

Afraid of the dark?

Perhaps too much light is the big problem

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Background

- I started because light pollution is bad for astronomy!... now morphed into a general interest into research integrity ... whether a research claim is trustworthy.
- Also concerns now about biodiversity loss. I'm no biologist ... but note, nearly 4 billion years of evolution, when the Earth has been dark for some of the time. Now recent huge light level increases! 'No effects without side effects!'
- Here I will examine claims of benefit to public safety.
- Academic research can be bad, human failings not helped by systemic perverse incentives.
- Industry research and claims, with its partisan nature, can be even worse!
- **Science:** Get as close as possible to 'Truths about the World'. (A balanced process).
- **Public Relations:** Promote a position in the most favourable way (A selective process).

My 'Interest'

- “...Paul Marchant, statistician at Leeds Metropolitan University who argues that statistics used in the Home Office Study 251 could equally be used to show that street lighting actually increases levels of crime. This is an argument which the APPLG, alongside the ILE, would hope to show as utterly absurd. Of course it is worth noting that Paul Marchant is also an astronomer as well as being a statistician, and that this may lead to some bias in his interpretation of the statistics he refers to.”

P56 of the March/April 2004 issue of the Lighting Journal, the magazine of the Institution of Lighting Engineers.

APPLG= The All-Party Parliamentary Lighting Group

ILE= The Institution of Lighting Engineers

Light has a good press!

An advertising agency would die for a celebrity endorsement like this!

Genesis Chapter 1 in the St James Bible

Verse 3 'And God said, Let there be light: and there was light'.

Verse 4 'And God saw the light, that it was good....'.

.... and God divided the light from the darkness ...& called the light day & the darkness he called night.

Humanity has mixed them up ... at increasing pace!

It seems 'wicked' to question the 'goodness' of light. (Very +ve language)

However, there is a 'dark side'; lighting's additional impacts, e.g. on biodiversity, not just astronomy that was my initial interest.

It would seem natural that humans feel uneasy about darkness, as we are a diurnal species. (Nocturnal species presumably feel uneasy about being in light!).

The question is what effect does lighting have on actual safety today ... on crime and on road safety? (Obviously, we need some light to see our way at night and not trip over but softer, less-intense lighting of appropriate spectral content that is only on when needed might suffice).

Some themes that I will talk about:

- 1) Grave errors in pro-lighting research sufficiently severe to nullify the claims of large public safety benefits from increasing lighting.
- 2) Studies of better quality (including my own!) do not detect any change in public safety when lighting is changed.
- 3) The problems the light pollution causes.

Punchline: I am very sceptical that bright lighting does very much to keep people safe & it might make matters worse. When I started I thought I would find a modest benefit.

The amount of light received at the Earth's surface throughout the day

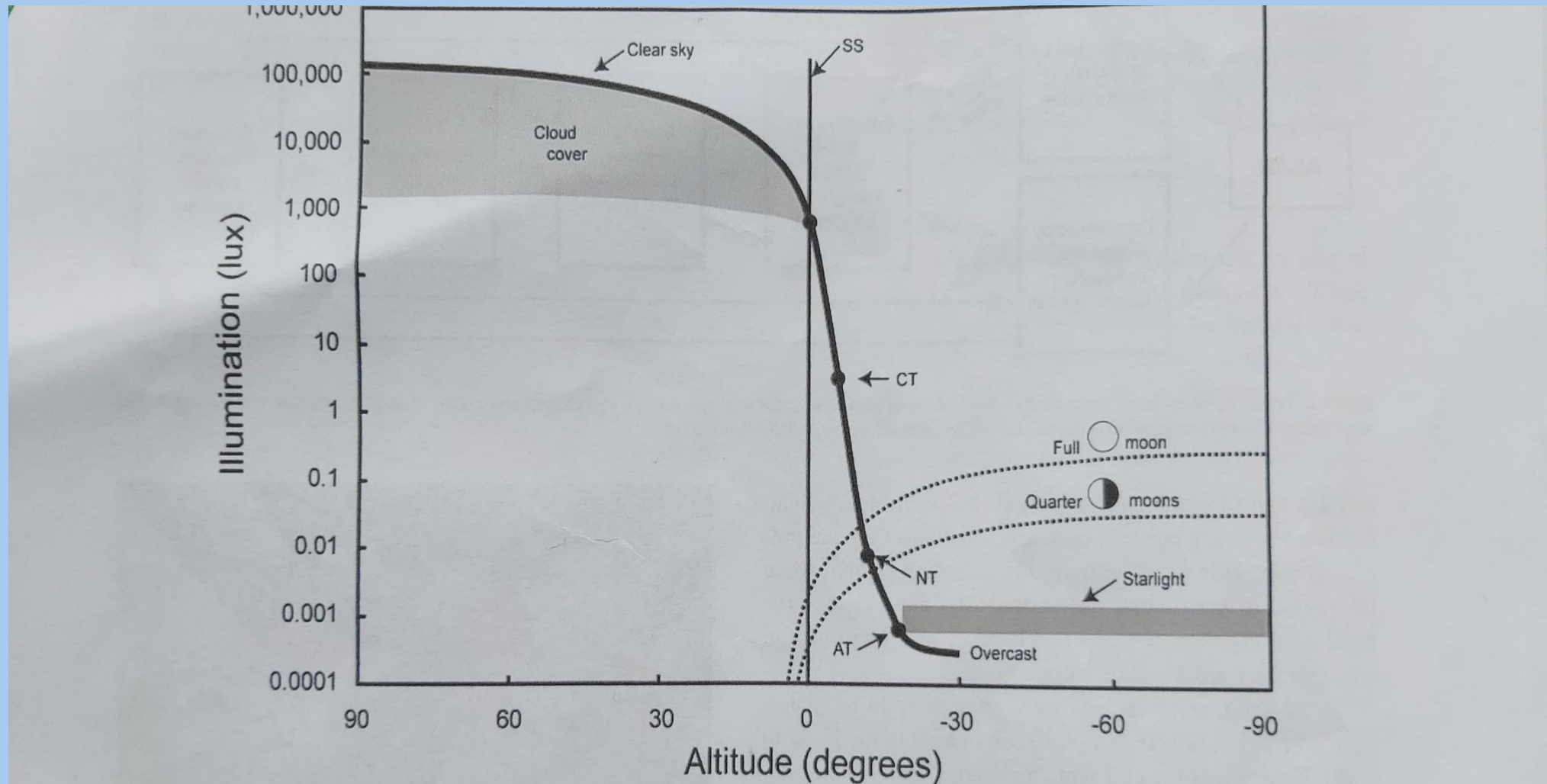


Figure 5. Natural illumination during the day and at night. The solid black line is the amount of light falling on surfaces near the ground. Certain times are indicated: SS = sunset (when the Sun's angle above the horizon reaches 0°); CT = end of civil twilight (Sun angle = -6°); NT = end of nautical twilight (Sun angle = -12°); AT = end of astronomical twilight (Sun angle = -18°). Note that the increments on the vertical axis increase in factors of ten. The horizontal axis shows the Sun's angle above or below the horizon. Dotted lines show the illumination by the Moon for its full and quarter phases. Cloud cover decreases the ground brightness by the amount in the shaded region at upper left. The shaded region at lower right is the contribution from starlight under clear skies. Adapted from (108); figure courtesy of T. Longcore.

The North Sky, Sept: The Midnight Sky, 1869 by Edwin Dunkin



THE MIDNIGHT SKY AT LONDON, LOOKING NORTH, SEPTEMBER 15.





Some history

- I got annoyed that increasing light pollution was messing with my amateur observational astronomy through 80s and 90s.
- Cochrane collaboration aims for best understanding effects of health care interventions by doing systematic reviews. If appropriate, meta-analyse to get a trustworthy estimate of the effect of a healthcare treatment.
- I was working on a review & went to a Cochrane Statisticians meeting in 2001. Aim: what comes out of reviews was top-notch ... EQUATOR network.
- It was great! That gave me the idea of asking what is the evidence that more lighting gives better protection from danger.
- I looked and found there was such a review, HORS251. It was very positive about street lighting. BUT statistically it was appalling. One of its authors was described to me as “the worlds greatest criminologist”!!
- ‘Meta-analyst; one who thinks that if enough manure is piled high enough it will smell of roses.’ In ‘Dicing with Death’ by Stephen Senn

Science & Statistics

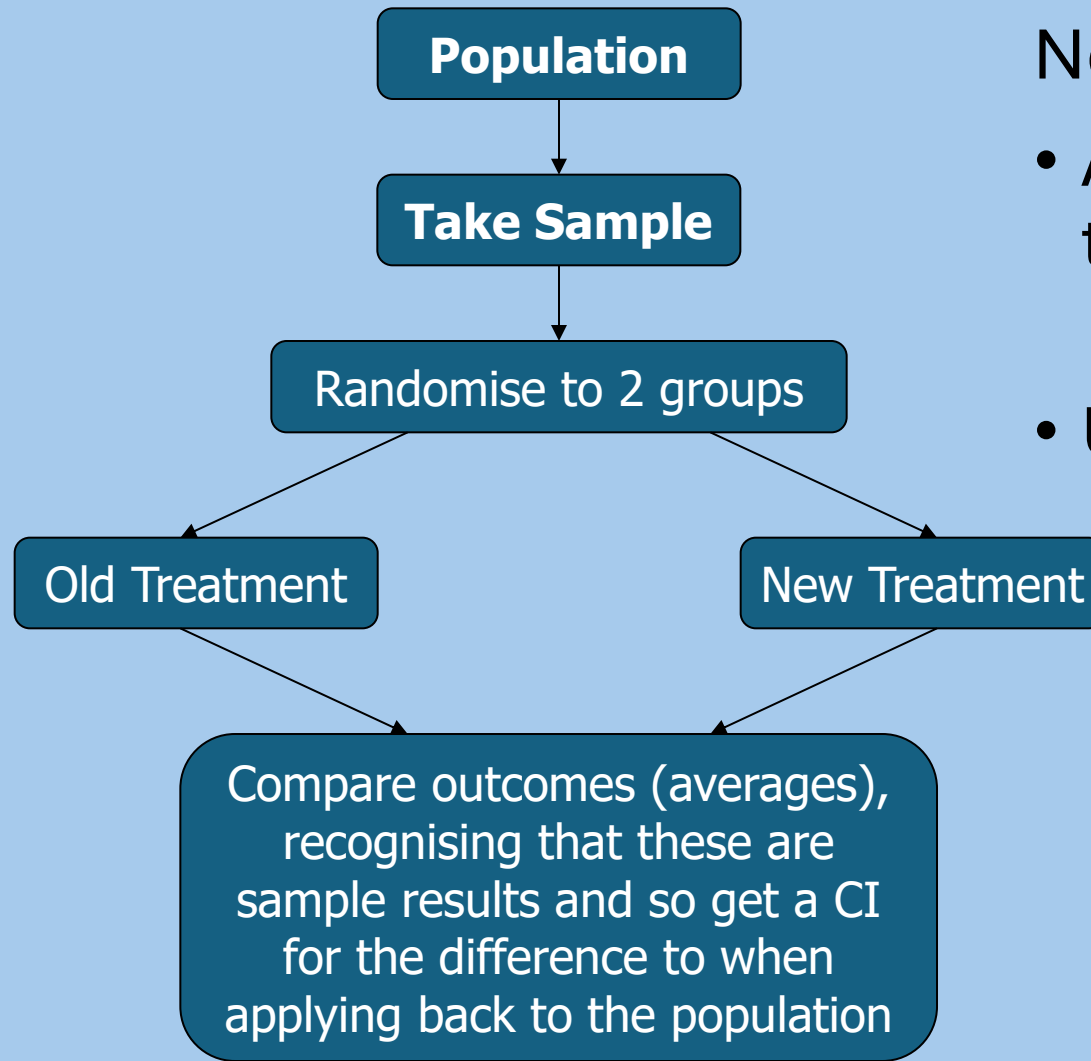
Statistics is a big subject cropping up in all areas of scientific enquiry

Statistics is at the heart of science. Science tells us what the world is like, and statistics tells us about doing science. ('Gives a logical path from study design & data collection to conclusion'). Statistics is therefore a very important subject..... the reason I'm keen on it... And more people should be.

All Science is 'Social' to some extent (the social structure of 'the science business' itself....power, money, employer-employee relationships, progression etc.).

Human foibles and frailty.

The Randomised Controlled Trial: marvellous scientific invention. Compares like with like, perfectly if the sample is infinite.



Note to avoid 'bias':

- Allocation is best made tamper-proof.
(e.g. use 'concealment')
- Use multiple blinding of:
 - patients,
 - physicians,
 - assessors,
 - analysts ...

A brief review of some errors

HORS251 authors made the error of assuming crime counts are Poisson distributed. Poisson would apply to the number of clicks on a fixed Geiger counter monitoring a lump of a long-lived radioactive substance as there is a constant underlying rate and the events (clicks) are statistically independent. But NOT to crime as not statistically independent. (Road Traffic Collisions more realistically closely independent). Crime counts are more variable than Poisson.

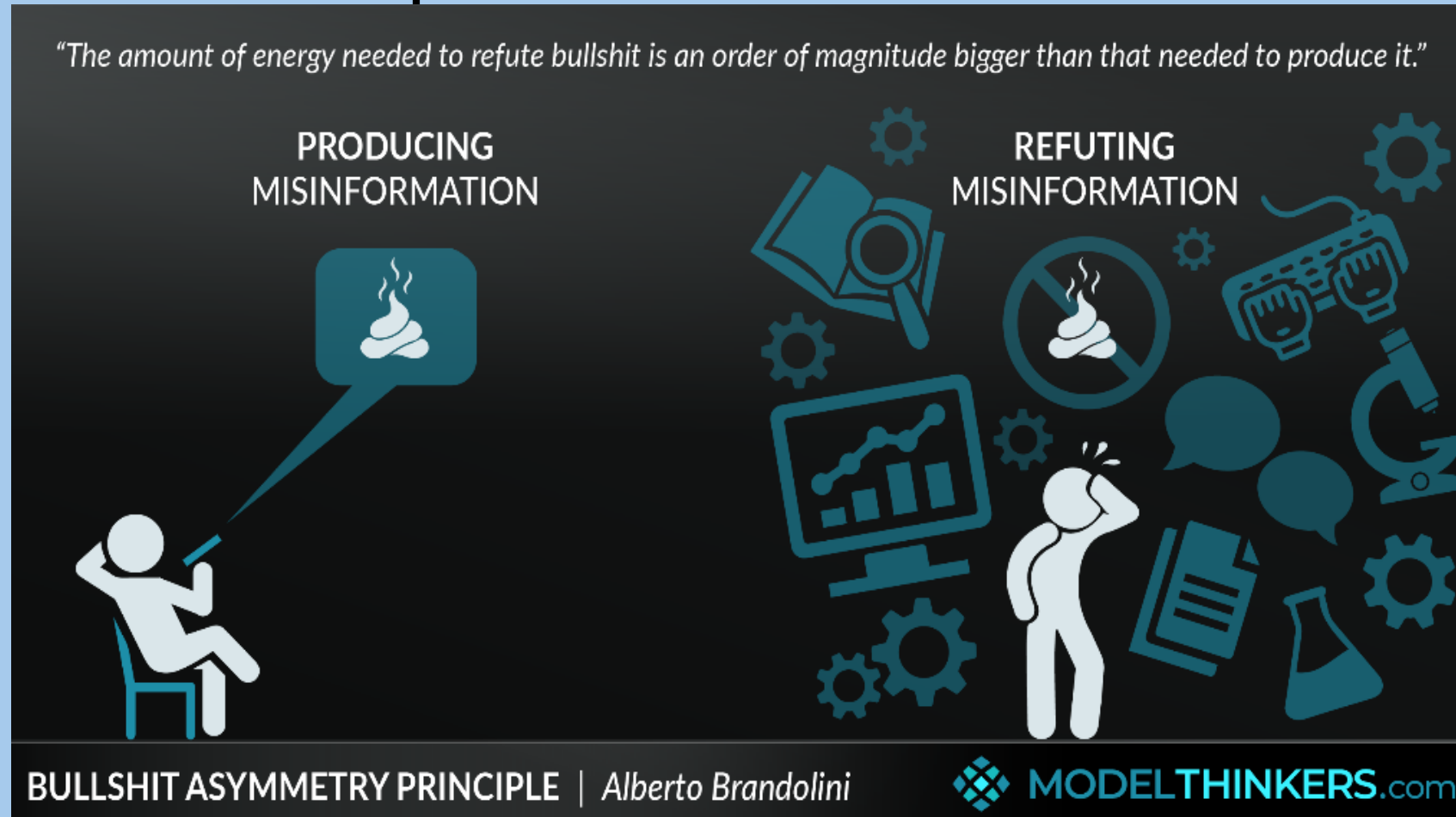
HORS251 authors talk of 'trials' but they are NOT RCTs as just one area gets new streetlights and is compared with just one other area. Not randomised & tends to be the more crime-ridden area that gets the new lights ... not comparing like with like. Comparing high with lower leads to Regression Towards the Mean in which the next measurement is likely to be closer to the mean irrespective of whether the intervention works or not. (RTM discovered by Galton in 19th C) . I told the Home Office HORS251 was 'questionable'.

Also, Publication Bias is a risk. Exciting, positive, pleasing results tend to get published more than dull, uninspiring, null results. This is why research needs to be registered before it's carried out so it can't just disappear. (AllTrials)

Brandolini's Law 2013

Also known the *Bullshit Asymmetry Principle*, it states:

The amount of energy needed to refute bullshit is an order of magnitude bigger than that needed to produce it.



Road Traffic Collisions (RTCs)

- I didn't start with RTCs and lighting, but these are easier to deal with because the events tend to be nearly statistically independent. Therefore, the Poisson distribution can be applied to counts in a period.
- RTCs a big problem, as about 1.3 Megadeaths/year globally due to RTCs, with a sizeable proportion at night.

Industry organisations like the CIE (International Commission on Illumination) who set lighting standards are not good at science IMHO. They use the **cross sectional** study Hargroves R A & Scott P P (1979) finding of a negative relationship of night/day collision rate ratio and brightness of roads to say:

Brighter roads CAUSE fewer RTCs !!

BUT ... CORRELATION does not mean CAUSATION.

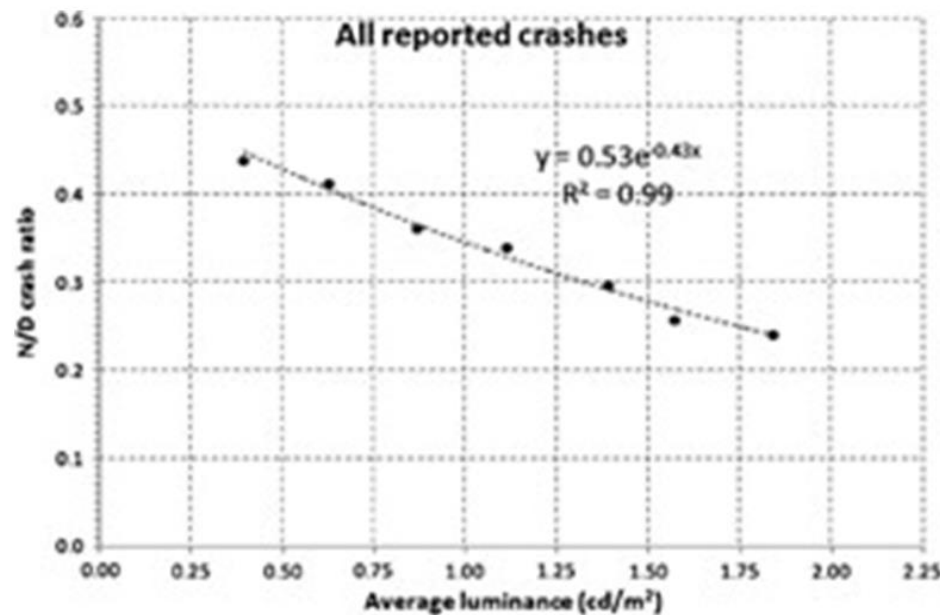
CONFOUNDERS (lurking variables) exist. Many differences exist between the different roads sampled other than lighting.

A particularly bit of bad RTC science is that of Jakkett and Frith 2013

done by two highways engineering consultants in NZ.

They also assume correlation means causation! But what about different money spent on different roads, differential night/day traffic flows, the type of traffic, driver behaviour etc, etc ... They published this graph on **grouped then averaged** data to claim an R^2 of 0.99!!! I wrote a Significance article on this and also a longer one exposing the many shortcomings.

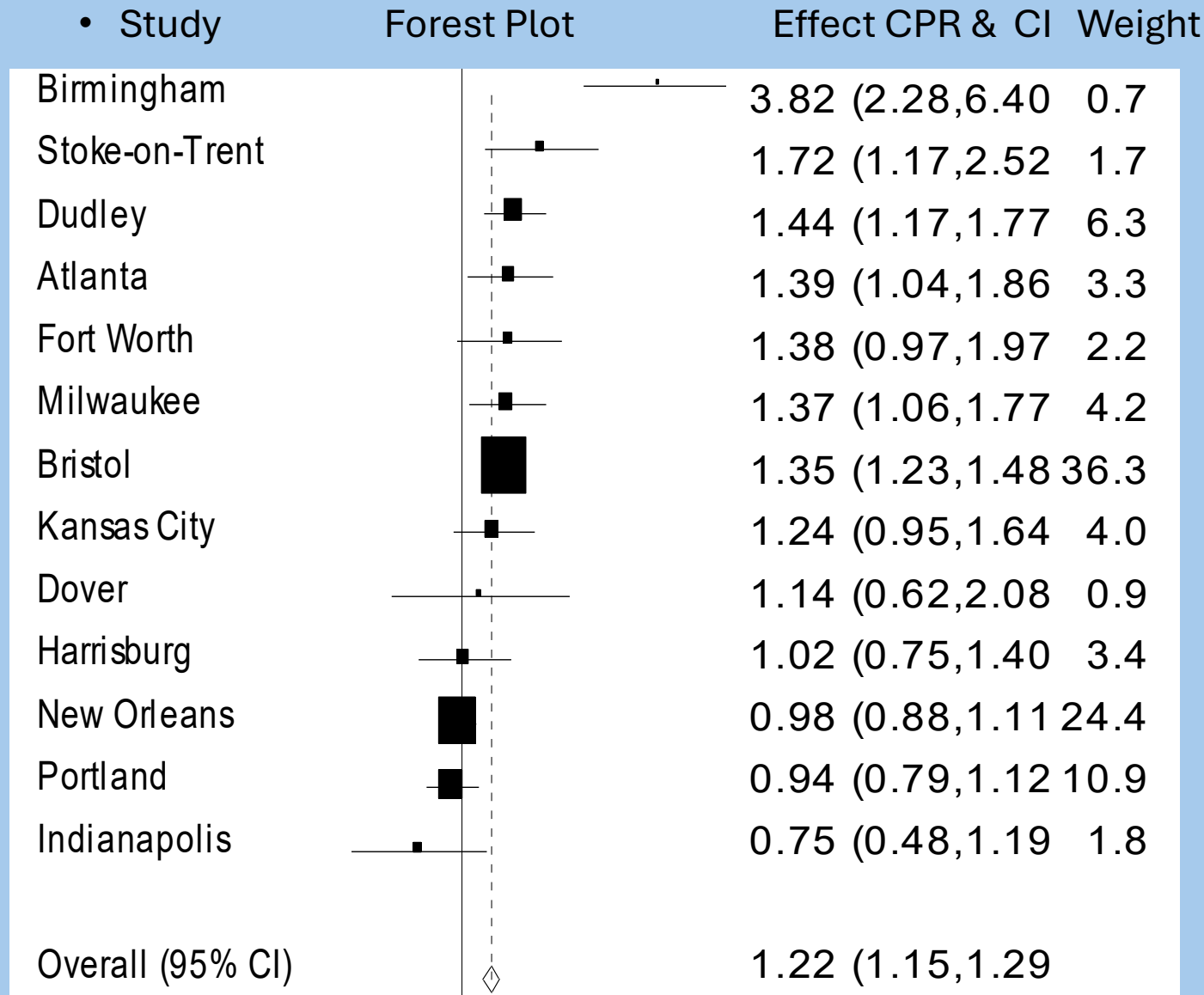
FIGURE 1 The relationship between average luminance and the night-to-day crash ratio for all reported crashes. ...



There are more crimes against statistics in the JF work

- Variables which indicate detrimental effects of increased road lighting are removed from the modelling without proper justification and other variables not included in the first analysis appear in the subsequent cosmetic analyses. The latter falsely give an illusion of certainty.
- Bad practice of the (Elsevier) journal, IATSS Research (IATSS stands for International Association of Traffic and Safety Sciences) where the paper appeared. It does not allow the publication of critical responses.
- The paper has been used to promote increased road lighting costing A\$ 1+ Billion by the Institute of Public Works Engineering Australasia report, titled 'SLSC Roadmap: Smart Lighting Smart Controls', ... in which it disclaims any responsibility if the report is wrong!

Meta-analysis of the lighting and crime studies HORS251, 2002

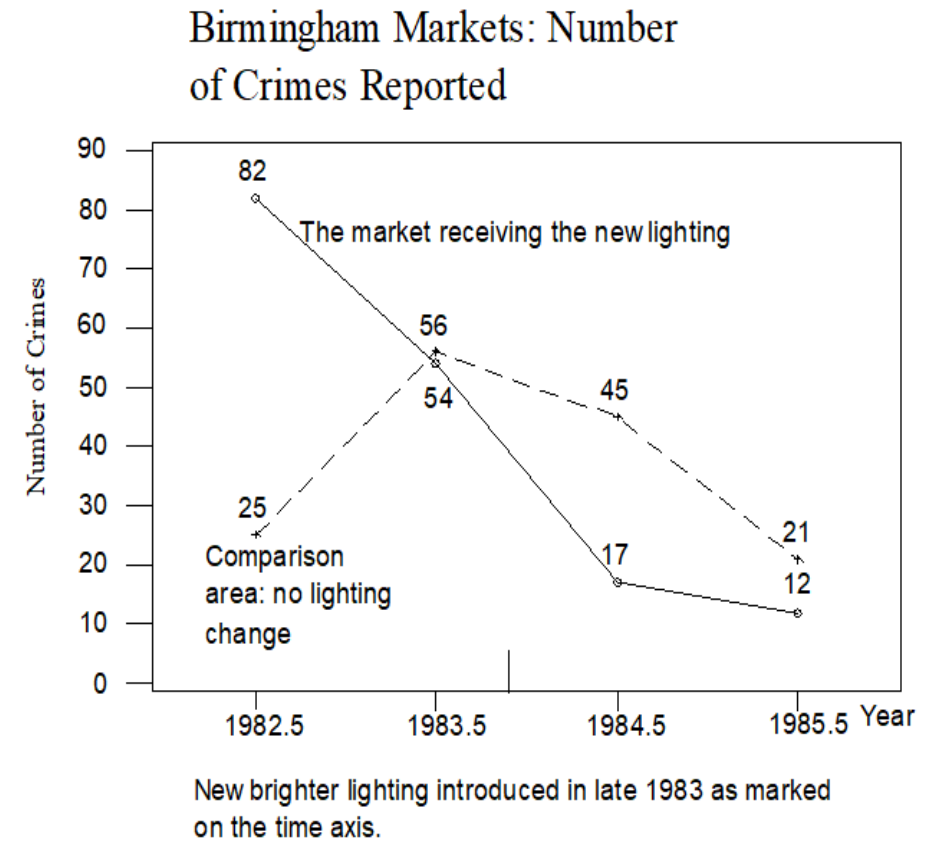
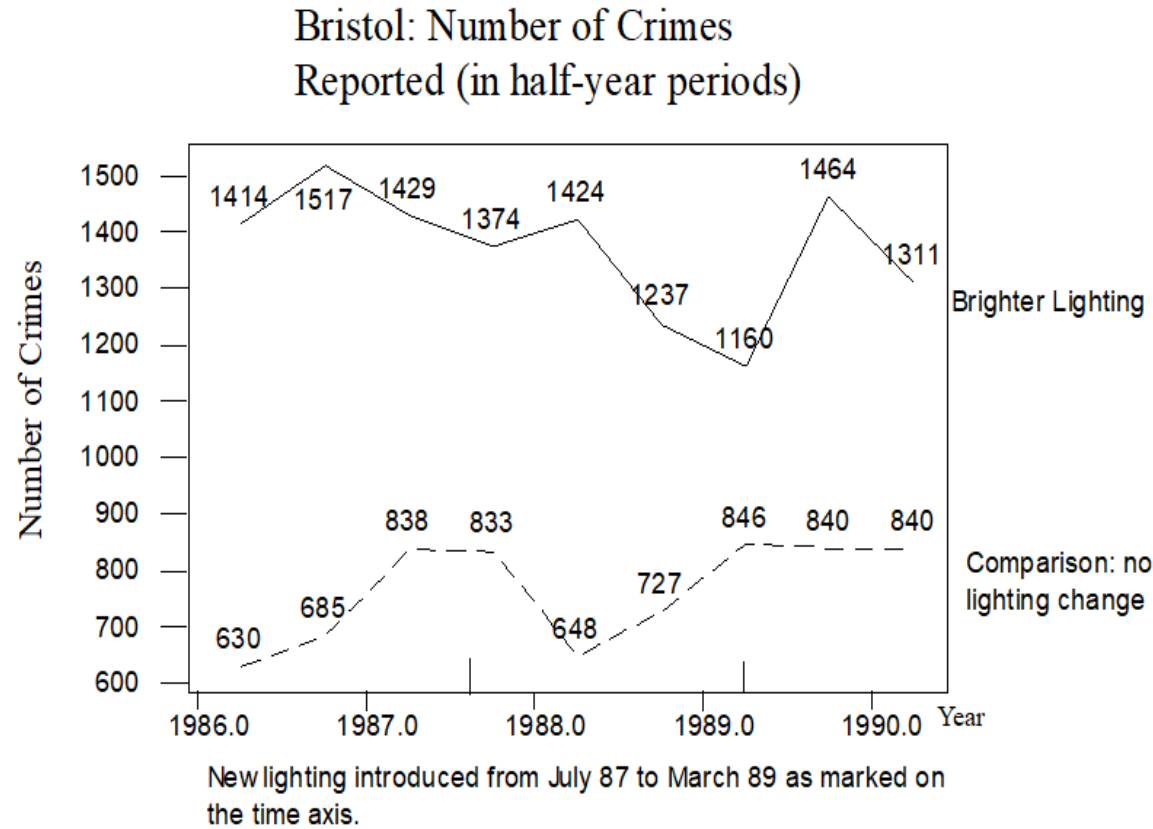


Problems

- All taken as simple Controlled Before After (CBA) studies
- (Some studies have more than just 4 data points)
- Point estimate given by $CPR = (a/b)/(c/d) = ad/bc$.
- Originally authors assumed Poisson to obtain the standard error of each study, but not correct to do so. Therefore, the variances of every study estimate are unknown but are needed to assign the weights for the meta-analysis.
- No guarantee that the individual studies are comparing ‘like with like’ to a sufficient degree to avoid the threat of such as **Regression to the Mean** if lights were added hoping to reduce an unexpectedly high crime level.
- Poor statistical practice, like wrongly using **one tailed testing**.
- Draw a different conclusion from the original study’s author.
- Dubious meta-analysis published again in 2022 which claims the rather puzzling result that brighter street lights do reduce crime if the studies used the round the clock measure for the count of crime, but no benefit was detected for those studies that just counted those crimes occurring at night!

	Before	After
	Crime Count	Crime Count
Gets new lighting	a	b
Control (No lighting change)	c	d

Studies with more than 4 data points don't appear to show the very high levels of statistical significance claimed. (There's a big problem of model uncertainty.)



Shaftoe said 'no discernible lighting benefit', but WFD says $z=4.67$. Note: had the data for the year immediately prior to the introduction of the relighting, i.e. periods 2 and 3, been used rather than unnaturally just using periods 1 and 2 which leaves a gap of $\frac{1}{2}$ year, the effect found would have been half of that claimed. (Shows large variability.)

‘**LANTERNS**’ project. An evaluation of the effect of Reduced Street lighting but also added Change to White Light.

- A big National Institute of Health Research funded (£414,315.32) project: data from 62 of the 174 England & Wales local authorities. A **longitudinal** study, from 2000 to 2013, around 40,000 km of road had experienced lighting changes. There were 859,935 road crashes in the dataset.
- The protocol and other information is on the NIHR Public Health Research website along with the report. (Good!). The NIHR PHR project number is 03110 . **Article: Steinbach et al 2015**
- No change to road safety was detected, whatever was done to streetlighting in this longitudinal study (Switch-off rate ratio (RR) 0.97; 95% CI (0.82 to 1.15), Dimming 1.00 ; (0.91 to 1.10), Part-night lighting 0.95; (0.84 to 1.07). ‘Undeclared variation of protocol’ occurred: Change to White Light was examined too, 1.01; (0.93 to 1.09). Also examined **crime** but only 3 of years data. White light 0.89; (0.77 to 1.03).
- I don’t doubt the null result, but I would like to have the data and apply the (superior!) multilevel method. However, the data of positions and changes to the streetlights (public assets) is apparently confidential! Nothing is said about this in the protocol! I mention this lack of ‘openness’ in my Research Integrity submission to UK Parliament, RES0042.
- Their Cost Benefit Analysis only examines Part Night Lighting & shows PNL to be beneficial. But is silent on the cost dis-benefit of changing to white light.
- Little publicity has been given to the fact that £billions spent on changing to white light, yet there is no good evidence that it has enhanced public safety, despite prior claims that the change would do this.

Work I've done with others to assess the change to safety by relighting with white lamps.

(1st a 2011 study of London crime at borough level ... gave a null result for relighting.)

Two studies on RTCs & one on crime published in 2020, 2022 & 2025 respectively.

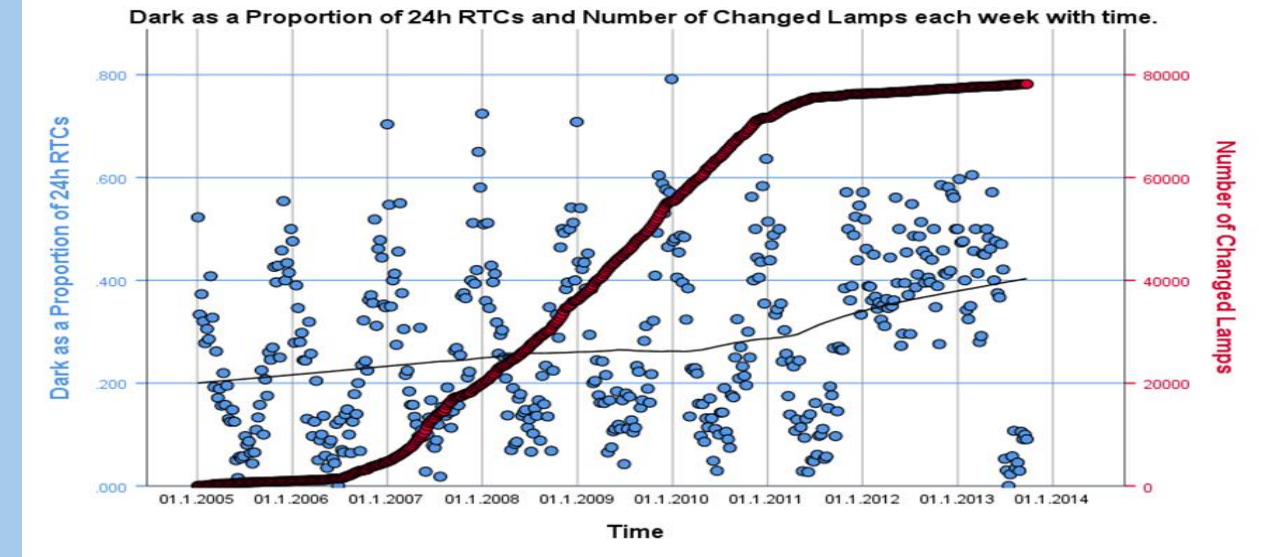
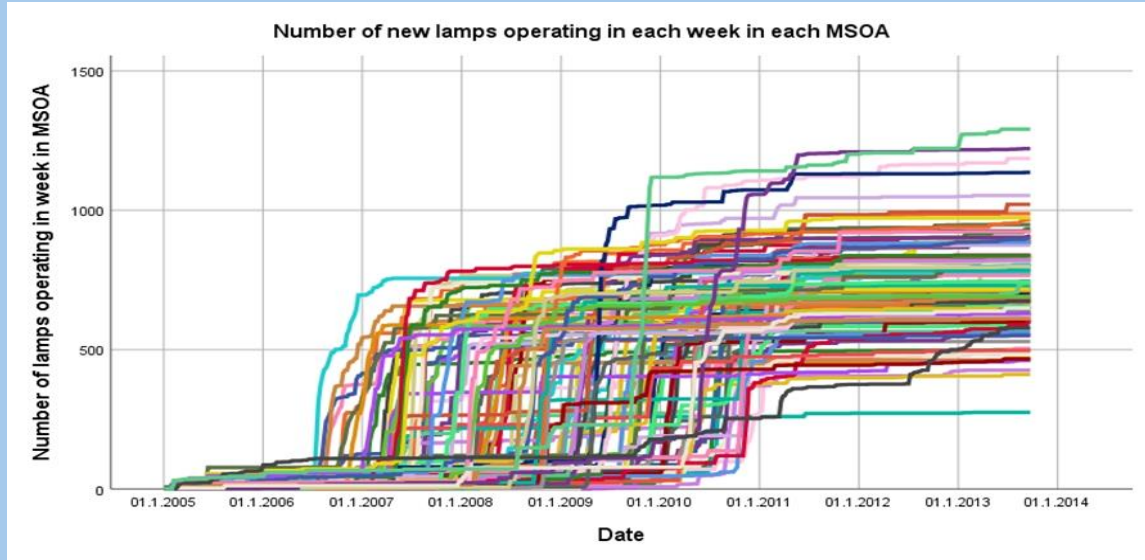
- All use over 8 years of weekly event counts in darkness & daylight in over 100 areas (MSOAs). The method tracks these time series as old lamps are replaced with white light & sees how RTCs & crime respond. All publications are open access and open data.
- **Birmingham RTCs** with James Hale & Jon Sadler of Birmingham University.
- **Leeds RTCs & Crime** done with Paul Norman of Leeds University.
- Nearly 80,000 white lamps fitted at convenience of contractor => independence.
- nearly 20,000 RTCs from STATS19 data (28% RTCs reported as in darkness).

Police Recorded Crime (Leeds)

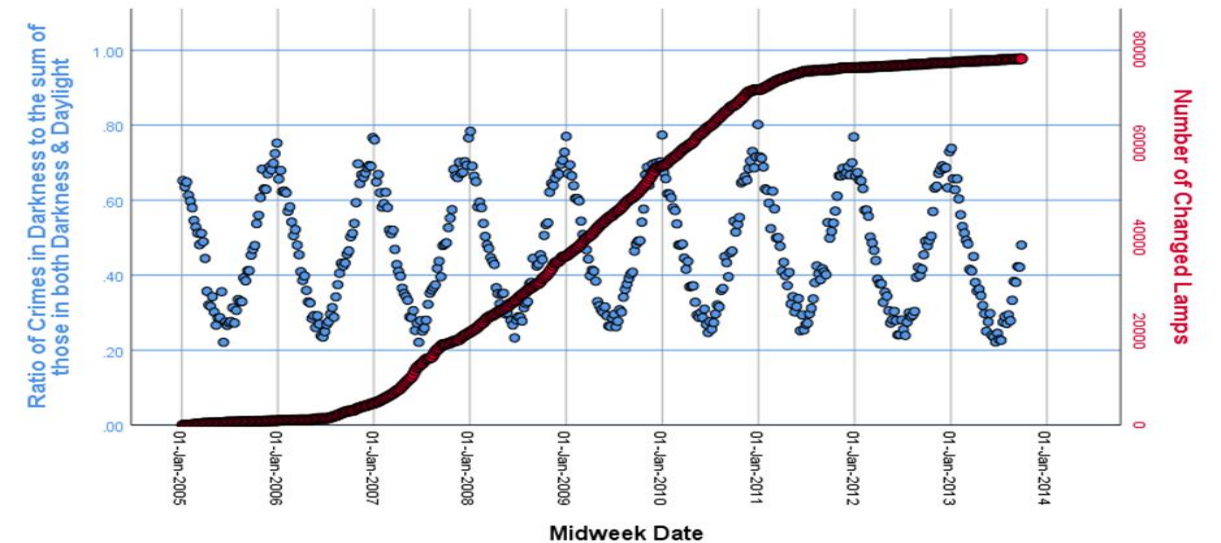
For a crime, first had to assess whether it occurred in darkness or daylight. Code written for this from the time of earliest & latest possible occurrence in its record.

221,644 PRCs occurred in darkness, 249,730 occurred in daylight, making 471,374 where the lighting condition was known. (The lighting condition could not be determined for 208,078 PRCs .)

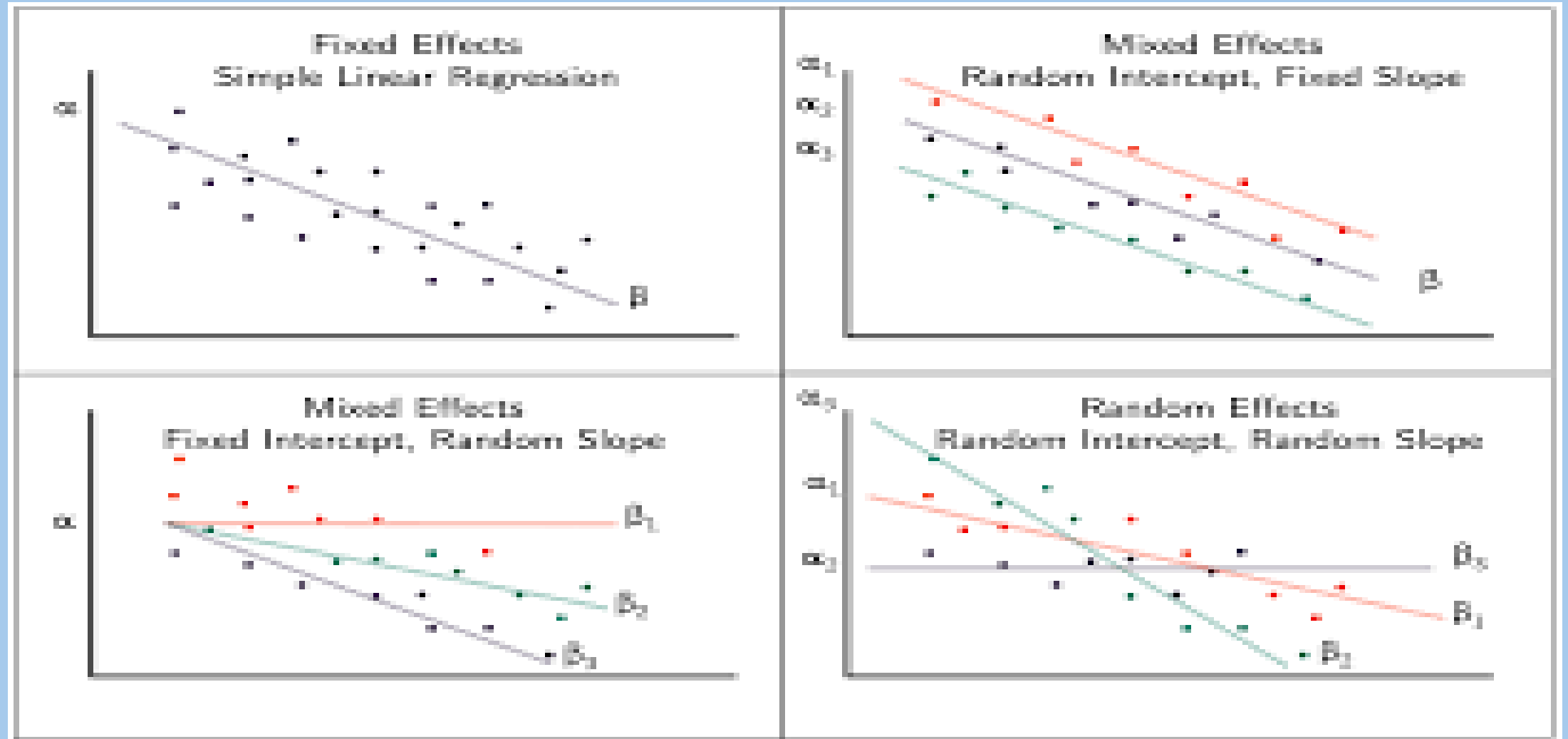
Leeds new lamps & dark to day event rate ratio over time.



The ratio of the number of crimes in darkness to the sum of those both darkness and daylight



Modelling (Multilevel) 100+ time series together



$$\text{logit}(\pi_{ij}) = \log(\pi_{ij}/(1-\pi_{ij})) = \beta_0 + \beta_1 t + \beta_2 t^2 + \dots + \beta_{Mk} \text{Month}_k + \beta_{Hl} \text{PubHol}_l + \beta_W (L_{ij} - \langle L_{ij} \rangle_j) + \beta_B (\langle L_{ij} \rangle_j - \langle \langle L_{ij} \rangle \rangle)$$

Results: The ratio of the rate of darkness events to those in daylight, after to before (the Daylight Adjusted Rate Ratio). A value > 1 means more events (bad news).

Multilevel logistic models fitted with MLwiN

RTCs

- For Leeds it gives a rate ratio 95% CI (0.80,1.10) . Underlying darkness to daylight RTC has a linear rise over time, independent of new lamp installation
- For Birmingham rate ratio CI (0.88,1.23) (Fewer lamps changed in Birmingham than Leeds) (Flat time trend)
- Combining these 2 results, weighted by the inverse variance, CI (0.84,1.12). All null.
- So, the evidence suggests between a 16% decrease to 12% increase in RTCs
- Consistent with the NIHR LANTERNS 7% decrease to 9% increase. (5 times Leeds road length & done on road segments rather than MSOAs.)

Police Recorded Crime.

The modelling for Leeds crime is trickier than for RTCs (higher weekly counts than for RTCs). Overdispersed binomial required. Requires 6th degree polynomial for the underlying time trend with up to 4th power random effects. Investigated including lagged crime counts but did not change the lighting effect.

Gives a rate ratio (0.97 to 1.07) daylight adjusted & (1.00 to 1.06) for 24 hour, narrower but consistent with NIHR LANTERNS null result also done on MSOAs, CI (0.77 to 1.03) for 24 hour. (Steinbach et al 2015)

The NIHR authors claim their result is weak evidence for white lights' effectiveness. They make the same claim for weak evidence for effectiveness, for dimming road lamps CI (0.70 to 1.02) too. This is a strange claim, as white lights brighten the roads and dimming makes them darker! Also, the CI includes 1, the null.

(Perhaps they wanted to say something positive, especially as the Institution of Lighting Professionals (ILP) was involved!)

The meaning of the results?

- Why doesn't having more light reduce RTCs? Perhaps having more light and visibility just enables people (drivers) to feel safer and so behave more recklessly. A collision involving greater speed will cause more injury and so become more likely to be registered by the police, as it's a Personal Injury Accident and so enter the records.
- Why might having more light not reduce crime? Perhaps having brighter light just enables criminals to see better, so it's easier to spot opportunities and targets. Criminals need light to work by, as do we all! Being able to see to commit crime perhaps outweighs any suppression due to enhanced surveillance that might prevent it. (Tompson et al 2022 found that switching street lights off reduced theft from cars.)

Some thoughts

- Better large-scale studies don't detect any impact on public safety through changed lighting. This suggests: Crime and RTCs are not lighting problems but perhaps societal problems. More publicity needs to be given to these results.
- It would be good if the multilevel longitudinal studies that I've shown could be replicated in other situations where there are substantial lighting changes.
- Several local authorities in the UK are reducing their street lighting and would be unlikely to do it if they thought it unsafe.
- The cost of good research (inc. evaluation) is small compared to wrong policy implementations!
- Need better quality, open and transparent research in all specialisms.
- “Trust no-one, check everything.” Stephen Senn.

Some Issues

- It is not just street lights that produce light pollution ...
- Protecting against LP is not always 'rocket science' but just about lampshades and switches (On/Off & dimmer).
- Bright lighting is used as a beacon to draw customers to spend their money at an establishment. This leads to arms races between establishments.
- Problem for the natural world is not just intensity, but wavelengths contained (also straying into U/V & IR), also polarisation.
- LEDs although have potential to be better shielded, but because cheap to run, there's a great proliferation of lighting. It's unclear if there are global overall money savings due to LEDs.
- LEDs produce blue light first which then has to be changed to whitish light, but some blue remains. Blue light signals daytime. Many LEDs are 'harsh' containing much of the original blue, rather than 'warm white'.
- Not just astronomers deprived by LP, but artists, poets, lovers, everyone. Destroys cultural affinity with the night sky, e.g. Native Australians.

Artificial Light at Night (ALAN) its effects on the natural world

- Life in all its myriad forms has grown up over 4 billion years on a world where it has been pretty dark to very dark some of the time.
- Effects have been seen among birds; fish; mammals; reptiles; amphibians; insects and other invertebrates; molluscs; plankton; microorganisms and plants.
- ALAN disrupts circadian rhythm of individual species and what they do, e.g. phototaxis, but also groups of organism Predator-prey balance.
- Fish badly affected (The German Leibniz Institute of Freshwater Ecology and Inland Fisheries is very active in the ALAN field).
- Birds' migration is affected by bright cities and buildings. (Weather radar is used to track flocks.) If lights switched off during the night, trapped birds can escape.
- Insects are affected ... note the loss of insects ... Buglife ran a citizen science 'splat test' study. Insects swarm around lights What might they be doing otherwise? Ecosystem services, e.g. pollination, esp. of food crops! => 'insect apocalypse', in conjunction with other pressures on insects (e.g. pesticide use).



Humans

- Humans have a basic approximate 24h cycle (as do most living things, even the most primitive). This is stopped from drifting way-off by daily signals of night and day through the SCN (suprachiasmatic nucleus). This is the master biological clock in the brain, located in the hypothalamus, that regulates the body's circadian rhythms by responding to light and coordinating daily cycles of sleep, hunger, hormone release, and other vital functions.
- Related to this is secretion of the hormone melatonin (as in many species). This occurs in darkness and is involved in 'the body repairing itself'.
- If you don't sleep you are in big trouble, ...

which via the song 'New York, New York, the city that never sleeps ...' indicates why the USA is such an odd place!

Five Principles for Responsible Outdoor Lighting Practices (From DSI & IES)

If light is deemed useful and necessary, follow these guidelines to prevent, or when that's not possible, minimize light pollution.

USEFUL All light should have a clear purpose.

Before installing or replacing a light, determine if light is needed. Consider how the use of light will impact the area, including wildlife and the environment. Consider using reflective paints or self-luminous markers for signs, curbs, and steps to reduce the need for permanently installed outdoor lighting.

TARGETED Light should be directed only to where needed.

Use shielding and careful aiming to target the direction of the light beam so that it points downward and does not spill beyond where it is needed.

LOW LIGHT LEVELS Light should be no brighter than necessary

Use the lowest light level required. Be mindful of surface conditions as some surfaces may reflect more light into the night sky than intended.

CONTROLLED Light should be used only when it is useful

Use controls such as timers or motion detectors to ensure that light is available when it is needed, dimmed when possible, and turned off when not needed.

COLOUR Use warmer colour lights where possible

Limit the amount of shorter wavelength (blue-violet) light to the least amount needed.

- ALAN (Artificial Light at Night) and consequent Light Pollution is a bigger problem than many realise, probably due to us being a daytime species and so like light! Other threats are more recognised, perhaps because they seem unnatural.
- A useful reference is: Artificial Light at Night: State of the Science 2025, DarkSky International, DOI: 10.5281/zenodo.15492393, 500+ references.
- A database of research publications relevant to ALAN
https://www.zotero.org/groups/2913367/alan_db 5000 + references.
- Other problems above our heads, the fleets of satellites, visually and when they burn up in the very thin atmosphere, as well as using space for military purposes & so potential for conflict. Such wider concerns are the province of <https://www.spaceenvironmentalism.org/>

References to my more recent work

- **To Determine if Changing to White Light Street Lamps Reduces Crime: A Multilevel Longitudinal Analysis of Crime Occurrence during the Relighting of Leeds, a UK City** Paul R Marchant & Paul D Norman *June 2025 Applied Spatial Analysis and Policy* 18(3) DOI: 10.1007/s12061-025-09675-1
- **In the best light? Road safety and public spending** June 2023 *Significance* 20(3):30 Paul R Marchant & Paul D Norman <https://academic.oup.com/jrssig/article/20/3/30/7190566> DOI <https://doi.org/10.1093/jrssig/qmad046>
- **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**, July 2022 *Applied Spatial Analysis and Policy*, [Paul R Marchant](#) & Paul D Norman <https://link.springer.com/article/10.1007/s12061-022-09468-w>
- **Reprint of: Bad Science: Comments on the paper ‘Quantifying the impact of road lighting on road safety — A New Zealand Study’ by Jackett & Frith**, *Radical Statistics*, March 2022, [Paul R Marchant](#) <https://www.radstats.org.uk/no131/Marchant131.pdf>
- **Bad Science: Comments on the paper ‘Quantifying the impact of road lighting on road safety — A New Zealand Study’ by Jackett & Frith (2013)**, March 2020, *World Transport Policy and Practice*, [Paul R Marchant](#) [No longer available online]
- **Does changing to brighter road lighting improve road safety? Multilevel longitudinal analysis of road traffic collision frequency during the relighting of a UK city**. March 2020, *Journal of Epidemiology and Community Health*, [Paul R Marchant](#), [James David Hale](#), [Jon Paul Sadler](#) <https://jech.bmj.com/content/74/5/467>
- **Do brighter, whiter street lights improve road safety?** Volume 16, Issue 5, October 2019, Pages 8–9, *Significance*, [Paul R Marchant](#) <https://academic.oup.com/jrssig/article/16/5/8/7029303> <https://doi.org/10.1111/j.1740-9713.2019.01313.x>

Thanks for listening!

Any thoughts on the material?

Perhaps converse afterwards?

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