The effects of exposure to natural light in the workplace on the health and productivity of office workers: a systematic review protocol

Protocol for the degree of Master of Clinical Science within The Joanna Briggs Institute, Faculty of Health Sciences, The University of Adelaide

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June 2010
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Review question/objective

The objectives of this review are to examine studies that evaluate offices with windows to the external environment which permit the entry of natural light on the health and productivity of the workers as monitored by output, staff turnover, sickness and absence from work and measures of their health status.

The specific question to be answered:

• Do office workers with exposure to daylight experience better general health?
• Do office workers with exposure to daylight demonstrate a higher productivity of work output?

Definitions

For the purpose of this study office workers are defined as people working in an office environment as opposed to a factory, school or retail facility. Office workers within other facilities may be included, however this population must be able to be considered discretely.

It is anticipated that office workers will be adults over 18 years of age.

Background

Human beings spend a large amount of time indoors and with the increase in the use of computers for both business and recreational purposes, the potential for sedentary, indoor life increases. Office workers form a large percentage of the healthcare workforce and a large percentage of the business world. Human resources form a significant percentage of business expenses. It follows that the efficient use and sustainability of this resource is of benefit to the business, the personnel in it and the wider business and economic world.

Minimising cost is always a consideration and a greater one at times of economic crisis. Globally we are all aware of the increased need for environmental responsibility and the necessity to conserve our resources and consider the sustainability of our planet as a whole. These two factors come together when considering the productivity of our greatest business resource (human resources) along with the initial, running and maintenance costs of the structures we build and utilise (material and energy costs) and the financial and practical considerations of sustaining these in the longer term. It makes sense that we should
be building healthy and sustainable environments that will suitably accommodate our human resources so that they might function at sustainable, optimum levels.

**People and light**

At different times in the world’s history human beings have spent more or less of their time in the sun. In the 1600s in Europe people dressed to cover their whole bodies, a pale skin was desirable and people stayed out of the sun. It is estimated that in this period 90% of children suffered with rickets to some degree caused by acute vitamin D deficiency.\(^3\) It is the fear of the detrimental effects of sunlight exposure that has driven people out of the sun, particularly in Australia during the early 1980s with the increase in skin cancers.\(^3\) The cover up and ‘SunSmart’ campaigns and policies have been so successful that exposure to direct sunlight is in most of the population is quite minimal. Many people with cancer and multiple sclerosis also have low Vitamin D levels, although it has not been established if this is a contributing cause or a symptom.\(^3\)

Sunlight emits different types of ultra violet radiation (UVR); ie. (a) UVA which makes up approximately 95-97% of the UVR reaching earth, penetrates the skin and can contribute to skin cancers; and (b) UVB which causes sunburn but also enables the synthesis of Vitamin D.\(^3\) Mead suggests that spending a few minutes outdoors each day with skin exposure to direct sunlight is sufficient for the human body to synthesise healthy levels of Vitamin D.\(^3\) While glass (windows) reduce UVB radiation significantly (by approximately 95%\(^4\)), receiving this though glass over a longer period of time is preferable to not receiving it at all. Boubekri suggests that people are not exposed to sufficient sunlight, even in climates enjoying long sunlight hours and that the optimum quantity of sunlight people require should be established.\(^4\) Vitamin D deficiency has been linked as cause of, or being present in, many other ailments including cancers other than melanoma, multiple sclerosis, psoriasis, hypertension and some cardiac abnormalities.\(^3\) Stevens links reduced sunlight with health issues that include reduced melatonin levels, stress, fear, sleep deprivation, changes in menstrual cycle length and oestrogen and the impact of these things on the risk of breast cancer.\(^5\) Stevens also discusses links between blind persons with increased light exposure and lower risk of breast cancer, concluding that the benefit of light exposure is beyond the light received visually.\(^5\)

There are a number of benefits of exposure to natural light. As well as its necessity for Vitamin D synthesis, daylight also plays a critical role in maintaining circadian rhythm.\(^6\) Sunlight is the trigger for melatonin creation and release which is vital to regulating circadian rhythms. It has been demonstrated that people treated for melanoma have improved recovery if they continue to have some direct sunlight exposure and it is suggested that a lack of light exposure causes an alteration in melatonin production.\(^3\) Human beings have been designed to function optimally with light during the day (suppressing melatonin production) and complete absence of light at night. The body produces melatonin when there is an absence of light and it is melatonin that allows us to sleep.
People tend to feel better, more cheerful and energised in daylight. Lack of sunlight was recognised with the discovery of Seasonal Affective Disorder (SAD) in the early 1980s. SAD is most prevalent in latitudes higher than 30 degrees when daylight hours are short. Those suffering SAD may be gloomy and lack energy and may also have difficulty concentrating, withdraw socially and experience difficulty sleeping.

As human beings we are designed for bright daylight exposure and require complete darkness for sleeping to function with optimum sleep levels, happiness, health and fitness. There is no doubt that sunlight exposure is beneficial to health and a necessity, but a dilemma is: how much is enough and when it is too much?

**People and buildings**

It has been estimated that human beings spend between 80% and 90% of their lives indoors. More than one third of the Netherlands's workforce work in offices and it has been found that 20% of these workers suffer health complaints. In general, office staff work upward of seven and a half hours each day, with some break times. With the majority of office work occurring during the day, office workers may have limited available daylight hours. Available daylight hours vary depending upon location (latitude on the globe), season and the time of year. Weather conditions also impact on the amount of available light.

In the 1980s the “Sick building syndrome” received significant attention. This syndrome is related to the quality of air in a building, generally due to gaseous by-products of plastics products used in finishing the building, new furnishings and new furniture that are due to a low introduction of additional outside air leading to symptoms of headache, lethargy, tiredness and poor concentration. Availability of daylight is not one of the key building associated with “Sick building syndrome”, however, as conventional fluorescent lighting has been identified as a factor causing eyestrain and headaches lighting that does not cause glare or flickering and as much daylight as possible is recommended.

**Lighting in buildings**

Prior to the 1950s daylight was the primary source of lighting the interior of buildings. Buildings were planned and in built shapes designed to maximise available daylight, eg. ‘X’ shaped buildings in London, which had more external walls exposed to the sky and daylight. The depth of penetration of light from a window into a building was considered to be approximately 16 feet (5 metres), space located further away from natural light than this was considered to be inadequately lit.

The focus of the building design industry was initially based on the ‘right to light’, an ancient Roman law which dictates that once you have enjoyed light through a window for a minimum of 20 years that you then have a right to continue to enjoy that light, thus preventing others from building in ways that obstruct light. Both Percy J Waldram and John Swarbrick developed visual representations of light received, or
loss of light, through a window, primarily to demonstrate defence of this law in court. As early as 1913 the Illuminating Engineering Society of the United States of America (IES) formulated levels of lighting (measured by ‘foot candles’) required for safety issues and productivity. Levels of lighting for different types of activities were recommended. During World War II companies voluntarily increased illumination to increase productivity so enforcement of codes was not as necessary. The building industry was significantly altered in the 1950s with the invention and ability to mass-produce the fluorescent light tube. This changed the world of building design. No longer were high ceilings required to allow larger windows for maximum light. Ceilings were lowered to 9’ 6” (2.9 metres), which enabled more building area, with multiple floors, on a given ground space. Building environments in the 1960s focused on electric lighting and controlled conditions. Corner offices with light and views were typically occupied by senior executives and more general office staff were deprived of exposure to windows. In the late 1960s an emerging trend toward buildings admitting little or no daylight were constructed which had a dramatic effect on mental alertness, productivity and psychological well being. In 1965 the “congress of occupational medicine stated that humans do not need natural lighting in work environments” (p1). A series of studies were conducted by the Herschong Mahone Group between 1999 and 2003 examining the effect of natural light on telephone call centre workers, school students and retail shoppers with findings of increased productivity, performance and sales correlated with the introduction of daylight.

Crone suggests that many architects overlook, do not appropriately understand and under utilise natural lighting, particularly the dynamic nature of daylight and its variability in different seasons and countries. It is only in the last two decades that this is becoming easier with the availability of more complex computer modelling. In 1991 Kendrick argued that the variability of daylight should be recognised and considered in design beyond the base level overcast grey skies of Great Britain and Northern Europe.

Windows and lighting have been considered in varying ways in the history of buildings design, with consideration of environmental and cost saving issues. To achieve energy efficiencies daylighting has been used for the primary purpose of illumination as it is estimated that 30-50% of the energy cost in office buildings is spent on lighting. There has also been a move away from extensive windows with thought to save on heating costs.

Phillips suggests that “[l]ight is as much a building material as the structure of which it is made” and that considerations of the indoor environment requires thought regarding sunlight and air quality. Boyce recognises that lighting in buildings should not be considered only for visual impact as the spectral content of daylight stimulates both visual and non-visual systems. Windows are not the only way of providing daylighting to buildings, “[a]tria have the potential to provide environmental (and sustainable) solutions to the energy performance of buildings.” A major part of this is replacing or supplementing artificial light with daylight.
The 1990 'Light and Health' study was released with the main finding that daylight was crucial for the health of working people and around this time legislation was introduced in Germany and the Netherlands to ensure that office workers were required to be within 10 metres of a window to allow adequate daylighting for each worker.

Lighting is a very complex issue as light glare or 'discomfort glare in the working environment' is of importance and can be detrimental in offices particularly with the increased use of computing screens. It is difficult to design with computing in mind as computers are portable and positioning may change at different times in the building's life. Glare and reflection are impacted not only by colours and surfaces of the environment but also by furniture.

**People, buildings and productivity**

People are the major asset and expense of a company. Lippiatt estimates that employee salaries are about 13 times the building cost. It stands to reason that this resource be managed for optimum productivity, efficiency and sustainability. Productivity costs are difficult to quantify and assess as they are not clearly visible. Generally, non-productivity is not accounted for in accommodation expense. Even a minor productivity gain or loss has major cost consequences. Health should be the concern of the business as well as the employee as absenteeism represents a high cost to any business. Sick leave can be considered to be a 100% loss of productivity and gains can be made if this is minimised. The mental health and well being of workers should also be considered to maintain a sustainable work force. Known factors that influence the mental and physical health of staff should be considered and recognised.

It is more satisfying for workers when their output is of a quality that they can be proud of. Given an option most people would prefer not to be sick. Recognising these factors as a starting point can be of benefit to business. If there are opportunities to improve the satisfaction and happiness of workers in a viable way, productivity increases and staff turnover (also a significant business cost) decreases. Boubekri suggests that, "...buildings that don't admit sunlight provoke disease, either directly or indirectly" (p128). Therefore, admitting daylight to the work area may "...increase worker satisfaction and productivity while slashing energy costs".

Phillips suggests that it is "...impossible to judge the need for daylight and sunlight in engineering terms alone, the human factor is at least of equal importance." This is demonstrated by the results of the following case studies of businesses examined by Romm.

In 1993 a new Wal-mart building was erected in Oklahoma. It was designed with half daylighting via skylights in one half of the building. Sales tracking later showed that "sales pressure (sales per square foot) was significantly higher for those departments located in the day-lit half of the store." This significant increase was supported by existing sales data which was compared with data from the same departments and products in other Wal-mart stores.
In 1983 a redevelopment of the Lockheed Building 157 (p8) was completed. It was designed for energy-conscious day lighting. The energy savings covered the cost of the improvements in just over four years. Officials reported productivity gains of 15% on the first major project (p9). Productivity data for these and other cases examined by Romm were derived from data already captured, not tracked specifically following the refit or redevelopment. The authors concluded that these gains were realised by improving “visual acuity and thermal comfort” (p13).

A much cited study suggests that post-operative hospital patients with a nature view take fewer painkillers and recover faster than patients without a view. This suggests that the view from the window may be as, or more, important than daylight alone.6

**This systematic review**

There is some evidence demonstrating the effect that natural light exposure within office space has on the health and productivity levels of office workers. No systematic reviews addressing this topic have been identified. However, a literature review conducted in 2002 provides a narrative summary of selected studies relating to natural light and effects on building occupants that includes literature up to and including 2001.29

More recently ‘green buildings' have been designed for economic benefit while reducing environmental impact. Considerations include daylight, to reduce cost of electric lighting, and improved air circulation.

There is significant literature relating to the level of lighting optimum to perform specific tasks. Consideration should be given to any specific benefit of having daylight as opposed to simply ‘good lighting’ suitable for the task performed. Many types of alternative electric lighting are available, some that resemble natural daylight, but do they have the same impact on health and well being as natural lighting?

This review will examine the literature and impact of natural lighting specifically in relation to the health benefits to office workers.

"Although my investigations focus on trends in quantitative recommendations, it is necessary to evaluate those trends in the context of qualitative needs and assumptions. After all, quantitative recommendations are made in light of qualitative aspirations." (p1)16

**Inclusion criteria**

**Types of participants**

This review will consider studies that include adults who work in an office environment. It is anticipated that all study participants will be over 18 years of age and regularly working in an office or office-like
environment.

Studies considering effects on night-shift office workers will be included with outcomes considered separately from day-time office workers.

Studies that consider regular part-time or full-time workers will be included in the review. This review will consider studies including males and females regardless of any pre-existing medical conditions. However, participants with pre-existing medical conditions will be examined in a sub-group analysis.

**Types of intervention**

For the purpose of this the office environment is considered to be an administrative work place as opposed to a factory, school or retail facility. Office workers within other facilities may be included, however this population must be able to be considered discretely.

The review will consider studies that evaluate office space with windows, skylights, atria or any facility allowing exposure to daylight from the external environment with or without a nature view compared to office space without facility to allow exposure to daylight and having lighting provided exclusively by electric light sources. i.e.

- **Intervention:** office space with windows, skylights, atria or any facility allowing exposure to daylight from the external environment with or without a nature view
- **Comparator:** office space without facility to allow exposure to daylight and having lighting provided exclusively by electric light sources.

**Types of outcomes**

This review will consider studies that include health and work productivity outcome measures for office workers.

- Health outcomes measured by sickness and absentee rates, and measures of health status (e.g. the SF-36 or SF-12 health status measures), and quality of life measurements;..
- Work productivity outcomes measured by one or more of the following (but not limited to): work outputs, sickness and absenteeism, staff retention and turnover rates

**Types of studies**

As the review question is not suitable for study by randomised controlled trial as study participants are unable to be blinded to the intervention, experimental research designs will be considered for inclusion such as non-randomised controlled trials, case control studies as well as before and after studies to enable the identification of current best available evidence regarding the impact of the availability of
external windows, skylights, atria and other facilities allowing natural light in office areas in relation to the health and productivity of workers.

**Review methods**

**Search strategy**

The search strategy aims to find both published and unpublished studies in English language. A three-step search strategy will be utilised in each component of this review. An initial limited search of MEDLINE and PsycINFO will be undertaken followed by analysis of the text words contained in the title and abstract, and of the index terms used to describe the article. A second search using all identified keywords and index terms will then be undertaken across all included databases.

Thirdly, the reference list of all identified reports and articles will be searched for additional studies.

The databases to be searched include:

- MEDLINE
- PsycINFO
- CINAHL
- API /RIBA
- Avery index to architectural periodicals
- Business Source Complete
- Emerald Fulltext
- The Campbell Library
- CSA Sociological Abstracts
- Social Service Abstracts
- Scopus
- EPOC

The search for unpublished studies will include:

- Current Contents
- Dissertation Abstracts International
- Mednar
- Google (using government domain filter)
Initial keywords to be used will be:

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<tr>
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<th>Outcome</th>
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Searching will not be time limited due to the long history of building and daylighting, all studies relevant to the review question are to be included. However it is to be recognised that the study will be limited by ability to access full text of older studies. The systematic review will also be limited to studies available in English language due to the cost of translational resources.

**Assessment of methodological quality**

Papers selected for retrieval will be assessed by two independent reviewers for methodological validity prior to inclusion in the review using standardised critical appraisal instruments from the Joanna Briggs Institute Meta Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI). Refer to Appendix I. Any disagreements that arise between the reviewers will be resolved through discussion, or with a third reviewer.

**Data collection**

Data will be extracted by the review author from papers included in the review using the standardised data extraction tool from JBI-MAStARI (Appendix II). The data extracted will include specific details about the
intervention, population, study methods and outcomes of significance to the review question and specific objectives.

Data synthesis

Papers will, where possible, be pooled in statistical meta-analysis using the Joanna Briggs Institute Meta Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI). All results will be subject to double data entry. Odds ratio (for categorical data) and weighted mean differences (for continuous data) and their 95% confidence intervals will be calculated for analysis. Heterogeneity will be assessed using the standard Chi-square. Where statistical pooling is not possible the findings will be presented in narrative form.

Results of the systematic review will be assigned levels of evidence, in-line with the levels developed by the Joanna Briggs Institute (refer Appendix III).

Conflict of interest

No conflict of interest to declare. However, it should be noted that the author/primary reviewer currently works in an office that has no external windows.

Acknowledgements

Special thanks to Derrick Kendrick who was willing to share a career of background knowledge to assist me in understanding a little more about daylighting and the building design field.

References


## Appendix I - Appraisal instruments

### MASIARI Appraisal instruments

**Assessment for: Name of Assessment**

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<td>3) Was allocation to treatment groups concealed from the allocator?</td>
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<td>4) Were the outcomes of people who withdrew described and included in the analysis?</td>
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<td>O</td>
<td>O</td>
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<tr>
<td>5) Were those assessing outcomes blind to the treatment allocation?</td>
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<td>6) Were the control and treatment groups comparable at entry?</td>
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<td>7) Were groups treated identically other than for the named interventions?</td>
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<td>8) Were outcomes measured in the same way for all groups?</td>
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<td>9) Were outcomes measured in a reliable way?</td>
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<td>4) Are confounding factors identified and strategies to deal with them stated?</td>
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<td>5) Are outcomes assessed using objective criteria?</td>
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<td>6) Was follow up carried out over a sufficient time period?</td>
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<td>7) Were the outcomes of people who withdrew described and included in the analysis?</td>
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<td>8) Were outcomes measured in a reliable way?</td>
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## Assessment for: Name of Assessment

**Type:** Primary  
**User:** Default  
**Design:** Descriptive / Case Series Studies

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<td>4) Were outcomes assessed using objective criteria?</td>
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<td>5) If comparisons are being made, was there sufficient descriptions of the groups?</td>
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## Appendix II - Data extraction instruments

MASIARI data extraction instruments

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Court, A

Daylight and office worker health: systematic review protocol

16
**Study Information**

**Method**

**Setting**

**Participants**

**# Participants**

Group A: [ ]  Group B: [ ]

**Interventions**

Interventions A: [ ]

Interventions B: [ ]

**Authors**

Conclusion: [ ]

**Reviewers**

Comments: [ ]

**Complete**

No [ ]

Yes [ ]

Save Details

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**Study Information**

**Method**

**Setting**

**Participants**

**# Participants**

**Interventions**

**Authors**

Conclusion: [ ]

**Reviewers**

Comments: [ ]

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Yes [ ]

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## Appendix III – Levels of evidence

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<td>Metasynthesis of research with unequivocal synthesised findings</td>
<td>Metasynthesis of research with unequivocal synthesised findings</td>
<td>Meta-analysis (with homogeneity) of experimental studies (eg RCT with concealed randomisation) OR One or more large experimental studies with narrow confidence intervals</td>
<td>Metasynthesis (with homogeneity) of evaluations of important alternative interventions comparing all clinically relevant outcomes against appropriate cost measurement, and including a clinically sensible sensitivity analysis</td>
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<tr>
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<td>Metasynthesis of research with credible synthesised findings</td>
<td>Metasynthesis of research with credible synthesised findings</td>
<td>One or more smaller RCTs with wider confidence intervals OR Quasi-experimental studies (without randomisation)</td>
<td>Evaluations of important alternative interventions comparing all clinically relevant outcomes against appropriate cost measurement, and including a clinically sensible sensitivity analysis</td>
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<td>3</td>
<td></td>
<td>a. Metasynthesis of text/opinion with credible synthesised findings</td>
<td>a. Metasynthesis of text/opinion with credible synthesised findings</td>
<td>a. Cohort studies (with control group) OR b. Case-controlled studies OR c. Observational studies (without control group)</td>
<td>Evaluations of important alternative interventions comparing a limited number of appropriate cost measurement, without a clinically sensible sensitivity analysis</td>
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<td></td>
<td></td>
<td>b. One or more single research studies of high quality</td>
<td>b. One or more single research studies of high quality</td>
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<tr>
<td>4</td>
<td>Expert opinion</td>
<td>Expert opinion</td>
<td>Expert opinion</td>
<td>Expert opinion, or physiology bench research, or consensus</td>
<td>Expert opinion, or based on economic theory</td>
</tr>
</tbody>
</table>