What is the contribution of street lighting to keeping us safe? An investigation into a policy.

Paul Marchant

Introduction

Lighting of roads is said to be of benefit beyond giving the ability to be able to see in the dark. It is claimed for example that lighting reduces crime and traffic accidents by a considerable amount and it is therefore necessary to have it for these reasons. My view remains that this claim lacks evidence of a sufficiently high standard to warrant using public safety as an argument. On the other hand there are reasons why having a lot of light at night might be a bad thing. This work continues a previous talk and article for Radical Statistics (Marchant 2006)

My initial interest in this area was sparked through my interest in astronomy because light pollution makes it hard to appreciate the wonders of the night sky. It seemed to me that the belief that lighting reduces crime was questionable.... I then embarked on investigating the crime reduction claim and found it suspect, as detailed in the 2006 Radical Statistics article. (See also Marchant 2004, 2005, 2007, 2009)

Negative consequences of artificial light

There are terrestrial reasons to be bothered about artificial lighting.

Some of the concerns are:

The financial costs of installing, running, maintaining and eventually disposing of lighting equipment are considerable. Large sums of money are being spent through Private Finance Initiatives on 'improving' (to use the industry's term) lighting across the country. PFI funding of £620 million was given by the Government to seven local authorities in February 2010 for this purpose. (The website of Lighting Magazine remarked "The Government said, better street lighting will help to improve road safety in these areas as well as helping to reduce crime.")

The cost of running the lights is the reason that a number of local authorities are switching off lights late at night. Similarly the

Highways Agency is switching off some lighting of its strategic road network for a portion of the night.

There are environmental costs too, as discussed in the report on Artificial Light in the Environment (the Royal Commission on Environmental Pollution, 2009).

Wildlife has evolved in a world which has dark some of the time. The problems caused by light at night are increased with broadband light (i.e. white light, which emits across the whole of the visible spectrum, rather than in just a narrow band as in the orange Low Pressure Sodium light). It is shorter wavelengths, blue and ultraviolet that seem to be particularly damaging, e.g. to insect species.

There are negative impacts on humans also. Glare, for example, is identified in the American Medical Association Resolution 516 against Light Pollution 2009.

It is light pollution rather than light itself, that myself, astronomers, biologists and others have concerns about. (Campaign for Dark Skies www.britastro.org/dark-skies/, the International Dark Sky Association www.darksky.org , the Campaign to Protect Rural England www.cpre.org.uk/ with its Night Blight campaign). Light pollution could be substantially reduced by having lighting fixtures properly directed and adequately shielded so that light on only goes where it is needed, thus increasing the efficiency as a consequence.

Robustness of Research

"Can research findings be plausibly explained by means other than that given by the original researcher?" is a question that everyone should be asking. For example, are there potential artefacts that may be seriously afflicting research through systematic errors / statistical bias? Publications in physics often have estimates of the effect of these, in terms of their nature and size, alongside a measure of statistical uncertainty, when results are given.

The potential for corporate influence is an issue too. 'Big Pharma' is rightly viewed with suspicion by many people but other industries are much less regulated and their adverse events are perhaps less obvious. Scientists for Global Responsibility (2009) produced a report, 'Science and the Corporate Agenda: the detrimental effects of commercial influence on science and technology', which sets some of the scene. Companies want to sell products and satisfy their share holders; trading under the 'Banner of Science' is useful in this regard. Certainly the lighting industry uses the claim of enhanced public safety to promote its wares, despite what I consider to be the very poor evidence for the claim. Clearly we need light to see where we are going at night but, is it effective in reducing crime and road accidents?

Also reduction of 'fear of crime' is used as a justification for increasing lighting. It seems to me that one wants to find out what the real risks are and address those, rather than what might be people's irrational fears. Stoking up 'fear of crime' and then providing a means to address the fear is a useful marketing tool. (Rather like religion capitalising on fear of death). There are other matters to be fearful of; …'Fear of the NHS being messed up by privatisation' for example.

The Case of Road Accidents

In March 2007 the UK Highways Agency revised its estimate of the effectiveness of road lighting at reducing road accidents down from 30% to 10%.

Some quotes from the Chief Highways Engineer:

> "Recent work has shown that the night-time personal injury accident (PIA) savings attributable to road lighting are not as high as previously assessed".
>
> "….requires the Road Safety Engineer to play a key role in the appraisal process which should no longer be solely undertaken by the lighting designer."
>
> "The economic case for lighting on individual schemes will now be more focused with the consequence that road lighting may no longer be economically justifiable in some situations where it may have been in the past. Where existing lighting is being considered for replacement there may not always be an economic case for such action."

Indeed, as remarked above, the Highways Agency is switching off some of its lights as in this 17 July 2010 BBC news story www.bbc.co.uk/news/uk-england-lancashire-10672886

A contrary view of the effectiveness of lighting was given in a Cochrane Collaboration systematic review by Beyer and Ker (2009) on street lighting for preventing road traffic injuries which suggested, from meta analysis of studies, that road lighting is very effective at preventing road injuries.

There are however potential problems with this particular meta-analysis. The non-randomised (and rather old) 'controlled' studies utilised in the review are prone to biases. They are not RCTs, so we have no real idea how controlled they are. Regression towards the mean is a potential threat to their validity.

The results of individual studies in the review vary by more than would be expected if measuring the same size of effect while the counts of accidents are varying via the Poisson distribution. (A quick fix solution is that the size of effect is not … so do random effect analysis). It maybe also be that the Poisson distribution needs

modifying for such studies, e.g. through overdispersion, and this would affect the weight that each contributes to the overall result. There is no information on this because of the nature of the studies which have just one measurement of count of number of accidents before and one after.

However the very big issue is publication bias. Are we seeing the pro-lighting tip of a much more mixed iceberg? Policy studies might be much more likely to be written up for publication if the result is 'good news'. There is no trials register for such studies.

I made these points in a response comment fed back to the Cochrane Collaboration review system in May 2009. My piece was incorporated in a revision in February 2010 together with a reply from the review's authors.

Their revision said

> "The authors were able to pool crash or injury data from 15 of the studies. **The risk of bias in these studies was judged to be high" ....**
>
> However the review also states "The results indicate that street lighting **can prevent** road traffic crashes, injuries and fatalities." …

The final sentence does not follow from the previous one… as bias in the original studies leads to bias in the conclusion.

It is worth referring to the Cochrane Handbook (Higgins and Green, 2009). "Whole studies may be missing from a review because they are never published, are published in obscure places, are rarely cited, or are inappropriately indexed in databases. Thus review authors should always be aware of the possibility that they have failed to identify relevant studies. There is a strong possibility that such studies are missing because of their 'uninteresting' or 'unwelcome' findings (…the presence of publication bias)." High risk of bias is sufficient to affect the interpretation of results.

I submitted further comments to the Cochrane Collaboration and these were published in the revision of the review 7 July 2010.

I was pleased to find similar concerns to my own raised independently on the website associated with David Spiegelhalter (FRS, Prof. of Public Understanding of Risk) and his team http://understandinguncertainty.org/node/231 . It starts: "Cochrane Reviews are usually taken as the gold standard in putting the evidence together to check whether a treatment works. But a new Cochrane Review that examines how much the 'treatment' of putting in street lights prevents injuries and saves lives seems to suffer from some major flaws which could mean the claimed benefits from street lighting are greatly exaggerated."

Crime Reduction

The claim that lighting reduces crime has similarities to the claim that traffic accidents are reduced. Only poor quality studies have been done to examine the situation and the threat of publication bias looms large.

However it is interesting to note (on the operational front) that in parts of England trials of switching off street lights late at night are occurring, to save energy costs. When switch-offs are mooted they seem often to be accompanied by assertions that civilisation will end! For example, the Daily Mail headline on 1 February 2008 was “Return of the blackout: Crime fear as councils switch off streetlights to save the planet”. In fact I understand that the police are happy … certainly in Essex and further trials in other counties are being started, I understand. We surely would have heard if a disaster had been attributed to lack of light; the lighting industry PR machine would have swung into gear no doubt.

It is amusing to note the retraction made by a local newspaper in Essex, a place where a switch-off has occurred. The Dunmow Broadcast 10 July 2008 wrote; “The Broadcast wishes to retract a statement made in last week's article on street lights in Dunmow. In the story we stated "a massive rise in crime has been recorded". In fact, figures indicate that there has actually been a substantial fall in crime, particularly in the hours the street lights have been switched off.”

Note that local authorities are very nervous of switching off lights and in fact we might expect an increase in crime simply because of Regression towards the Mean, because switch-offs only happen in very low crime areas.

Welsh and Farrington (2008) (re-)published their previous Home Office Research Study 251 (HORS251) as a Campbell Collaboration Systematic Review, accompanied by an up-beat press release. One of the most bizarre assertions is their repeated claim that having new street lights reduces crime in day time too. The meta analysis of the systematic review comprises the same 13 non-RCT studies and basically similar methods as HORS251 and unsurprisingly reaches the same conclusion. The Confidence Interval for lighting effect is between a 9% and a 47% reduction at its most cautious (i.e. the widest CI given). A systematic review is supposed to include all eligible studies, yet at least one (by Morrow et al. done in Chicago which found lighting detrimental as the newly re-lit area suffered increased crime compared with its status quo comparator) does not appear. Although this of itself is insufficient to nullify the meta analysis result, it does undermine confidence in their search for studies.

Publication bias is mentioned but no caution is given. "It is difficult to test for publication bias." True: there are only 13 studies…These authors just carry on without further reference to such bias. There is no trials register, as for the case of road accident studies, and again one suspects that policy trials are susceptible to publication bias with a biasing tendency towards proclaiming 'good news'.

The review gives nine characteristics of each of the studies …. but not who paid for each study or instigated it. The potential for biasing a result towards what the funder would wish to see is always a problem. We need to be told of funding sources and indeed other matters which might cause potential bias, e.g. was the publication planned from the start or was it something decided upon after the data had been seen?

The protocol for the systematic review gives one way of estimating over-dispersion, yet the review uses another. (Data from a CCTV evaluation is used in a regression approach. I've not been able to see the CCTV data although I asked for it and so cannot check the method used. - I wonder if anyone has.)

I am mentioned.

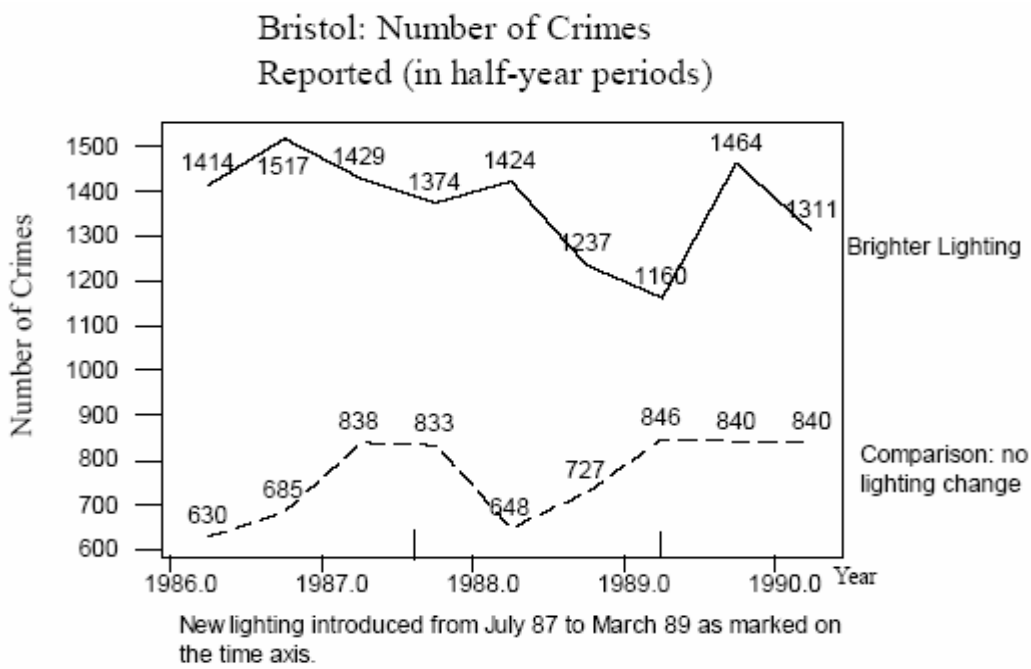
> "Dr. Marchant of Leeds Metropolitan University is a statistician who financially supports this Campaign (*The British Astronomical Association's Campaign for Dark Skies*), and he has criticized our research…."

However note that the Conflicts of Interest section of the systematic review has the following statement

> "There is no conflict of interest on the part of either author. It is important to note that the second author (Farrington) was involved in 2 of the included evaluations (Dudley and Stoke-on-Trent). Farrington served as an independent researcher on these evaluations and both were published prior to the initiation of this systematic review (see Painter 1997, 1999a)."

However readers of the systematic review might like to know that the studies mentioned, of which Kate Painter was the first author, were funded by the Urbis Lighting company. Urbis continues to fund the Institute of Criminology at Cambridge where Farrington is Professor with a post entitled the Urbis Lighting Fellow … the incumbent is Kate Painter and has been for many years. She was the subject of the Private Eye article in 2005 'Conflicts of Interest: Let there be light' on matters surrounding the lighting and crime issue. This article alleged very close involvement, including family ties, between the commissioning of research from the Home Office, academic researching and lighting industry involvement. Interestingly Painter's PhD thesis on street lighting and crime was approved 21 November 1995 but was restricted until 22 April 2008 in the Cambridge Library. One wonders why.

My view is the review of Welsh and Farrington is unreliable. The individual studies are unreliable as is the meta analysis of them….A detailed critique of their work will not be given here. However just one example exhibiting too much optimism and certainty is provided by their treatment of the Bristol study. Here two areas of the city were compared. Crimes were counted in a series of six month periods. One area received lighting in a gradual build-up way mid way through the series. The other area was left unchanged. The time series of the crime counts for the areas are shown on the graph. The area relit has the higher counts. There are markers on the time axis when the build up of lighting in the treated area was started and finished.



The original author (Shaftoe, 1994) made no claim for lighting benefit (Marchant, 2004). However the authors of the review claim that there is evidence, with p = 0.011 for lighting benefit. (Note Farrington and Welsh claimed a *z*-statistic for the effect of 6.6, so p< 1 part in a billion, in their original predecessor HORS251 review, before I pointed out overdispersion in crime data.) Their p = 0.011 claim is based on what they call a time series analysis, which is in fact a standard regression model.

The model chosen has the following characteristics:

1) a different intercept for each area

2) an identical linear time trend in both areas

3) a term for the proportion of new lighting. (This is zero before any lighting is introduced and remains so for the un-relit area, rising in a

linear fashion during the lighting build-up and remaining constant thereafter.) It is the coefficient for this term which has p = 0.011 and they use to support their claim of lighting benefit.

They don't mention p = 0.069 for the linear time period trend, which under the usual p < 0.05 convention would be deemed not to be statistically significant. Removing the time trend from the model and running this reduced model removes the statistical significance of lighting.

I would argue that just by looking at the time plot above that the data do not provide reliable evidence of lighting benefit; just like the original author who collected the data said and I expect many people would agree. Surely one must recognise that there is a great deal of model uncertainty in this Bristol study situation.

We need to know much more background to any studies used…funding etc. Ideally we need proper 'tamper-proof' RCTs to inform policy decisions especially when these involve large sums of public money. (Note the Review of Home Office Science 2007 said in Recommendation 11 that RCTs should be the rule rather than the exception. The points I made in my submission to the review are given in the Appendix).

The Campbell review authors have produced a book 'Making Public Places Safer' (Welsh and Farrington 2009) which propagates their conclusions from their systematic review on lighting and crime.

It is of concern that meta analysis is an easy thing to do without thinking through any of the tricky issues. It lends itself to a crude factory approach. The sentiment in a quotation / definition expressed in Stephen Senn's book 'Dicing with Death' is apposite "Meta-analyst; one who thinks that if enough manure is piled high enough it will smell of roses". I am in favour of systematic reviews. A review of 'what is out there' in a particular field is useful but the temptation to do simplistic meta analysis needs to be resisted. One must think hard what could be go wrong rather than just go and get a pooled estimate of effect willy nilly.

Is crime reduced in areas with new PFI lights?

In order to estimate the effect of lighting on crime I have used Police recorded crime data from the London area, a subset of the nearly 400 Crime and Disorder Reduction Partnership areas of England and Wales published annually. I coupled this with a measure of the amount of progress in relighting in those London areas receiving the PFI lighting schemes. There is a time series of crime counts of 6 key offences from which a total number of crimes occurring in each area can be calculated for each of 7 years. This work, involving multi-level

modelling, is yet to be completed but suggests that the factor by which the number of crimes is increased has a 95% confidence interval of (0.87, 1.11), i.e. a range of a 13% reduction to a 11% increase. Contrast this with the estimate from the Welsh and Farrington review, giving a clear benefit, of a range between a 9% and a 47% reduction. There is some overlap in these intervals but my view is the crime reducing benefit is probably considerably overestimated by Welsh and Farrington for the reasons given above.

Wider Considerations

I believe the pressure for universities to bring in funds is detrimental to sound research as the emphasis becomes quantity rather than quality, coupled with a reluctance to admit shortcomings. The real reason for research should surely be to provide reliable conclusions. It is worth noting that a scientific answer is one that can be surprising or unwelcome, whereas a PR answer is one that gives the right impression. The spirit which is found in voluntary scientific societies, e.g. astronomical, needs to be retained in universities.

Conclusion

- The claims for lighting benefit need to be checked and weighed against any detriment.
- I don't think that light pollution is the worst problem the world faces although I suspect it is a bigger problem than most people think.
- 'Mother Nature' does need a 'defence counsel' otherwise all kinds of abuse will occur. I think it is very important that all evidence is closely scrutinised so that it is properly checked, particularly where consequences are large.
- If public money is spent to achieve some stated aim then we ought to check, after implementing the scheme, that it is doing what it supposed to.

References

Beyer FR and Ker K (2009), 'Street lighting for preventing road traffic injuries' Cochrane Collaboration Systematic Review

http://onlinelibrary.wiley.com/o/cochrane/clsysrev/articles/CD004728/frame.html

http://onlinelibrary.wiley.com/o/cochrane/clsysrev/articles/CD004728/pdf_fs.html

Farrington DP and Welsh BC (2002) *Home Office Research Study 251, Effects of Improved Street Lighting on Crime: a Systematic Review*
http://www.homeoffice.gov.uk/rds/pdfs2/hors251.pdf

Higgins JPT, Green S (editors). *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.0.2 [updated September 2009]. The Cochrane Collaboration, 2009. www.cochrane-handbook.org.

Marchant P (2004) A Demonstration that the Claim that Brighter Lighting Reduces Crime is Unfounded, *British Journal of Criminology*, 44, (3) May 2004, pp.441-447.
http://bjc.oxfordjournals.org/cgi/content/abstract/44/3/441

Marchant P (2005) What Works? A Critical Note on the Evaluation of Crime Reduction Initiatives, *Crime Prevention and Community Safety* 7 (2) 7-13.

Marchant P (2006) Investigating whether a crime reduction measure works *Radical Statistics* No 91 www.radstats.org.uk/no091

Marchant P (2007) Are the claims of lighting benefits true? How can we tell? Chapter 7 of *Proceedings of the 6th European Dark-skies Symposium* http://www.britastro.org/dark-skies/cfds2006/proceedings.pdf

Marchant P (2009) Contribution to the Chapter on Lighting and Crime in *Blinded by the Light? a handbook on light pollution* www.britastro.org/dark-skies/handbook.html

Private Eye (2005) '*Conflicts of Interest: Let there be light*' Issue No. 1142, p28, 30 Sept 2005

Royal Commission on Environmental Pollution (2009) *Artificial Light in the Environment*
www.rcep.org.uk/reports/sr-2009-light/documents/RCEP_artificiallight.pdf

Scientists for Global Responsibility (2009) *Science and the corporate agenda: the detrimental effects of commercial influence on science and technology* www.sgr.org.uk/SciencePolicy/SGR_corp_science_full.pdf

Welsh BC and Farrington DP (2008) Effects of improved street lighting on crime, Campbell Collaboration Systematic Review

Welsh BC and Farrington DP (2009) *Making Public Places Safer*, Oxford University Press

Other Material

See
praxis.leedsmet.ac.uk/praxis/Publications/publicationsmarchant.htm

Appendix Review of Home Office Science Dec. 2007

Points I made in my submission to the Review

1. Independent assessors of Home Office research should include at least one qualified statistician, e.g. Chartered Statistician of the Royal Statistical Society.

2. Statisticians need to be involved at a high level in any research commissioned. It should not be assumed that academics with expertise in other areas are necessarily able to deal satisfactorily with statistical issues.

3. The Home Office should take responsibility for commissioned work, and for dealing with any challenges to this. The tendency to veer toward the side of status quo needs to be avoided and similarly resist the well known tendency to want to 'saying something positive'. In science we want a realistic estimation of uncertainties and statistical biases.

4. Data needs to be made publicly available for checking so as to satisfy the need for wider scrutiny.

5. Sources used in any review of scientific / statistical evidence need to be made available to others.

6. Conflicts of interest should be minimised and potential conflicts of interest should be declared.

Paul Marchant
p.marchant@leedsmet.ac.uk