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 (any other existent review on the topic?). 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, 7 additional papers were selected. In total, 53 were reviewed. A flow chart of included studies is shown in Figure 1.

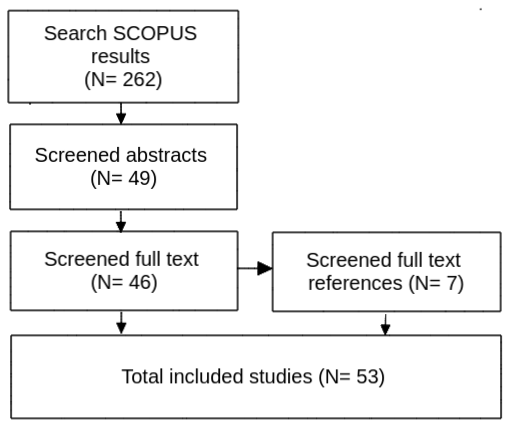


Figure 1: flow chart

# 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, 35 were empirical and 9 were reviews (Figure 1).

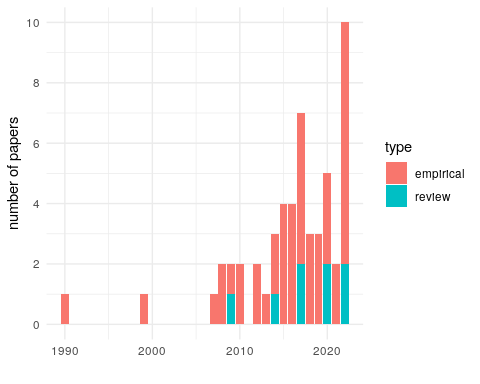


Figure 2: number of papers reviewed by type and year

## Cycling behaviour and lighting

Previous research has found a clear association between active travel or physical activity levels and road lighting.

“Studies in both developed world cities (DWC) and Sub-Saharan African (SSA) urban contexts point out that lack of street lighting can decrease the levels of cycling (Ribbens 2008; Segadilha and Sanches 2014; Winters and Teschke 2010) . 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).

“Studies in both SSA cities and DWC are unanimous that street lighting has an enormous influence on cycling. In line with Winters et al. (2010), 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).

“Positive associations were found for street lighting” (Prince et al. 2022).

“Nighttime brightness have pronounced effects on ATTS” (Luo et al. 2022).

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”.

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

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).

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 build environment and active travel in older adults, Cerin et al. (2017) observed positive associations with availability of street lights.

“Cycle tracks were valued the most, followed by street lighting and bicycle lanes” (Poorfakhraei and Rowangould 2015).

“Respondents reported good lighting is the most important facilitator of walking and cycling” (Lee and Moudon 2008).

## Cycling collisions and lighting

One of the main reasons that cycling decreases in the dark is because cyclists need to see obstacles on the road and be seen by other road users.

The probability of suffering a traffic collision in the dark among pedestrians and cyclists is much greater than among other road users (reference needed). Not only the frequency but also the severity of injury is higher at night-time (reference needed).

“The joint effect of heavy vehicles and diminished light conditions was associated with a 71% increased probability of sustaining KSIs” (Wiratama et al. 2022).

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

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

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).

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

Intersections: an study showed that “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 lightings” (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).

“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).

“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 fundamental factor that explains less cycling during night-time is fear of crime.

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 AT in countries in Latin America” (Castillo-Paredes et al. 2022).

“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” (Lusk et al. 2019).

“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.

“for pedestrians, the deterrence of darkness was similar for males and females, which disagrees with previous studies” (S. Fotios, Uttley, and Gorjimahlabani 2022).

Older people may detect object differently than younger people (reference needed).

“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 large number of papers found in our search focused on investigating which type of road lighting is most appropriate to improve cyclists reassurances. I.e. How lighting attributes such as illuminance, light temperature, uniformity and glare, affect cycling.

Papers on Smart Street Lighting (that adapts to movement by pedestrians, cyclists, and cars)(e.g. Gagliardi et al. (2020); Abdullah et al. (2019); Juntunen et al. (2018)).

“Visual function is reduced under the mesopic lighting conditions of night driving and that these effects are exacerbated by increasing age and visual impairment. 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).

“A number of actions are suggested that should enable lighting’s contribution to the safety of cyclists to be realized” (S. Fotios and Castleton 2017).

“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.

#### 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 sectors of society such as women, children, the elderly, and certain disadvantaged groups.

#### 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 at the intersection between cycling and road lighting.

Despite the recent growth of articles on this subject, it is still very little 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).

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