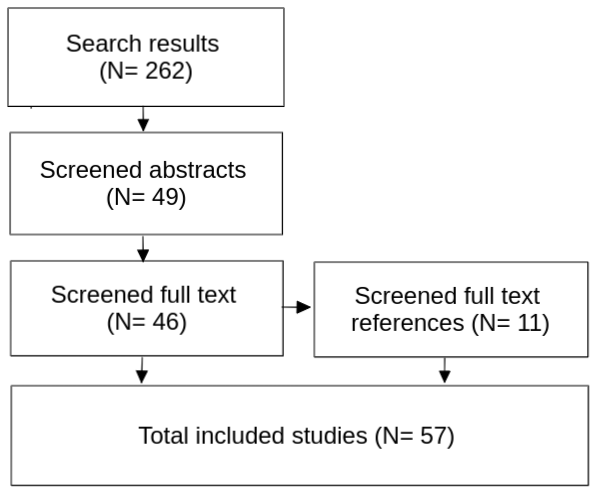


Figure 1: flow chart

# Results

The scientific literature was found to be broadly spread across several disciplines, including engineering, transport, road safety, and public health.

Five main themes emerged:

1. Cycling behaviour and lighting
2. Cycling collisions and lighting
3. Cycling, crime and lighting
4. Cycling inequalities in lighting
5. Proper lighting for cyclists

Most of the studies were written in the last decade, 49 were empirical and 8 were reviews (Figure 1).

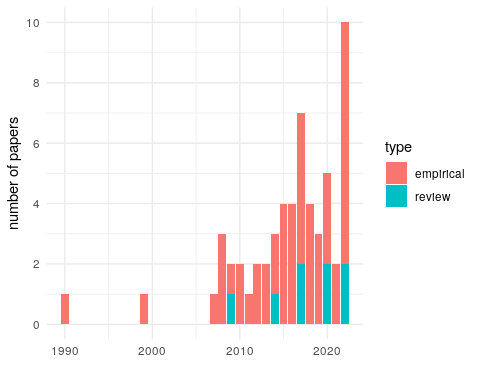


Figure 2: number of papers reviewed by type and year

## Cycling behaviour and lighting

Previous research has found a positive association between street lighting and active travel and physical activity (references needed). Street lighting increases cyclists’ sense of safety at night by helping them see and be seen by other road users during their journey. It also provides them with a greater sense of security against possible threats in the dark.

A recent review on differences and similarities in cycling between sub-Saharan African cities (SSA) and developed world cities (DWC) found that studies in both SSA cities and DWC are unanimous that street lighting has an important influence on cycling (Mendiate et al. 2022). “Ribbens (2008) indicate that cyclists avoid poorly lit streets in the townships of South Africa. Buyana and Shuaib (2014) indicate that”cyclists in the suburbs of Kampala are likely to forego a trip if the access road is not well-lit. Similarly, Winters et al. (2010) in their study in Vancouver (Canada) cite that not well-lit bicycle lanes are strongly linked to the reduction of cycling rates. In addition, Chandra and Radhakrishnan (2015) indicate that people avoid cycling in areas with cycle paths that do not have street lights at night” (Mendiate et al. 2022). “lack of street lighting can contribute to poor visibility, perception and fear of crime thus decreasing bicycle use. This is particularly relevant in SSA due to the generalized lack of security and safety.” (Mendiate et al. 2022).

In a review on research on built environment and physical activity among children and youth, prince\_examining\_2022 found street lighting positively associated with total physical activity among youth and children/youth, but not among children.

Luo et al. (2022) found that nighttime brightness had pronounce effects on active travel.

Using Strava Heatmap data and spatial regression models, Linchuan Yang et al. (2022) found street lighting positively associated with running, but not with cycling.

Using odd ratios to compare traffic flows in case and control hours, Steve Fotios and Robbins (2022) found that darkness had a significant negative effect on the number of pedestrians and cyclists, but not on the number of motorized vehicles.

Using satellite and street view imagery and linear regressions, Zacharias and Meng (2021) found street lighting highly significantly associated with higher uptake and deposit of dock-less shared bicycle trips.

“Elements positively associated with physical activity in older adults were (…) street lighting; crime-related safety; traffic-related safety. Negatively associated with physical activity were (…) barriers to walking/cycling; crime-related unsafety; unattended dogs; inadequate street lighting and upkeep; vandalism, etc.” (Bonaccorsi et al. 2020).

Using odd ratios, Uttley, Fotios, and Lovelace (2020) found that the drop in cycling levels after dark was substantially greater in unlit locations, compared with lit locations. Uttley, Fotios, and Lovelace (2020) also found a non-linear relationship between relative brightness and the reduction in cyclists after-dark, suggesting that a minimal amount of lighting could be enough to promote cycling after dark.

“Pedestrians and cyclists have similar preferences for road segments with building lower than 6 floors, 50% retail shops in frontage, more greenery, lamps between 15 m and 30 m, more crossing facilities, wider sidewalk/bike lane and not crowded” (Liu et al. 2020).

S. Fotios, Uttley, and Fox (2019) found that “ambient light has a significant impact: For a given time of day, more people walk or cycle when it is daylight than after dark and more people cycle on cycle trails and walk on foot paths after dark when they are lit than when they are unlit”.

This supported previous work which “indicated the numbers of pedestrians and cyclists during the case period were significantly higher during daylight conditions than after-dark, resulting in a 62% increase in pedestrians and a 38% increase in cyclists” (Uttley and Fotios 2017).

“Some bicyclists favor routes which are planted with street trees or installed with street lights” (Chen, Shen, and Childress 2018).

Using self-reported commuting data, Lin Yang et al. (2017) found that individuals living in neighbourhoods with higher density of street light were more likely to active commuting.

In a review of forty two quantitative studies that estimated association between neighbourhood built environment and active travel in older adults, Cerin et al. (2017) observed positive associations with availability of street lights.

In a paper that estimated welfare change associated with improvements in urban bicycling facilities, Poorfakhraei and Rowangould (2015) found that “cycle tracks were valued the most, followed by street lighting, and bicycle lanes”.

“Winters et al. (2011) found that a major deterrent to cycling was if the route was not well lit after-dark. The deterrent effect was largest for people who don’t currently cycle but potentially would do in the future, highlighting the importance of lighting in encouraging uptake of cycling” (Uttley, Fotios, and Lovelace 2020).

Respondents in a study that examined if neighbourhood environments were associated with walking and cycling, reported that good lighting at night is an important facilitator of cycling (Lee and Moudon 2008).

## Cycling collisions and lighting

One of the main reasons that cycling decreases at night is cyclists’ fear of not being seen in the dark and thus being hit by a motorised vehicle (reference needed). The probability of suffering a traffic collision in the dark among pedestrians and cyclists is much greater than among other road users (e.g. Wiratama et al. (2022); Samerei et al. (2021)). Not only the frequency of injuries but also their severity is higher at night-time (Asgarzadeh et al. 2018; Wang, Lu, and Lu 2015).

“Certainly lighting condition is directly related with visibility which primarily affects the risk of accidents, but also affects severity due to lack of evasive action (e.g. driver did not see bicyclist) which leads to greater impact and thus severity” (Kim et al. 2007).

Wiratama et al. (2022) found that children pedestrians and cyclists “involved in backover crashes with heavy vehicles and diminished light conditions had a 71% higher risk of sustaining Killed or seriously injured than those involved in crashes with other vehicles and optimal light conditions”.

“It is found that unsafeness of interaction between rider and infrastructure depends on lighting and road surface meteorological conditions” (Malik, Dala, and Busawon 2022).

Samerei et al. (2021) found “that the factors that increase the risk of fatalities and serious injuries of bicyclists in all clusters are elderly bicyclist, not using a helmet, and darkness condition”.

A study on bicycle-motor vehicle crashes found that “crashes in low light conditions and during early morning hours are more likely to result in higher injury severity” (Asgarzadeh et al. 2018).

“when cycling on a lit road, cycle lighting frequently offers no benefit for peripheral detection and may make it worse. It was demonstrated that position matters” (S. Fotios et al. 2017).

“cyclist–motorist crashes were nonlinearly associated with light pole densities” (Osama and Sayed 2017).

“An increase in intersection illuminance from low (<0.2 fc) to medium (≥ 0.2 fc and <1.1 fc) could reduce nighttime crash frequency and night-to-day crash ratios by approximately 50%. When illuminance was kept at 0.9 fc or higher, the risk of fatality and severe injury decreased significantly, especially in crashes that involved pedestrians and bicycles, head-on crashes, and angle crashes” (Wei et al. 2016).

Nabavi Niaki et al. (2016) found that “an increase in road lighting was associated with more bicycle and pedestrian accidents, which might have been explained by the decision to add or increase the amount of lighting at locations in which accidents occurred”.

“Improving street lighting can decrease the likelihood of cyclist injuries” (Chen and Shen 2016).

“Inadequate use of lights in dark conditions were linked with increased injury severity” (Wang, Lu, and Lu 2015).

“Most nighttime fatal crashes were related to absence of street lighting” (Lu, Wang, and Wang 2015).

“To improve visibility of pedestrians and cyclists, street lighting has been suggested as an intervention able to improve driver’s visual capabilities and ability to detect roadway hazards and to prevent car crashes” (Porchia, Baldasseroni, and Dellisanti 2014).

“Cycling in late evening darkness is associated with higher injury rates than cycling in daylight conditions. In comparison to late evening darkness, relative injury rates in early morning darkness are much higher. This is the case for crashes with large differences among the age groups, suggesting that in addition to the absence of daylight also age related risk factors are at play” (Twisk and Reurings 2013). “The proportion of seriously injured cyclists who have been drinking is highest in early morning darkness and has strongly increased over the last decades” (Twisk and Reurings 2013).

“The presence of street lighting had a point estimate that indicated a reduction in the odds of a severe injury. Some aesthetic and safety items, such as streetlights and high surveillance showed a 30%–40% reduction in the odds of severe injury” (Romanow et al. 2012).

“Street lighting is an additional factor that appear to improve cycling safety” (Reynolds et al. 2009).

“The most important variables influencing non-motorist injury severity are the age of the individual (the elderly are more injury-prone), the speed limit on the roadway (higher speed limits lead to higher injury severity levels), location of crashes (those at signalized intersections are less severe than those elsewhere), and time-of-day” (Eluru, Bhat, and Hensher 2008).

“Darkness without streetlights increases the probability of fatal injury by 110.9% in accidents compared to accidents occurring in daylight or darkness with streetlights” (Kim et al. 2007).

“Injury accidents in on lit roads are reduced by 50%. The effect on fatal accidents is slightly larger. The effect during twilight is about 2/3 of the effect in darkness. The effects on pedestrian, bicycle and moped accidents are significantly larger than the effects on automobile and motorcycle accidents. The risk of injury accidents was found to increase in darkness. The average increase in risk was estimated to 17% on lit rural roads and 145% on unlit rural roads. The average increase in risk with respect to pedestrian accidents is about 140% on lit rural roads and about 360% on unlit rural roads” (Wanvik 2009).

“Variables that significantly increase injury severity include darkness” (Klop and Khattak 1999).

“The proportion of cyclists involved in fatalities at night increases with increase in age. Almost 80% of nighttime accidents occurred on links on arterial roads, and the majority in the high speed limit zones (75 kph and over). A greater proportion of accidents was initiated by cyclists. In 90% of nighttime cyclist fatalities the cyclist was hit from the rear, compared with 40% in daytime” (Mazharul Hoque 1990).

## Cycling, crime, and lighting

Another factor that explains why there is less cycling at night is the fear of crime. This is much less investigated than the relationship between lighting and cycling collisions. There is evidence that street lighting decreases crime and enhances reassurance and confidence of pedestrians and cyclists after dark (e.g. Castillo-Paredes et al. 2022).

“Variables related to crime and lighting of public spaces were associated with active travel in countries in Latin America” (Castillo-Paredes et al. 2022).

Lusk et al. (2019) asked lower-income predominantly-minority residents what bicycle routes surface or context they perceived as safest from crime and crashes. They reported that “clean signs, balconies, cafes, street lights, no cuts between buildings, and flowers were low risk for crime and witnesses, little traffic, and bike signals low risk for crash”.

“Violent crimes appear to significantly deter people from choosing to walk or bicycle, potentially exposing themselves to threats of personal injury” (Appleyard and Ferrell 2017).

“High-crime neighborhoods tend to discourage residents from walking or riding a bicycle” (Ferrell and Mathur 2012).

## Cycling inequalities in lighting

Fear of danger of injury from traffic, falls, or violence seems to affect groups differently.

S. Fotios, Uttley, and Gorjimahlabani (2022) found that darkness has a greater deterrent effect on female cyclists than male cyclists.

“Recent research (Sustrans 2018) found that only 23% of women felt safe cycling during hours of darkness, compared with 36% of men, which suggests that Lighting may also contribute to addressing the current gender imbalance in cycling by encouraging more women to cycle after-dark” (Uttley, Fotios, and Lovelace 2020).

“Both traffic safety concerns and personal security concerns were most strongly associated with poor neighborhood opportunities for exercise. Respondents living in lower-income communities reported greater barriers to pedestrian and bicycle safety and security than residents from wealthier neighborhoods” (Schneider, Wiers, and Schmitz 2022).

## Proper lighting for cyclists

A substantial number of papers found in our search focused on what type of road lighting is best suited for cyclists. That is, in investigating which lighting attributes, such as illuminance, light temperature, uniformity and glare, are the most appropriate to guarantee the safety of cyclists.

Some of these papers were on Smart Street Lighting. In other words, in lighting systems that adapts to the movement of pedestrians, cyclists, and cars (e.g. Gagliardi et al. (2020); Abdullah et al. (2019); Juntunen et al. (2018)).

“Light and glare from road lighting and headlights have significant impacts on vision and night driving and these effects are likely to change with evolving technologies” (Wood 2020).

“LED road lighting for vehicular traffic roads generally fulfilled the requirements, whereas that for pedestrian and bicycle roads generally corresponded to the lowest lighting class for L, and often did not meet the statutory requirements for Uo and UI” (Jägerbrand 2016).

# Discussion

The scientific literature on the intersections of cycling and lighting is spread across several disciplines such as such as engineering, transport, road safety, and public health.

Below, based on the results of the review, we answer the questions that guide this paper.

#### To what extent does darkness influence cycling behaviour?

The positive results obtained in studies looking at the association between cycling uptake and street lighting show the importance of light conditions as a policy measure to encourage cycling in the dark. Lighting conditions improvements not only may increase cycling trips in general, but also the inclusivity of cycling, since, as has been demonstrated, street lighting will benefit more certain groups such as women, children, the elderly, and disadvantaged populations.

#### To what extent does darkness increase the risk of road collision among cyclists?

#### To what extent does darkness increase the risk of being a victim of crime among cyclists?

#### Is the association between cycling and darkness the same between different groups?

#### What type of road lighting is the most suitable for cycling to increase and be safer?

## Research gaps

## Strenghts and limitations

# Conclusions

This paper reviewed published research on the intersection between cycling and road lighting.

Despite the recent growth of articles on this subject, it is still under-researched. More empirical work in the area of cycling and road lighting is needed.

# Disclosure statement

No potential conflict of interest was reported by the author(s).

# References

Abdullah, Aziera, Siti Hajar Yusoff, Syasya Azra Zaini, Nur Shahida Midi, and Sarah Yasmin Mohamad. 2019. “Energy Efficient Smart Street Light for Smart City Using Sensors and Controller.” *Bulletin of Electrical Engineering and Informatics* 8 (2): 558–68. <https://doi.org/10.11591/eei.v8i2.1527>.

Appleyard, Bruce S., and Christopher E. Ferrell. 2017. “The Influence of Crime on Active & Sustainable Travel: New Geo-Statistical Methods and Theories for Understanding Crime and Mode Choice.” *Journal of Transport & Health* 6 (September): 516–29. <https://doi.org/10.1016/j.jth.2017.04.002>.

Asgarzadeh, Morteza, Dorothee Fischer, Santosh K. Verma, Theodore K. Courtney, and David C. Christiani. 2018. “The Impact of Weather, Road Surface, Time-of-Day, and Light Conditions on Severity of Bicycle-Motor Vehicle Crash Injuries.” *American Journal of Industrial Medicine* 61 (7): 556–65. <https://doi.org/10.1002/ajim.22849>.

Bonaccorsi, Guglielmo, Federico Manzi, Marco Del Riccio, Nicoletta Setola, Eletta Naldi, Chiara Milani, Duccio Giorgetti, Claudia Dellisanti, and Chiara Lorini. 2020. “Impact of the Built Environment and the Neighborhood in Promoting the Physical Activity and the Healthy Aging in Older People: An Umbrella Review.” *International Journal of Environmental Research and Public Health* 17 (17): 6127. <https://doi.org/10.3390/ijerph17176127>.

Buyana, Kareem, and Lwasa Shuaib. 2014. “Gender Responsiveness in Infrastructure Provision for African Cities: The Case of Kampala in Uganda.” *Journal of Geography and Regional Planning* 7 (1): 1–9. <https://doi.org/10.5897/JGRP2013.0424>.

Castillo-Paredes, Antonio, Beatriz Iglésias, Claudio Farías-Valenzuela, Irina Kovalskys, Georgina Gómez, Attilio Rigotti, Lilia Yadira Cortés, et al. 2022. “Perceived Neighborhood Safety and Active Transportation in Adults from Eight Latin American Countries.” *International Journal of Environmental Research and Public Health* 19 (19): 12811. <https://doi.org/10.3390/ijerph191912811>.

Cerin, Ester, Andrea Nathan, Jelle van Cauwenberg, David W. Barnett, and Anthony Barnett. 2017. “The Neighbourhood Physical Environment and Active Travel in Older Adults: A Systematic Review and Meta-Analysis.” *International Journal of Behavioral Nutrition and Physical Activity* 14 (1): 15. <https://doi.org/10.1186/s12966-017-0471-5>.

Chandra, Shailesh, and Ramalingam Radhakrishnan. 2015. “Street Visibility-Dependent Path Finding for Pedestrians and Bicyclists in Urban Areas.” In. <https://trid.trb.org/view/1337600>.

Chen, Peng, and Qing Shen. 2016. “Built Environment Effects on Cyclist Injury Severity in Automobile-Involved Bicycle Crashes.” *Accident Analysis & Prevention* 86 (January): 239–46. <https://doi.org/10.1016/j.aap.2015.11.002>.

Chen, Peng, Qing Shen, and Suzanne Childress. 2018. “A GPS Data-Based Analysis of Built Environment Influences on Bicyclist Route Preferences.” *International Journal of Sustainable Transportation* 12 (3): 218–31. <https://doi.org/10.1080/15568318.2017.1349222>.

Eluru, Naveen, Chandra R. Bhat, and David A. Hensher. 2008. “A Mixed Generalized Ordered Response Model for Examining Pedestrian and Bicyclist Injury Severity Level in Traffic Crashes.” *Accident Analysis & Prevention* 40 (3): 1033–54. <https://doi.org/10.1016/j.aap.2007.11.010>.

Ferrell, Christopher E., and Shishir Mathur. 2012. “Influences of Neighborhood Crime on Mode Choice.” *Transportation Research Record: Journal of the Transportation Research Board* 2320 (1): 55–63. <https://doi.org/10.3141/2320-07>.

Fotios, S, and Hf Castleton. 2017. “Lighting for Cycling in the UK—A Review.” *Lighting Research & Technology* 49 (3): 381–95. <https://doi.org/10.1177/1477153515609391>.

Fotios, S, H Qasem, C Cheal, and J Uttley. 2017. “A Pilot Study of Road Lighting, Cycle Lighting and Obstacle Detection.” *Lighting Research & Technology* 49 (5): 586–602. <https://doi.org/10.1177/1477153515625103>.

Fotios, Steve, and Chloe Jade Robbins. 2022. “Effect of Ambient Light on the Number of Motorized Vehicles, Cyclists, and Pedestrians.” *Transportation Research Record* 2676 (2): 593–605. <https://doi.org/10.1177/03611981211044469>.

Fotios, S, J Uttley, and S Fox. 2019. “A Whole-Year Approach Showing That Ambient Light Level Influences Walking and Cycling.” *Lighting Research & Technology* 51 (1): 55–64. <https://doi.org/10.1177/1477153517738306>.

Fotios, S, J Uttley, and S Gorjimahlabani. 2022. “Extending Observations of Ambient Light Level and Active Travel to Explore Age and Gender Differences in Reassurance.” *Lighting Research & Technology*, June, 14771535221080657. <https://doi.org/10.1177/14771535221080657>.

Gagliardi, Gianfranco, Marco Lupia, Gianni Cario, Francesco Tedesco, Francesco Cicchello Gaccio, Fabrizio Lo Scudo, and Alessandro Casavola. 2020. “Advanced Adaptive Street Lighting Systems for Smart Cities.” *Smart Cities* 3 (4): 1495–1512. <https://doi.org/10.3390/smartcities3040071>.

Jägerbrand, Annika. 2016. “LED (Light-Emitting Diode) Road Lighting in Practice: An Evaluation of Compliance with Regulations and Improvements for Further Energy Savings.” *Energies* 9 (5): 357. <https://doi.org/10.3390/en9050357>.

Juntunen, Eveliina, Esa-Matti Sarjanoja, Juho Eskeli, Henrika Pihlajaniemi, and Toni Österlund. 2018. “Smart and Dynamic Route Lighting Control Based on Movement Tracking.” *Building and Environment* 142 (September): 472–83. <https://doi.org/10.1016/j.buildenv.2018.06.048>.

Kim, Joon-Ki, Sungyop Kim, Gudmundur F. Ulfarsson, and Luis A. Porrello. 2007. “Bicyclist Injury Severities in Bicycle–Motor Vehicle Accidents.” *Accident Analysis & Prevention* 39 (2): 238–51. <https://doi.org/10.1016/j.aap.2006.07.002>.

Klop, Jeremy R., and Asad J. Khattak. 1999. “Factors Influencing Bicycle Crash Severity on Two-Lane, Undivided Roadways in North Carolina.” *Transportation Research Record: Journal of the Transportation Research Board* 1674 (1): 78–85. <https://doi.org/10.3141/1674-11>.

Lee, Chanam, and Anne Vernez Moudon. 2008. “Neighbourhood Design and Physical Activity.” *Building Research & Information* 36 (5): 395–411. <https://doi.org/10.1080/09613210802045547>.

Liu, Yanan, Dujuan Yang, Harry J. P. Timmermans, and Bauke de Vries. 2020. “Analysis of the Impact of Street-Scale Built Environment Design Near Metro Stations on Pedestrian and Cyclist Road Segment Choice: A Stated Choice Experiment.” *Journal of Transport Geography* 82 (January): 102570. <https://doi.org/10.1016/j.jtrangeo.2019.102570>.

Lu, Linjun, Chen Wang, and Tao Wang. 2015. “Improving E-Bike Safety on Urban Highways in China.” *Discrete Dynamics in Nature and Society* 2015: 1–8. <https://doi.org/10.1155/2015/415237>.

Luo, Yuanyuan, Yanfang Liu, Lijun Xing, Nannan Wang, and Lei Rao. 2022. “Road Safety Evaluation Framework for Accessing Park Green Space Using Active Travel.” *Frontiers in Environmental Science* 10 (May): 864966. <https://doi.org/10.3389/fenvs.2022.864966>.

Lusk, Anne, Walter Willett, Vivien Morris, Christopher Byner, and Yanping Li. 2019. “Bicycle Facilities Safest from Crime and Crashes: Perceptions of Residents Familiar with Higher Crime/Lower Income Neighborhoods in Boston.” *International Journal of Environmental Research and Public Health* 16 (3): 484. <https://doi.org/10.3390/ijerph16030484>.

Malik, Faheem Ahmed, Laurent Dala, and Krishna Busawon. 2022. “Intelligent Nanoscopic Cyclist Crash Modelling for Variable Environmental Conditions.” *IEEE Transactions on Intelligent Transportation Systems* 23 (8): 11178–89. <https://doi.org/10.1109/TITS.2021.3101118>.

Mazharul Hoque, Md. 1990. “An Analysis of Fatal Bicycle Accidents in Victoria (Australia) with a Special Reference to Nighttime Accidents.” *Accident Analysis & Prevention* 22 (1): 1–11. <https://doi.org/10.1016/0001-4575(90)90002-3>.

Mendiate, Classio Joao, Alphonse Nkurunziza, Julio A. Soria-Lara, and Andres Monzon. 2022. “Cycling in Sub-Saharan African Cities: Differences and Similarities with Developed World Cities.” *IATSS Research* 46 (3): 398–410. <https://doi.org/10.1016/j.iatssr.2022.05.003>.

Nabavi Niaki, Matin S., Ting Fu, Nicolas Saunier, Luis F. Miranda-Moreno, Luis Amador, and Jean-François Bruneau. 2016. “Road Lighting Effects on Bicycle and Pedestrian Accident Frequency: Case Study in Montreal, Quebec, Canada.” *Transportation Research Record* 2555 (1): 86–94. <https://doi.org/10.3141/2555-12>.

Osama, Ahmed, and Tarek Sayed. 2017. “Evaluating the Impact of Socioeconomics, Land Use, Built Environment, and Road Facility on Cyclist Safety.” *Transportation Research Record: Journal of the Transportation Research Board* 2659 (1): 33–42. <https://doi.org/10.3141/2659-04>.

Poorfakhraei, Amir, and Gregory M. Rowangould. 2015. “Estimating Welfare Change Associated with Improvements in Urban Bicycling Facilities.” *Journal of Transportation Engineering* 141 (11): 04015025. <https://doi.org/10.1061/(ASCE)TE.1943-5436.0000799>.

Porchia, B. R., A. Baldasseroni, and C. Dellisanti. 2014. “Effectiveness of Two Interventions in Preventing Traffic Accidents: A Systematic Review.” *Annali Di Igiene Medicina Preventiva e Di Comunità*, no. 1 (January): 63–75. <https://doi.org/10.7416/ai.2014.1959>.

Reynolds, Conor CO, M Anne Harris, Kay Teschke, Peter A Cripton, and Meghan Winters. 2009. “The Impact of Transportation Infrastructure on Bicycling Injuries and Crashes: A Review of the Literature.” *Environmental Health* 8 (1): 47. <https://doi.org/10.1186/1476-069X-8-47>.

Ribbens, Dr Hubrecht. 2008. “The Impact of an Inadequate Road Environment on the Safety of Non-Motorised Road Users,” 22.

Romanow, Nicole T. R., Amy B. Couperthwaite, Gavin R. McCormack, Alberto Nettel-Aguirre, Brian H. Rowe, and Brent E. Hagel. 2012. “Environmental Determinants of Bicycling Injuries in Alberta, Canada.” *Journal of Environmental and Public Health* 2012: 1–12. <https://doi.org/10.1155/2012/487681>.

Samerei, Seyed Alireza, Kayvan Aghabayk, Nirajan Shiwakoti, and Amin Mohammadi. 2021. “Using Latent Class Clustering and Binary Logistic Regression to Model Australian Cyclist Injury Severity in Motor Vehicle–Bicycle Crashes.” *Journal of Safety Research* 79 (December): 246–56. <https://doi.org/10.1016/j.jsr.2021.09.005>.

Schneider, Robert James, Hayley Wiers, and Andrew Schmitz. 2022. “Perceived Safety and Security Barriers to Walking and Bicycling: Insights from Milwaukee.” *Transportation Research Record: Journal of the Transportation Research Board* 2676 (9): 325–38. <https://doi.org/10.1177/03611981221086646>.

Sustrans. 2018. “BIKElife, All Cities Publication. Inclusive City Cycling. Women: Reducingthe Gender Gap.”

Twisk, D. A. M., and Martine Reurings. 2013. “An Epidemiological Study of the Risk of Cycling in the Dark: The Role of Visual Perception, Conspicuity and Alcohol Use.” *Accident Analysis & Prevention* 60 (November): 134–40. <https://doi.org/10.1016/j.aap.2013.08.015>.

Uttley, Jim, and Steve Fotios. 2017. “Using the Daylight Savings Clock Change to Show Ambient Light Conditions Significantly Influence Active Travel.” *Journal of Environmental Psychology* 53 (November): 1–10. <https://doi.org/10.1016/j.jenvp.2017.06.003>.

Uttley, Jim, Steve Fotios, and Robin Lovelace. 2020. “Road Lighting Density and Brightness Linked with Increased Cycling Rates After-Dark.” Edited by Quan Yuan. *PLOS ONE* 15 (5): e0233105. <https://doi.org/10.1371/journal.pone.0233105>.

Wang, Chen, Linjun Lu, and Jian Lu. 2015. “Statistical Analysis of Bicyclists’ Injury Severity at Unsignalized Intersections.” *Traffic Injury Prevention* 16 (5): 507–12. <https://doi.org/10.1080/15389588.2014.969802>.

Wanvik, Per Ole. 2009. “Effects of Road Lighting: An Analysis Based on Dutch Accident Statistics 1987–2006.” *Accident Analysis & Prevention* 41 (1): 123–28. <https://doi.org/10.1016/j.aap.2008.10.003>.

Wei, Fulu, Zhenyu Wang, Pei-Sung Lin, Ping P. Hsu, Seckin Ozkul, Jason Jackman, and Michael Bato. 2016. “Safety Effects of Street Illuminance at Urban Signalized Intersections in Florida.” *Transportation Research Record: Journal of the Transportation Research Board* 2555 (1): 95–102. <https://doi.org/10.3141/2555-13>.

Winters, Meghan, Michael Brauer, Eleanor M. Setton, and Kay Teschke. 2010. “Built Environment Influences on Healthy Transportation Choices: Bicycling Versus Driving.” *Journal of Urban Health* 87 (6): 969–93. <https://doi.org/10.1007/s11524-010-9509-6>.

Winters, Meghan, Gavin Davidson, Diana Kao, and Kay Teschke. 2011. “Motivators and Deterrents of Bicycling: Comparing Influences on Decisions to Ride.” *Transportation* 38 (1): 153–68. <https://doi.org/10.1007/s11116-010-9284-y>.

Wiratama, Bayu Satria, Li-Min Hsu, Yung-Sung Yeh, Chia-Che Chen, Wafaa Saleh, Yen-Hsiu Liu, and Chih-Wei Pai. 2022. “Joint Effect of Heavy Vehicles and Diminished Light Conditions on Paediatric Pedestrian Injuries in Backover Crashes: A UK Population-Based Study.” *International Journal of Environmental Research and Public Health* 19 (18): 11689. <https://doi.org/10.3390/ijerph191811689>.

Wood, Joanne M. 2020. “Nighttime Driving: Visual, Lighting and Visibility Challenges.” *Ophthalmic and Physiological Optics* 40 (2): 187–201. <https://doi.org/10.1111/opo.12659>.

Yang, Linchuan, Bingjie Yu, Pengpeng Liang, Xianglong Tang, and Ji Li. 2022. “Crowdsourced Data for Physical Activity-Built Environment Research: Applying Strava Data in Chengdu, China.” *Frontiers in Public Health* 10 (April): 883177. <https://doi.org/10.3389/fpubh.2022.883177>.

Yang, Lin, Simon Griffin, Kay-Tee Khaw, Nick Wareham, and Jenna Panter. 2017. “Longitudinal Associations Between Built Environment Characteristics and Changes in Active Commuting.” *BMC Public Health* 17 (1): 458. <https://doi.org/10.1186/s12889-017-4396-3>.

Zacharias, John, and Si’an Meng. 2021. “Environmental Correlates of Dock-Less Shared Bicycle Trip Origins and Destinations.” *Journal of Transport Geography* 92 (April): 103013. <https://doi.org/10.1016/j.jtrangeo.2021.103013>.