Article:

Safety on the roads? Safety of the public purse?

By Paul Marchant and Paul Norman

Many people might think that when a city has all its road lighting changed from old style orange lamps (low pressure sodium) to white ones, night time road traffic collisions (RTCs) would markedly reduce. That is what the city council of the British city of Leeds thought when it applied to get its road lighting changed. However, perhaps this supposition is incorrect. In our open access, open data paper[1] we find no evidence that there was any improvement in road safety in Leeds after nearly 80,000 lamps were changed to white light. The outcome measure used was the customary ratio of the darkness RTC rate to daylight RTC rate, as this tends to compensate for any changes in the safety level of an area, made during the study-period, that are independent of it being night or day. The RTC data was that reported to the police during 2005 to 2013 while replacement white lamps were being installed. Over the period, there were nearly 14,000 collisions in daylight and over 5,000 collisions in darkness reported .

The study was 'longitudinal', examining the RTC rate over time as the lighting was changed in the 107 Middle Super Output Areas (MSOAs) that comprise Leeds. It involved a multilevel approach as some areas had lighting changed in a given week, whilst others did not. The analysis involved finding a single mathematical formula (model) that gave a good comprehensive fit to the weekly ratios of the darkness to daylight RTC rates (that is, the count of the number of RTCs in darkness to the count in daylight, in the 456 weeks, in the 107 areas). The model included an underlying long-term time trend, accounted for seasonality too by including the month in which the RTC occurred and also for the fact that traffic flows can be different in weeks which have a public holiday in them. The point of the modelling was to see how the increase in the amount of new lighting altered the weekly ratio of the number of RTCs in darkness to that in daylight.

BOX

The quantity modelled was actually the logarithm (log) of the ratio of the number of RTCs in darkness to the number of RTCs in daylight, in each week, in each area. (The 'argument' of the logarithm, that is the quantity of which the logarithm is taken, is also referred to as 'the ratio of the darkness RTC rate to the daylight RTC rate' and, as well, can be called 'the daylight adjusted RTC rate'. The quantities are rates because they refer to the number of RTCs per week).

Denoting the mean number of RTCs in darkness in week i and area j as $\mu dark_{ij}$ and the mean number of RTCs in daylight in week i and area j as $\mu daylight_{ij}$, we modelled $\log(\mu dark_{ij} / \mu daylight_{ij})$.

Also, it is a mathematical fact that the logarithm of a ratio is identically equal to the difference of the log of the numerator and log of the denominator.

Therefore, $\log(\mu dark_{ij} / \mu daylight_{i}j) = \log(\mu dark_{ij}) - \log(\mu daylight_{ij})$

So, as well as modelling $\log(\mu dark_{ij} / \mu daylight_{i}j)$ directly, we are able to model the log of the number of RTCs in darkness, $\log(\mu dark_{ij})$, and the log of the number of RTCs in daylight, $\log(\mu daylight_{ij})$, separately and take the difference to obtain the result. (Note that calculating the variance assumes the approximate statistical independence of the two quantities, which is reasonable in the case of RTCs.)

We did this and found the results for impact of the new lighting given by the two methods to be pleasingly in very close agreement (phew!).

END BOX

The plausible range of effect found (as indicated by the 95% Confidence Interval produced by the analysis) spans roughly a 20% reduction to a 10% increase in RTCs, which of course means that zero is included. This inability to detect any difference is a 'statistically non-significant result', also known as a 'null result'. When this result is combined with that of another similar study[2], on Birmingham relighting, the interval shrinks a little and moves in the direction of harm, becoming a 16% reduction to a 12% increase in collisions for a typical area.

Perhaps the non-detection of an effect on road safety should come as little surprise however, as a study, https://fundingawards.nihr.ac.uk/award/11/3004/02 , also could not detect any effect. This latter one (Award ID: 11/3004/02), funded to the tune of £414,315.32 by the National Institute for Health Research (NIHR) used a somewhat different method, and involved the Institution of Lighting Professionals. This too got a statistically non-significant ('null') result for changing to white light, spanning a 7% reduction to a 9% increase in RTCs.

The NIHR-study was originally designed to just look at lighting reductions, as reflected in its title 'What is the effect of reduced street lighting on crime and road traffic accidents at night? A mixed methods study'. However, in a variation to protocol, it added changing to white light, which occurred on 15,833 km of roads in its data from 62 local authorities. This NIHR-funded study found all its results to be null, despite its extensive data; both for lighting reductions and for whitening, for all the investigations of lighting's effect on both RTCs and crime.

It is surprising more publicity is not being given to these null results, considering the amount of money spent on lighting, especially at a time of high energy costs. It is also surprising that the lighting data, about the times and places of road lamp changes, collected at public expense, used in the NIHR study is not made available. Road collision data on the other hand is open on the Department for Transport website. The absence of the lighting data makes the NIHR study irreproducible, that is it cannot be checked by others.

Not being able to detect any effect is, of course, not the same as there being zero effect, and also of course, the result is consistent with either a little benefit or a little detriment. It would be good to have a suitably precise (and indeed accurate!) estimate of the effect of re-lighting a city, as then this would enable meaningful comparison of costs and benefits with those of other road safety measures.

The costs of lighting, it should be recognised, are not just financial, as there are environmental costs and these are not just in the use of materials, and energy. The effects on biodiversity are considerable. Artificial light at night can for example change the predator-prey balance between species. White light is comprised of all the colours of the rainbow. Other organisms with which we share our planet have different responses to the various wavelengths of light radiation. The blue component of white light is thought to be particularly damaging because it signals daytime. Life, it should be remembered, has evolved on Planet Earth over billions of years when it has been periodically dark for some of the time, when it has just been illuminated by starlight.

Although the design of modern lamps allows the directionality of emitted light to be better controlled, the increasing brightness means more light is scattered from surfaces into the environment.

There are many concerns about the quality of scientific research in general, such as outlined for example in Stuart Ritchie's book, 'Science Fictions'3. Some of the issues of poor quality in the way that lighting research is done, published, and promoted, can be seen in articles,4,5 .
Indeed, our paper on the Leeds lighting change draws attention to some problems with the research adduced in the city council's bid to obtain the substantial sum of money (£94.6M) to carry out the work under the government Private Finance Initiative (PFI) scheme.

One of the problems of lighting research is that it can be done by those with perhaps a technical background but without professional statistical support, from such as CStats, PStats and AStats. Therefore, such work, although having potentially large consequences for both public finances and the environment, does not have the same level of checking as much of that done, for example, in healthcare. Also, some of those public servants assessing lighting proposals are likely to be ill-equipped to make satisfactory judgments on any purportedly scientific evidence with which they are presented, as they are unlikely to have sufficient scientific/statistical background to spot flaws. The more recent results from the large scale, better quality research, mentioned above, may suggest that the high levels of lighting currently used may not be justified.

Declaration of interest: Author PM has concerns about light pollution affecting astronomical observations and biodiversity, so was motivated to examine the claims of benefit for increased public lighting. Author, PN has concerns that public money may be being wasted on schemes that have no proof they are achieving what they are supposed to.

References:

1 Marchant P. R. and Norman P. D. To determine if changing to white light street lamps improves road safety: A multilevel longitudinal analysis of road traffic collisions during the relighting of Leeds, a UK city, *Applied Spatial Analysis and Policy*, July 2022
https://link.springer.com/article/10.1007/s12061-022-09468-w https://doi.org/10.1007/s12061-022-09468-w

2 Marchant P. R., Hale J. D. and Sadler J. P., Does changing to brighter road lighting improve road safety? Multilevel longitudinal analysis of road traffic collision frequency during the relighting of a UK city., *Journal of Epidemiology and Community Health*, March 2020
https://jech.bmj.com/content/74/5/467 https://doi.org/10.1136/jech-2019-212208

3 Ritchie S., *Science Fictions: Exposing Fraud, Bias, Negligence and Hype in Science* Imprint: Vintage, Published: 16/09/2021,ISBN: 9781529110647,

4 Marchant P. R., Do brighter, whiter street lights improve road safety? *Significance*, Volume 16, Issue 5, October 2019, Pages 8–9, https://academic.oup.com/jrssig/article/16/5/8/7029303
https://doi.org/10.1111/j.1740-9713.2019.01313.x

5 Marchant P. R., Why Lighting Claims Might Well Be Wrong*, International Journal of Sustainable Lighting,* July 2017, https://www.lightingjournal.org/index.php/path/article/view/71
https://doi.org/10.26607/ijsl.v19i1.71 Errata: the correct dates for the following references are: [14] 2011, [17] 2016, [31] 1605.