CONSULTING REPORT: 644-00233

June 2013

Trafford LED Street Lighting Programme Health Impact Assessment

HIA REPORT

FINAL

Report Author/s: Dr Salim Vohra, Director, IOM Centre for Health Impact Assessment
Reviewed by: Dr Sue Wright, Associate HIA Specialist, IOM Centre for Health Impact Assessment

The Institute of Occupational Medicine (IOM) is a major independent centre of scientific excellence in the fields of occupational, environmental and public health, hygiene and safety.

Our ethos is: Integrity | Independence | Authority.

We were founded as a charity in 1969 by the UK coal industry in conjunction with the University of Edinburgh and became a fully independent charity in 1990.

Our mission is to benefit those at work and in the community by providing quality research, consultancy and training and by maintaining our independent and impartial position as an international centre of excellence.

We have more than 130 scientific and technical staff based in Edinburgh, Chesterfield, Stafford and London. Our consultancy work is undertaken through IOM Consulting Limited which is a wholly owned subsidiary.

The Centre for Health Impact Assessment (IOM CHIA) was setup in September 2007 to:

- further develop the public and environmental health work of the Institute;
- to bring together the various health impact assessment research, consulting and teaching that was taking place between Edinburgh and London; and
- to be an internationally recognised Centre of Excellence in Health Impact Assessment.

CONSULTING : RESEARCH : SUPPORT: TRAINING

policies : plans : programmes : projects

Health Impact Assessment
Health in All Policies
Healthy Urban Planning
Health Impact Evaluation
Health Equity

FINAL

TITLE: Trafford LED Street Lighting Programme HIA			
COMMISSIONED BY: Trafford Council			
STRATEGIC CONSULTING PROJECT NO: 644-00233			
	Name	**Signature**	**Date**
Prepared by	Salim Vohra Director IOM Centre for Health Impact Assessment		10-06-2013
Reviewed by	Sue Wright Associate HIA Specialist IOM Centre for Health Impact Assessment	Sue Wright	10-06-2013
Approved by	Salim Vohra Director Centre for Health Impact Assessment		10-06-2013

DRAFTS

Revision Number	Details	Prepared by	Reviewed by	Approved by	Date
02	Draft	SV	SW	SV	06-06-2013
01	Draft	SV	SV	SV	06-06-2013

- This report has been prepared by IOM Consulting Limited ("IOM" and "IOM CHIA") for the use of a client and any other stakeholders that the client considers appropriate.
- It has been produced in line with generally accepted best practice consultancy and HIA principles and the project's terms of reference.
- Information provided by third parties and referred to in the report has been assumed to be correct and has not been separately verified by IOM unless explicitly stated in the report.
- No third parties should make decisions based on this report without discussing it first with the Client and IOM.

Table of Contents

Executive Summary

Introduction

ES.1 This Health Impact Assessment has been commissioned by Trafford Council.

ES.2 The overall aim of this report is to provide a fair and balanced assessment of the potential and likely positive and negative health and wellbeing impacts of implementing LED street lighting given the emerging nature of the research in this area.

ES.3 HIA is a key systematic approach to predicting the magnitude and significance of the possible health and wellbeing impacts, both positive and negative, of new plans and projects.

ES.4 The aim of HIA is to support and add value to the decision-making process by providing a systematic analysis of the potential impacts as well as recommending options, where appropriate, for enhancing the positive impacts, mitigating the negative ones and reducing health inequalities/inequities.

Scientific evidence on the health effects of LED street lighting

ES.5 The evidence review undertaken for this HIA has found no evidence that that LED street lighting specifically has any additional health and wellbeing effects beyond that found for artificial lighting in general.

ES.6 The majority of reviews are cautious in making wide ranging recommendations (only one does so) and where they do they apply to the whole range of artificial lighting that people are exposed to and all call for more research in this area. This is because the current evidence is weak and mostly associated with animal, in vitro and ecological/cross-sectional studies (where accurate levels of exposure and cause and effect relationships are difficult to identify).

ES.7 The research reviews identified in this evidence review all agree that artificial lighting can have some negative health and wellbeing impacts depending on the intensity, duration, pattern and characteristics of the light exposure alongside levels and types of exposure in the hours beforehand. This includes indoor lighting, light emitting devices such as computers as well as outdoor lighting.

ES.8 The main difference between LED lighting and other forms of artificial lighting is that it can produce light that is more in the blue part of the light spectrum, i.e. producing a more whiter bluer light than incandescent, fluorescent or outdoor sodium or metal halide lighting which can be much yellower and can be more intense (given the size and shape of LEDs and the way the lighting system is constructed with reflectors and lenses to focus the light). Exposure to light in the blue part of the spectrum particularly single blue colour (monochromatic blue) light can have a greater effect on the circadian rhythm.

Findings of this HIA

ES.9 The proposed LED street lighting programme has overall no (neutral) or a minor positive health and wellbeing impact for the residents, workers and visitors of Trafford compared to the existing type of street lights being used.

ES.10 Though there is some research that shows a relationship between exposure to artificial lighting and physical and mental health and wellbeing effects, the research evidence is weak, and these are not likely to occur because of the LED Street Lighting Programme because of the type and intensity of the light likely to be emitted and the low duration and intermittent pattern of exposure to almost all Trafford residents, workers and visitors.

Measures to minimise the potential negative and maximise the potential positive health and wellbeing impacts

<u>Procurement of the LED lighting systems and its management</u>

ES.11 Ensure where, within the limits of commercial viability, some future-proofing is written into the procurement contract, such that during the life of the LED lighting systems and its management there is scope for both operational and failed LED lights to be replaced with ones that better meet the changing requirements of local residents needs and the local authority so that environmental and health and safety benefits, within existing/future financial and economic constraints, are maximised over the life of the programme.

ES.12 Ensure that there are contingency technologies or other appropriate measures written into the procurement contract to deal with glare from the new lighting system coming into local residents' homes.

ES.13 Check with other councils, particularly those in the Greater Manchester area, to ensure that the best LED lighting system is procured from a combined environmental, health and economic standpoint.

Design aspects of the LED lighting and technology

ES.14 The following set of measures are based on a single USA study so it may not be directly applicable to the UK context but do address many of the issues raised in the evidence review about mitigating the negative impacts of artificial lighting and LED lighting. Where possible:

- Light colour (Correlated Colour Temperature) should be white, preferably 3,500 Kelvin, but with an adjustable range from 2,800 to 5,000 Kelvin.
- The Colour Rendering Index should be greater than 80.
- The fixtures should be down-firing.
- The LED light source should not be visible to drivers, bicyclists or pedestrians unless they are directly under the fixture.
- The preferred lighting pattern on the ground should be overlapping ovals.
- Basic controls to allow dimming from 6 footcandles (65 lux) to 1.5 footcandles (16 lux) and adjusting colour temperature between 2,800 and 3,500 Kelvin.

ES.15 Aim to make the LED lighting system poles in keeping with the wider architectural environment and streetscape in residential areas.

ES.16 Aim to use existing street light locations on streets and heights of lighting fixtures/ And avoid changing the spacing between street lights or moving the location nearer to the boundary of householders properties.

Construction phase

ES.17 Ensure that any construction or setting up of the LED lighting is communicated beforehand and undertaken in a manner that reduces any potential disruption to local residents both in terms of access and, more importantly, night-time illumination.

ES.18 Develop a communication plan involving the use of local newspaper and radio, door-to-door leaflets, residents' associations, local community/ voluntary/ charity groups, etc. to ensure local residents' are aware of the construction/setting up and where they can complain and get issues remedied.

ES.19 Develop a construction/setting up management plan ensuring that sub-contractors are appropriately briefed about what they are doing and why this is being done as well as be briefed on how to ensure that they minimise any disruption to local residents and what to do and who to contact if there is likely to be unanticipated disruption e.g. that street lights could not be switched on, etc. so that the local authority can take remedial action and inform local people about why the street lights are not on or access is disrupted.

ES.20 Have a clear and communicated (within the council and to key local organisational stakeholders as well as local residents through a variety of media) complaints and grievance procedure with a telephone number, email address and postal address as well as a designated person within the council who will take responsibility and has the authority and power to deal with and resolve local residents' complaints and concerns in a timely manner. A designated council member of staff is important even if the lighting programme is the responsibility of a private sector third party.

<u>Operation phase</u>

ES.21 Ensure that there is a clear and communicated set of procedures and processes in place within the council to deal with glare into local residents' homes from the new lighting system.

ES.22 Ensure that glare, light spillage or any other lighting system issues that affect residents in their homes (including gardens) are resolved within 2 weeks.

ES.23 Where dimming is considered ensure that:

- Develop a set of criteria that determines which locations are not dimmed in consultation with local residents and key public and private stakeholders such as emergency services and local businesses.
- There is initial and on-going, regular two-way dialogue and discussion between residents, residents groups and the council.
- Monitor key crime, safety and road traffic incident statistics.
- Consider switching lights back to normal brightness if there are significant complaints from local residents and alternative options are not able to address residents' complaints.

Monitoring and evaluation of health impacts

ES.24 Develop a monitoring and evaluation programme to monitor and evaluate the health and wellbeing impacts of the LED street programme by using a mix of the following indicators:

- Residents' complaints/concerns about disruption to access or lack of street lighting

- Residents' complaints/concerns about glare or other health and wellbeing related concerns
- Pedestrian, cyclist and motor vehicle driver complaints/concerns about glare or other new lighting system issue
- Residents' representative sample telephone survey – 6 months and 1 year from date of operation
- Complaints/concerns/complaints expressed by other local stakeholders e.g. environmental groups, health groups, residents' associations, business groups, voluntary groups, charities, etc.
- Complaints/concerns expressed by other local stakeholders e.g. environmental groups, health groups, residents' associations, business groups, voluntary groups, charities, etc.
- New research findings on LED street lighting and health and wellbeing published in a scientifically and/or governmentally recognised peer-reviewed scientific journal and/or undertaken by a recognised and respected individual/team of scientists.

Conclusion

ES.25 Overall, the proposed LED Street Lighting Programme has overall no (neutral) or a minor positive health and wellbeing impact for the residents, workers and visitors of Trafford compared to the existing type of street lights being used.

ES.26 Though there is some research that shows a relationship between exposure to artificial lighting and physical and mental health and wellbeing effects, the research evidence is weak, and these are not likely to occur because of the LED Street Lighting Programme because of the type and intensity of the light likely to be emitted and the low duration and intermittent pattern of exposure to almost all Trafford residents, workers and visitors.

ES.27 The measures described in the Chapter 10 if appropriately considered and incorporated are likely to ensure that the majority of the negative health and wellbeing impacts of the LED Street Lighting Programme are mitigated and the positive health and wellbeing benefits enhanced.

1 Introduction

1.1.1 This Health Impact Assessment has been commissioned by Trafford Council.

1.1.2 The overall aim of this report is to provide a fair and balanced assessment of the potential and likely positive and negative health and wellbeing impacts of implementing LED street lighting given the emerging nature of the research in this area.

1.1.3 The objectives of the HIA were to:

i. Undertake a rapid review of the evidence on the health and wellbeing impacts of LED (Light Emitting Diode) street lighting.

ii. Assess the potential positive and negative health and wellbeing impacts of the implementation (construction and operation) of LED street lighting in Trafford as a whole.

iii. Identify any potential mitigation and enhancement measures to maximise the potential positive and minimise the potential negative health and wellbeing impacts.

2 What is Health Impact Assessment

2.1 Introduction

2.1.1 This chapter outlines what health impact assessment (HIA) is and the Institute's ethos and approach to HIA.

2.2 Health Impact Assessment

2.2.1 The international Gothenburg consensus definition of HIA is: "A combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population."[1]

2.2.2 The more recent International Association for Impact Assessment's definition of HIA, which updates the earlier Gothenburg Consensus definition, is that HIA is:

> "A combination of procedures, methods and tools that systematically judges the potential, sometimes unintended, effects of a policy, plan, programme or project on the health of a population, including the distribution of those effects within the population, and identifies appropriate actions to manage those effects."[2]

2.2.3 HIA is a key systematic approach to predicting the magnitude and significance of the possible health and wellbeing impacts, both positive and negative, of new plans and projects.

2.2.4 HIA uses a range of structured and evaluated sources of qualitative and quantitative evidence that includes public and other stakeholders' perceptions and experiences as well as public health, epidemiological, toxicological and medical knowledge.

2.2.5 HIA is particularly concerned with the distribution of effects within a population, as different groups are likely to be affected in different ways, and therefore looks at how health and social inequalities might be reduced or widened by a proposed plan or project.

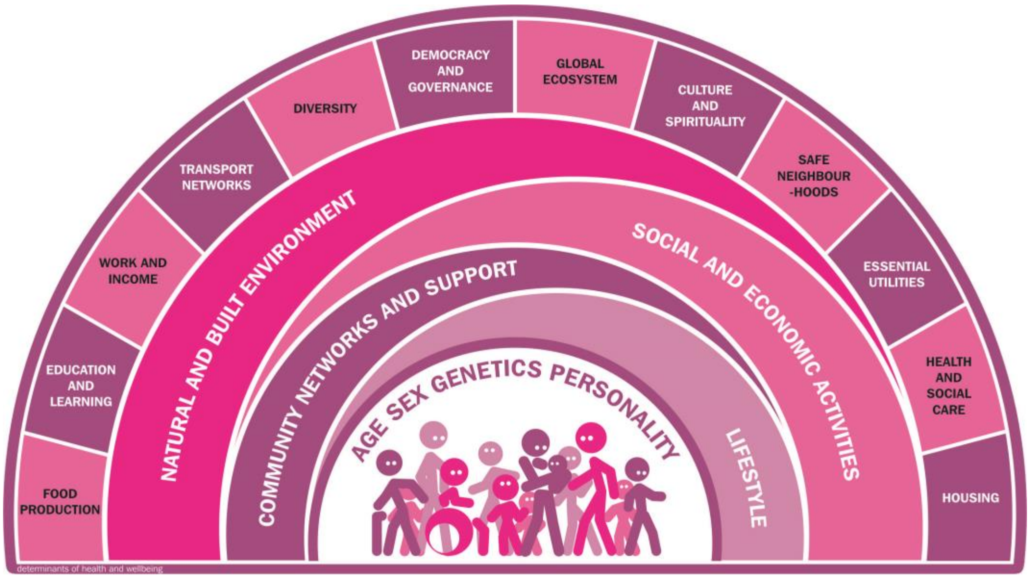
[1] WHO European Centre for Health Policy. (1999). Health impact assessment: main concepts and suggested approach. Gothenburg consensus paper. WHO Regional Office for Europe.

[2] International Association for Impact Assessment. Health Impact Assessment International Best Practice Principles. Special Publication Series No. 5. Fargo, USA. 2006.

2.2.6 The aim of HIA is to support and add value to the decision-making process by providing a systematic analysis of the potential impacts as well as recommending options, where appropriate, for enhancing the positive impacts, mitigating the negative ones and reducing health inequalities/inequities.

2.2.7 HIA uses both a biomedical and social definition of health, recognising that though illness and disease (mortality and morbidity) are useful ways of measuring health they need to be fitted within a broader understanding of health and wellbeing to be properly useful (See Figure 2.1).

Figure 2.1: The determinants of health and wellbeing[3]



2.2.8 HIA therefore use the following, or similar, World Health Organization psycho-social definition of health in our work: Health is "the extent to which an individual or group is able to realise aspirations and satisfy needs, and to change or cope with the environment. Health is therefore a resource for everyday life, not the objective of living; it is a positive concept, emphasizing social and personal resources, as well as physical capacities."[4]

[3] Adapted by Salim Vohra and Dean Biddlecombe. (2006). From Dahlgren G and Whitehead, Policies and strategies to promote social equity in health. Institute of Future Studies. Stockholm. 1991.

[4] World Health Organization. (1984). Health Promotion: A Discussion Document on the Concepts and Principles. WHO Regional Office for Europe. Copenhagen.

2.2.9 This definition builds on and is complementary to the longer established World Health Organization definition that "Health is a state of complete physical, social and mental wellbeing and not simply the absence of disease or infirmity"[5].

2.2.10 The general methodology used by IOM is based on established good practice guidance on HIA developed by the English Department of Health and the Devolved Countries in the UK and international agencies such as the International Finance Corporation and the International Association of Impact Assessment.[6 7 8 9. 10 11 12]

2.3 A holistic approach to health impacts

2.3.1 HIA takes a holistic or 'systems view' of potential health impacts and Figure 2.2 shows how this HIA conceptualises the general links between a new policy, plan, programme or project (proposals) and their potential health and wellbeing impacts.

2.3.2 A proposal makes changes to the physical, natural, social, economic and/or cultural environments which lead to changes in these environments in ways that modify these environments and the facilities, amenities and opportunities that they encompass and in turn impact on a given population or individual (termed the environmental and social determinants of health). These impacts can vary between individuals and population sub-groups depending on characteristics such as age, gender, ethnicity and disability. These impacts lead to changes in key health outcomes/effects: infectious diseases, non-infectious/chronic diseases, nutritional disorders, physical injury and mental health and wellbeing.

[5] World Health Organization. (1948). Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference. New York, 19-22 June 1946, and entered into force on 7 April 1948.

[6] Health Development Agency. (2002). Introducing health impact assessment (HIA): informing the decision-making process, England.

[7] NHS Executive. (2000). Resources for HIA: Volumes 1 & 2. England.

[8] Welsh Assembly Government and Health Challenge Wales. (2004). Improving Health and Reducing Inequalities: a practical guide to health impact assessment.

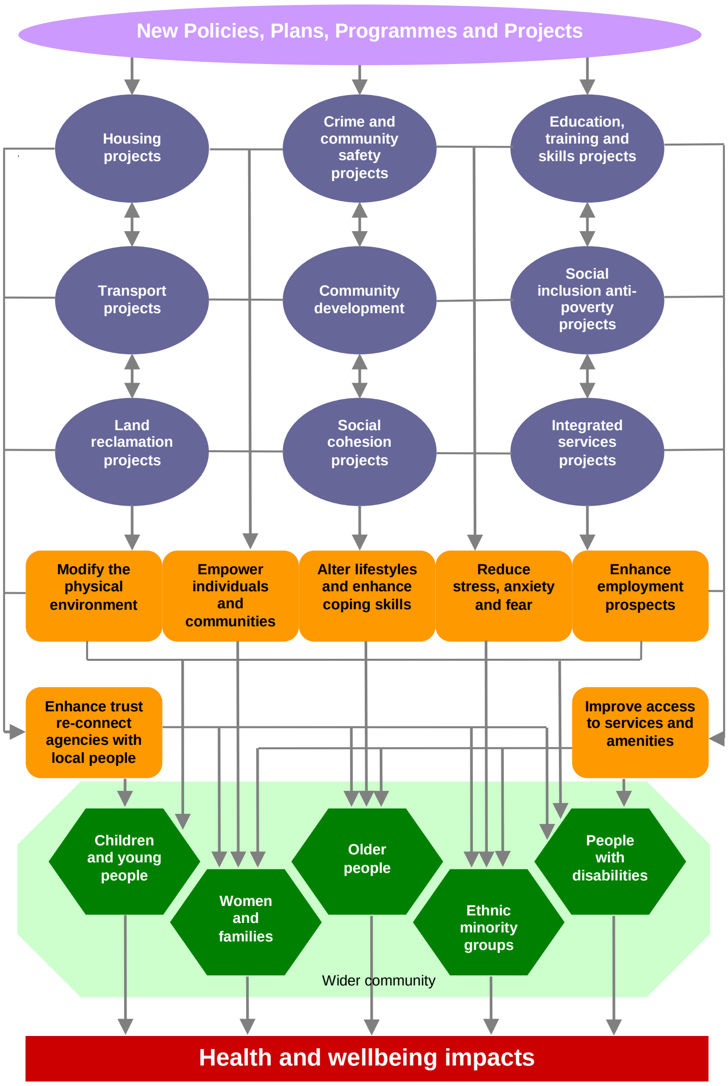
[9] Public Health Institute of Scotland. (2001). HIA: a guide for local authorities; Scottish HIA network; 2001.

[10] International Association for Impact Assessment. Health Impact Assessment International Best Practice Principles. Special Publication Series No. 5. Fargo, USA. 2006.

[11] International Finance Corporation. (2010). Introduction to Health Impact Assessment.

[12] Institute of Public Health in Ireland. (2009). HIA Guidance.

Fig 2.2: A systems view of new policies, plans, programmes and projects and their potential health and wellbeing impacts[13]



2.4 General steps in HIA

Screening

2.4.1 This stage assesses the value of carrying out a HIA by examining the importance of a plan or project and the significance of any already identified potential health impacts.

Scoping

[13] Adapted by Salim Vohra. (2005). From Hirschfield et al; Health impact assessment: measuring the effect of public policy on variation in health. University of Liverpool. 2001.

2.4.2 This stage sets the 'terms of reference' for the HIA i.e. the aspects to be considered, geographical scope, population groups that might need particular focus, what will be excluded from the HIA, how the HIA process will be managed and so on.

Baseline assessment and community profile

2.4.3 This stage uses routine national and local datasets e.g. national census, local surveys, area profiles, and other demographic, social, economic, environmental and health information to develop a community profile with a strong focus on health and wellbeing issues, and identification of vulnerable groups, as a baseline from which to assess the potential positive and negative impacts and any health inequalities.

Stakeholder consultation and involvement[14]

2.4.4 This stage applies to intermediate and comprehensive HIAs where no previous consultation on a development has taken place. It uses workshops, questionnaires, interviews, surveys and other methods of consultation and involvement to engage key stakeholders, in particular local people, in the identification and appraisal of the potential health and wellbeing impacts, in the development of mitigation and enhancement measures; and in developing options for monitoring and evaluating the identified impacts.

Evidence and analysis

2.4.5 This stage involves the collation of key evidence and the systematic analysis of the potential impacts, their significance, the groups likely to be most affected and the strength of the evidence for these impacts through the use of tables, matrices and models.

Mitigation and enhancement measures

2.4.6 This stage involves the identification of a range of measures to minimise the potential negative health effects and maximise the positive health benefits identified in the previous stages.

Health impact statement

2.4.7 This stage produces the final HIA report or health statement.

[14] **Rapid HIAs** are rapid desktop analyses that take days or weeks to carry out and sometimes include or are based on a professional stakeholder workshop. **Intermediate In-depth HIAs** are detailed desktop analyses with some focussed professional and public stakeholder consultation or feedback, e.g. stakeholder workshops and interviews that take weeks and months to carry out. **Comprehensive In-depth HIAs** are detailed desktop and survey fieldwork based analyses involving representative consultation of stakeholders through surveys, workshops and interviews that take a year or more to carry out.

2.4.8 It involves summarising the key conclusions, options and recommendations emerging from the assessment including identifying, where appropriate, monitoring indicators to ensure that health and wellbeing are maintained during the whole lifecycle of a project or plan.

Follow up

2.4.9 This stage involves the active follow up of the project or plan to monitor and/or ensure that mitigation and enhancement measures have been put in place after a project or plan is approved.

2.4.10 It can also involve: a) the development of a detailed Health Management Plan or Health Action Plan; b) presentation of the findings to key professional stakeholders; c) the development and implementation of a health impact or risk communication plan to ensure that local communities fully understand the findings of the HIA and how and why it was carried out; and d) the evaluation of the effectiveness and value of the HIA process itself.

3 Methodology and Scope of this HIA

3.1 Introduction

3.1.1 The following sections describe the methodology applied to this HIA. They describe the scope and process of the HIA i.e. the study area and study population; sources of information consulted; consultation and consultee feedback; assessment criteria and assessment framework.

3.1.2 There were discussions with the Trafford Director of Public Health in terms of informing the scope of the HIA, the issues raised by local people in relation to the LED Street Lighting Programme, the local community health context and the local policy context

3.1.3 This HIA was a rapid HIA with no HIA-specific community consultation.[15] This was because firstly, this issue was originally raised by some scientific research studies and reviews so the focus of the HIA was to review the current state of the evidence on the health effects of LED street lighting and its implications for the population of Trafford. Secondly, the LED Street Lighting Programme is changing existing street lighting with another technology and the health and wellbeing issues only relate to the specific lighting technology and the type of light that this technology generates i.e. the construction, operation and maintenance processes and activities are similar to what would be involved for existing and past street lighting.

3.1.4 The analysis was qualitative because there are currently no established methods to conduct a quantitative analysis of the potential positive or negative health and wellbeing impacts of LED street lighting.

3.1.5 The HIA was undertaken between May and June 2013.

3.1.6 The following tasks were undertaken within this HIA:

- Brief policy review on the LED Street Lighting Programme.
- Brief community health profile of Trafford.

[15] **Rapid HIAs** are rapid desktop analyses that take days or weeks to carry out and sometimes include or are based on a professional stakeholder workshop. **Intermediate HIAs** are detailed desktop analyses with some focussed professional and public stakeholder consultation or feedback, e.g. stakeholder workshops and interviews that take weeks and months to carry out. **Comprehensive HIAs** are detailed desktop and survey fieldwork based analyses involving representative consultation of stakeholders through surveys, workshops and interviews that take a year or more to carry out.

- Rapid evidence review of the current research and reviews on LED street lighting and health and wellbeing and, where appropriate, LED lighting and artificial lighting in general.
- Analysis of the potential positive and negative health and wellbeing impacts identified in the evidence review.
- Development of feasible and credible mitigation and enhancement measures to minimise the potential negative and maximise the potential positive health and wellbeing impacts.

3.2 Screening

3.2.1 A screening was undertaken by Trafford Council that judged that a rapid HIA was worth undertaking in response to community concerns about the LED Street Lighting Programme.

3.3 Scoping

HIA Steering/Advisory Group

3.3.1 Given the nature of the HIA a formal steering/advisory group was not considered worthwhile. The HIA team liaised with the Director of Public Health for Trafford, Abdul Razzaq.

Study area

3.3.2 The geographic scope of this HIA was Trafford.

Study population

3.3.3 The population scope of this HIA was Trafford residents as they would be affected by the LED Street Lighting Programme the most. People working in Trafford but living outside of Trafford and those people visiting Trafford were excluded because they would have less exposure to the LED Street Lighting Programme compared to residents as they would generally be in Trafford mostly during the day and for short periods of time.

3.3.4 The main sensitive population sub-groups that this HIA considered were: children and young people; older people; people with disabilities; women; people from minority ethnic backgrounds and people on low incomes/or are unemployed.

3.3.5 Workers working on implementing and maintaining the LED street lights have not been included in this analysis as they are covered by existing health and safety legislation and guidance.

Health outcomes and determinants of health considered

3.3.6 The key health and wellbeing outcomes considered were:

- infectious diseases
- non-infectious/chronic diseases (including the effects from air, water, soil and noise pollution)
- nutritional disorders
- physical injury (including poisoning)
- mental health and wellbeing (including nuisance and annoyance effects)

3.3.7 The key environmental and social determinants of health and wellbeing that were considered were:

- employment and economy
- housing and shelter
- transport and connectivity
- learning and education
- crime and safety
- health, social care and other essential public services
- shops and retail amenities (i.e. commercial goods and services)
- social capital and community cohesion (including severance)
- spirituality, faith and traditions
- arts and cultural activities
- leisure and recreation
- lifestyle and daily routines
- governance and public policy
- energy and waste
- land and spatial

Exclusions

3.3.8 The health and wellbeing impacts of the costs of implementing the LED Street Lighting Programme and the potential cost-savings of the programme in the future were not considered.

- For the costs of the scheme, this was because it is likely that a) the costs associated with this programme would be spent on changing the technology of street lighting used at some future point in time and b) it is unclear how the costs saved from not implementing this scheme would be used and how this alternative spending would impact on the health and wellbeing of the residents of Trafford and c) there is debate about the likely costs of implementation.

- For the potential future savings, this was because again it is unclear how the future savings would be used and how this would impact on the future health and wellbeing of the residents of Trafford and c) there is debate about the likely future financial savings.

3.4 Baseline assessment and community health profile

3.4.1 The rapid baseline assessment and community profile was developed from the Association of Public Health Observatories (www.apho.org.uk, soon to become Public Health England) and Info Trafford (www.infotrafford.org.uk). This provides a baseline from which the potential health and wellbeing impacts can be judged through an understanding of the existing health status of local people and the identification of any potentially vulnerable population groups.

3.5 Consultation and involvement

3.5.1 There was discussion with and feedback from the Trafford Director of Public Health on the local context, sources of key information and the current community concerns. No HIA-specific community consultation was undertaken. See Paragraphs 3.1.2 and 3.1.3 which explain the rationale for this.

3.6 Evidence review

3.6.1 This HIA identified the following key sets of documents:

3.6.2 Key secondary scientific research reviews and more recent primary research articles on the actual and potential health effects of:

- LED street lighting
- LED lighting
- Artificial light

3.6.3 Research studies and surveys of LED street lighting pilots and programmes.

3.6.4 Past HIAs on street lighting and LED street lighting.

3.6.5 There are many online and print media news articles but these were only used to identify the key words to be used to identify scientific material and to understand the key concerns and benefits identified for LED lighting and LED street lighting.

3.6.6 See Appendix A for more details on the bibliographic databases searched and key words used.

3.7 Analysis of health and wellbeing impacts

3.7.1 The analysis of health impacts was qualitative and used professional judgement and the findings of the evidence review. A health matrix table with social determinants as columns and different population groups as rows was used to analyse the potential positive and negative health and wellbeing impacts. The identified impacts were then classified using the significance levels described in Appendix B.

3.7.2 The potential impacts were not compared to a 'Do Nothing' option as there seems to be wide consensus that the current lighting if used indefinitely into the future would have no health and wellbeing impacts for Trafford residents beyond that generated by artificial and natural lighting in general.

3.7.3 The potential impacts of the construction/implementation phase were not assessed though some mitigation measures have been proposed as the impacts during the construction phase are similar as those in the past, for other lighting options and are readily identifiable and temporary.

3.7.4 For each potential health impact ten key issues were considered

- Which population groups are affected and in what way?
- Is the impact (and associated health outcomes/effects) beneficial, neutral or adverse?
- Is it permanent or temporary?
- Is it reversible or irreversible?
- Does it increase or decrease with time?
- Does the it occur over the short, medium or long term?
- Does it occur at a local, regional, national or global level?
- Are the impacts direct, indirect and or cumulative?
- Are public health or environmental health standards breached?
- Are mitigating measures available and is it reasonable to require these?

3.8 Mitigation and Enhancement Measures

3.8.1 A set of mitigation and enhancement measures were identified and developed for Trafford Council to consider should the LED Street Lighting Programme go ahead.

3.9 Follow up

3.9.1 A set of possible indicators that could be used to monitor and evaluate health and wellbeing were identified.

3.10 Limitations of this HIA

3.10.1 The main limitations were:

- This was a rapid non-systematic review of the key current scientific literature in an emerging field. There was therefore little specific literature on LED street lighting and human health. The majority of the literature has focused on artificial lighting in general and various types of lighting including LED, fluorescent and incandescent lighting.
- The opportunity costs and opportunity savings of the programme could not be accurately judged.

4 Trafford LED Street Lighting Programme Background

4.1 Introduction

4.1.1 This chapter provides background details of Trafford's LED Street Lighting Programme.[16]

4.2 Background context to the programme

4.2.1 The proposed street lighting improvement and investment programme, of the implementation of LED street lighting which is a part of this programme, will deliver a number of long term financial savings and service improvements. The current street lighting stock is of mixed age and specification. Significant energy and carbon consumption expenditure are predicted to rise at above inflation rates in coming years.

4.2.2 At present, the stock consists of 26,475 columns, the majority of which are steel with a few thousand made of concrete and iron. The lighting units are predominantly SON or SOX – a lighting source which is now considered out of date, due to the energy and cost required to maintain the lamps. These have lower performance than current LED technology.

4.2.3 Current annual expenditure is approximately £2.4m per annum and is expected to increase over future years;

- £838k Maintenance Spend (£745k Variable, £93k Fixed for electrical inspections)
- £1,200k Energy costs;
- £108k Carbon Reduction Commitment (CRC) tax, although it is expected that the Council will fall below the qualification criteria in 2014;
- £300k Capital programme allocation of which £100k is lantern renewal cost and £200k column replacement.

4.2.4 Trafford has a commitment to achieving a 48% reduction of energy and carbon by 2020. The street lighting service constitutes 75% of the Council's electricity bill and contributes approximately 60% of Trafford's CO_2 emissions, excluding schools.

[16] Trafford Council. (2013). Investment in Street Lighting. Report to Executive 29 April 2013 and Council 30 April 2013. Report of Executive Member for Highways & Environment and the Corporate Director of Environment, Transport & Operations.

4.2.5 Currently the Council spends £300k each year from the capital programme for the replacement of lighting columns and lanterns. If the LEDs are installed there will be no need to replace the lanterns in the near future and all the funding can be used for column replacement. The current investment allows for approximately 300 columns to be replaced each year, meaning it would take 89 years to replace the entire network including lantern replacement or 76 years excluding lantern replacement. The design lifetime of a column is 25 years, although in reality an actual lifespan of 40 years in not uncommon. However to adhere to this 25 year lifespan would require additional investment of approx. £600K each year. If a 40 year life could be obtained the additional annual investment would be £260k.

4.3 Aim of the programme

4.3.1 The proposal is to convert existing SOX etc. lamps to LED over a two year period and also transfer maintenance of all street lamps to a private sector operator.

4.3.2 The investment will include a central management system which will allow individual lights to be controlled, including the ability to brighten or dim.

4.3.3 A two phased approach has been evaluated and concluded to derive the most benefit to deliver sustainable financial savings.

4.3.4 The first phase will be to replace the existing luminaires with LED technology over a two year period. A Central Management System (CMS) can be installed at the same time as the luminaire replacement. The second phase of the project will be to maintain the network for a further 18 years at significantly reduced cost than currently forecast. This can include a replacement programme for columns which reach the end of their life, either through damage or deterioration (see later).

4.3.5 The benefits derived from this proposal include:

- Maintaining existing service standards and levels of illumination whilst delivering long term budget savings;
- Upgrading inefficient low quality light sources;
- 61% - 70% reduction in energy consumption (54% without a CMS);
- A reduction in customer complaints due to lanterns not working (outages);
- Reduced maintenance regime due to remote monitoring of CMS (removing the need for night time inspections) and improved reliability and performance of LED luminaires;
- Significant contribution to reducing the Council's carbon reduction targets;
- A 20 year guarantee on LED technology;

- Environmental benefits through reduction in obtrusive light and reduction in upward light;
- Enabling individual lights to be controlled centrally to respond to service needs and future budget pressures (e.g. the ability to turn lights up/down, on/off without having from a remote location);
- Effective risk management to protect communities for safety issues associated with aged stock;
- The ability to retrofit LED technology to heritage areas, and taking into account any conservation area implications

4.3.6 Potential risks in implementing the programme

- Strength of company(s) providing warranty on LED lamps;
- Energy prices, but unlikely to fall;
- Acceptance by energy suppliers of the CMS as the basis for charging;
- How quickly energy suppliers reflect LED installations in their billing systems;
- Changes to Carbon Reduction Commitment;
- Ability to sell redundant lamps;
- Impact on staff working in this area if the work is transferred to a private sector provider. Should it be deemed that there is a relevant transfer of an entity, then the Council will ensure that due process is followed in order to protect employment under the provisions of TUPE. The Council may need to provide supplementary resources for the tender process and review existing structure.

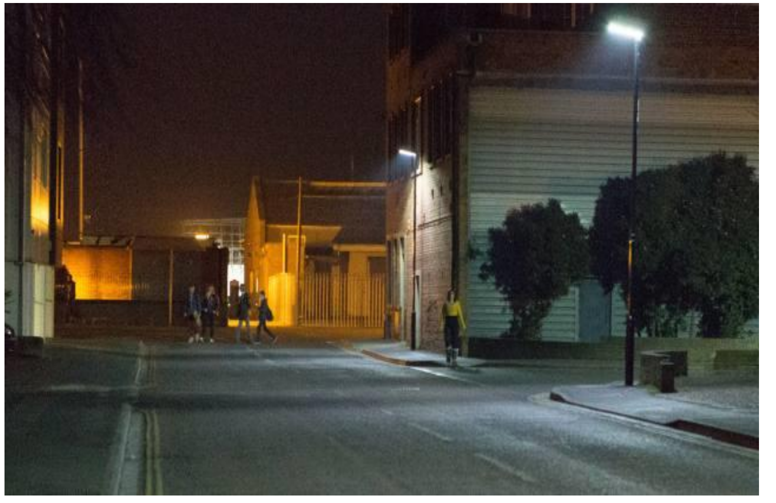
4.4 Examples of sodium and LED street lighting

4.4.1 Figure 4.1 shows an example of a before and after photos of street lighting in Cowes, Isle of Wight showing the difference in the type of illumination provided by existing sodium and the new LED street lamps.

Figure 4.1: Examples of LED street lamps and sodium lamps in Cowes, Isle of Wight[17]

This set of images was taken from the web and inevitably there can be distortions depending on how the photo was taken, these two images are illustrative and were the best images that were identified that give an independent 'real world' sense of the difference in the type of illumination provided by LED compared to sodium street lamps.

Sodium lamp illumination in Cowes (before)



LED lamp illumination in Cowes (after)

Example of a sodium lamp (not from Cowes) [18]

Example of the LED street lamps used in Cowes[19]

[17] Tuck, R. (2013). Cowes residents the first to get new LED streetlamps (updated). http://onthewight.com/2013/04/05/cowes-residents-the-first-to-get-new-led-streetlamps/

[18] http://www.simoncornwell.com/lighting/collect/lanterns/gec-z9484-1/index.htm

[19] http://www.iwradio.co.uk/articles/2013-05-27-lighting-scheme-praised-for-protecting-islands-environment

5 Policy Context

5.1 Introduction

5.1.1 This chapter summarises the key policy context in relation to street lighting.

5.1.2 LED street lighting has been and is either being considered or being implemented in other parts of the UK and internationally, most notably in the USA. [20] [21] [22] [23] [24] [25] [26] [27] Most have been implemented for the same or similar reasons to those proposed by Trafford Council.

5.2 National policy

5.2.1 Climate Change Act (2008)

The Climate Change Act set ambitious and legally binding targets; taking powers to help meet those targets; strengthening the institutional framework; enhancing the UK's ability to adapt to the impact of climate change and establishing clear and regular accountability to the UK Parliament and to the devolved legislatures.

Two key aims of the Act are to improve carbon (i.e. energy) management, helping the transition towards a low-carbon economy in the UK, and to demonstrate UK leadership internationally, signalling commitment to reducing global emissions.

Key provisions of the Act are a legally binding target of at least an 80% cut in greenhouse gas emissions by 2050, to be achieved through action in the UK and abroad, and an interim target for reduction of emissions of at least 34% by 2020. Both these targets are against a 1990 baseline. Additionally, powers for the Government to require local councils to report their annual greenhouse gas emissions, as well as powers to introduce new emissions trading schemes such as the Carbon Reduction Commitment (CRC) Energy Efficiency Scheme (2013),

[20] http://onthewight.com/2013/04/05/cowes-residents-the-first-to-get-new-led-streetlamps/

[21] https://www.sheffield.gov.uk/roads/works/lighting.html

[22] http://www.bromley.gov.uk/info/200089/street_care_and_cleaning/213/street_lighting/2

[23] http://www.salford.gov.uk/d/Urban_Vision_Stree_Lighting.pdf

[24] http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/consortium-participant-list.pdf

[25] http://bsl.lacity.org/led.html

[26] http://www.cleveland.com/cityhall/index.ssf/2013/04/cleveland_public_power_to_test.html

[27] http://www.cityofboston.gov/publicworks/lighting/led.asp

which became mandatory for large organisations such as councils. Failure to meet targets could result in local councils being fined.

5.2.2 Street Lighting Policy Framework (1st Edition, 2012)

There is no specific guidance on LED lighting in this framework. It provides a simple framework on which to base a lighting policy and acts as a prompt for authorities revising or setting down a Policy document for the first time. The following though are relevant issues discussed in the document.

There are several benefits of providing an effective street lighting service which could be linked to support the authorities corporate objectives relating to road safety, community safety, social inclusion and quality of life including:

- To reduce night time traffic accidents
- Reduce street crime
- Reduce the fear of crime
- Promote sustainable transport (public transport, cycling and walking)
- Facilitate social inclusion by providing freedom to use streets after dark
- Support the 24 hour leisure economy, promoting economic development
- Provide safe access to educational facilities supporting lifelong learning
- Assist emergency services to identify locations and shorten response times
- An effective street lighting service can contribute significantly to the following:
    - Improving local conditions for economic development
    - Improving community safety
    - Targeting support to vulnerable communities

5.2.3 Well-lit Highways – Code of Practice (Revised 24 May 2013, Original 2004)

There is no specific guidance on LED lighting in this code of practice developed by the UK Roads Liaison Group. The following recommendations though are relevant issues discussed in the document:

Summary Recommendations (pg. 10)

1. The authority's policy in relation to the provision of its public lighting service should be clearly stated and should cover all the organisation and services involved in delivering the service.

8. Lamp replacement policies should be carefully evaluated taking account of local technical and geographic considerations, to maintain light output whilst limiting the number of lamp failures to an acceptable level.

21. To meet set national targets to reduce carbon emissions introduced by the CRC Energy Efficiency Scheme (3.1), Authorities should consider a number of options. These options include switching off lighting as well as investigating other ways of energy reduction that may be achieved through the use of remote monitoring and dimming using a Central Management System (CMS). The latter option may not necessarily require the complete replacement of existing equipment as the modification of current equipment may be possible.

25. European Directive 2005/32/EC for Energy using Products has been transported into UK law under Statutory Instrument (SI 2007 No:2037). This together with the Eco-Design Directive (2009/125/EC) has established a frame work for the setting of eco-design requirements for Energy related Products (ErP). These Directives and laws set out performance targets for various lamp types used to illuminate the highway. Some lamp types and types of control gear will be phased out altogether. It is essential that local authorities consider and review the lamp and gear types currently used within their public lighting operations to ensure the continuity of the service.

27. Authorities should seek to minimise the impact of obtrusive light. Areas which may be impacted include: dark rural landscapes, neighbouring properties, and; consideration should also be given to legal and planning requirements relating to sites designated for their nature conservation interests, legally protected or controlled species

28. When introducing or replacing road lighting schemes consideration should be given to eliminating or minimising the amount of obtrusive light. Obtrusive light for purpose of this Complementary Guidance is defined as: ‘artificial light that, due to quantitative, directional or spectral attributes, significantly increases outdoor light levels or shines (spills) where it is not needed, impairing activities, causing annoyance to people, compromising an existing dark landscape, and/or impacting natural systems (e.g. plants, animals, insects).

Actions aimed at eliminating or minimising obtrusive light could therefore include:

- avoiding over-lighting;
- using luminaires that restrict light emitted above the horizontal;
- considering whether there is actually a need for road lighting, especially blue/ultraviolet-rich lighting, near or on Sites of Special Scientific Interest (SSSIs) or other sensitive locations (both terrestrial and aquatic); or areas specifically committed to protecting the quality of the night sky, for example, National Parks and Areas of Outstanding Natural Beauty (AONB);
- considering switching road lights off during the hours of darkness;
- dimming of road lighting schemes during periods of lower traffic usage; and / or turning road lights on later in the evening and switching them off earlier in the morning, (trimming), by the use of, more commonly, PECUs with alternative settings to the conventional ones used for low pressure sodium (SOX) lamps. Whilst addressing the negative impacts of obtrusive light, having well directed light at the appropriate level can help to reduce carbon emissions and energy consumption but also costs of operating a road lighting service.

5.2.4 A Guide to the Specification of LED Lighting Products (2012)

This is guidance from the Lighting Liaison Group. It introduce a universal set of quality criteria from the IEC/PAS (International Electrotechnical Commission Publicly Available Specifications) documents. They state that it is important that users of LED luminaires apply the same set of standardised quality criteria when evaluating manufacturer’s claims.

While there is no specific discussion of health effects on residents and communities the following in relation to workers is relevant [Bullet numbering refers to the original numbering in the guide]:

p) Optical Risk -The Control of Artificial Optical Radiation at Work Regulations 2010 apply to light emitted from all artificial light sources including LEDs. These regulations require employers to protect the eyes and skin of workers from exposure to hazardous sources of artificial optical radiation. Exposure limits defined in the standard EN-62471 are in European regulation (directive 2006/25/CE) These are based on a combination of source power and exposure time.

- Risk Group 0 Exempt
- Risk Group 1 Low

- Risk Group 2 Moderate
- Risk Group 3 High

When light sources are placed in a luminaire, the Risk Group classification can change due to the optics used in the luminaire

5.2.5 The Control of Artificial Optical Radiation at Work Regulations (2010)

This regulation provides guidance on assessing the risks of adverse effects to the eyes or skin created by exposure to artificial optical radiation [lighting] at the workplace. Though this guidance applies to workers who work with industrial lighting e.g. lasers the following though are relevant issues discussed in the document. [Bullet numbering refers to the original numbering in the regulation.]

3. (5) The assessment must also include consideration of-

- the level, wavelength and duration of exposure;
- the exposure limit values;
- the effects of exposure on employees or groups of employees whose health is at particular risk from exposure;
- any possible effects on the health and safety of employees resulting from interactions between artificial optical radiation and photosensitising chemical substances;
- any indirect effects of exposure on the health and safety of employees such as temporary blinding, explosion or fire;
- the availability of alternative equipment designed to reduce levels of exposure;
- appropriate information obtained from health surveillance, including where possible published information;
- multiple sources of exposure;
- any class 3B or 4 laser that is classified in accordance with the relevant IEC (International Electrotechnical Commission) standard that is in use by the employer and any artificial optical radiation source that is capable of presenting the same level of hazard; and

- information provided by the manufacturers of artificial optical radiation sources and associated work equipment in accordance with the relevant European Union Directives.

4. (1) An employer must ensure that any risk of adverse health effects to the eyes or skin of employees as a result of exposure to artificial optical radiation which is identified in the risk assessment is eliminated or, where this is not reasonably practicable, reduced to as low a level as is reasonably practicable.

5.2.6 Design Manual for Roads and Bridges: Volume 8, Traffic Signs and Lighting, Section 3 Lighting, TA 49/07 Appraisal of new and replacement lighting on the strategic motorway and all-purpose trunk road network (2007)

This guidance applies to strategic routers rather than residential and smaller roads it and many of the appraisal issues are not relevant for this HIA. The guidance recommends considering/assessing the following areas as relevant (for strategic road lighting): noise, air quality, landscape, townscape, heritage, biodiversity, physical fitness, journey ambience, accidents, security, severance and government policy.

5.3 Local policy

5.3.1 Climate Change Strategy for Greater Manchester 2011-2020 (2011)

This strategy has now been adopted by the Association of Greater Manchester Authorities (AGMA). The Strategy has the following objectives:

- A rapid transition to a low carbon economy.
- An overall reduction in carbon emissions by 48% by 2020 on a 1990 baseline.
- Greater Manchester (GM) will be better prepared for and actively adapting to a rapidly changing climate.
- GM will have embedded ‘carbon literacy’ into the culture of organisations, lifestyle and behaviour.

5.3.2 Low Carbon Economic Area for the Built Environment" (LCEA) (2009)

In 2009, the Government at that time designated the Greater Manchester city region a "Low Carbon Economic Area for the Built Environment" (LCEA). The GM Environment Commission, working together with the GM Commission for the New

Economy, devised a Joint Delivery Plan (JDP) for the LCEA, financed by the AGMA authorities to the amount of £3.75 million over the five year period 2010-2015.

The original Plan was based on the vision that: “By 2015, Greater Manchester has established itself as a world leader in the transformation to a low carbon economy”.

Greater Manchester’s approach to the low carbon economy is one which seeks to integrate investment in capital programmes, which reduce carbon emissions with those that capture the economic opportunity. This approach is structured as six discrete but linked work programmes:

- Residential retrofit
- Non-residential retrofit
- Low carbon infrastructure
- Skills and employment
- Business growth
- Low carbon laboratory

Combined, these will enable Greater Manchester to become a national leader in:

- The Green Deal
- Low carbon infrastructure
- Low carbon skills
- Developing a strong and flourishing supply chain

Securing the necessary finance for investment in the Plan’s capital programmes will be critical to achieving both economic objectives and carbon reduction targets. The LCEA for the Built Environment will address and balance the need to reduce Greater Manchester’s carbon footprint with the economic opportunities created as they strive for a low carbon future.

5.4 Policy analysis

5.4.1 The LED Street Lighting Programme is in line with national and local policy on reducing energy use and playing a part in mitigating the global impact of climate change.

6 Baseline and Community Profile

6.1 Introduction

6.1.1 This chapter provides a rapid health and wellbeing focused baseline and community profile of Trafford. It is from this baseline understanding that the predictions on the potential health and wellbeing impacts of the LED street lighting programme have been considered.

6.1.2 The profile has been developed from the Trafford Joint Strategic Needs Assessment (JSNA) Report.

6.2 Demography

6.2.1 It is one of the smaller District Councils within the Greater Manchester conurbation in terms of population, with an estimated 217,000 residents, living in 96,000 dwellings.

6.2.2 The demographic split between age groups is similar to that of England; the population is amongst the healthiest in the North West though the North West is the least healthy region in the country.

6.2.3 Mid-2010 estimates put Trafford's population at 217,307, and the latest sub-national population projections for England show that Trafford's population is expected to grow by 14% to 247,600, over the next two decades to 2030.

6.2.4 The proportion of people under 18 in the population in Trafford, 22.4%, is slightly higher than that seen in the population nationally (20.8%) and the proportion of people over 65 is fractionally lower in Trafford, 16.2%, than seen nationally, 16.6%.By 2015 there will be 1,500 more people aged 0-17. There will be 1,300 more people aged 18-64 and 2,700 more people aged over 65 years. Currently, the borough has a slightly higher percentage of older people than the profile of Greater Manchester as a whole. Whilst the proportion of people in the under 18 age group in Trafford is predicted to remain stable at around 22.5%, the over 65 population will increase quite markedly so that by 2030, almost 20% - 1 in 5 people - will be in this age group in Trafford. This rate of increase, however, is significantly below the rate of increase for England as a whole: 21.6% of people will be aged over 65 by 2030, a 48% increase from current numbers. The greatest rate of increase will be seen in those people aged over 85. In Trafford there is predicted to be a 78% increase, from the current 5000, to 8,900 by 2030. The two main factors in this population growth are increased life expectancy and birth rate. The average life expectancy of a person born in Trafford today is almost 79 years for men and 83 years for women, both slightly above the national averages. This has been increasing over the last decade and more, and is expected to increase for the foreseeable future. This means more and more people will live into what is currently considered to be extreme old age (90+). Alongside this, in 2010 there were 2,876 births to mothers resident in Trafford. This number has been increasing over the last decade, from around 2,300 10 years ago. It is also around 1,000 more than the number of deaths in Trafford in 2010. There are 21 electoral wards in Trafford and highest birth rates (2006-10) were in Bucklow-St Martins, followed by Clifford and Hale Central. The lowest rates were in the wards of Bowdon, Davyhulme West and Timperley.

6.3 Ethnicity

6.3.1 Current estimates put Trafford's Black and Minority Ethnic (BME) population at slightly under 12%, around 26,000 people, an increase from the 10.8% estimated in 2006.

6.3.2 The largest of Trafford's minority groups is people who identify themselves as being of Pakistani origin, making up 2.4% of the total population. The vast majority of Trafford's population identify themselves as White British (82.6%). There are around 4,600 (2.1%) people who identify as 'White Irish' and around 7,000 (3.25%) people who identify as 'White Other'.

6.3.3 The overall figure hides significant, but expected, differences between age groups. For people aged 0-15, 16.5% of people identify as being of non-white origin. For people of working age, 13.1% of people identify as being of non-white origin. For older people, aged over 65, 4.2% of people identify as being of non-white origin.

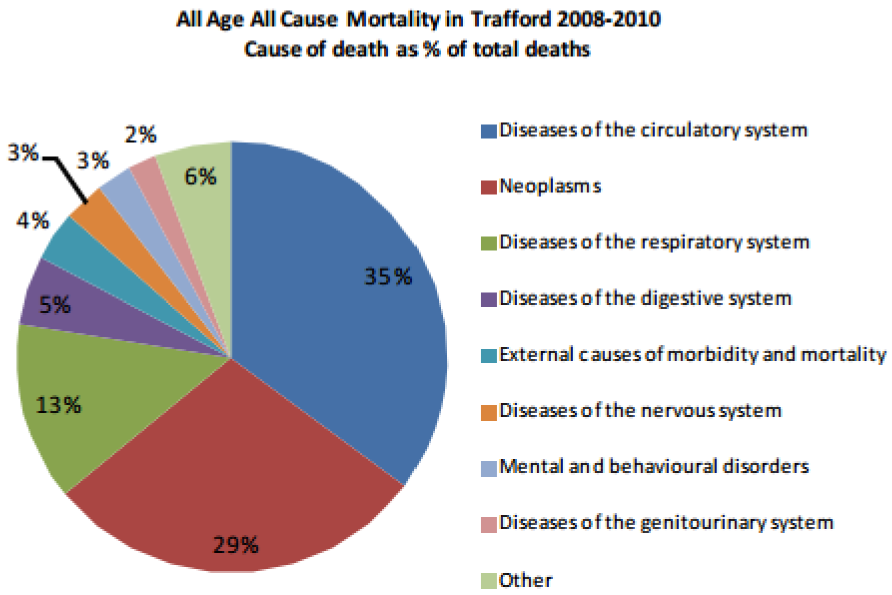
6.4 Heath status and key health risks and disease

6.4.1 The latest Health Profile for Trafford shows a number of indicators are significantly better than the England average and a range of indicators are not significantly different from the England average. One measure, however, is significantly worse than the England average: hospital stays due to alcohol related harm, although this is significantly better than the regional average. Related to this, the incidence of increasing and higher rate drinking, although not significantly different from the

England average, is shown as being worse than the regional average. See Figure 6.1.

6.4.2 Figure 6.2 shows the cause of death as a proportion of all deaths in Trafford.

Fig 6.2: Proportion of all age all cause deaths by cause of death in Trafford 2008-10 (Source: JSNA Cause of Death Report, data from Office for National Statistics)



6.4.3 The following paragraphs highlight the major health and wellbeing issues identified in the JSNA report and is not a comprehensive analysis of all the key disease conditions found in Trafford.

Lifestyle risk factors

6.4.4 Some of the key factors that influence health in working age adults this age group are the lifestyles which people adopt, such as smoking, obesity, lack of exercise, and too much alcohol all have a major influence on premature mortality and chronic disease including dementia.

Fig 6.1: Trafford Health profile 2012 (Source: Department of Health)

Health summary for Trafford

E08000009

The chart below shows how the health of people in this area compares with the rest of England. This area's result for each indicator is shown as a circle. The average rate for England is shown by the black line, which is always at the centre of the chart. The range of results for all local areas in England is shown as a grey bar. A red circle means that this area is significantly worse than England for that indicator; however, a green circle may still indicate an important public health problem.

- Significantly worse than England average
- Not significantly different from England average
- Significantly better than England average

England Worst — 25th Percentile — England Average — 75th Percentile — England Best

Domain	Indicator	Local No. Per Year	Local Value	Eng Avg	Eng Worst	England Range	Eng Best
Our communities	1 Deprivation	23016	10.8	19.8	83.0		0.0
	2 Proportion of children in poverty ‡	6860	15.9	21.9	50.9		6.4
	3 Statutory homelessness ‡	135	1.5	2.0	10.4		0.0
	4 GCSE achieved (5A*-C inc. Eng & Maths)	1975	69.8	58.4	40.1		79.9
	5 Violent crime	2233	10.4	14.8	35.1		4.5
	6 Long term unemployment	675	4.9	5.7	18.8		0.9
Children's and young people's health	7 Smoking in pregnancy ‡	244	9.1	13.7	32.7		3.1
	8 Breast feeding initiation ‡	2108	77.2	74.5	39.0		94.7
	9 Obese Children (Year 6) ‡	367	16.4	19.0	26.5		9.8
	10 Alcohol-specific hospital stays (under 18)	29	59.8	61.8	154.9		12.5
	11 Teenage pregnancy (under 18) ‡	125	31.0	38.1	64.9		11.1
Adults' health and lifestyle	12 Adults smoking ‡	n/a	20.1	20.7	33.5		8.9
	13 Increasing and higher risk drinking	n/a	22.6	22.3	25.1		15.7
	14 Healthy eating adults	n/a	30.1	28.7	19.3		47.8
	15 Physically active adults ‡	n/a	11.2	11.2	5.7		18.2
	16 Obese adults ‡	n/a	21.4	24.2	30.7		13.9
Disease and poor health	17 Incidence of malignant melanoma	33	15.5	13.6	26.8		2.7
	18 Hospital stays for self-harm ‡	336	165.3	212.0	509.8		49.6
	19 Hospital stays for alcohol related harm ‡	5312	2064	1895	3276		910
	20 Drug misuse	1062	7.5	8.9	30.2		1.3
	21 People diagnosed with diabetes ‡	10326	5.6	5.5	8.1		3.3
	22 New cases of tuberculosis	24	11.1	15.3	124.4		0.0
	23 Acute sexually transmitted infections	1593	733	775	2276		152
	24 Hip fracture in 65s and over ‡	191	371	452	655		324
Life expectancy and causes of death	25 Excess winter deaths ‡	121	21.0	18.7	35.0		4.4
	26 Life expectancy – male	n/a	78.8	78.6	73.6		85.1
	27 Life expectancy – female	n/a	83.1	82.6	79.1		89.8
	28 Infant deaths ‡	10	3.6	4.6	9.3		1.2
	29 Smoking related deaths	354	217	211	372		125
	30 Early deaths: heart disease and stroke ‡	163	70.3	67.3	123.2		35.5
	31 Early deaths: cancer ‡	257	112.3	110.1	159.1		77.9
	32 Road injuries and deaths ‡	52	24.2	44.3	128.8		14.1

‡ Substantially similar to indicator proposed in the Public Health Outcomes Framework published January 2012

Indicator Notes

1 % people in this area living in 20% most deprived areas in England, 2010 2 % children (under 16) in families receiving means-tested benefits & low income, 2009 3 Crude rate per 1,000 households, 2010/11 4 % at Key Stage 4, 2010/11 5 Recorded violence against the person crimes, crude rate per 1,000 population, 2010/11 6 Crude rate per 1,000 population aged16-64, 2011 7 % mothers smoking in pregnancy where status is known, 2010/11 8 % mothers initiating breast feeding where status is known, 2010/11 9 % school children in Year 6 (age 10-11), 2010/11 10 Persons under 18 admitted to hospital due to alcohol-specific conditions, crude rate per 100,000 population, 2007/08 to 2009/10 (pooled) 11 Under-18 conception rate per 1,000 females aged 15-17 (crude rate) 2008-2010 12 % adults aged 18 and over, 2010/11 13 % aged 16+ in the resident population, 2008/2009 14 % adults, modelled estimate using Health Survey for England 2006-2008 15 % aged 16 and over, Oct 2009-Oct 2011 16 % adults, modelled estimate using Health Survey for England 2006-2008 17 Directly age standardised rate per 100,000 population, aged under 75, 2006-2008 18 Directly age sex standardised rate per 100,000 population, 2010/11 19 Directly age sex standardised rate per 100,000 population, 2010/11 20 Estimated users of opiate and/or crack cocaine aged 15-64, crude rate per 1,000 population, 2009/10 21 % people on GP registers with a recorded diagnosis of diabetes 2010/11 22 Crude rate per 100,000 population, 2008-2010 23 Crude rate per 100,000 population, 2010 (chlamydia screening coverage may influence rate) 24 Directly age and sex standardised rate for emergency admissions, per 100,000 population aged 65 and over, 2010/11 25 Ratio of excess winter deaths (observed winter deaths minus expected deaths based on non-winter deaths) to average non-winter deaths 1.08.07-31.07.10 26 At birth, 2008-2010 27 At birth, 2008-2010 28 Rate per 1,000 live births, 2008-2010 29 Directly age standardised rate per 100,000 population aged 35 and over, 2008-2010 30 Directly age standardised rate per 100,000 population aged under 75, 2008-2010 31 Directly age standardised rate per 100,000 population aged under 75, 2008-2010 32 Rate per 100,000 population, 2008-2010

More information is available at www.healthprofiles.info Please send any enquiries to healthprofiles@sepho.nhs.uk

6.4.5 Smoking:

Smoking is the single biggest preventable cause of early death and illness. The estimated costs of smoking and obesity to the NHS and the general economy are massive. It is estimated that over 30% of circulatory disease and many cancers could be avoided by stopping smoking, improving diet and increasing physical activity. Just over 20% of adults in Trafford smoke. This is lower than the North West average but similar to the England average. There are about 345 deaths a year for Trafford as a consequence of smoking, which is 18% of deaths among adults aged 35 years and over.

6.4.6 Alcohol intake:

Regular drinking of alcohol in some parts of the population is leading to a rapid increase in liver disease which is now the fifth highest cause of death in England. The latest estimates of drinking in Trafford suggest that there are nearly 8,000 people drinking at a higher risk level, and nearly 40,000 drinking at an increasing risk level. There have been year on year increases in the rate of hospital admissions in which alcohol is an underlying factor. Death rates from liver disease for people under 75 years are highest in Clifford, Gorse Hill and Longford wards.

6.4.7 Diet:

Many adults in Trafford do not have a healthy diet and this impacts on levels of obesity and on development of diseases associated with a poor diet such as cancer, heart disease and stroke. The estimated number of obese adults in Trafford is 42,000. The estimated number of very obese adults is over 3,000 and if current trends continue this will rise to 4000 by 2015. Income, ethnicity and social deprivation affect the likelihood of becoming obese. Obesity increases the risk of cancer, heart disease, high blood pressure, diabetes, fatty liver and depression. Obesity is also a major risk factor for type 2 diabetes.

6.4.8 Obesity:

Two out of three adults are obese and only three in ten adults say they do the recommended levels of physical activity every week (although this was reported to be even lower, 1.6 in 10 adults, from the latest Health Inactivity Tool, 2013).. Obesity levels in children are falling and are significantly better than the England average for children aged 4-5 years (almost 8%) but there is variation in rates of obesity across the borough. By year 6 (10 – 11 years old), around 16% of Trafford children are classed as obese. Although this level has reduced and is similar to the England average, significantly higher levels of obesity in this age group have been identified in

Urmston, Hale Barns, Timperley, Broadheath and Village – all with at least 20% of children classed as obese at this age.

6.4.9 High blood pressure:

It is estimated that over 25,000 people in Trafford have high blood pressure as identified by GP data. It is more common in the Old Trafford population as it is more common among people of Afro-Caribbean and South Asian origin.

6.4.10 Illicit drug use:

More than 1 in 12 adults use illicit drugs and drug users are more likely to be involved in crime, to be unemployed and to lose contact with family. The data suggests that the use of drugs in Trafford is changing. Fewer people are using heroin or opiates than ten years ago; however there is a slight rise in the use of cannabis and cocaine, this especially amongst our younger community. The choice of drug has changed substantially as has the age group and this requires a different approach to its management. If young people do not engage with specialised interventions now, they too could become long term addicts and still require help when they are in their 40's and 50's.

6.4.11 Sexual and reproductive health:

Diagnoses of sexually transmitted infections (STIs) are increasing. Sexual health issues contribute significantly to health inequalities as they affect certain groups disproportionately: Young people, people from deprived areas, Black and Minority Ethnic, Lesbian, gay and transgender groups. The areas most affected in Trafford are Old Trafford, Partington, Stretford and Sale West National and Greater Manchester data sources such as surveys designed to capture sexual orientation and behaviour show5-7% of the population is classed as Lesbian, Gay and Bisexual (LGB).

6.4.12 Trafford has a low rate of teenage pregnancies compared to their neighbours. Whilst the number of teen pregnancies has oscillated over the last 14 years, the overall trend in conceptions has been generally downwards. However, overall sexual health remains a concern. Higher rates on teenage pregnancy are found in the areas of lower socio-economic advantage.

6.4.13 For young people, Chlamydia is the key sexual health issue. Due to the high number of asymptomatic cases, it is important for a universal screening approach to be taken for the high risk age group. Almost 9% of tests for Chlamydia in under 25 year olds in Trafford are positive, which is higher than the average for Greater Manchester.

6.4.14 Mental health:

Mental health expenditure in Trafford remains very low against national comparisons.

However Whilst evidence suggests that most areas of specialist Mental Health support need are now generally well catered for, there remains a gap in support for common mental health problems, as around:

- 16% of population have a common mental health problem
- 90% of mental health care is provided solely by primary care
- 33% of GP time taken-up by Mental Health problems
- 70% of GP consultations have a significant mental health component
- Continued high prescription rates for antidepressant and antipsychotic medication for a variety of conditions

6.4.15 The impact of more people living into very old age has huge implications for mental health services in Trafford. As people get older, the likelihood of developing dementia increases. By the age of 90, around 30% of people will be living with dementia.

6.4.16 The referral rate to Child and Adolescent Mental Health Services (CAMHS) continues to increase. The referrals for the last 4 months of 2011 show a 20% increase on referrals for the same period in 2010. This is across the ages for CAMHS but the highest proportion of referrals are for teenagers. The largest diagnosis group for psychiatry cases for under 18s is behavioural, emotional and social difficulties including ADHD (Attention Deficit Hyperactivity Disorder).

6.4.17 Respiratory conditions:

Mortality from Chronic Obstructive Pulmonary Disease (COPD) has declined, but it remains a key cause of mortality. Trafford's figures are below the North West average but above the England figure and above the rates in areas similar to Trafford in other parts of the country. Premature mortality from bronchitis, emphysema and other COPD is significantly lower in Trafford than in the North West, although not significantly so in males. Premature mortality from COPD is significantly higher in Trafford than other PCTs in the same Office for National Statistics (ONS) classification group.

6.4.18 Diseases of the respiratory tract are the biggest single reason for admission to hospital in people aged under 18, and children under the age of 4 account for 84% of admissions for lower respiratory tract infections. Whilst there appears to be a trend in increasing rates across the deprivation quintiles, there were also relatively high rates of hospital admissions in the least deprived quintile.

6.4.19 Emergency admissions for children due to asthma are relatively high in some areas of the borough, the rate in Clifford being significantly higher than the Trafford average. Although rates of admission for asthma are low compared to the rest of Greater Manchester, these are high compared to the England average.

6.4.20 Cancer:

Cancer is the leading cause of death for people under 75 years in Trafford and accounted for 38% of premature deaths in Trafford in 2008-10. The incidence of cancer in Trafford is rising, with around 1,200 new diagnoses each year and it appears to be rising faster than the national and regional rates.

6.4.21 However, mortality from cancer in people aged under 75 is falling and is similar to that seen nationally.

6.4.22 There are approximately 500 deaths per year due to cancer in Trafford. It is estimated that there are approximately 6,900 people who have been diagnosed with cancer and who are still alive in a year. Of these, 36% are aged 75 years or over.

6.4.23 Whilst the incidence rates of cancer in Trafford appear to be higher in than comparator groups, but the mortality rates are similar, or better than those groups, this would suggest that there is a higher rate of early identification of cancer and so earlier treatment leading to better outcomes and chances of survival for people in Trafford.

6.4.24 Rates of premature deaths from all cancers show much higher rates in the most deprived part of the population compared to the least deprived. The rate of premature mortality from all cancers is highest in the wards of Gorse Hill, Longford and Bucklow-St-Martins. The rate in Davyhulme West is significantly lower. The mortality rate for cancer in the most deprived 20% of the population is almost double that seen in the least deprived 20%. This gradient is especially stark in men highlighting the importance of men's health in tackling inequalities in Trafford. However, NW data shows there is no clear trend in five and one-year survival by level of deprivation (NWCIS 2010).

6.4.25 The most common causes of cancer for men in Trafford are prostate, lung and large bowel. The most common causes for women are breast cancer, lung and large bowel.

6.4.26 Whilst incidence is rising and mortality falling in most cancers, some cancers, such as of the oesophagus (the gullet) and upper gastro-intestinal, show an increase in both incidence and mortality. Whilst data shows that generally, mortality and incidence rates rise with increasing levels of deprivation, this does not appear to be the case for breast cancer, where it appears that women from the least deprived quintiles have higher mortality rates.

6.4.27 Cardiovascular disease:

Although mortality from cardiovascular disease is falling in Trafford and nationally it remains the most common cause of death: 1 in 5 men and 1 in 6 women die from the disease.

6.4.28 Mortality from coronary heart disease (CHD) in persons of all ages in Trafford is significantly lower than the North West, but significantly higher than England. There are differences within Trafford. Mortality from CHD per 100,000 population ranges from 55 in Hale Central to 147 in Bucklow-St-Martins. Mortality from CHD is significantly higher in Bucklow-St-Martins than both Trafford and the North West. The wards of Bucklow-St-Martins, Clifford, Longford, Priory, Sale Moor and Stretford have a higher rate of mortality from CHD than the North West (although not statistically significant). Hale Barnes and Hale Central have significantly lower rates of mortality from CHD than Trafford and the North West overall. The high mortality rates in Trafford mirror areas with higher levels of deprivation.

6.5 GP perspectives on the key community health and wellbeing issues

6.5.1 An informal survey of Trafford GPs identified the following issues for the communities that they serve:

Health:	mental health, cardiovascular, alcohol
Social/Environment:	income, housing, alcohol and substance abuse
Service needs:	mental health support, more responsive social services

6.6 Deprivation and inequalities

6.6.1 Deprivation refers to problems caused by a general lack of resources and opportunities and not just a lack of money. It is a wider concept than poverty and includes health status, level of education, access to services, living conditions and the state of the local environment.

6.6.2 The affluence and high levels of achievement hides local differences and inequalities. Whilst there are some very affluent areas in the Borough, some amongst the most affluent in the country, there are also some of the most relatively deprived areas in the country within the Borough. These areas are highlighted throughout the Indices of Multiple Deprivation (IMD), across a range of indicators, as being amongst the most deprived nationally. Between 2007 and 2010, Trafford has slipped slightly, but not significantly, in its overall rank. Perhaps more significantly, it should be noted that the gap between the national rank of the least deprived and the most deprived areas in the Borough has widened in the 2010 IMD compared to 2007.

6.6.3 There are a small group of areas that have multiple, and persistent, health and wellbeing issues afflicting the people and communities that live in them. These areas are parts of Partington, Clifford ward, Sale West estate, followed by Broomwood estate, parts of Longford and Broadheath wards all being in the 10% of Lower Super Output Areas most relatively deprived in the country.

6.6.4 These areas face the following health and wellbeing issues: higher rates of mothers smoking during pregnancy, higher rates of low birth weight babies, lower educational attainment through childhood and youth, higher rates of worklessness, higher rates of mental health problems through life and higher rates of premature mortality across a range of specific diseases.

6.7 Economy and employment

6.7.1 Trafford is a relatively affluent Borough both regionally and nationally.

6.7.2 The area has a strong local business base, high skill levels, a massively successful enterprise culture and above average levels of economic activity.

6.7.3 The unemployment rate is below the regional average.

6.8 Housing and households

6.8.1 There are currently around 97,000 households in Trafford, a 6% increase since 2001 (91,400). Around 81,000 of these are in the private sector (owned / privately rented), and around 16,000 provided by Registered Providers (RSL / Housing Association). This level of Registered Provider stock (16.4%) in Trafford is above regional (15%) and national levels (10.2%).

6.8.2 Since 2007, the numbers of people found to be ‘statutorily’ homeless in Trafford have been generally decreasing. However, as the recession took hold, the level of homelessness in 2010 bumped this trend, seeing an increase of 6.10% on the previous year.

6.8.3 Overall, 2001 Census data suggested that almost 5% of households are overcrowded compared with 7% nationally. Levels of under-occupation are higher than those found nationally or regionally.

6.8.4 Affordability has been, and remains, a huge problem for many of those wanting to get onto the Trafford property ladder. Currently the average house price in Trafford is £182,202, compared to £160,780 for England and Wales. The average household income in Trafford is £27,872 which gives an income to house price ratio of 1 to 6.5.

6.9 Crime and safety

6.9.1 Crime is low and crime and antisocial behaviour has significantly reduced over the last 5 years. Trafford has seen a 37% reduction in crime levels in this period and 45% reduction in antisocial behaviour.

6.9.2 There are high levels of public confidence and satisfaction in relation to tackling crime and anti-social behaviour.

6.9.3 Reoffending rates amongst Young Offenders and Adults have fallen significantly over recent years.

6.9.4 However, there are areas which experience disproportionate levels of crime and antisocial behaviour and these areas have remained constant over time. They are also the areas which experience higher levels of deprivation. Local research around burglary, antisocial behaviour, 'signal criminality' (criminal damage and environmental crime) and deliberate fires highlights areas around Old Trafford, Lostock / Stretford, Sale West, Partington and Sale Moor as those with a higher incidence of crime.

6.10 Transport and connectivity

6.10.1 Trafford has a wide ranging public transport offer with good links to trains, the Metrolink system and easy access to the motorway network.

6.10.2 There are geographically remote areas of Trafford where residents report difficulties in the ability to travel around the Borough due to a lack of public transport access and provision.

6.10.3 Trafford has one of the best records in Greater Manchester on road casualties and compares well against regional and national averages too. Our current 5-year annual average for 'KSI' (Killed and Seriously Injured) casualties is 57 KSI casualties per year (2006-2010), down from 133 for the equivalent period 20 years ago (1986-1990) despite overall increases in road use in that period.

7 Scientific Evidence on the Health Effects of LED Street Lighting

7.1 Introduction

7.1.1 The aim of this rapid review of the scientific research literature was to identify and assess the significance of the key health and wellbeing impact of exposure to LED street lighting.

7.1.2 There is no specific research literature on the health effects of LED street lighting as such and this Chapter has therefore focused on the health effects of LED lighting and where appropriate to outdoor and indoor artificial lighting in general. The focus of the review has also been on the general public with healthy eyes though general conclusions for people with existing relevant health conditions are stated.

7.1.3 The actual conclusions as stated by a review report or journal article are presented to enable the readers of this report to come to their own conclusions and to be able to identify the passages in these documents. Discussion and interpretation of the conclusions of these review reports and journal articles is then undertaken in the conclusion.

7.1.4 For most of the time that societies have had artificial light it has been seen as wholly positive for health and wellbeing both in terms of direct exposure to the light and indirectly through their ability to enable all of us to work – indoors and outdoors - and to engage in social and recreational activities when there is little or no natural light.

7.1.5 The issue of LED street lighting and health fits within a broader scientific research area on the potential health effects of artificial lighting in general both in home and, especially, in the work setting i.e. in context where lighting can be relatively high (workplaces, outdoors) and low (homes). It also includes the potential impacts of incandescent and fluorescent lighting as well as the implications of LED lighting in LED TVs, computer screens and handheld computing devices such as smart phones and tablets.

7.1.6 One additional issue of note is how relevant animal research on artificial lighting and health is to the human health effects of artificial lighting (rats, mice and hamster, particularly using experimental animal strains that are more prone for example to develop cancers). Overall, animal models can be suggestive of areas that need further human research but tend not to be definitive or strong proof that a human health effect is likely.

7.1.7 This chapter is therefore split into four sections, key findings of:

- Scientific reviews (secondary research) on LED street lighting or artificial lighting in general.
- Scientific research on human health effects of LED and artificial lighting as presented through scientific journal (primary research) since the publication year of the latest review identified and the present.
- Research studies and surveys of the piloting or use of LED street lighting and the concerns, if any, that have been raised in what have mostly been short term exposure surveys.
- Past HIAs on proposals to implement LED street lighting.

7.1.8 A more detailed description of the approach used to identify literature in this HIA is provided in Appendix A.

7.1.9 It is important to note that, the HIA team judges that all important research has been covered, as the aim has been to search widely rather than narrowly and to attempt to capture as much useful literature as possible, it is possible that some key research has been missed.

7.2 Existing scientific review report

7.2.1 Nine existing review reports were identified:

- Health effects of artificial light. (2012). Scientific Committee on Emerging and Newly identified Health Risks (SCENHIA). European Commission.
- Adverse effects of night-time lighting. (2012). Council on Science and Public Health. American Medical Association.
- Health effects of lighting systems using light-emitting diodes (LEDs). (2010). Opinion of the French Agency for Food, Environmental and Occupational Health & Safety (ANSES).
- Light at night the latest science. (2010). US Department of Energy.
- Artificial light in the environment. (2009). Royal Commission on Environmental Pollution. UK.

- Impact of outdoor lighting on man and nature. (2000). Health Council of the Netherlands. Publication No. 2000/25E
- Biological effect of light. (Year of publication unknown, possibly 2008). Metrology for Solid State Lighting. European Metrology Research programme. Programme of EURAMET (European Association of National Metrology Institutes).
- Light and human health: an overview of the impact of optical radiation on visual, circadian neuroendocrine and neurobehavioural responses (2008).
- Ocular lighting effects on human physiology and behaviour. (2003). International Commission on Illumination.

7.2.2 Statements within square brackets [] have been added to make a point or amend a typographical error in the original.

7.2.3 References within quoted extracts have been removed to aid clarity of reading.

<u>HEALTH EFFECTS OF ARTIFICIAL LIGHT. (2012).
SCIENTIFIC COMMITTEE ON EMERGING AND NEWLY IDENTIFIED HEALTH RISKS (SCENHIR). EUROPEAN COMMISSION</u>

METHODOLOGY

7.2.4 Information was primarily obtained from studies published in international peer-reviewed scientific journals in the English language. Additional sources of information were also considered, including web-based information retrieval, and documents from Governmental bodies and authorities, Non-Governmental Organizations (NGOs), and the lighting industry. The weight of evidence for a particular outcome was based on data from human, animal and mechanistic studies (the primary evidence) along with exposure. The overall quality of the studies was taken into account, as well as the relevance of the studies for the issue in question. The weighting also considered if causality was shown or not in the relevant studies.

OVERALL CONCLUSION

7.2.5 "In general, the probability is low that artificial lighting for visibility purposes induces acute pathologic conditions, since expected exposure levels are much lower than those at which effects normally occur, and are also much lower than typical daylight exposures. Certain lamp types (including also incandescent light bulbs) may emit low level UV radiation. According to a worst case scenario the highest measured UV emissions from lamps used in offices and schools, but not the very low emissions lamps used for household lighting, could add to the number of squamous cell carcinomas in the EU population."

7.2.6 "There is no evidence that blue light from artificial lighting belonging to Risk Group 0 ("exempt from risk") would have any impact on the retina graver than that of sunlight. Blue light from improperly used lamps belonging to Risk Groups (RG) 1, 2, or 3 could, in theory, induce photochemical retinal [damage].[28] There is no evidence that this constitutes a risk in practice. Other damages to the eye from chronic artificial light exposure during normal lighting conditions are unlikely. Exposure to light at night (independent of lighting technology) while awake (e.g. shift work) may be associated with an increased risk of breast cancer and also cause sleep, gastrointestinal, mood and cardiovascular disorders."

THOSE WITH EXISTING CONDITIONS

7.2.7 "UV, and in some patients, visible light can induce skin lesions of true photodermatoses. Although sunlight is reported by most patients as the main trigger of disease activity, artificial lighting is reported to play a role in some cases."

7.2.8 "The blue or UV components of light tend to be more effective than red components in aggravating skin disease symptoms related to pre-existing conditions such as lupus erythematosus, chronic actinic dermatitis and solar urticaria. UV and/or blue light could also possibly aggravate the systemic form of lupus erythematosus."

7.2.9 "It is recommended that all patients with retinal dystrophy should be protected from light by wearing special protective eyeware that filters the shorter and intermediate wavelengths."

7.2.10 "The previous SCENIHR opinion on Light Sensitivity stated that modern CFLs are basically flicker-free due to their electronic high frequency ballasts. However, some studies indicated that perceivable flicker can occur during certain conditions with both CFLs and incandescent lamps. This statement is still valid."

7.2.11 "There is no scientific evidence available to evaluate if conditions such as Irlen-Meares syndrome, myalgic encephalomyelitis, fibromyalgia, dyspraxia, autism, and HIV are influenced by the lighting technologies considered in this opinion**."**

STUDIES IDENTIFIED

7.2.12 "There are no studies available on the possible effects of domestic artificial light on the human eye."

[28] LED lighting is considered as Risk Group (RG) 0 or 1 by the European lamp Companies Federation

7.2.13 “However, studies have been performed on hazards of specific artificial lights, mostly ophthalmologic instruments, on human eyes.”

7.2.14 “A considerable number of studies are also available on the effects of artificial light on the retina of laboratory animals (e.g. mice, rats, monkeys, dogs...). These studies have been the basis of the understanding of light induced toxicity to the retina and have defined the wavelengths responsible for photochemical damage to the retina.”

CONCLUSIONS ON THE ACUTE PHYSICAL EFFECTS OF THE HEALTHY EYE

7.2.15 “There is no evidence that artificial light from lamps belonging to RG0 or RG1 would cause any acute damage to the human eye. It is unlikely that chronic exposures to artificial light during normal lighting conditions could induce damage to the cornea, conjunctiva or lens. Studies dedicated to investigating whether retinal lesions can be induced by artificial light during normal lighting conditions are not available.”[29]

7.2.16 “There is a moderate overall weight of evidence that ill-timed exposure to light (light-at- night indirectly measured by night shift work), possibly through melatonin suppression and circadian disruption, may increase the risk of breast cancer. There is furthermore moderate overall weight of evidence that exposure to light-at-night, possibly through circadian disruption, is associated with sleep disorders, gastrointestinal and cardiovascular disorders, and with affective disorders. The overall evidence for other diseases is weak due to the lack of epidemiological studies.”

Circadian rhythms, circadian rhythm disruptions, sleep and mood

7.2.17 “Despite the beneficial effects of light, there is mounting evidence that suggests that ill-timed exposure to light (light-at-night), possibly through circadian rhythm disruption, may be associated with an increased risk of breast cancer and also cause sleep disorders, gastrointestinal, and cardiovascular disorders, and possibly affective states. Importantly, these effects are directly or indirectly due to light itself, without any specific correlation to a given lighting technology.”

7.2.18 “Specifically under certain conditions blue light may be more effective in influencing human biological systems than other visible wavelengths. Thus, monochromatic blue light or light artificially enriched in blue is particularly effective in melatonin phase shift and suppression. However monochromatic or blue-enriched light of this type is not

[29] An earlier section of this conclusions states “Under specific circumstances, exposure to sunlight or artificial light can cause acute as well as chronic effects and damage to various structures of the eye.” Before going on to the concluding paragraph stated above.

produced by lamps for the general population, so the relevance for the evaluation of effects of common light sources is unclear."

ADVERSE EFFECTS OF NIGHTTIME LIGHTING. (2012).
COUNCIL ON SCIENCE AND PUBLIC HEALTH. AMERICAN MEDICAL ASSOCIATION.

METHODOLOGY

7.2.19 English language studies on humans were selected from a PubMed search of the literature from 1995 to March 2012 using the MeSH terms "circardian/biological clocks/rhythm", "chronobiology/disorders", "photoperiod", "light/lighting" "sleep", "work schedule", or "adaptation", combined with the terms "physiology", "melatonin", "adverse effects/toxicity", "pathophysiology", "neoplasm", "epidemiology/etiology", "mental disorders", "energy metabolism", and "gene expression". Additional articles were identified by manual review of the 25 references cited in these study publications; others were supplied by experts in the field who contributed to the report.

OVERALL CONCLUSION (FROM END OF MAIN REPORT)

7.2.20 "The natural 24-hour cycle of light and dark helps maintain precise alignment of circadian biological rhythms, the general activation of the central nervous system and various biological and cellular processes, and entrainment of melatonin release from the pineal gland. Pervasive use of night-time lighting disrupts these endogenous processes and creates potentially harmful health effects and/or hazardous situations with varying degrees of harm. The latter includes the generation of glare from roadway, property, and other artificial lighting sources that can create unsafe driving conditions, especially for older drivers. Current AMA [Americal Medical Association] policy advocates that all future outdoor lighting be of energy efficient designs to reduce energy use and waste. Future streetlights should incorporate fully shielded or similar nonglare design to improve safety of our roadways for all, but especially for vision-impaired and older drivers."

7.2.21 "More direct health effects of night-time lighting may be attributable to disruption of the sleep-wake cycle and suppression of melatonin release. Even low intensity night-time light has the capability of suppressing melatonin release. In various laboratory models of cancer, melatonin serves as a circulating anticancer signal and suppresses tumor growth. Limited epidemiological studies support the hypothesis that night-time lighting and/or repetitive disruption of circadian rhythms increases cancer risk; most attention in this arena has been devoted to breast cancer. The quality and duration of sleep and/or period of darkness affect many biological processes that are currently under investigation."

7.2.22 "Further information is required to evaluate the relative role of sleep versus the period of darkness in certain diseases or on mediators of certain chronic diseases or conditions including obesity. Due to the nearly ubiquitous exposure to light at inappropriate times relative to endogenous circadian rhythms, a need exists for further multidisciplinary research on occupational and environmental exposure to light-at-night, the risk of cancer, and effects on various chronic diseases."

POLICY AND PUBLIC HEALTH IMPLICATIONS OF LIGHT AT NIGHT

7.2.23 "Some responses to public health concerns associated with light-at-night exposures are readily apparent, such as developing and implementing technologies to reduce glare from vehicle headlamps and roadway lighting schemes, and developing lighting technologies at home and at work that minimize circadian disruption, while maintaining visual efficiency and aesthetics. Additionally, clinical studies support efforts to reduce child and adolescent night-time exposure from exogenous light derived from various media sources, especially in the bedroom environment. Recommendations to use dim lighting in residences at night raise issues for elderly patients. The American Geriatrics Society recommends ensuring well lit pathways within households to reduce the incidence of falls in elderly patients. Individuals who are subject to shift work experience disrupted circadian rhythms, fatigue, and cognitive dysfunction. Many industries, including hospitals, require a 24-hour workforce. The American College of Occupational and Environmental Medicine has established guidelines to address fatigue risk management in the workplace. In healthcare workers, such as nurses who experience rapidly rotating shifts, brief morning light exposure improves subjective symptoms and performance. The judicious use of bright light and/or melatonin supplements can improve adaptation to permanent, long-term night work."

RECOMMENDATIONS

7.2.24 The Council on Science and Public Health recommends that the following statements be adopted and the remainder of the report be filed:

"That our American Medical Association:

- Supports the need for developing and implementing technologies to reduce glare from vehicle headlamps and roadway lighting schemes, and developing lighting technologies at home and at work that minimize circadian disruption, while maintaining visual efficiency.

- Recognizes that exposure to excessive light at night, including extended use of various electronic media, can disrupt sleep or exacerbate sleep disorders, especially in children and adolescents. This effect can be minimized by using dim red lighting in the night-time bedroom environment.
- Supports the need for further multidisciplinary research on the risks and benefits of occupational and environmental exposure to light-at-night.
- That work environments operating in a 24/7 hour fashion have an employee fatigue risk management plan in place.
- That Policy H-135.937 'Advocating and Support for Light Pollution Control Efforts and Glare Reduction for Both Public Safety and Energy Savings' be reaffirmed."

<u>HEALTH EFFECTS OF LIGHTING SYSTEMS USING LIGHT-EMITTING DIODES (LEDS). (2010).</u>
<u>EXPERT PANEL OF THE FRENCH AGENCY FOR FOOD, ENVIRONMENTAL AND OCCUPATIONAL HEALTH & SAFETY (ANSES).</u>

7.2.25 There are small differences between the conclusions and recommendations of the expert appraisal report and the written Opinion developed by ANSES. The following are statements taken from the Expert Appraisal.

METHODOLOGY

7.2.26 The Working Group convened ten times in plenary session between 13 May 2009 and 26 March 2010. It also interviewed French and international scientific experts, and representatives of the French Lighting Association (Association Française de l'Eclairage – AFE) in order to obtain all relevant information for carrying out the investigation. To conduct its appraisal, the Working Group carried out a broad review of the international. scientific literature alongside its interviews with leading scientists. At the group's request, the French Environment and Energy Management Agency (ADEME) submitted a written contribution on the French and European market for lighting systems and the recycling of lamps. The bibliographical analysis carried out by the 'LED' Working Group was as thorough as possible. The scientific studies taken into account in the report were all published in international, English-language, peer-reviewed journals.

OVERALL CONCLUSIONS

7.2.27 "As a result of its analysis of the existing scientific literature and the information collected during the additional hearings, the Working Group identified potential health issues related to the use of LEDs."

7.2.28 “The technology behind light-emitting diodes is based on the polarisation of a semiconductor by applying a voltage that causes photons to be emitted in the form of quasi-monochromatic radiation, whose wavelength depends on the semiconductor used. There are no semiconductors capable of emitting white light on their own. There are, however, currently three different ways of producing white light indirectly with an LED. Given the technological constraints and the imperatives concerning electrical efficiency, currently the most widely-used method for producing white light uses a yellow luminophore to transform part of the light from a blue diode.”

- “Spectral imbalance within the blue
  The light spectrum from white LEDs is largely made up of very weak emissions ranging between blue and yellow, but with a high proportion of blue light (a blue spike in the spectrum). These characteristics are highly specific to LEDs, and are not found in other, traditional types of lighting.”
- “High luminance
  LEDs are point sources of light that can be aggregated in lighting units to achieve high luminous flux. Because the emission surfaces of LEDs are highly concentrated point sources, the luminance of each individual source produces very high luminance, at least 1 000 times higher (107 cd/m2) than that from a traditional lighting source.”
- “Stroboscopic effect
  Depending on their architecture, the electrical power supplied to LED lighting systems can vary, causing fluctuations in the intensity of the light produced that are barely perceptible to the naked eye. These fluctuations have not yet been characterised in any detail. The frequency of these effects can vary from a few Hertz to several hundred Hertz17 for those LEDs that have already been studied.”

7.2.29 “The main health risks associated with LED-based lighting systems result from their high luminance (i.e. the high brightness density per surface unit emitted by these very small sources) associated with the unusual emission spectrum of white LEDs, which have a high proportion of blue (shortwave) light. Other potential effects are raised in the report, such as disturbance to circadian rhythms and stroboscopic effects.”

7.2.30 “With regard to the many potential health effects identified (photochemical effect, glare, etc.), there is currently little information on human exposure to lighting to enable us to quantify the corresponding health risks adequately, whether for systems using LEDs or other types of light sources.”

7.2.31 "The Working Group was therefore only able to make quantified risk assessments for exposure to blue light, under the terms of the NF EN 62471 standard for photobiological safety. However, this standard is unsuited to lighting systems using LEDs. In the light of current knowledge, the maximum exposure limits given in this standard do not take account of daily exposure to LEDs. In the following description of the risks identified by the Working Group, the effects on the eye, both thermal and photochemical, have been dealt with separately from the other effects particularly related to disturbance of circadian rhythms."

RISK RELATED TO THE THERMAL EFFECT OF LIGHT

7.2.32 "The risk of thermal effects is related to burns to the retina, generally resulting from short-term exposure to a very intense light. This type of danger concerns all wavelengths, from ultraviolet to infrared and the entire visible spectrum. This type of risk, usually associated with lasers, is unlikely in conventional uses of LEDs."

RISK RELATED TO THE PHOTOCHEMICAL EFFECT OF BLUE LIGHT

Characterisation of the risk

7.2.33 "The risk of photochemical effects is related to human exposure to blue light and the risk level depends on the accumulated dose to which the person is exposed. It therefore generally involves repeated, low-intensity exposure over long periods."

7.2.34 "In adults, the crystalline lens (which, as it turns yellow, partly absorbs blue radiation) and the macular pigments partially protect against this toxicity through their capacity to absorb blue light. These protective mechanisms are weaker in children (whose crystalline lenses are transparent), aphakics (with no crystalline lenses) and pseudophakics (with artificial crystalline lenses). There is also less protection available in cases of reduced macular pigment, as observed during certain macular pathologies (e.g. ARMD)."

Exposure to LEDs

7.2.35 "There is currently no information about human exposure to lighting, whether for systems using LEDs or other types of light sources."

Photobiological safety standards

7.2.36 "The expert appraisal states there are gaps in the current French standards which are also aligned with the European Directive 2006/25/CE concerning artificial optical radiation and put forward original by ICNIRP [International Commission on Non-Ionizing Radiation Protection]."

7.2.37 "They identify the following gaps/inadequacies in the French lighting safety standard:

- Maximum exposure limits unsuitable for repeated [daily chronic] exposure to blue light, the current limits are based on exposure to a light source in the field of vision for one 8-hour working day with an experimental data reduction factor weighting of 5-10 times that which caused observable lesions (i.e. the limit was set at a level that was 5-10 below that where animal studies should some kind of adverse health effect).
- Ambiguity in the measurement distances used to classify lighting technology into Risk Groups (RG); most common lighting technology are assessed at a distance at which a brightness of 500 lx is produced while other lighting is assessed at a worst case observation case distance of 200mm (20cm). LED lights can be assessed using either distance creating ambiguity in the classification of Risk Groups.
- Failure to take into account populations sensitive to blue light e.g. children and those with eye disease making them more sensitive to blue light or less able to filter it out."

Measurements taken by the Working Group

7.2.38 "Some LEDs fall into the Risk Group 2 category while all other light sources currently on sale to the public fall into either Risk Group 0 or 1. The maximum exposure times implied by placing these items in Group 2 vary from a few seconds for certain royal blue LEDs to a few tens of seconds for certain cold white LEDs. LEDs and LED-base lighting systems can be classified in different Risk Groups depending on their radiance and hue (cold white, warm white, etc.), thus increasing the difficulty of [assessing and] preventing this risk."

Sensitive or highly exposed population groups

7.2.39 "Three population groups have been identified as being either especially sensitive to the risk or highly exposed to blue light:

- children (because of the transparency of their crystalline lens) and both aphakics (with no crystalline lens) and pseudophakics (with artificial crystalline lenses) who consequently either cannot or can only insufficiently filter short wavelengths (especially blue light);
- population groups which are already light-sensitive: patients suffering from certain eye and skin conditions and patients taking treatments one of

whose side-effects is to increase photosensitivity, etc., for whom blue light can be an aggravating factor for their condition;

- population groups highly exposed to LEDs (certain categories of workers: those installing lighting systems, theatre and film industry professionals, etc.) which are subjected to high-intensity lighting, and are therefore susceptible to exposure to large quantities of blue light."

Conclusions concerning the risk related to blue light

7.2.40 "It is important to emphasise that other widely-used sources of lighting, particularly high-pressure gas discharge lamps (metal-halide lamps for outdoor lighting), also fall into Risk Group 2. However, these lamps are intended for use in clearly-identified applications and can only be installed by professionals who are required to limit the exposure level for the population."

7.2.41 "The arrival of LEDs on the lighting market for the general public is an unprecedented development: it is the first time that sources classified in Risk Group 2 have become accessible to the general public, for use in the home and, most importantly, with no indication of the risk."

7.2.42 "The same LED considered individually or integrated in a lighting system could be assigned to different Risk Groups depending on the evaluation distance imposed by the NF EN 62 471 [French lighting safety] standard."

7.2.43 "As the technology behind LED lighting evolves over the next few years, lighting performance is likely to improve considerably. The risks associated with exposure to LED-based lighting systems are therefore likely to increase as the radiance increases."

7.2.44 "The methodology adopted in this report [the expert appraisal report] enabled the experts to evaluate the photobiological risks related to LEDs producing a luminous flux close to the mean of LEDs found in the range of fluxes available on the market at the time of writing this document. At present and for the next few years it seems unlikely that technological progress will yield LEDs that can be classified in Risk Group 3. On the other hand, with the increase in both luminous flux and radiance, there is no doubt that more and more LEDs will fall into Risk Group 2."

RISK RELATED TO GLARE

7.2.45 “There are two types of glare: discomfort glare and disability glare.

- Discomfort glare produces a disagreeable sensation, without necessarily impairing the vision of objects. It is related to the luminance of the lighting unit and to contrast differences. It is associated with a momentary reduction in visual performance.
- Disability glare perturbs the vision of objects (veiling luminance) without necessarily causing a disagreeable sensation. It is related to the quantity of incident light on the eye and the luminance of the lighting unit. It can cause accidents in the home (either slip-and-trip falls or falls from heights), in traffic (collisions) and elsewhere.”

7.2.46 “In indoor lighting, it is generally agreed that luminance higher than 10,000 cd/m2 causes visual discomfort irrespective of the position of the lighting unit in the field of vision. This value is commonly cited for discomfort glare in indoor lighting as being the value above which subjects are bound to suffer the effects of glare.”

7.2.47 “The French NF X 35 103 standard for visual ergonomics gives a limit value of 2,000 cd/m2 for discomfort glare, for the case of a small source located in the central area of the field of vision.”

7.2.48 “Because the emission surfaces of LEDs are highly concentrated point sources, the luminance of each individual source can be at least 1000 times higher than the luminance from traditional lighting sources. The level of direct radiation from this type of source greatly exceeds the level of visual discomfort.”

7.2.49 “The Working Group recorded luminances of more than 10,000,000 cd/m2 for certain LEDs with an electrical power of 1 W (in devices on public sale for domestic use).”

7.2.50 “In LED lighting systems available on the market, the LEDs are often directly visible in order to avoid attenuating the level of brightness produced. This leads to non-compliance with the requirements laid down in the standards (visual ergonomics and safety requirements) for lighting intended to avoid excessive luminance in the field of vision.”

RISK OF DEREGULATING THE BIOLOGICAL CLOCK AND PUPIL CONTRACTION

7.2.51 “In humans, the biological clock and pupil contraction are regulated by wavelengths close to 480 nm which suppress the production of melatonin (a hormone participating in the regulation of the biological clock and therefore the circadian cycle).”

7.2.52 “The spectrum produced by LEDs differs fundamentally from that of natural light, with a very low proportion near 480 nm. This could expose subjects to a risk of deregulation of their biological clocks and, in consequence, of their circadian rhythms. These risks are exacerbated by high- temperature colours (cold white and blue), which are frequently found in LED-based lighting systems.”

RISK RELATED TO FLICKER IN THE LIGHT EMITTED BY LEDS

7.2.53 “As a consequence of the manner in which they are powered electronically, the light emitted by LEDs may be subject to rapid fluctuation of great amplitude. This fluctuation, combined with the fact that LEDs have very low remanence, is usually imperceptible to human vision. In situations involving movement or in confined spaces with periodic variations in contrast, it can be responsible for stroboscopic effects. Although such stroboscopic effects have never been studied in depth, they can have a direct impact on health (epileptic seizures for subjects at risk), visual performance and safety. A recent publication showed that LEDs can produce fluctuations in light at frequencies known to produce effects on health (from 3 to 60 Hz for visible fluctuations and from 120 à 150 Hz for non-visible fluctuations).”

RECOMMENDATIONS

7.2.54 Considering health risks related to exposure to LEDs – blue light:

- “banning the sale to the public of lighting systems falling into Risk Groups higher than 1, evaluated at an observation distance of 200 mm;
- reserving LEDs falling into Risk Groups higher than 1 for applications designed to be installed safely by professionals.”

7.2.55 Considering health risks related to exposure to LEDs – glare:

Manufacturers and integrators;

- “design lighting systems such that the beams emitted by LEDs are not directly visible. In particular, the CES recommends the use of optical devices that reduce the intensity of light perceived directly or by reflection and to make the sources of LED light more diffuse;
- take account of the progressive wear of phosphor layers in white LEDs, which in time could lead to devices moving to a higher photobiological risk group.”
- in order to protect the drivers of vehicles, pedestrians, cyclists and motorcyclists from the risk of glare related to excessive luminance emitted by LED headlights, only be authorised to install LED-based lighting systems from

Risk Groups 0 or 1 for motor vehicle headlights by day or night, given that daytime running lights will be mandatory for all new cars from February 2011 (European Directive on daytime lighting 2008/89/EC)."

7.2.56 Considering uncertainty around chronic low exposures and biological clock/pupil contraction effects; sensitive population groups; and susceptible workers:

- "for children, avoiding the use of sources emitting a cold white light or blue light in places frequented by children (maternity wards, nurseries, schools, recreation centres, etc.) or in the objects they use (toys, electronic display panels, game consoles and joysticks, night lights, etc.);
- developing appropriate means of protection (such as safety goggles specifically to protect against exposure to LEDs) for workers highly exposed to LED lighting systems;
- informing patients taking medicines one of whose side-effects is to increase photosensitivity about the risks related to exposure to cold light and particularly light emitted by LEDs, even those classified as belonging to Risk Group 0; informing health workers of the existence of this risk;
- employing caution in the use of devices to increase the effective size of LEDs, even if such devices do not increase the luminance (such as optical collimators and multichip assemblies of LEDs). Indeed, [if] the use of these devices leads to shorter maximum exposure times to blue light than in the case of single chip LEDs without additional optics. A higher Risk Group may then be appropriate."

7.2.57 Considering "LED-based products for light therapy, comfort and well-being:

- evaluating the safety and compliance of these devices."

7.2.58 Considering that the "standards in force for lighting installations are not always applied by professionals (electricians, lighting specialists, designers of lighting systems) in the case of LED systems and that the standards related to photobiological safety might prove to be ill-adapted to LED lighting systems:

Professionals installing LED-based lighting systems be obliged to apply all standards relative to lighting quality;

- French standard NF X 35-103 (Ergonomics: Ergonomic principles applicable to the lighting of workplaces for visual comfort);
- NF EN 12464-1 ('Lighting of workplaces – Part 1: indoor workplaces');

- NF EN 12464-2 ('Lighting of workplaces – Part 2: outdoor workplaces');
- the series of NF EN 13201 standards ('Street Lighting');
- NF EN 12193 ('Sports Lighting')."

7.2.59 [Considering] "Adapting the NF EN 62 471 standard ('Photobiological safety of lamps and lamp systems') to cover lighting systems using LEDs. It is essential to make it easier for manufacturers to take this standard into account and remove any doubt as to how it should apply to LED systems:

- specifying in the NF EN 62 471 standard the conditions for measuring and evaluating LED systems;
- publishing a guide to applying this standard, exclusively for LED systems;
- determining the risk group for the worst case of observation: at a distance of 200 mm from the system, thus giving the most unfavourable Risk Group;
- adapting the standard to cover children and people who are either aphakic or pseudophakic, taking into account the phototoxicity curve of the relevant type of light published by the ICNIRP;
- proposing sub-groups for each risk group that would allow the risk to be assessed more precisely as a function of exposure time;
- in the case of risk groups greater than 0, evaluating safe distances (distance at which observation corresponds to Risk Group 0) and for these to be indicated explicitly on products intended for consumers (the case of devices for the general public) or for professionals responsible for installing lighting systems."

7.2.60 [Considering] "Introducing photobiological safety requirements into all safety standards covering LED lamps, LED modules and LED lighting units."

7.2.61 Considering the lack of information available to the public concerning LED-based products:

- "ensuring that manufacturers and integrators of LEDs carry out quality and traceability controls on LEDs; apart from the quality in terms of lighting, it is essential that they ensure that their products comply with their assigned Risk Group;

- considering a labelling system that will be comprehensible for consumers and contain all relevant information (power, voltage, colour temperature, luminous flux, etc.);
- making it mandatory to indicate the photobiological safety Risk Group on the packaging of LED products, after assessing the product at a distance of 200 mm. For light sources falling into Risk Group 1, the labelling should also indicate the safety distance beyond which the risk moves down to Group 0;
- making it mandatory to indicate the photobiological safety Risk Group for all types of lighting;
- considering the creation of a quality label (reproducibility, ecolabelling, etc.)."

7.2.62 Considering the lack of data on exposure of the general public and the working population to artificial light:

- "characterising and studying the exposure of the population to artificial light;
- defining a suitable index for evaluating the intensity of glare produced by an LED-based source, as the Unified Glare Rating (UGR) used for other types of lighting is not appropriate for LEDs, which are sources of low-angle light."

7.2.63 Considering studies and research on the health effects of LED lighting systems:

- "studying the cumulative medium- and long-term effects of exposure to blue light;
- carrying out prospective and retrospective studies of subjects undergoing light therapy with blue LEDs;
- implementing experimental protocols for evaluating the consequences of prolonged and accumulated exposure at levels inferior to the exposure limit values;
- further studies to improve characterisation of the spectra of action of the mechanisms by which light regulates the human biological clock;
- quantifying the impact of exposure to cold artificial lights on circadian rhythms and diminished pupil contraction;
- in general, studying how health is affected by light pollution (linked with possible disruption of the biological clock) and systematic installation of LED lighting systems;

- systematically studying the triggering and/or aggravation of photo-dermatoses caused by LED lighting."

7.2.64 Considering studies and research to be carried out on LED technology to prevent health risks:

- "encouraging research for the development of new emissive materials coupled with optimised luminophores, to obtain a high quality white light, with the highest possible luminous efficacy;
- developing research into the design of lighting units adapted for LEDs (small size and considerable luminous flux) with a view to reducing luminance, by applying optical solutions;
- studying the mechanisms that cause the degradation of white LEDs, potentially leading to a drift towards the blue end of the visible spectrum in the light emitted."

<u>LIGHT AT NIGHT THE LATEST SCIENCE. (2010).</u>
<u>US DEPARTMENT OF ENERGY.</u>

METHODOLOGY

7.2.65 A panel of leading experts was assembled to explore what today's science can tell us about light at night

OVERALL CONCLUSIONS

7.2.66 "Given the available research, it is unclear what changes, if any, should be made to current best-practice lighting design. So what do we know, and what remains murky? It is clear that additional peer-reviewed research and validation are required to determine the relative significance of the visual and the photoneural effects of typical light exposures on circadian, neuroendocrine, and neurobehavioral regulation. It is also apparent that additional guidance is needed from the IES [Illuminating Engineering Society] to inform the quantitative selection of appropriate spectra for particular visual tasks and environments. Night-time lighting systems are most likely to be safe and efficient if these consensus recommendations are followed, and LEDs remain a viable option for a growing number of applications. Basic panel recommendations, following from the presentations and discussion, are outlined in the following tables. Note that these tables are arranged in logical sequence"; e.g., items in Table 7.1 may be contingent on progress for items in Table 7.2.

Table 7.1: Light at night the latest science: needed research

Area	Task	Comments
Human vision	Characterize mesopic effects	Probably no single action spectrum
	Characterize color contrast	Significance vs. luminous contrast?
Human health	Bridge the research gap between humans and laboratory animals	Biology varies between species
	Gather more naturalistic/ecological data for full 24-hour cycles	What constitutes a "typical" exposure and a "typical" response?
	Better characterize the relationship between variables	E.g., timing, duration, spectrum, intensity, photic history
Basic biological studies	Detail of report must be adequate for translation and applicability to humans	Elaborate on lighting equipment and measurement methods used
Wildlife impacts	Detail of report must be adequate for use by lighting researchers	A daunting task, given the great diversity of species
Sky glow	Develop a complete algorithm proven to accurately calculate scatter as a function of light intensity, angle, wavelength, local atmospheric conditions, etc.	Would ideally consider both direct and reflected uplight (to credit reduced average illuminance and to account for spectral reflectance)

Table 7.2: Needed guidance from IES (Illuminating Engineering Society)

Area	Task	Comments
Minimum day-time exposure for humans	Develop a metric to characterize adequate exposure	
	Consider increasing recommended light levels where appropriate	Likely accomplished using daylighting, not electric
	Consider increasing short-wavelength content where appropriate	
Maximum night-time exposure for humans	Develop a metric to characterize excessive exposure	Likely a function of "typical" daytime exposure, etc.
	Consider reducing recommended light levels where appropriate	
	Consider reducing short-wavelength content where appropriate	This must be weighed against compro-mises to luminous efficacy
Circadian lumens	Adopt an action spectrum (or set of action spectra) for circadian sensitivity	
Mesopic lumens	Adopt an action spectrum (or set of action spectra) for mesopic sensitivity	
Color contrast	Consider establishing recommended minimum color rendering/quality criteria for outdoor applications	To supplement other criteria driven by luminance contrast
Ecological conservation	Develop criteria for protection of those species that have been adequately characterized and shown to be at risk	Age can be a factor, so may for example only apply to hatchlings Criteria should only be applied where the particular species is present
Sky glow	Incorporate an unambiguous algorithm for estimation of relative sky glow (see Table 3)	IES TM-10 would be the likely medium The latest draft MLO doesn't characterize atmospheric scatter

Table 7.3: Needed changes in lighting practice

Area	Task	Comments
Specifications	Design based on relevant empirical data	Well-intentioned interpretations may not produce the desired results
	Design for visual and biological needs of humans	CCT does not appear to adequately characterize the SPD of a light source
	Design with sensitivity to environmental concerns	Produce no more or less light than is needed
	Consider incorporating controls to reduce levels during periods of low activity	

CCT = Correlated colour temperature; SPD = Spectral Power Distribution

7.2.67 A linked factsheet "Light at night and human health" Produced by the US Department of Energy states the following:

- "Duration. Phase shift appears to increase exponentially with duration of exposure to Light At Night (LAN), and the first half of the exposure period appears to be more significant than the second half.[30]
- Timing. Daytime exposure to high levels of blue-rich illumination (like daylight) appears to be strictly beneficial in terms of circadian phototransduction and visual performance. In contrast, excessive exposure to LAN appears to hinder synchronization to the natural light-dark cycle.[31]
- History. Akin to the mechanism of visual adaptation, the sensitivity of the circadian system to LAN appears to be decreased if exposed to high levels of entraining illumination during the day.
- Quantity. Research indicates that circadian sensitivity is not accurately modeled by the photopic or scotopic functions. Also, since the amount of optical radiation reaching the retina depends on pupil size, simple measurements of optical radiation "at the eye" may be inadequate.[32]
- Spatial distribution in the visual field. Melatonin production appears most sensitive to exposure of the lower-inside portion of the retina to optical radiation."

[30] Phase shift is the delay or advancing of biological rhythms relative to the natural light/dark cycle.

[31] Phototransduction is the conversion of optical radiation signals into neural signals for vision and for other body functions.

[32] Photopic vision is the vision of the eye under well-lit conditions. In humans and many other animals, photopic vision allows color perception, mediated by cone cells, and a significantly higher visual acuity and temporal resolution than available with scotopic vision.
Mesopic vision is a combination of photopic vision and scotopic vision in low but not quite dark lighting situations.
Scotopic vision is the vision of the eye under low light conditions.

- Spectral content. The circadian system is most sensitive to nearly monochromatic blue light. However, if a given blue light source is supplemented by light of non-blue wavelength(s), as in the case of broadband white light, this sensitivity is reduced. This appears to be due to spectral opponency.[33]

- Since sensitivity to LAN appears to be a function of daytime exposure, all lighting systems may require scrutiny, whether interior or exterior, daytime or night-time. Evening exposures to lighting in common interior environments may be of greater significance than typical exposures encountered outdoors.

- Nearly all light sources, including incandescent and fluorescent lamps, produce some blue light and thus may be affected by the outcomes of research on LAN. Because so little is understood now about how humans respond to LAN, even moonlight may require consideration as a source of exposure to LAN.

- For most types of light sources, efficacy is not highly dependent on the correlated color temperature (CCT) selected. This is not the case with high-performance LED devices using current phosphor conversion technology, where typical photopic efficacy decreases of approximately 25% can be expected in choosing warmer 3000K over cooler (generally bluer) 6500K. While this may change with improvements in technology, a restriction on spectral content would currently prevent the use of more efficient light sources, with clear implications in terms of pollution from electricity production. Substantial gaps in the spectrum can also reduce visibility through reduced visual contrast and color rendition, thereby potentially compromising safety and security. Research into mesopic vision has shown that exterior light sources with greater scotopic content can improve peripheral detection without compromising on-axis vision,5 suggesting an even greater performance gap between LEDs of high and low CCT in these applications. However, as with circadian stimulus research, mesopic vision research is ongoing and currently lacks the validation and consensus required to establish standardized design recommendations.

- It would be irresponsible to encourage major changes in lighting practice without first establishing clear cause-and-effect relationships in these budding

[33] Spectral opponency is the mechanism by which sensitivity to one wavelength is reduced (a sub-additive response) when the visual system is exposed to additional wavelengths.

and very complex fields of science. A rush to judgment could result in tremendous and unnecessary lighting expenditures, while reducing safety at night and increasing the emissions of greenhouse gases, with no improvement in human health. Further research is needed and is already underway. In the meantime, those responsible for the selection of light sources are encouraged to follow local and federal regulations and the current and forthcoming safety guidelines offered by the Illuminating Engineering Society of North America (IES)."

<u>ARTIFICIAL LIGHT IN THE ENVIRONMENT. (2009).</u>
<u>ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION. UK.</u>

7.2.68 This report does not go into any detail on the impact of artificial light in the environment on human health. However it does make the following statement:

7.2.69 "Human health problems have been associated with exposure to light at night inhibiting production of melatonin. The inhibition of the production of melatonin is associated with the incidence of certain breast cancers. It should be emphasised that, so far, this possible effect has been confined to night shift workers exposed to high levels of indoor lighting; we do not deal with this effect further in our report where the focus is on light in the outdoor environment, but more recent work suggests changes in the nature of external lighting may mean this is more of an issue in the future. [Footnote: There is some evidence to suggest that blue-enriched white light is very effective at keeping people alert throughout the day and in re-setting the body clock, so that we sleep better at night. See for example: van Bommell, W. (2006). The biological effect of lighting. Lighting Journal, 71(1); and Donoff, E. (2009). Light's impact on health is playing a central role in design. Lighting Journal, 74(1).] However, the association between light at night and melatonin production is indicative of the largely unresearched effects that light can have on all organisms. Furthermore, people report negative health impacts from sleep disturbance due to light intrusion into their homes from road lamps that are left on all night. They may also experience stress from unwelcome illumination, such as security lighting, spilling onto their property from that of their neighbours."

<u>IMPACT OF OUTDOOR LIGHTING ON MAN AND NATURE. (2000).</u>
<u>HEALTH COUNCIL OF THE NETHERLANDS. PUBLICATION NO. 2000/25E</u>

7.2.70 This report does not identify how they undertook their review of the evidence on the health effects of outdoor lighting. It has therefore been difficult to identify key paragraphs that are worth quoting.

7.2.71 "Light has been demonstrated to control the day-night rhythm in the secretion of melatonin, which in turn affects the sleeping-waking rhythm, the movement rhythm and brain activity."

7.2.72 "It seems obvious to assume that a disturbance of the day-night rhythm and seasonal rhythm of man would have a detrimental effect, as it does with other mammals. That effect will generally be less severe in man, as man has not followed the normal day-night rhythm since the invention of artificial light. One possible way that artificial light may affect man's health is through stress. Stress occurs if something is at stake that is important at the time for an individual's well-being in terms of important objectives and values. An individual may experience stress, and over time an impact on health, from a disturbance of the environment by artificial light during the evening and night, depending on how much the person concerned considers this to be a nuisance. The combined exposure to other stress factors in the environment may increase this indirect effect of artificial lighting."

7.2.73 "The research into the nuisance caused by outdoor lighting in the evening and at night for surrounding residents focused mainly on the phenomenon of psychological blinding known as discomfort glare. Glare of this kind creates a nuisance or gives a feeling of unease without affecting visual perception (unlike in the case of physical blinding). There are various kinds of visual nuisance for surrounding residents. Not only residents of houses in the immediate vicinity of the outdoor lighting may experience the illumination of their bedrooms or gardens by the outside lighting as a nuisance."

<u>BIOLOGICAL EFFECT OF LIGHT. (YEAR UNKNOWN, POSSIBLY 2008). METROLOGY FOR SOLID STATE LIGHTING. EUROPEAN METROLOGY RESEARCH PROGRAMME. PROGRAMME OF EURAMET (EUROPEAN ASSOCIATION OF NATIONAL METROLOGY INSTITUTES)</u>

METHODOLOGY

7.2.74 There was no explicit methodology statement in this report.

OVERALL CONCLUSIONS

7.2.75 "It is known that light has an effect on the melatonin suppression but it does provide an explanation of the effects on the circadian processes. Anatomic studies have shown that the SCN (suorachiasmatic nuclei) is connected to many other parts of the brain such as the hypothalamus, the pituitary gland, the septum and the mesencephalon (midbrain). These parts regulate the production of a wide range of hormones which probably have an impact on many different physiological functions."

7.2.76 "The spectral effect of polychromatic light (and thus for almost all relevant lighting applications) has only been researched in a small number of studies and thus is not yet securely defined."

7.2.77 "The $s_{ms}(\lambda)$ curve only describes the melatonin suppressive effect of monochromatic light and thus only part of the biological effects of light."

7.2.78 "There are research studies that show that other parameters also have an influence on the melatonin suppressing effect such as the: local distribution on the retina, point in time of exposure to light and lighting scenarios of the previous hours and days (regarding lighting level, spectrum and time duration). All these parameters must be implemented into the action spectrum in order to be able to predict the effect."

7.2.79 "It is also important to look for the negative effects of light on the circadian rhythm. The fact that there may well be negative effects is indicated by the relationship between light therapy and in case of SAD ailments and the accelerated growth of tumours in case of exposure to light during the night. These findings should serve as a warning against the hasty application of light as a measure for improving one's health."

7.2.80 "The current level of knowledge is not sufficient for the deduction and development of control concepts for the lighting of work places. There are still many questions to be answered if light is to be used for stimulating the circadian system. Currently the spectral sensitivity, the relative spectral sensitivity of different retina zones, the question if adaptation processes exist as in the visual system, how the exposure to light over time can be integrated and the influence of the control over time of the exposure to light are of primary importance."

LIGHT AND HUMAN HEALTH: AN OVERVIEW OF THE IMPACT OF OPTICAL RADIATION ON VISUAL, CIRCADIAN NEUROENDOCRINE AND NEUROBEHAVIOURAL RESPONSES. (2008).
ILLUMINATING ENGINEERINGSOCIETY.

METHODOLOGY

7.2.81 There was no explicit methodology statement in this report.

OVERALL CONCLUSION

7.2.82 "This Technical Memorandum was developed to discuss the basic aspects of and latest information about biological systems affected by optical radiation reaching the human retina. Optical radiation detected by the retina impacts the individual's behavior, psychology, and perception of the world environment.

7.2.83 "Thus far, most published scientific research in this area has been based primarily on controlled laboratory and clinical experiments. Some studies have attempted to implement the basic research results into practical situations where they could prove beneficial. Therefore, it is premature to make design recommendations in this Technical Memorandum. Once more field studies investigating the impact of optical radiation on human health and well-being are conducted and the robustness of optical radiation's effects outside of laboratory conditions have been demonstrated, the Light and Human Health Committee will report on the practical implications. This will include a discussion of new applications being adopted by lighting practitioners, descriptions of emerging technologies, and identifying unresolved problems that require further research/development. The goal remains a more complete understanding of human visual, circadian, neuroendocrine, and neurobehavioral responses leading to improved designs for all lighted environments."

KEY FINDINGS

7.2.84 "Optical radiation reaching the retina not only impacts on how humans see the world, it also regulates physiology and behavior, both directly and indirectly. This includes acute effects such as suppressing pineal melatonin production, elevating morning cortisol production, increasing subjective alertness, enhancing psychomotor performance, changing brain activation patterns to a more alert state, elevating heart rate, increasing core body temperature, activating pupil constriction, and even stimulating circadian clock gene expression."

7.2.85 "Perhaps the most important and long-term effect of optical radiation is its ability to reset the internal circadian body clock and synchronize it to local time. Circadian rhythms are daily rhythms that repeat approximately every 24 hours and are driven by an endogenous clock. Nearly all behavioral and physiological parameters exhibit circadian rhythms and thus circadian clock synchronization is paramount to the body's efficient and appropriate functioning. The neurobehavioral (e. g., sleep/wake cycle) and neuroendocrine (e. g., hormone production) axes are thus influenced by optical radiation both directly (acute effects) and indirectly, via circadian clocks that drive and coordinate the rhythmicity in these systems."

Quantity:

7.2.86 "More than two decades ago, it was demonstrated that optical radiation could affect the circadian system but it was thought that bright light (~2500 lux [~250 fc] at the direction of gaze which is about 7,500-10,000 lux [1000 fc] on the horizontal surface) was required and that dim light (100 lux [10 fc] at the cornea, which is about 300-500 lux on horizontal surface) was ineffective. 121-123 Soon after those initial discoveries, however, it was demonstrated (under tightly controlled laboratory conditions) that exposure to between 1 lux and 5 lux (0.1 fc and 0.5 fc) at the cornea of specific monochromatic wavelengths of optical radiation (460 nm and 509 nm, respectively) could suppress melatonin in healthy humans44, 124 suggesting that the system was much more sensitive than initially thought."

7.2.87 "Levels of optical radiation required to impact the circadian clock outside of laboratory conditions are still unknown, largely because such studies have not been extensively conducted. One study131 that measured optical radiation using a photosensor around the subjects' neck as a medallion suggested that levels as low as 40 lux (4 fc) measured on a vertical surface (which is about 200 lux [20 fc] on the horizontal surface) for three hours in the evening (between 22:00 and 01:00 hours) may have induced a 0.6-hour phase delay of the subjects' circadian pacemakers. The minimum levels of optical radiation necessary to impact the circadian clock in the real world will likely differ from those observed under laboratory conditions. Photic history has a profound effect on system sensitivity70-72 in that there is increased sensitivity following an interval of dim lighting. Thus, it might be predicted that higher levels of optical radiation would be required to induce a response following a period of high light levels (i. e., daylight)."

Spectrum:

7.2.88 "But it is now widely accepted that sensitivity peaks in the short wavelength portion of the visible spectrum, and that multiple photopigments have the capacity to participate in circadian phototransduction. Several groups have demonstrated the sensitivity of both circadian and other acute responses to short-wavelength optical radiation."

Timing:

7.2.89 "Crucial in determining the direction and magnitude of circadian phase-resetting effects is the timing of any optical radiation exposure. Exposure at one time of day can shift the circadian pacemaker timing earlier (i. e., advance the clock phase) ; exposure at another time of day can shift the pacemaker timing later (i. e., delay the clock phase). The change in direction and magnitude of the phase shift as a function of time of exposure to optical radiation can be plotted as a Phase Response Curve (PRC)."

Duration:

7.2.90 "The phase-shifting effects of optical radiation are also dependent on the duration and pattern of optical radiation exposure, and vary exponentially with duration. A daily three-hour exposure to 5000 lux (500 fc) at the cornea was as effective as a six-hour exposure for adaptation to an experimental night shift. 146 The PRC [Phase Response Curve] for a one-hour exposure to 10,000 lux (1000 fc) from a polychromatic light source at the cornea has approximately 45 percent of the PRC amplitude for a 6.7-hour exposure to the same optical radiation."

7.2.91 "Intermittent, as opposed to continuous, exposure induces a greater phase shift than predicted by a simple linear response to optical radiation duration."

Spatial distribution:

7.2.92 "It has been shown, however, that optical radiation coming from the upper visual field (and reaching the lower part of the retina) is more effective in suppressing melatonin than the same amount of radiant flux coming from below the horizon and stimulating the upper part of the retina. Other studies suggest that the exposing the nasal portion of the retina evokes a stronger melatonin suppression than exposing the temporal portion."

Adaptation (photic history):

7.2.93 "Evidence is emerging that the human circadian system's sensitivity to optical radiation may be determined by optical radiation exposure over the hours (and possibly days) immediately preceeding, with non-visual phototransduction exhibiting an adaptation response. The importance of relative changes in optical radiation level, rather than the absolute level, has been known for several decades from animal studies in relation to the photoperiod effects of optical radiation. Photic history (from the preceding days and weeks) also influences human sensitivity to optical radiation at night as measured by melatonin suppression. The higher the exposure to optical radiation during the day (e. g., one week of exposure for four hours/day to outdoor lights), the lower the human circadian system's sensitivity becomes to optical radiation at night (measured by nocturnal melatonin suppression in Hebert et al.). Even as little as two hours exposure to dim white incandescent light at 4 cd/m2 (0.37 cd/ft2) can significantly dampen the subsequent melatonin suppression response to blue light in healthy subjects."

OCULAR LIGHTING EFFECTS ON HUMAN PHYSIOLOGY AND BEHAVIOUR. (2003). INTERNATIONAL COMMISION ON ILLUMINATION.

METHODOLOGY

7.2.94 “The report was based on an invited address by Brainard and Bernecker at the CIE session in New Delhi updated and expanded in some areas. For example, expansion of interest in the new area of photoimmunology has led the committee to add this area to its report. This report is based on published work up to February 2002, when it was written.”

7.2.95 “Exploring the behaviour of light and the mechanisms of vision has been a passion for philosophers and scientists for two millennia or more. As a result we have well-developed recommendations for lighting practice based largely on visual system requirements. In contrast, the empirical study of the nonvisual, systemic effects of light is relatively new, spanning only a few decades. These decades have seen rapid advances in which controlled laboratory and clinical studies have demonstrated that light can influence human physiology, mood and behaviour. We are developing light treatments for specific clinical disorders as well as improving adaptation to shift work and jet travel. These advances, however, are not yet enough to support clear statements about the optimal light and dark needs for good human health, nor to lead to modifications or adaptations of lighting practice that blend the requirements for good health with the requirements for the visually-mediated processes implicated in human response to the lit environment. Researchers from many disciplines and lighting practitioners of all kinds will need to collaborate to attain that goal. The challenges involved are many (Veitch et al., 1998), but that the effort is worthwhile we do not doubt.”

KEY FINDINGS

7.2.96 “The daily light dose received by people in Western countries might be too low.”

7.2.97 “Healthy light is inextricably linked to healthy darkness.”

7.2.98 “Light for biological action should be rich in the regions of the spectrum to which the nonvisual system is most sensitive.”

7.2.99 “The important consideration in determining light dose is the light received at the eye, both directly from the light source and reflected off surrounding surfaces.”

7.2.100 “The timing of light exposure influences the effects of the dose.”

7.2.101 “Good-quality lighting includes lighting for health in parallel with meeting the other needs of people who will occupy the lit space. Principles of good lighting practice should be the starting point for lighting design; we can expect that these might be amended as our knowledge about what constitutes healthy light improves. These principles include energy-efficiency and environmental considerations that should not be forgotten. Healthy light in the broadest sense must also be ecologically sound."

7.3 Primary research studies published since the latest research reviews

7.3.1 A Georgia case-control study looking at light at night and breast cancer risk, with lung cancer cases as a control population (lung cancer is not currently though to be affected by light exposure), found that breast cancer cases with a white ethnicity but not other ethnicities had a high risk of breast cancer from high exposure to light at night.[34]

7.3.2 A Germany cross-sectional study looking at the level of eveningness (evening behaviour and activity) found that adolescents living in brightly illuminated urban districts had a stronger evening-type orientation than adolescents living in darker and more rural municipalities.[35] This result persisted when controlling for time use of electronic screen media, intake of stimulants, type of school, age, puberty status, time of sunrise, sex, and population density. Time spent on electronic screen media use, a source of indoor light at night was also correlated with eveningness, as well as intake of stimulants, age, and puberty status, and, to a lesser degree, type of school and time of sunrise. Adequate urban development design and parents limiting adolescents' electronic screen media use in the evening could help to adjust adolescents' zeitgeber to early school schedules when they provide appropriate lighting conditions for daytime and for night-time.

7.3.3 A Japan cross-sectional study found that exposure to Light At Night (LAN) in an uncontrolled home setting is associated with impaired obese and lipid parameters independent of nocturnal urinary melatonin excretion in elderly individuals. Moreover, LAN exposure is associated with higher risk of obesity and dyslipidemia (abnormal blood fat levels) independent of demographic and socioeconomic characteristics.[36]

[34] Bauer SE, Wagner SE, Burch J, Bayakly R and Vena JE. (2013). A case-referent study: light at night and breast cancer risk in Georgia. International Journal of Health Geographics. 12:23.

[35] Vollmer C, Michel U and Randler C. (2012). Outdoor light at night (LAN) is correlated with eveningness in adolescents. Chronobiology International. May, 29(4):502-8.

[36] Obayashi K, Saeki K, Iwamot J, Okamoto N, Tomioka K, Nezu S, Ikada Y and Kurumatani N. (2013). Exposure to light at night, nocturnal urinary melatonin excretion and obesity/dyslipidemia in the elderly: a cross-sectional analysis of the HEIJO-KYO study. The Journal of Clinical Endocrinology & Metabolism. 98 (1): 337.

7.4 Research studies and survey of LED street lighting pilots and programmes

7.4.1 There seem to be no publically available survey reports online analysing the views and attitudes of communities to pilot and implemented LED street lighting projects.

7.4.2 A survey study by Transport for London, UK, for a LED street lighting trial found that most people did not notice the change in lighting (unprompted and prompted).[37] Only one respondent experienced a problem with the LED lighting; they were dazzled when they looked directly at them. A few respondents also felt that the lighting should not be introduced as it was too bright.

7.4.3 A City of Pittsburgh, USA research study and survey, undertaken by Carnegie Mellon University, considered the following seven key aspects of street lighting:[38]

- Dimensions of night-time vision looked at how the human eye sees at night; how glare affects vision; how uniformity of illuminance affects vision; and age-related vision loss.
- Considerations of lighting the public right-of-way included aspects of placemaking and wayfinding such as intensity, color temperature, color changing, and focal points.
- Aesthetic evaluations examined materials, facade lighting, luminaire style, and standardization.
- Performance considerations included varying viewpoints, illumination levels, glare and light trespass, uniformity, color rendering, ambient light, and safety.
- Operational considerations dealt with energy use, monitoring, durability, reliability, and light output.
- Political and social issues were addressed, including climate change, light pollution, age-related equity, and spatial equity.
- Biological/Public Health Considerations included color temperature and circadian rhythm.

The study recommended using the following criteria for LED replacement luminaries in Pittsburgh:

- The entire luminaire head is to be replaced.

[37] Transport for London. (2011). LED street lighting trial assessment report. Mayor of London.

[38] Remaking Cities Institute. (2011). LED street light research project. Carnegie Mellon University.

- Light color is to be white, preferably 3,500 Kelvin, but with an adjustable range from 2,800 to 5,000 Kelvin.
- The Color Rendering Index must be 80 or greater.
- The fixtures shall be primarily down-firing. Up-firing fixtures, if used for aesthetic effect, must be aimed at white horizontal reflectors to produce diffused light downward to prevent dark sky intrusion.
- The LED light source should not be visible to drivers, bicyclists, or pedestrians unless they are directly under the fixture
- LED luminaires should be guaranteed for a minimum ten-year life span with no more than a 30% deterioration of illuminance as measured by footcandles.
- The preferred lighting pattern on the ground shall be overlapping ovals.
- Luminaires will be placed on existing poles. Typical spacing for luminaires on 25' to 30' poles can vary from 85' to 150.' On 15' to 18' poles the spacing is usually 80.'
- All luminaires should be control-ready with the ability in the future to be individually monitored and controlled by wired or wireless central networks.
- Back-lighting of building facades should not exceed a height of 6" above the sidewalk.
- Contemporary luminaire design is encouraged except in historic districts where luminaire design should be compatible with the local context.
- Testing and evaluation of the replacement luminaires should be conducted in a laboratory with proper photometric equipment.
- Also, field evaluation of installed LED luminaires in the three selected business districts should be conducted using a scoring system that will rate beam spread, color rendering, light intensity, clarity, glare, integration with the surrounding context, visual experience, and luminaire enclosure design.

The study suggests four upgrade options to the above base criteria:

- Basic controls to allow dimming from 6 footcandles to 1.5 footcandles and adjusting color between 2,800 Kelvin and 3,500 Kelvin.

- Enhanced Smart Street Lighting Control System to provide real time data on energy use, outages, lamp life, and to enable remote control of strobing, flashing, integration with emergency services, and special event effects, in addition to basic controls for dimming and color adjusting.
- Accessory color lighting fixture with red, green, blue LED's that can be attached to the existing street light poles for wayfinding, special events, artistic effects, and emergency signaling.
- A light cueing feature on the luminaires to allow a small amount of light to be visible above the cutoff level to serve as a visual indication that the fixtures are on.

7.5 Past HIAs on LED street lighting programmes

7.5.1 There are no known HIAs in the public domain on LED street lighting programmes.

7.5.2 There is one HIA on the dousing (dimming/switching off) of street lighting but this did not explicitly discuss the issue of using LED lighting.[39]

7.5.3 One research study has looked at the health effects of large LED screens on local residents in Canada.[40] The study found that:

- "The light-emitting diode (LED) screens were erected as part of an overall upgrade to the sports stadium. A total of three screens were installed, each measuring 30 feet by 50 feet. Two of the screens are illuminated daily from 6:00 am to 11:00 pm. Software adjusts the intensity of the screens over the course of the day. From 9:00 am to 7:00 pm, these two screens operate at 50% capacity; at all other times, they operate at 25%. The third screen operates on a seasonal schedule and is illuminated from sunrise to sunset with the exception of "event" nights such as soccer or football games. From 9:00 am to 5:00 pm, the third screen operates at 50%; on event nights, this period is extended to the start of the event. It otherwise operates at 20%. All three screens are illuminated until 15 minutes after the particular event finishes.

[39] Welsh Health Impact Assessment Support Unit. (2009). Dousing of street lighting in Wales: impacts on health and wellbeing.

[40] National Collaborating Centre for Environmental Health. (2013). Health effects of large LED screens on local residents. Canada. Available at http://ncceh.ca/en/professional_development/practice_questions/LED_health_effects

- The following possible health effects of artificial light from LED sources were identified as:
  - Photosensitive Epilepsy
  - Retinal Damage
  - Stress and Annoyance
  - Circadian Rhythm and Sleep Disruption
- Most of the [current] research examines indoor lighting, personal screen use, or occupational exposures to industrial lighting and thus may not be generalizable to the scenario of exposure to a large outdoor screen.
- Additional information regarding the LED screen, exposure, and population characteristics is needed to fully assess the issue of potential health effects associated with residing nearby the LED billboard screens.
- The risk of photosensitive epilepsy should be minimal if images on the LED screen comply with the International Telecommunications Union recommendations to prevent photosensitive seizures.
- The screen's maximum luminance should be less than 10,000 cd/m2 to avoid retinal damage. Given that the screen is operating at less than full capacity at all times, it seems unlikely to exceed the 10,000 cd/m2 threshold. If the luminance of the screen exceeds this limit, a more detailed exposure assessment is required. Although the possibility of retinal damage seems limited, no research has been done specifically on large LED screen exposure and retinal damage.
- As a bright light source from which the residents have no control, the LED screen may promote annoyance and stress to residents living nearby. The LED technology should eliminate perceptible flicker, which has itself been associated with annoyance. The screens contribute to the light associated with urban space. However, we are not able to determine the degree to which extraneous light from the LED screens contributes to the disruption of sleep or circadian rhythms, if any, in local residents; light is only one of many factors affecting these biological rhythms.
- The lack of information on exposure characteristics of the LED video billboards and the affected population, along with the lack of scientific

evidence informing the process, precludes undertaking a current risk assessment."

7.6 Conclusion

7.6.1 This evidence review has found no evidence that that LED street lighting specifically has any additional health and wellbeing effects beyond that found for artificial lighting in general.

7.6.2 The majority of reviews are cautious in making wide ranging recommendations (only one does so) and where they do they apply to the whole range of artificial lighting that people are exposed to and all call for more research in this area. This is because the current evidence is weak and mostly associated with animal, in vitro and ecological/cross-sectional studies (where accurate levels of exposure and cause and effect relationships are difficult to identify).

7.6.3 The research reviews identified in this evidence review all agree that artificial lighting can have some negative health and wellbeing impacts depending on the intensity, duration, pattern and characteristics of the light exposure alongside levels and types of exposure in the hours beforehand. This includes indoor lighting, light emitting devices such as computers as well as outdoor lighting.

7.6.4 Importantly, the effect of artificial lighting is nuances, subtle and complex and there is some evidence that people can adapt to different lighting conditions and that this can reduce the effects of artificial lighting.

7.6.5 Some people with certain existing health conditions that are affected by light, and possibly children, may be more sensitive to artificial lighting.

7.6.6 Only one review, focusing on LED lighting, identified LEDs as potentially more problematic than other forms of artificial lighting. Even this review did not specifically focus on outdoor LED lighting but was more concerned about indoor household lighting.

7.6.7 There are some regulatory issues in terms of whether existing regulatory guidance on assessing the light emitted by artificial lighting systems is able to adequately categorise the likely light exposure from LED lighting systems.

7.6.8 The main difference between LED lighting and other forms of artificial lighting is that it can produce light that is more in the blue part of the light spectrum, i.e. producing a more whiter bluer light than incandescent, fluorescent or outdoor sodium or metal halide lighting which can be much yellower and can be more intense (given the size and shape of LEDs and the way the lighting system is constructed with reflectors and lenses to focus the light). Exposure to light in the blue part of the spectrum particularly single blue colour (monochromatic blue) light can have a greater effect on the circadian rhythm.

8 Local Authority Reviews on Street Lighting Options

8.1 Introduction

8.1.1 Some local authorities have undertaken a review of the key potential risks of street light dimming/LED/energy efficient street lighting incorporating scientific, professional and anecdotal evidence on the potential health and wellbeing impacts not covered in Chapter 7.

8.1.2 The local authorities that undertook such reviews were Worcestershire County Council and Warwickshire County Council

8.1.3 Footnote references shown in this chapter have come from the original review reports. Words and phrases in square brackets [ ] have been added to aid clarity.

8.2 Worcestershire County Council Review (2012)

8.2.1 <u>Switching off lights</u>

Assessment of the risks of switching off lights is largely subjective, but there has been a great deal of research showing that the introduction of street lighting reduces crime.[41] The Institute of Lighting Professionals (ILP) and the police told the scrutiny [committee] that in their view higher levels of darkness increase the risks of crime, fear of crime, road accidents and litigation. They also noted that, when street lights are turned off, some residents installed security lighting, which led to complaints from other residents. British Standards guidance requires higher levels of lighting in 'high crime areas', although types of crime are not defined. The police did however comment that a large proportion of crime is “local” and opportunistic and the greatest deterrent to burglary is whether a property looks occupied (rather than how well lit the area is). There is a lack of research into the long term impact of turning off lights in low crime areas. The scrutiny therefore looked at what had happened in other local authority areas when street lighting had been turned off and found a variety of consequences:

[41] Pease, K (1999) A review of street lighting evaluations: crime reduction effects, Crime Prevention Studies, 10, pp.

- In Cambridgeshire and Hertfordshire, there had been no significant increase in crime following a night time switch-off.
- In Gloucestershire crime/antisocial behaviour had reduced after switching off lights after 10pm in a rural parish.
- In Cardiff, a fatal traffic accident happened during a trial of part night lighting on a traffic route.
- In Buckinghamshire a woman had been hit by a car in an area where lighting had been switched off; the coroner had directly linked the lack of lighting to the accident, although the Worcester Crime Risk Manager noted that drivers should reduce speed as appropriate in unlit areas.

8.2.2 Dimming

However, some areas should not be dimmed. Full lighting on traffic routes is considered necessary when traffic is at its peak, usually between 5pm to 7.30pm and at junctions all night. The ILP consider that in residential areas lights should also be fully on up to 7.30pm. In addition, careful thought needs to be given to dimming in places with CCTV, high levels of crime, or a history of road accidents. This may result in only low crime, affluent, residential areas being dimmed.

8.2.3 LED lights

There have been a few trials of LED [lights] in Worcestershire and a mix of zero and negative feedback. The light quality is harsher; the optic design includes many bulbs mounted on a board, which project small beams of light in different directions, producing glare. Current designs are felt to be not ideal for street lighting, but it is expected that designs will improve.

8.3 Warwickshire County Council Review (2012)

8.3.1 Crime

The first authority to implement part-night lighting was Essex County Council and according to figures published on their website, crime levels have fallen, although fear of crime is still an issue.[42] Other authorities, including Gloucestershire County Council have reported minor reductions in crime levels following the implementation of part-night lighting schemes. Although encouraging, the figures referenced above are taken

[42] It's worth noting that crime levels across the Country tend to fall slightly year-on-year so attributing that decrease to part-night lighting may not be appropriate.

from very small rural localities with total area crime figures in the low hundreds and therefore are not very representative.

At the time of writing, no local authority has released comprehensive figures for either crime or road accidents before and after the implementation of part-night lighting; however, a number of authorities that the Task and Finish Group contacted have committed to doing reviews in the next twelve months.

Nationally recognised papers are similarly inconclusive. The most widely referenced paper claiming that increasing street lighting reduces crime is called Home Office Research Study 251 (2002) and was written by two criminologists, Farrington and Welsh. The study was an important justification for Central Government policy at the time. However, Paul Marchant, a Statistician at Leeds Metropolitan University, makes the claim in his essay, ‘Shining a light on evidence-based policy: street lighting and crime’, that the use of statistical methods in the study lacked rigour and that the claims made in the paper were not properly supported by the data.

The paper, ‘The influence of street lighting on crime and fear of crime’ (1991), written by Stephen Atkins, Sohail Husain and Angele Storey, directly contradicts Home Office Research Study 251 by concluding that, “better street lighting has had little or no effect on crime.” However, they did find that improved street lighting “provided a measure of reassurance to some people.”. There is a lack of research into the long term impact of turning off lights in low crime areas. The scrutiny therefore looked at what had happened in other local authority areas when street lighting had been turned off and found a variety of consequences:

Road safety

Milton Keynes Council recently made national headlines after a decision to switch a significant number of their street lights back to all night operation following two major road accidents in darkened areas. It is important to note that, in terms of road safety, Milton Keynes is unique in that it has a US-style grid road system that allows cars to reach very high speeds and removing lights along certain sections meant that it was possible drivers would have seen a disorienting stroboscopic effect which may have contributed to the accident.

Street lights have also been switched back on at five of 46 part-night lighting locations in Buckinghamshire because of increases in the number of accidents at four of the five sites.[43] Despite increases in the levels of accidents at a small number of sites, the average number of injury collisions across the County fell by 26%.

[43] Three of the four sites where collisions increased were roundabouts which are covered by WCC’s exemption criteria.

The majority of Local Authorities that responded to the Task and Finish Group's questionnaire reported that part-night lighting had no measurable impact on road safety.

Evidence on both sides of the debate is far from conclusive but members were largely encouraged by the figures published so far, that show no significant increases in the levels of crime or road accidents following the operation of part-night lighting..

Warwickshire County Council's (WCC) Street Lighting team liaised with the Police, Ambulance, and Fire services, as well as WCC's own Road Safety and Community Safety teams. The criteria determining which lights would be left on throughout the night came out of those discussions.

Following advice from the Police, engineers have also liaised with District and Borough Councils to determine the locations of local authority operated CCTV cameras to ensure they remain fully lit throughout the night. The Police also requested that lighting was left on all night in specific 'Police priority areas'.

Working with the Police, WCC has developed a process for allowing lights to be quickly switched back on in cases of emergency. Police Officers will direct requests for lights to be switched on through the central Police Command Centre, the Centre will then call WCC's on-duty street lighting engineer and ask for a specific area to be illuminated. Lights can be controlled from the engineers home laptop so the time elapsed from the initial Police call to lights being illuminated on the ground should be very short. Ultimately the Police's Commanding Officer will be responsible for which requests are sent through to WCC engineers.

WCC's Street Lighting team will continue to work closely with the Police and its own internal Community Safety and Road Safety teams to monitor the situation following implementation and any significant changes to crime or road safety figures will be carefully investigated. To ensure any changes to the levels of crime or road safety are highlighted early, the Task and Finish Group recommend that Officers report review data to the Communities Overview and Scrutiny Committee and monitor the situation at other authorities who have switched street lights back on due to accidents and safety concerns.

<u>Public engagement on the criteria used to determine which lights stay lit throughout the night</u>

After consultation with the Police, Road Safety and Community Safety teams certain locations were identified by WCC's Street Lighting engineers where lighting would remain on all night. The final locations that formed the public exemption criteria were:

- Where there are potential hazards on the highway such as roundabouts, traffic signal controlled junctions, central carriageway islands, traffic calming features, road humps etc.
- At formal pedestrian crossings (Zebra, Pelican, Puffin, Toucan, and Pegasus).
- Areas covered by permanent Local Authority/Police CCTV cameras.
- Areas adjacent to elderly people care homes, sheltered accommodation complexes and Accident and Emergency departments.
- Lighting adjacent to operational taxi ranks.
- Lighting on public footpaths, alleyways and cycle paths which are located away from roads.

9 Health Impacts of the Trafford LED Street Lighting Programme

9.1 Introduction

9.1.1 The analysis of health impacts examined the likely effects of the LED Street Lighting Programme on the health and wellbeing of local residents during the operation phase of the programme when residents would be exposed to LED light from the new LED street lights.

9.1.2 The construction phase (erecting and setting up) of the programme has not been considered because changing the programme will replace existing street lamps and columns so the location and approach to erecting and setting up the street lighting is similar to what has occurred in the past. The new street lighting will be setup during the daytime and in the majority of cases will be operational and in the majority of cases will not reduce the levels of night-time street lighting during the construction phase. The two issue that are most likely to have the potential to cause negative health and wellbeing impacts are:

- disruption to the pavements near people's homes, where they work or go to an educational or recreational facility/amenity; and
- if the construction phase activities involve not having street lights on overnight for one or more nights.

9.1.3 It is worth noting that the assessment of the potential health and wellbeing impacts is at a population level.

9.1.4 Workers working on implementing and maintaining the LED street lights have not been included in this analysis as they are covered by existing health and safety legislation and guidance.

9.1.5 A summary health impact table is provided at the end of this chapter (See Table 9.1).

9.1.6 This analysis has taken into account the relatively large number of places where LED street lighting has been implemented and the lack of specific health and wellbeing issues emerging from these places some of which have had LED street lighting for a number of years.

9.2 Factors influencing the construction phase

9.2.1 How the replacement of the current lighting on a street by street basis will determine whether there are any disruptions to access to people's homes or places of work and to the availability of night-time illumination.

9.2.2 There are likely to be no or minor health and wellbeing impacts related to whether there is more than a day's disruption to access, night-time illumination and, potentially, replacing existing decorative street light poles with new LED lighting system poles which are not in keeping with the wider architectural environment and streetscape.

9.3 Factors influencing the operation phase

9.3.1 There are two main factors that are likely to influence health and wellbeing during the operation phase. These are:

- What areas of Trafford, if any, are likely to be dimmed.
- How any glare into people's homes is managed.

9.4 Health impacts operation phase

9.4.1 Overall, the operation phase is likely to have no or minor positive health and wellbeing impacts.

9.4.2 In terms of transport and connectivity; crime and safety; and health and other essential services; and energy and waste there are likely to be no (neutral) or minor positive health and wellbeing impacts.

9.4.3 The potential minor positive health and wellbeing impacts relate to the improved night-time visibility that the new LED lighting is likely to provide compared to existing street lights. This is likely to make it more attractive, i.e. perceived as safer, to use public transport, walk and cycle in the evening and at night. It could also deter crime and anti-social behaviour more because the new lighting provides better visibility of properties and paths. It could also make it easier for emergency services to travel at night and carry out emergency procedures outdoors.

9.4.4 There is a potential for a moderate positive health and wellbeing impact in terms of energy and waste depending on the reductions in energy use and hazardous waste that are generated.

9.4.5 There is a potential minor negative health and wellbeing impact on those residents who face medium to long term (months and years) glare from the LED lights into their homes, particularly their bedrooms.

9.4.6 Exposure to LED street lighting is not likely to lead an increase in eye problems, cancers or any other physical or mental health condition. This is because of the likely type and intensity of the light that would be emitted and the low duration and intermittent pattern of exposure for almost all residents, workers and visitors. The major negative health and wellbeing impact will be through visual intrusion caused by light pollution from the LED street lighting coming into their homes.

9.4.7 There is a potential uncertain, potentially negative, health and wellbeing impact if street lights are dimmed as there is a potential for an increased risk in road traffic incidents and reduction in perceived safety for people using those streets for walking, cycling and using public transport. There is also a potential for an increased in road traffic incidents and more difficulty for emergency services to get to and carry out emergency procedures outdoors.

9.5 Health impacts on children and young people

9.5.1 There are unlikely to be any additional health and wellbeing impacts on children during the operation phase. There is a potential for a positive health and wellbeing impact in relation to transport and connectivity if the LED street lighting improves visibility both for pedestrians and motor vehicle drivers. This is likely to be through greater physical activity and social interaction as parents perceive it to be safer for their children to go out in the evening on foot, by cycle or public transport. There is a potential for a moderate positive health and wellbeing impact in terms of transport and connectivity depending on the reductions in road traffic incidents involving children and the increase in physical activity of children in the evenings.

9.6 Health impacts on women, older people and people with disabilities

9.6.1 There are unlikely to be any additional health and wellbeing impacts on women, older people and people with disabilities during the operation phase. There is a potential for a positive health and wellbeing impact in relation to transport and connectivity if the LED street lighting improves visibility both for pedestrians and motor vehicle drivers. This is likely to be through greater physical activity and social interaction as they perceive it to be safer for them to go out in the evening on foot, by cycle or public transport. There is a potential for a moderate positive health and wellbeing impact in terms of transport and connectivity depending on the increase in physical activity of children in the evenings

9.7 Health impacts on ethnic groups

9.7.1 There are unlikely to be any additional health and wellbeing impacts on different ethnic groups.

9.8 Health impacts on people on low income/unemployed people

9.8.1 There is a potential for some unemployed people to benefit from jobs directly or indirectly generated through the LED Street Lighting Programme. This is likely to be a no or minor positive health and wellbeing impact.

9.9 Long term and cumulative impacts

9.9.1 There are unlikely to be any additional long term or cumulative health and wellbeing impacts of the LED Street Lighting Programme.

9.10 Equity impacts

9.10.1 As the LED Street Lighting Programme will be implemented across the whole of Trafford there are unlikely to be any equity or inequality impacts.

9.11 Conclusion

9.11.1 The proposed programme has overall no (neutral) or a minor positive health and wellbeing impact for the residents, workers and visitors of Trafford compared to the existing type of street lights being used.

9.11.2 Though there is some research that shows a relationship between exposure to artificial lighting and physical and mental health and wellbeing effects, the research evidence is weak, and these are not likely to occur because of the LED Street Lighting Programme because of the type and intensity of the light likely to be emitted and the low duration and intermittent pattern of exposure to almost all Trafford residents, workers and visitors.

9.11.3 The next chapter identifies some key mitigation and enhancement measures to minimise the potential negative health and wellbeing impacts and maximise the positive impacts.

Table 9.1: Operation phase summary health impact matrix

red = (-) negative impact	green = (+) positive impact	amber = uncertain impact (+ or –)	white = no impact or not identifiable

People affected	Overall	Chronic diseases incl pollution	Physical injury	Mental health and wellbeing	Jobs and economy	Housng and shelter	Transprt and connctvty	Eduction and learning	Crime and safety	Health and other essential services	Shops and retail	Social capital and cmmty cohesion	Arts and leisure	Lifestyle and daily routines	Energy and waste	Land and spatial
Trafford Residents (living and working in Trafford)	~/+	~	~	~/+	~/+	~	~/+	~	~/+	~/+	~	~	~	~	+/++	~
Trafford Residents - having glare in home (only the impacts relevant to this issue have been analysed, other impacts are likely to be similar to the row above, Trafford Residents (living and working in Trafford)	-/~/+			- (if glare in home)												
Trafford Residents, Workers in Trafford and Visitors to Trafford - using dimmed roads - if dimming of street lighting implemented	~/-	~	~	~/- (on dimmed roads, reduced perceived safety)	~	~	~/- (on dimmed roads, increase in road incidents)	~	~/- (on dimmed roads, reduced perceived safety)	~/- (on dimmed roads, more difficult for emergency vehicles and staff)	~	~	~	~		~
Workers in Trafford who live elsewhere (e.g. car commuters, freight lorry drivers, etc.)	~/+	~	~	~/+	~	~	~/+	~	~/+	~	~	~	~	~	~	~
Visitors to Trafford	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
Gender – Women	~	~	~	~	~	~	~/+		~/+/++	~	~	~	~	~/+/++	~	~
Gender – Women - using dimmed roads - if dimming of street lighting implemented	~/-	~	~	~/- (on dimmed roads, reduced perceived safety)	~	~	~	~	~/- (on dimmed roads, reduced perceived safety)	~	~	~	~	~		~
Gender – Men	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~

People affected		Overall	Chronic diseases incl pollution	Physical injury	Mental health and wellbeing	Jobs and economy	Housng and shelter	Transprt and connctvty	Eduction and learning	Crime and safety	Health and other essential services	Shops and retail	Social capital and cmmty cohesion	Arts and leisure	Lifestyle and daily routines	Energy and waste	Land and spatial
Ethnicity	Asian (Indian subcontinent)	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
	Black	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
	East Asian (Chinese etc)	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
	Mixed ethnicity	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
	White (incl. Irish and European)	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
Age	Older people							**~/+**		**~/+/++**					**~/+/++**		
	Older people - using dimmed roads – if dimming of street lighting implemented	**~/-**	~	~	**~/-** (on dimmed roads, reduced perceived safety)	~	~	~	~	**~/-** (on dimmed roads, reduced perceived safety)	~	~	~	~	~		~
	Children and young people							**~/+**		**~/+/++**							
	Children and young people - using dimmed roads – if dimming of street lighting implemented	**~/-**	~	~	**~/-** (on dimmed roads, reduced perceived safety)	~	~	**~/-** (on dimmed roads, increase in road incidents)	~	**~/-** (on dimmed roads, reduced perceived safety)	~	~	~	~	~		~
Disability	Physical	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
	Sensory	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
	Learning	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~

	People affected	Overall	Chronic diseases incl pollution	Physical injury	Mental health and wellbeing	Jobs and economy	Housng and shelter	Transprt and connctvty	Eduction and learning	Crime and safety	Health and other essential services	Shops and retail	Social capital and cmmty cohesion	Arts and leisure	Lifestyle and daily routines	Energy and waste	Land and spatial
	Mental health	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
Faith	Christian	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
Faith	Muslim	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
Faith	Other	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
Other	Unemployed people	~	~	~	~	**~/+**	~	~	~	~	~	~	~	~	~	~	~
Other	People with long term limiting illnesses	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
Other																	

10 Mitigation and Enhancement Measures

10.1 Introduction

10.1.1 The measures described in this section if appropriately considered and incorporated are likely to ensure that the majority of the negative health and wellbeing impacts of the LED Street Lighting Programme are mitigated and the positive health and wellbeing benefits enhanced.

10.1.2 The measures are likely to also ensure that health inequalities are not widened.

10.2 Procurement of the LED lighting systems and its management

10.2.1 Ensure where, within the limits of commercial viability, some future-proofing is written into the procurement contract, such that during the life of the LED lighting systems and its management there is scope for both operational and failed LED lights to be replaced with ones that better meet the changing requirements of local residents needs and the local authority so that environmental and health and safety benefits, within existing/future financial and economic constraints, are maximised over the life of the programme.

10.2.2 Ensure that there are contingency technologies or other appropriate measures written into the procurement contract to deal with glare from the new lighting system coming into local residents' homes.

10.2.3 Check with other councils, particularly those in the Greater Manchester area, to ensure that the best LED lighting system is procured from a combined environmental, health and economic standpoint.

10.3 Design aspects of the LED lighting and technology

10.3.1 The set of measures described listed below are based on a single USA study (see Chapter 7, Paragraph 7.4.3, this has the full list while below only the health-relvant study recommendations are presented) so it may not be directly applicable to the UK context but do address many of the issues raised in the evidence review about mitigating the negative impacts of artificial lighting and LED lighting. Where possible:

- Light colour (Correlated Colour Temperature) should be white, preferably 3,500 Kelvin, but with an adjustable range from 2,800 to 5,000 Kelvin.

- The Colour Rendering Index should be greater than 80.
- The fixtures should be down-firing.
- The LED light source should not be visible to drivers, bicyclists or pedestrians unless they are directly under the fixture.
- The preferred lighting pattern on the ground should be overlapping ovals.
- Basic controls to allow dimming from 6 footcandles (65 lux) to 1.5 footcandles (16 lux) and adjusting colour temperature between 2,800 and 3,500 Kelvin.

10.3.2 Aim to make the LED lighting system poles in keeping, with the wider architectural environment and streetscape in residential areas.

10.3.3 Aim to use existing street light locations on streets and heights of lighting fixtures; and avoid changing the spacing between street lights or moving the location nearer to the boundary of householders properties.

10.4 Construction phase

10.4.1 Ensure that any construction or setting up of the LED lighting is communicated beforehand and undertaken in a manner that reduces any potential disruption to local residents both in terms of access and, more importantly, night-time illumination.

10.4.1.1 Develop a communication plan involving the use of local newspaper and radio, door-to-door leaflets, residents' associations, local community/ voluntary/ charity groups, etc. to ensure local residents' are aware of the construction/setting up and where they can complain and get issues remedied. Ensure that materials are translated into community languages where appropriate (e.g. Urdu for Pakistani communities). Work with community development team to target these materials at relevant communities.

10.4.1.2 Develop a construction/setting up management plan ensuring that sub-contractors are appropriately briefed about what they are doing and why this is being done as well as be briefed on how to ensure that they minimise any disruption to local residents and what to do and who to contact if there is likely to be unanticipated disruption e.g. that street lights could not be switched on, etc. so that the local authority can take remedial action and inform local people about why the street lights are not on or access is disrupted.

10.4.1.3 Have a clear and communicated (within the council and to key local organisational stakeholders as well as local residents through a variety of media; that are in appropriate languages for the local population where appropriate) complaints and grievance procedure with a telephone number, email address and postal address as well as a designated person within the council who will take responsibility and has the authority and power to deal with and resolve local residents' complaints and concerns in a timely manner. A designated council member of staff is important even if the lighting programme is the responsibility of a private sector third party.

10.4.1.4 Ensure a consistent and logical approach to how areas are converted to LED street lights and ensure that locally coherent neighbourhoods have similar lighting i.e. that areas are done once and then not returned to unless there is a technical problem or a residents' complaint.

10.4.1.5 Ensure that the light poles and LED fixtures are installed according to current health and safety standards for lighting; by professional lighting engineers or technicians supervised by lighting engineers; and by a lighting company that has a track record in doing this or similar kinds of work and low numbers of residets compalints in their previous projects.

10.4.1.6 Ensure the implementation phase is linked with the Council Tree Maintenance department to both preserve trees on the streets should extra digging on pathways be required but also to ensure that trees and tall shrubs are not reducing illumination or causing unintended lighting effects.

10.5 Operation phase

10.5.1 Ensure that there is a clear and communicated set of procedures and processes in place within the council to deal with glare into local residents' homes from the new lighting system.

10.5.2 Ensure that glare and any other lighting system issues are resolved within 2 weeks.

10.5.3 Where dimming is considered ensure that:

10.5.3.1 Develop a set of criteria that determines which locations are not dimmed in consultation with local residents and key public and private stakeholders such as emergency services and local businesses.

10.5.3.2 There is initial and on-going, regular two-way dialogue and discussion between residents, residents groups and the council.

10.5.3.3 Monitor key crime, safety and road traffic incident statistics.

10.5.3.4 Consider switching the lights back to normal brightness if there are significant complaints from local residents and alternative options are not able to address residents' complaints.

10.5.3.5 Below is a list of potential locations where street lights could generally remain on at night, based on the approach taken by other local authorities:

- Main traffic routes (dimming of street lights may be introduced if appropriate)
- Locations with above average road traffic night time injury accident record
- Areas provided with CCTV local authority/police surveillance equipment
- Areas with 24hr operational emergency services sites including hospitals
- Pedestrian crossings and subways
- Where there are potential hazards on the Highway (roundabouts, central carriageway islands, build-outs, speed-humps, etc.)
- Where the existing street lighting installation is considered unsatisfactory by virtue of excessive distance between individual street lights
- Where residents, through the consultation process, raise safety or crime and disorder concerns.

11 Monitoring and Evaluation of Health Impacts

11.1 Introduction

11.1.1 This Chapter identifies some useful indicators that could be used to monitor and evaluate the health impacts.

11.1.2 In general, it is difficult to identify routine direct health and wellbeing monitoring indicators such as disease incidence and prevalence rates (numbers of new cases of a disease or health condition; number of existing cases of a disease or health condition) that are:

- specifically linked to only that exposure of concern,
- sensitive enough to detect the localised changes; and
- easy to collect.

11.1.3 This report therefore identifies some possible indirect health and wellbeing indicators. However some are unlikely to be sensitive enough to detect small changes while others will require financial, time and staff resources to collect.

11.2 Monitoring and evaluation

Indicator (Complaint is an actual incident that occurred; concern is a worry about the potential for the incident to occur in the future)	Phase	Type of Data Collected	Recommended Lead Agency/ies
Residents' complaints/concerns about disruption to access or lack of street lighting	Construction	Number and type of complaints by date complained, date construction activity started and ended, postcode, gender, age and disability (of the resident affected if reported by a friend, relative/neighbour of the person affected)	Local Authority Management Company contracted to provide the LED Street Lighting Programme Sub-contractor installing the LED lighting systems
Residents' complaints/concerns about glare or other health and wellbeing related concerns	Operation	Number and type of complaints by date complained, date LED lighting system became operational, postcode, gender, age and disability (of the resident affected if reported by a friend, relative/neighbour of the person affected)	Local Authority Management Company contracted to provide the LED Street Lighting Programme
Pedestrian, cyclist and motor vehicle driver complaints/concerns about glare or other new lighting system issue	Operation	Number and type of complaints by date complained, date LED lighting system became operational, postcode/name of street/road and area where the issue occurred, gender, age and disability (of the person affected if reported by a friend, relative/neighbour of the person affected)	Local Authority Management Company contracted to provide the LED Street Lighting Programme

Indicator (Complaint is an actual incident that occurred; concern is a worry about the potential for the incident to occur in the future)	Phase	Type of Data Collected	Recommended Lead Agency/ies
Residents' representative sample telephone survey – 6 months and 1 year from date of operation	Operation	Questions about whether they like the new lighting or not, why do they like it, what they think about the quality of the light, whether they have had any problems with the light in the last 6months, how could the lighting be improved for them and their neighbourhood	Local Authority Management Company contracted to provide the LED Street Lighting Programme
Complaints/concerns/complaints expressed by other local stakeholders e.g. environmental groups, health groups, residents' associations, business groups, voluntary groups, charities, etc.	Construction	Number and type of complaints by date complained, date construction activity started and ended, postcode/name of street/road and area where the issue occurred, name of person reporting, organisation, type of organisation, organisation's concern/role in bringing this forward	Local Authority Management Company contracted to provide the LED Street Lighting Programme Sub-contractor installing the LED lighting systems
Complaints/concerns expressed by other local stakeholders e.g. environmental groups, health groups, residents' associations, business groups, voluntary groups, charities, etc.	Operation	Number and type of complaints by date complained, date LED lighting system became operational, postcode/name of street/road and area where the issue occurred, name of person reporting, organisation, type of organisation, organisation's concern/role in bringing this forward	Local Authority Management Company contracted to provide the LED Street Lighting Programme

Indicator (Complaint is an actual incident that occurred; concern is a worry about the potential for the incident to occur in the future)	Phase	Type of Data Collected	Recommended Lead Agency/ies
New research findings on LED street lighting and health and wellbeing published in a scientifically and/or governmentally recognised peer-reviewed scientific journal and/or undertaken by a recognised and respected individual/team of scientists.	Operation	Number and type of health issues raised, research team/organisation that undertook the research, the quality of the study methodology and methods used, the finding and their epidemiological significance, feedback from Public Health England on the research, assessment of the implications of the findings in relation to the LED Street Lighting Programme	Local Authority

12 Conclusion

12.1.1 Overall, the proposed LED Street Lighting Programme has overall no (neutral) or a minor positive health and wellbeing impact for the residents, workers and visitors of Trafford compared to the existing type of street lights being used.

12.1.2 Though there is some research that shows a relationship between exposure to artificial lighting and physical and mental health and wellbeing effects, the research evidence is weak, and these are not likely to occur because of the LED Street Lighting Programme because of the type and intensity of the light likely to be emitted and the low duration and intermittent pattern of exposure that almost all residents, workers and visitors.

12.1.3 The measures described in the Chapter 10 if appropriately considered and incorporated are likely to ensure that the majority of the negative health and wellbeing impacts of the LED Street Lighting Programme are mitigated and the positive health and wellbeing benefits enhanced.

Appendix A:

Search Strategy for the Evidence Review

APPENDIX A

Aims of review

The review was conducted to identify the actual and potential health and wellbeing impacts of LED (Light Emitting Diode) street lighting.

Background

A systematic review was not within the scope of this HIA. Instead the search aim was to be broad and encompass as much literature as possible before deciding on the value of including or excluding a source document. This has the potential for greater bias and so wherever appropriate actual extracts from the findings of key documents are presented and all review reports identified have been included in the review.

Review methods

1. This HIA identified key secondary scientific research reviews and primary research articles on the health effects of:
    - LED street lighting
    - LED lighting
    - Artificial light
2. Research studies and surveys of LED street lighting pilots and programmes.
3. Past HIAs on street lighting and LED street lighting.
4. There are many online and print media news articles but these were only used to identify the key words to be used to identify scientific material and to understand the key concerns and benefits identified for LED lighting and LED street lighting.

Search

Google, Google Scholar, Pubmed, Web of Knowledge, Medline and Scopus were searched. With Google and Google Scholar the first 500 serach items were reviewed for relevance. For Web of Knowledge and Scopus all the serach ites were reviewed for relevance.

The main search terms used were:

LED street light/ing health/health impacts
street light/ing health
artificial light/ing health
“light at night” health
“LED street lighting” “health risk”
LED light health risk

"LED street lighting" health

LED artificial leght health effects

LED street lighting sensory visual impairment disability

LED street lighting cause glare in elderly

driver glare from LED lighting

LED street lighting accident study

"LED lighting" brain

LED street lighting trial community surveys

LED street lighting trial assessment report

"LED street lighting" site:gov.uk

health risks indoor lighting

review scientific literature light human health -wind -EMF (- means that the following terms are excluded, in this wind and EMF were exckluded from the serach results)

Search Years

No specific start or end year were used.

Language

Only English language documents were considered.

Inclusion or exclusion criteria

Only reviews and peer-reviewed scientific journal articles written by scientific teams who could be searched for online and verified or sponsored or funded by governmental or other scientifically credible bodies, e.g. American Medical Association, were considered for inclusion in the evidence review.

Evaluation of quality

We did not conduct a systematic quality review of the studies and articles identified in the review as this was beyond the scope of this rapid HIA. As stated previously the aim was to be as broad as possible and to use scientifically credible secondary reviews as filters for the quality of the primary research in this area.

Appendix B:

Health Impact Matrix and Definition of Significance Levels and Criteria for Analysing the Potential Health and Wellbeing Impacts

Health Impact Matrix Template

red = (-) negative impact	green = (+) positive impact	amber = uncertain impact (+ or –)	white = no impact or not identifiable

	People affected	Overall	Chronic diseases incl pollution	Physical injury	Mental health and wllbeing	Jobs and economy	Housing and shelter	Transprt and cnnctvty	Educatn and learning	Crime & safety	Health and social care services	Shops and retail	Social capital and cmmnty cohesion	Arts and leisure	Lifestyle and daily routines	Energy and waste	Land and spatial
	Trafford Residents (living and working in Trafford)																
	Workers in Trafford who live elsewhere (e.g. car commuters, freight lorry drivers, etc.)																
	Visitors to Trafford																
Gender	Women																
Gender	Men																
Ethnicity	Asian (Indian subcontinent)																
Ethnicity	Black																
Ethnicity	East Asian (Chinese etc)																
Ethnicity	Mixed ethnicity																
Ethnicity	White (incl. Irish and European)																
Age	Older people																

People affected		Overall	Chronic diseases incl pollution	Physical injury	Mental health and wllbeing	Jobs and economy	Housing and shelter	Transprt and cnnctvty	Educatn and learning	Crime & safety	Health and social care services	Shops and retail	Social capital and cmmnty cohesion	Arts and leisure	Lifestyle and daily routines	Energy and waste	Land and spatial
	Children and young people																
Disability	Physical																
	Sensory																
	Learning																
	Mental health																
Faith	Faith 1																
	Faith 2																
	Other																
Other	Unemployed people																
	People with long term limiting illnesses																

Definition of significance levels and criteria for analysing potential health and wellbeing impacts

Significance Level	Criteria
Major +++/--- (positive or negative)	Health effects are categorised as a major positive if they prevent deaths/prolong lives, reduce/prevent the occurrence of acute or chronic diseases or significantly enhance mental wellbeing would be a major positive. Health effects are categorised as a major negative if they could lead directly to deaths, acute or chronic diseases or mental ill health. The exposures tend to be of high intensity and/or long duration and/or over a wide geographical area and/or likely to affect a large number of people (e.g. over 500) and/or sensitive groups e.g. children/older people. They can affect either or both physical and mental health and either directly or through the wider determinants of health and wellbeing. They can be temporary or permanent in nature. These effects can be important local, district, regional and national considerations. Mitigation measures and detailed design work can reduce the level of negative effect though residual effects are likely to remain.
Moderate ++/-- (positive or negative)	Health effects are categorised as a moderate positive if they enhance mental wellbeing significantly and/or reduce exacerbations to existing illness and reduce the occurrence of acute or chronic diseases. Health effects are categorised as a moderate negative if the effects are long term nuisance impacts, such smell and noise, or may lead to exacerbations of existing illness. The negative impacts may be nuisance/quality of life impacts which may affect physical and mental health either directly or through the wider determinants of health. The exposures tend to be of moderate intensity and/or over a relatively localised area and/or of intermittent duration and/or likely to affect a moderate-large number of people e.g. between 100-500 or so and/or sensitive groups. The cumulative effect of a set of moderate effects can lead to a major effect. These effects can be important local, district and regional considerations. Mitigation measures and detailed design work can reduce and in some/many cases remove the negative and enhance the positive effects though residual effects are likely to remain.

Significance Level	Criteria
Minor/Mild +/- (positive or negative)	Health effects are categorised as minor/mild whether, positive or negative, if they are generally lower level quality of life or wellbeing impacts. Increases or reductions in noise, odour, visual amenity, etc are examples of such effects. The exposures tend to be of low intensity and/or short/intermittent duration and/or over a small area and/or affect a small number of people e.g. less than 100 or so. They can be permanent or temporary in nature. These effects can be important local considerations. Mitigation measures and detailed design work can reduce the negative and enhance the positive effects such that there are only some residual effects remaining.
Neutral/No Effect ~	No health effect or effects within the bounds of normal/accepted variation.

EDINBURGH
HEAD OFFICE

Research Avenue North
Riccarton
Edinburgh, EH14 4AP
United Kingdom
Telephone: +44 (0)131 449 8000
Facsimile: +44 (0)131 449 8084

LONDON
IOM CENTRE FOR HIA

Research House Business Centre
Fraser Road
Perivale, Middlesex, UB6 7AQ
United Kingdom
Telephone: +44 (0)208 537 3494
Facsimile: +44 (0)208 537 3493

CHESTERFIELD

Taptom Park Innovation Centre
Brimington Road, Tapton
Chesterfield, Derbyshire, S41 0TZ
United Kingdom
Telephone: +44 (0)1246 557866
Facsimile: +44 (0)1246 551212

STAFFORD

Brookside Business Park
Cold Meece
Stone, Staffs, ST15 0RZ
United Kingdom
Telephone: +44 (0)1785 764810
Facsimile: +44 (0)1785 764811

Email: iom@iom-world.org