SWOV Fact sheet

What are the risks of cycling during darkness?

Summary
The majority of cycling crashes occur during daylight. This is the time most people cycle. If corrected for the distance travelled, it shows that the risk for cyclists to sustain serious injuries in a crash is most substantial during early-morning darkness (after midnight and until dawn). This applies for men, as well as for women (the mutual differences are minor) and for all age categories, except for seniors (75+) and young children (0-11-year olds). The relatively high risk during early-morning darkness especially applies for cycling crashes with no motor vehicles involved. It applies for 18-24-year olds, even more so than for other age groups, that they run an increased risk during darkness. There are indications that more and more often alcohol concentrations are found in the blood of cyclists who sustain serious injuries in a non-motor vehicle crash during the night. In recent years, this has been the case in circa 30% of all cycling casualties.

Background and content
It shows from international research that cycling during darkness is more hazardous than it is during daylight (Johansson, Wangi & Elvik, 2009; Reurings, 2010). In 2010, SWOV studied the risk of cycling during different light conditions; this had not been studied in the Netherlands prior to this date. The research was presented in the *How hazardous is cycling during darkness* report (Reurings, 2010). In 2013, SWOV studied the effects, if any, of daylight saving time and standard time on mobility during light and darkness (Bijleveld & Stipdonk, 2013).

This fact sheet will first discuss the hazards of cycling during darkness, and it will next examine the influence of the seasons, if any, the cyclists' age, alcohol use and the use of bicycle lights. Further general information about the safety of cyclists in traffic can be found in the SWOV Fact sheet *Cyclists*. Furthermore, we make a distinction between cycling crashes involving a motor vehicle (motor vehicle crashes) and those not involving a motor vehicle (non-motor vehicle crashes). In fact, these two types of cycling crashes differ substantially. From 1993 through to 2008, an annual average number of 180 police registered fatalities and 1,660 seriously injured occurred among cyclists in crashes in which the other crash party was a motor vehicle, and 18 police registered fatalities and 6,273 seriously injured in cycling crashes in which no motor vehicle was involved. As cycling crashes during darkness do not generally result in fatal accidents, this fact sheet will discuss data concerning serious road injuries.

Furthermore, in this fact sheet we will distinguish four periods of light condition other than daylight: 1) early-morning darkness (from midnight), 2) dawn, 3) dusk, and 4) late-night darkness (until midnight).

How hazardous is cycling during darkness?

Number of casualties
The majority of seriously injured cyclists as a result of a *motor vehicle crash* occur during daylight; the number of seriously injured cyclists involved in a motor vehicle crash during darkness (after dusk and before dawn) fluctuated between 14 and 17% in the 1993-2008 period. The number of seriously injured cyclists as a result of a motor vehicle crash during daylight decreased until 2001 and has been increasing since. The number of seriously injured cyclists as a result of a motor vehicle crash during darkness decreased until 2005 and has been substantially increasing since.

Cyclists more often sustain injuries in *non-motor vehicle crashes* than in motor vehicle crashes. It also applies to non-motor vehicle crashes that the majority occur during daylight. The number of seriously injured among cyclists in non-motor vehicle crashes increased during the entire period of 1993 through to 2008; this increase was most substantial during darkness. In fact, the number of seriously injured cyclists in non-motor vehicle crashes occurring during darkness increased from 13% in 1993 to 23% in 2008.

Risk

More cyclists sustain serious injuries in crashes during daylight, rather than during darkness. This is logical, because far more people cycle during the day. In order to compare the risk of cycling during darkness with cycling during daylight, we use the casualty risk, rather than the number of crashes or casualties. To compute the casualty rate during darkness, we divide the number of casualties occurring during darkness by the distance travelled during darkness. See for a further explanation of *risk*, SWOV Fact sheet *Risk in traffic*. If we take into account, by means of this method, the cycling mobility during the different periods of dawn, dusk, and darkness, it shows that the risk for cyclists to sustain serious injuries as a result of a *motor vehicle crash* is most substantial during early-morning darkness (from midnight to dawn). However, this type of crash is also dependent on the number of motor vehicles that cyclists encounter. Encounters with motor vehicles have indeed an impact on the risk of a bicycle - motor vehicle crash. We can take into account this contribution of the motor vehicle to the cycling risk by - first of all - dividing the risk by the vehicle mobility for different periods during the day. *Figure 1* shows the outcome. The risks have been presented as compared with the risk during daylight (the relative risk during daylight therefore being 1). The risk during late-night darkness was circa a factor of 8 higher than during daylight (in 2008). However, the risk is even more substantial during the three other periods of (semi-) darkness. Not yet shown on the relative scale of *Figure 1,* presented in Reuring's (2010), is the fact that the risk for cyclists to sustain serious injuries in crashes with a motor vehicle slightly decreased in the period of 1993 through to 2008.

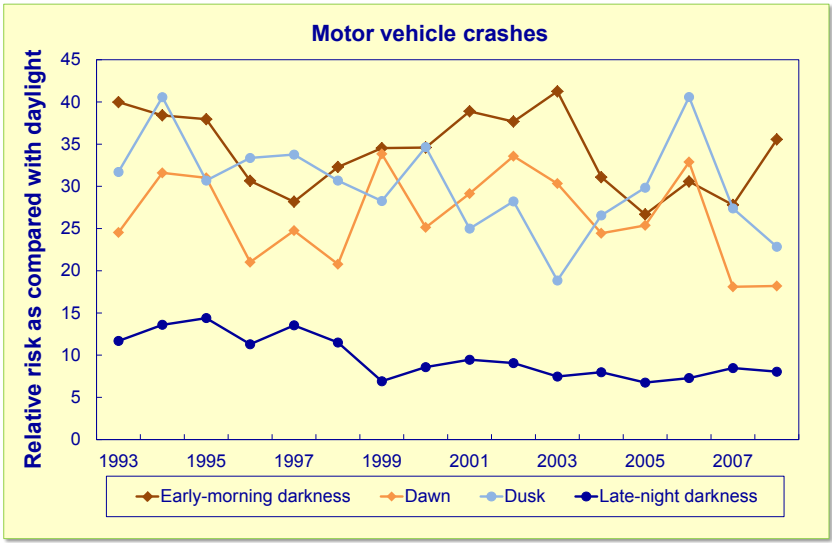

Figure 1. *The risk for cyclists to sustain serious injuries in a motor vehicle crash during darkness, dawn and dusk divided by the risk during daylight, and corrected for motor vehicle distance travelled. The risk has been measured by dividing the number of seriously injured among cyclists during the pertaining period of (semi-) darkness by the distance travelled by both cyclists and motor vehicles during this period.*

The risk for a cyclist to become seriously injured in a *non-motor vehicle crash* is four to five times as high as in the case of a motor vehicle crash (solely accounting for cycling mobility). In case of non-motor vehicle crashes, the risk also turns out to be most substantial during early-morning darkness. This is shown in *Figure 2*, which again presents the relative risk as compared with the risk during daylight. It turns out that the risk during dusk and during the night is not or hardly higher than during daytime, but far higher during early-morning darkness. A questionnaire study from 2008 confirmed this high nighttime risk: the risk of single cycling crashes (constituting more than 90% of cycling crashes in which no motor vehicles are involved) turns out to be most substantial during the night (Ormel, Klein Wolt & Den Hertog, 2009). *Figure 2* shows that this risk has been increasing over the years: in 1993 the risk during early-morning darkness was circa 3.5 times higher than during other light conditions; in 2008 it was 7 times higher (Reurings, 2010).

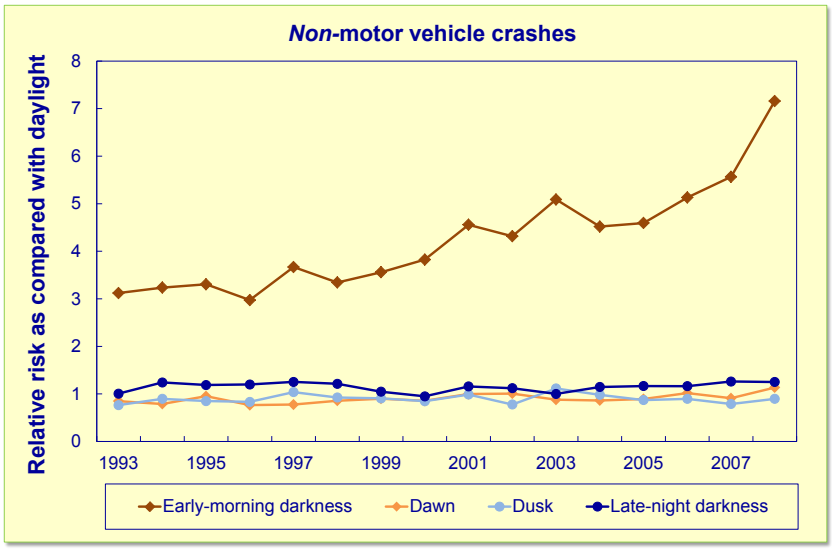

Figure 2. *The risk for cyclists to sustain serious injury in a non-motor vehicle crash during darkness, dawn and dusk as compared with the risk during daylight. The risk has been measured by dividing the number of serious road injuries among cyclists during the pertaining period of (semi-) darkness by the distance travelled in that period by cyclists.*

Do the seasons have an effect on the risk of cycling during darkness?

Since the duration of the periods of darkness vary over the year, we have studied whether variations in risk among the seasons could explain the increased risk of cycling during (dusk and) darkness. This turns out not to be the case with non-motor vehicle crashes. The risk for cyclists to sustain serious injury in a non-motor vehicle crash actually turns out to be higher in summer than it is in winter, whereas it was to be expected that the risk in winter would be higher because of slipperiness. However, in the case of motor vehicle crashes, the risk for cyclists to become seriously injured in winter is relatively high, even if corrected for variations in car mobility. Bijleveld & Stipdonk (2013) show that in the Netherlands cyclists travel considerably longer distances during darkness after the change towards standard time, especially during the evening rush hour. The higher risk in winter can be explained by the higher risk during darkness and the increased number of hours that are cycled during darkness.

Have differences been observed between men and women in the risk of cycling during darkness?

Men cycle more often than women and they do so relatively more often during darkness, dawn or dusk. The proportion of men sustaining serious injuries in a cycling crash is also slightly more substantial than the proportion of women. On the whole, the risk for men and women turns out to be similar. Minor differences can be observed between the risk for male and female cyclists to sustain serious injuries with various light conditions, especially in the case of non-motor vehicle crashes. The difference in risk-increase at night between men and women is most substantial in non-motor vehicle crashes during early-morning darkness, women having the higher risk-increase as compared with daylight conditions.

Does the age of the cyclist have an effect on the risk of cycling during darkness?

Seniors of 75+ run by far the most substantial risk to sustain serious injuries while cycling. Compared with other age categories, their risk is on average a factor of 6.4 higher for motor vehicle crashes and a factor 10 for non-motor vehicle crashes. However, seniors hardly ever cycle during darkness. The high risk during early-morning darkness (see *Figures 1* and *2*), especially in non-motor vehicle crashes, turns out to apply for all age categories, except for seniors (75+) and young children (0-11 years). It is therefore not true that cyclists run a high risk to sustain serious injuries during darkness, because during this time of day those cyclists ride their bicycles that run a risk under all circumstances. The increased risk during darkness applies to 18-24-year olds more substantially than it does for the other age categories. It also shows that cyclists of this age group relatively often sustain serious injuries during weekend nights. It is therefore interesting to examine the use of alcohol by those who cycle during darkness.

Is a connection observed between the use of alcohol and cycling crashes?
Li et al. (2001) already established that the use of alcohol among cyclists results in an increased risk, and an even greater increase (at a similar Blood Alcohol Concentration or BAC) than among car drivers. In the Netherlands, a similar study has never been conducted. To begin with, it should be concluded that no data is available of the use of alcohol among cyclists, whether or not during darkness. The use of alcohol can only be determined for cyclists who have been registered in the National Medical Registration (LMR). It showed from the registration that seriously injured cyclists were more often under the influence of alcohol after a non-motor vehicle crash (3% in 1993 to 7% in 2008) than after a motor vehicle crash (approx. 1%). This is consistent with earlier Swedish research results (Anderson & Bunketorp, 2002).

Table 1 shows the proportions of injured cyclists with high BAC under various light conditions, as on average during the 1993-2008 period. It is obvious that the use of alcohol is highest among seriously injured cyclists during darkness, and then mainly among casualties of non-motor vehicle crashes.

According to the LMR, among the seriously injured cyclists, men are more often under the influence of alcohol than women; the use of alcohol can therefore not be an explanation for the higher risk for women as compared to men during early-morning darkness. It also shows that seriously injured cyclists younger than 17 years and older than 60 years are least frequently under the influence of alcohol. During weekends, the number of cycling casualties under the influence of alcohol is relatively high, especially during the night.

With respect to non-motor vehicle crashes during darkness, the proportion of seriously injured cyclists under the influence of alcohol is considerable, from circa 10% in 1993 to circa 30% in recent years (see *Figure 3*). This is the case during weekends in particular (not indicated in the Table).

	Motor vehicle crash	Non-motor vehicle crash
Early-morning darkness	7.5%	15.9%
Dawn	0.4%	2.3%
Daylight	0.4%	2.1%
Dusk	1.9%	11.4%
Late-night darkness	4.0%	19.0%
Total	**1.2%**	**4.9%**

Table 1. *The proportion of seriously injured cyclists who, according to the LMR, were under the influence of alcohol, during the 1993-2008 period, with respect to light conditions during the crash.*

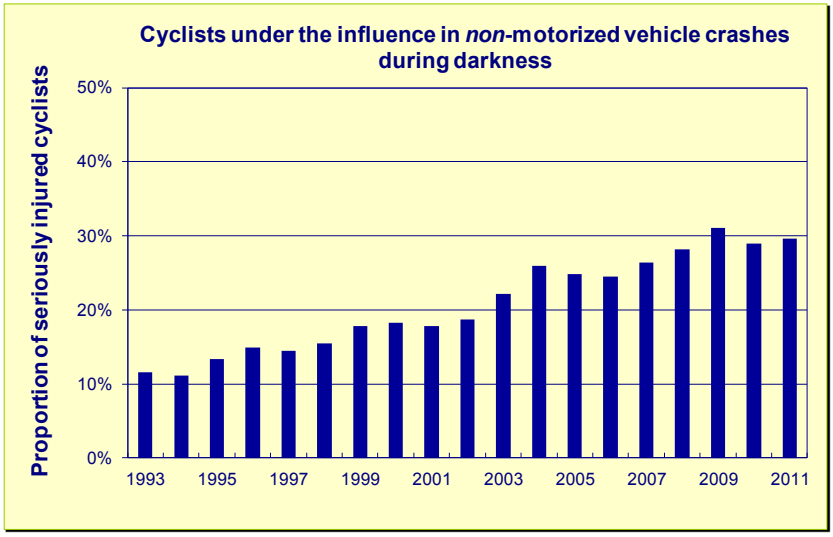

Figure 3. *The proportion of seriously injured cyclists, admitted between 10 p.m. and 7 a.m., who were under the influence of alcohol, according to the LMR.*

Where do cycling casualties occur most often during darkness?
By far the majority of cycling casualties (81%) in a motor vehicle crash occur in urban areas, 67% of which on intersections. Outside urban areas, relatively fewer cycling casualties (56%) occur on intersections. Circa 14 to 15% of the casualties in or outside urban areas occur during darkness. The correlation between road section and intersection is in general not different during darkness. No data is available about the distances travelled in and outside urban areas, or on intersections or road sections. As a result, the risk with respect to specific locations cannot be established.

Does the use of bicycle lights have an effect on road safety?
In 2010, research was conducted into the use of bicycle lights by registering among 17,245 cyclists whether they used bicycle lights or not (Boxum & Broeks, 2010). It turned out that 62% of the cyclists carried lights in conformity with the regulations. In the four major cities of the Netherlands (Amsterdam, Rotterdam, The Hague and Utrecht), fewer cyclists on average carried bicycle lights compared to other cities. Besides, adolescents and young adults carried relatively fewer bicycle lights that other age groups (Boxum & Broeks, 2010). It has never been sufficiently studied whether carrying bicycle lights by cyclists actually benefits road safety; therefore, no clear-cut conclusions can be drawn about this issue. Moreover, carrying bicycle lights is not registered as a standard in the case of crashes involving cyclists. It would be relevant to study the research question whether bicycle lights have an effect on road safety, because the outcome may direct the enforcement efforts by the police.

In a study into the causes for casualties among cyclists in Great-Britain (Knowles et al., 2009), not carrying bicycle lights during darkness or impaired visibility was indicated as a contributory factor among 5% of all fatalities among cyclists and 4% of all seriously injured cyclists. Contributory factors are defined as the main causes for casualties as perceived by police officials who are responsible for writing the report. It is therefore an estimate. If the estimate is correct, one in five of the casualties during darkness is the result of not carrying bicycle lights, considering that in Great Britain 22% of the casualties with fatalities and seriously injured cyclists occurred during darkness. As the case may be, this possible effect cannot simply be transposed to the Dutch situation, considering the difference in the composition in traffic and the road network, including the occurrence of bicycle lanes.

Conclusion
Taking into account the distances travelled, the risk for cyclists to sustain serious injuries in a crash is most substantial during early-morning darkness (after midnight and until dawn). Especially the risk of a cycling crash with no motor vehicle involved is particularly high during those light conditions. With respect to motor vehicle crashes involving cyclists, all dark or semi-dark periods are more hazardous than daylight. It applies for 18-24-year olds, even more so than for other age groups, that they run an increased risk during darkness. The use of alcohol may play a role in this case. Data in the National Medical Registration indicates that circa 30% of the cyclists that sustain serious injuries in a non-motor vehicle crash during the night test positive for alcohol concentrations in their blood. This proportion has increased over the last fifteen years. Not enough information about the effect of bicycle lights on cycling safety during darkness is available to draw conclusions.

Publications and sources

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