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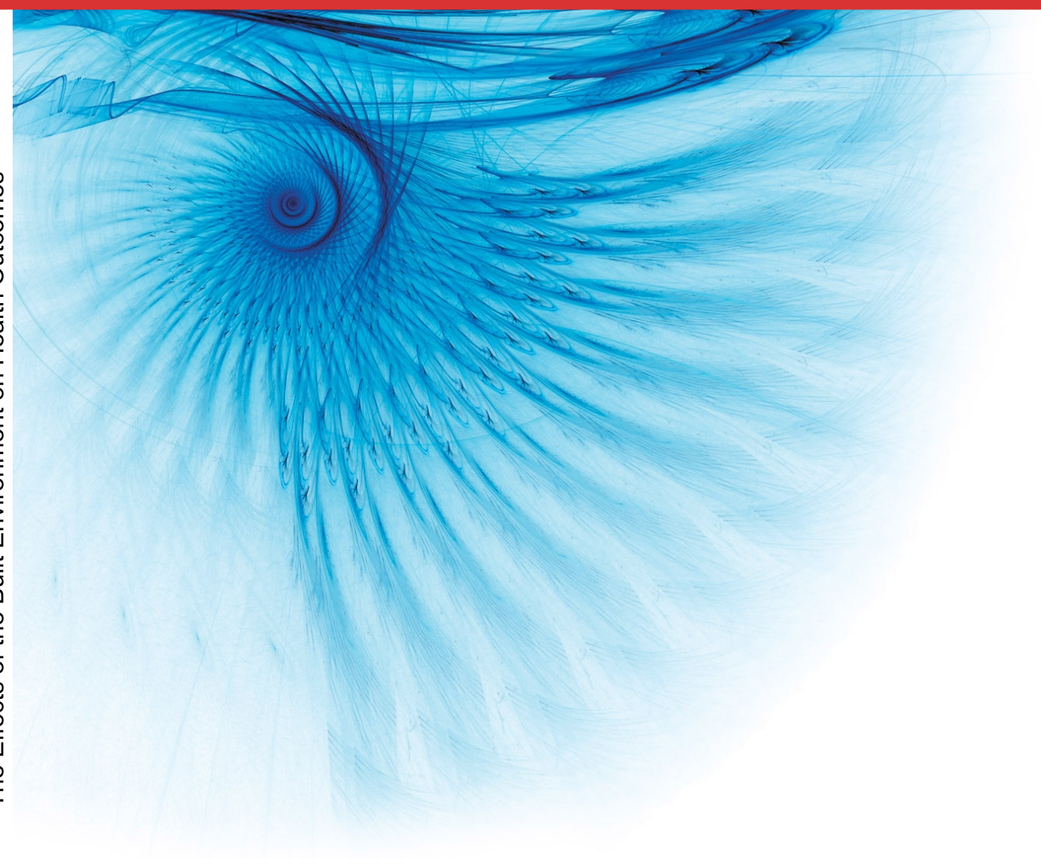
HaCIRIC
Health and Care Infrastructure Research and Innovation Centre

The Effects of the Built Environment on Health Outcomes

Research Report



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Health and Care Research and Innovation Centre

HaCIRIC is providing a strategic capability that helps create the tools and processes to embed innovation as normal business throughout healthcare infrastructure suppliers and users.

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THE EFFECTS OF THE BUILT ENVIRONMENT ON HEALTH OUTCOMES

RESEARCH REPORT

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October 2008

salford centre for research & innovation
in the built & human environment
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THE EFFECTS OF THE BUILT ENVIRONMENT ON HEALTH OUTCOMES

Research Report

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EXECUTIVE SUMMARY

Main Findings

- In the last 10 years, evidence-based policy and practice has been widely investigated to support decisions in different branches of socio-environmental sciences;
- There is a need for reliable evidence to support the prevailing belief that higher investment in initial phases of healthcare infrastructure projects reduces the life cycle costs and improves, in the long term, service delivery and patient experience;
- Although the use of systematic literature reviews in socio-environmental sciences is growing, the differences between its application in medical research and socio-environmental research has not yet been properly understood;
- There are several theories that explain how the (built) environment impacts on humans. Although there is no agreement in the theoretical debate, the identified theories assume that humans are psychologically affected and subsequent physical and physiological outcomes may occur;
- The subject of investigation in this research is multi-disciplinary. There is considerable variation in the conceptual and practical understandings of the issues involved in the relationships between the built environment and health outcomes. The existence of varying theories, concepts, terms and taxonomies causes confusion. In the literature is possible to identify concepts with different meanings. This contextual configuration imposes difficulties in aggregating the findings from different pieces of research;

Limitations

In the course of this review, several limitations emerged:

- A lack of explicit cause and effect relationships was identified; several studies used correlational relationships that may not take into account possible bewildering variables.
- There is no commonly agreed methodology for measuring the variables composing the built environment. There does not seem to be a strong enough understanding of the commonplace relationships between built environment factors being measured, the actions and behaviours to those factors and individual health outcomes.
- The generalisation of research findings can be restricted as different patient groups may experience the same conditions differently.
- There are too many possible design variations and combinations to be tested experimentally.
- Research methods generally adopted for gathering evidence fail to demonstrate cause-effect relationships between measurable variables, with existing research being too linear (single dependant variable) and reliant upon proxy indicators. This is a fundamental limitation and must drive any future evidence based research and policy responses.

Recommendations

- Although evidence-based practice has been deeply discussed in the medical field, the application of this approach to building design still needs further clarification. For instance, how evidence can be used to inform designers during the design process remains an issue. Thus, more theoretical debates about the implications of using evidence in the design process are needed.
- Generally, literature reviews on the impacts of the built environment on health outcomes present a short description of studies. Although, they are informative, they lack transparency in presenting the details (i.e. patient groups) which are necessary for decision making in design. Therefore, more systematic and transparent ways of gathering/presenting information should be developed.

Research Gaps and Future Agenda

- There is a substantial amount of information available in relation to the impact of the built environment on health outcomes. However, there is little information regarding how an evidence-base could be used to inform designers. The development of more "transparent" tools for managing information could be an idea for future developments.
- Due to the number of variables associated with the built environment and health outcomes, and the complex relationships between them, cause and effect relationships are not clear. Therefore, the development of a theoretical framework that considers not just isolated elements of the built environment (e.g. light, ventilation, colour) but also design compositions is necessary;
- The evidence-base approach uses empirical data to prove or disprove theoretical assumptions. The use of other research strategies to support the evidence-based approach should be investigated (for example, rationalist and phenomenologist epistemologies);
- Further investigation is needed to understand how knowledge management tools and techniques can be applied to inform designers about the existing evidence-base;
- To build an evidence-base about how changes in the operation of healthcare facilities can improve healthcare delivery is needed;
- Further research is needed to investigate how evidence supports existing theories of building design.
- This report contributes to an overview of the evidence-based policy and practice and the adaptation of systematic literature review techniques from medical to socio-environmental research. It also contributes to a broad picture of the research related to built environment and health outcomes.

Report Structure

This report is structured in 7 sections, organised as follow:

- The first section presents a brief introduction to the development of healthcare infrastructure in the UK and how evidence-based policy and practice is related to the improvement of healthcare delivery;
- The second section presents the research method used to conduct the research;
- The third section presents a discussion about evidence-based approach in medical research and its application to infrastructure design;
- The fourth section presents a discussion about systematic literature reviews;
- The fifth section presents theories which explain how the built environment impact on humans;
- The sixth section presents the variables which can be used to describe the built environment, patient status and health outcomes;
- The seventh section presents a discussion regarding the challenges for research, final considerations and conclusions.

1 INTRODUCTION

In the UK there is currently a need to improve healthcare delivery. The Department of Health (DOH, 2004a) has established the following goals: a) reduce waiting time, b) reduce patient length of stay in hospitals, c) reduce use of medicine, d) increase staff time per patient in hospitals, e) increase staff work effectiveness, and f) improve the NHS experience for patients.

To support the achievement of these goals, the UK government has been investing considerably in the improvement of healthcare delivery. The refurbishment and development of new healthcare facilities is part of the plan for achieving the targets. The development of new facilities has stimulated discussions about effective design for healthcare facilities.

Several aspects have been the focus of discussion about new healthcare facilities, e.g. the provision of healthcare facilities through public-private partnerships and the development of a business model for healthcare delivery. Increasingly, the focus is on well-being and meeting community needs. For example, leisure facilities have been developed alongside primary healthcare buildings aiming to stimulate healthier lifestyles and prevent illnesses. Such concepts tend to increase building complexity as new functions are included.

There are also other factors impacting on the development of healthcare facilities. One example is the increasing need for building flexibility, triggered by issues like the development and introduction of new technologies (e.g. materials, equipment) (Kendall 2005). Demand for services is another influencing factor. Due to population growth in the UK, more beds are necessary (Lawson and Phiri, 2004). New specialised units, such as cancer and diabetes units, need to be provided. Therefore, healthcare facilities should be able to accommodate service delivery flexibly as well as new technologies in future expansions.

Considering these aspects, i.e. a new program for development, higher product flexibility and constant change in demand, the complexity of the decision making process related to the development of healthcare facilities has increased (Tzortzopoulos *et al.* 2005). Therefore, academics and practitioners have engaged in debate about how to improve the process of designing new facilities. This has led to research aiming to investigate the use of scientific evidence to support decisions within the design process. This method has been called evidence-base design (Malkin, 2003; Ulrich *et al.*, 2004; Ulrich *et al.*, 2008).

Evidence-based design is an approach derived from evidence-based medicine (Malkin, 2003). A designer using an evidence-base, together with an informed client, makes decisions based on the best information available from research and project evaluations. This is a method applicable to many types of building projects, but is currently being used in the healthcare industry to help decision-makers (Malkin, 2003).

Research looking at the impact of the built environment in health outcomes has been used to build up an evidence-base (Academic journals such as Environment and Behavior and the Journal of Environmental Psychology have discussed the subject for many years. More recently, evidence has been made available by the Center for Health Design in the US – www.healthdesign.org). Such research is based on the assumption that the built environment can impact on humans' behaviour and influence people psychologically and physically (Proshansky *et al.*, 1976).

There are several theories (e.g. Proshansky *et al.,* 1976; Sundstrom *et al.,* 1996; and Lawson, 2001) which aim to explain how the built environment may affect humans in different ways. For instance, the environmental overload hypothesis assumes that humans have a finite capacity for processing stimuli and information and predicts that we cope with sensory or information overload through selective attention and ignoring low-priority inputs (Sundstrom *et al.* 1996).

However, such theories have been developed within different research fields (e.g. architecture, sociology and psychology). Therefore, different frameworks have been used to map out the connections between

the built environment and health outcomes. For instance, Ulrich and Zimring (2004), in their literature review, observed different aspects in the built environment that can improve staff work conditions and healthcare service. They also investigated features that may improve patient safety and reduce stress. Devlin and Arneill (2003) investigated evidence according to eight aspects of the built environment (including music, windows, views, art, light and colour) and their effect on health outcomes. Chaudhury *et al.* (2005) also explored this subject considering hospital managerial aspects as an input. Zeisel (2003) and Passini *et al.,* (2000) investigated how the built environment affects Alzheimer's patients.

Hospitals have been the main focus of attention in this research area and there is a great variety of subjects and methods that have been used (Daykin and Byrne 2006). This is a consequence of the complexity of hospital buildings, composed of a large number of different settings designed to support people with varied conditions. Due to such variety, there is confusion, fragmentation and lack of clarity in the knowledge base.

Considering this context, the aim of this report is to discuss the development of an evidence-base related to the impact of the built environment on health outcomes.

This report is structured is as follows: Firstly, the research method and an overview of the evidence-based approach and the process of systematic literature review is given. Then the features and characteristics of the built environment that may affect patient's health are presented. The patient variables which may affect the evidence are discussed and a brief discussion regarding health outcomes is presented. Finally, the challenges of research are discussed and conclusions are presented.

1.1 Aims and Objectives

The aims and objectives of this report are:

a) To discuss the evidence-base approach and its application to socio-environmental science;

b) To discuss systematic literature reviews and its use in socio-environmental research;

c) To investigate theories and variables which connect and explain the relationship between the built environment and health outcomes;

d) To develop a theoretical framework to map the variables linking the built environment and its impact on health outcomes.

1.2 Research Questions

The questions forming this research are:

1. What is the evidence-based approach and how does it apply to infrastructure design?
2. What is Systematic Literature Review and how does it applies to the socio-environmental research?
3. Which variables are involved in relationship between the built environment and health outcomes?
    a. Which features of the built environment have been investigated in previous research?
    b. How can health outcomes be measured?
    c. Which are the patient characteristics which may affect the health outcomes?
4. What are the challenges related to the construction of an evidence-base about healthcare building affecting health outcomes?

2 RESEARCH METHOD

The aim of this research was to investigate: which features are related to the construction of an evidence-base; what constitutes a systematic literature review, how the built environment affects health outcomes; and which existing theories explain this phenomenon.

The overall strategy adopted for this research is a literature review. However, due to differences amongst the research questions, different techniques were used to conduct the literature review. According to Cooper (1998) literature reviews can be categorised according to the research objectives – the main purposes being:

a) To present a theoretical debate regarding a specific phenomenon; and

b) To synthesise the results of empirical studies.

The objective of a theoretical review is to present the theories offered to explain a particular phenomenon and compare them in breadth, internal consistency, and the nature of their predictions. Theoretical reviews may contain descriptions of critical experiments already conducted or suggested, assessments of which theory is most powerful and consistent with known relations, and sometimes reformulations or integrations of abstract notions from different theories (Cooper 1998).

The theoretical literature approach was considered appropriate to investigate the theories explaining the connection between the built environment and health outcomes as well as to investigate the evidence-based approach because there is no consensus amongst existing theories (Sundstrom *et al.*, 1996).

According to Cooper (1998), literature synthesis has a focus on empirical studies and seeks to summarise past research by drawing overall conclusions from many separate investigations that address related or identical hypothesis. The research 'synthesist' aims to present the state of knowledge concerning the relation(s) of interest and to highlight important issues that research has left unsolved (Cooper 1998). In relation to this, it has been considered that the use of a systematic literature review adds rigour to the review process.

Another reason for the use of a systematic literature review in this research relates to the fact that this research was proposed as a continuation of an earlier project focused on construction of an evidence-base for building design and its impacts on health outcomes. The objective of that research was to synthesise the literature on this topic. The previous research reported difficulties associated to the use of systematic literature reviews for themes with wide scope. Although this research has also a wide scope, some aspects of the systematic approach were considered useful in the conduction of this work. More details about the research method are presented in the following.

The starting point of this review was to establish the method to identify and organise the large amount of information available. The identification of the steps for conducting systematic literature reviews are presented in section 4 of this report.

The first aspect in conducting a systematic literature review is the identification of 'key' publications presenting the state of the art in the field. Three main sources were found: Devlin and Arneill (2003); Ulrich and Zimring (2004); and NHS Estates (2005). From these publications, 293 journals were identified (Appendix 02). This information provided an initial overview of the areas of interest and fields of research investigating the impact of the built environment into health. This information was used in the development of a theoretical framework for data collection.

The second aspect was the establishment of the research steps to be systematically followed by the research team. The research steps were based on the research on design and health outcomes and included: **a)** the investigation of database availability; **b)** the selection of available databases; **c)** the selection of keywords **d)** the establishment of the criteria for the inclusion and exclusion of references; and **e)** the establishment of quality criteria for the assessment of references.

The selection of electronic databases in which to search (developed in the research about the effects of design into health outcomes references) followed

these steps: screening available databases; selection of potentially useful databases by subject areas; initial search to evaluate usefulness of each pre-selected database

(keywords: health or hospital or patient AND architecture or environment or design AND research or data or evaluation). In total, 14 databases were selected, but only 07 data bases were searched (see Table 1)

Table 1. Searched databases

Data base	Description
ASSIA – Applied Social Sciences Index and Abstracts (via CSA*)	Indexing and abstracting database covering health, social services, psychology, sociology, economics, politics, race relations and education. Updated monthly, ASSIA provides a comprehensive source of social science and health information for the practical and academic professional. Contains over 255,000 records from 650 journals in 16 different countries, including the UK and US.
CINAHL – Cumulative Index to Nursing Allied Health (via Ovid)	Bibliographic database which covers over 900 nursing, allied health and biomedical journals. Of particular use for physiotherapy and occupational therapy.
DAAI – Design and Applied Arts Index (via CSA)	A comprehensive database of design and craft journals covering 450 titles. It contains over 100,000 annotated references, as well as information on over 40,000 designers, craftspeople, studios, workshops, firms etc.
Article First, ECO, Worldcat (via First Search - OCCL)	http://www.oclc.org/support/documentation/firstsearch/databases/dbdetails/details/ArticleFirst.htm
HMIC - Health management information Consortium (via Ovid)	Health Management Information Consortium – Consists of 3 databases, DH-Data, HELMIS, and Kings Fund Database. Abstracts are available on the following subject areas health service and hospital administration and management, public health, community care, service development and NHS organisation.
MEDLINE (via Ovid)	Contains bibliographic citations of biomedical literature, including all foreign languages. Covers the whole spectrum of medicine, referencing over 3700 journals from 70 countries.
NHS Estates – Safer Environment Database, efm-evidence, Bryan Lawson and Michael Phiri	Data base developed University of Sheffield

The selection of keywords was based on the preliminary keyword list based on the scoping study about design and health outcomes. In that research, a discussion with a group of researchers involved in the subject area was used to refine the keyword list.

The resulting list was used in this research and they were classified into health-related, research method-related, built environment related, outcome-related, design-related, and others. Table 2 presents the list of the selected key-words.

Table 2. Selected key-words

1 – Health	2 - Research	3 - Built environment
(Heal* OR Medical OR Patient OR Care OR Therap* OR Stress OR Recovery OR Treat* OR Diagnos*)	(Research OR Outcomes OR Data OR Evaluation OR (Evidence and based) OR Strategy OR Effectiveness OR Dimensions OR (Post and Occupancy) OR Evaluat*)	(Hospital OR Environ* OR Ambient OR Cent?? OR Facilities OR Setting OR Design OR Architecture OR (Built and environ*))
4 - Outcome	5 - Design	6 - Others
(Perspective OR Percep* OR Satisfaction OR Safety OR Friendly OR Social OR Interac* OR Behavi*r OR (User and Needs))	(Garden OR Noise OR Landscape* OR Windows OR (Way and Finding) OR Colo*r OR Music OR Light* OR Texture OR Acoustics OR Smell OR (Nature or Natural))	(Art OR Music OR PFI OR Lift OR PPP)

The automatic criteria for inclusion or exclusion of studies considered that included references would have at least one of the keywords in each category, i.e. health, research, built environment, perception, design and others. The Boolean operator "and" was used between categories and "or" between words in each category. "*" was used for truncation.

It is important to report that a short glossary of terms was developed in parallel with the establishment of the keywords. The development of a glossary was necessary due to the multidisciplinary nature of the field. The glossary is presented in Appendix 01.

The result of the first search within six databases (ASSIA, CINAHL, DAAI, OCCL, HMIC and MEDLINE) resulted in 624 abstracts. The Safer Environment Database (NHS Estates 2005) was used as a second source of information. This database presents the abstracts of more than 500 papers related to the investigated subject.

The manual criteria for inclusion or exclusion of studies were used to select the resultant references. The criteria used are highlighted in

Table 3. The manual process of reference selection was based on reading the abstracts of selected papers. Additionally, a set of quality criteria was established aiming to assess the quality of the selected papers (Table 4). .

Table 3. Manual inclusion criteria

N – Inclusion Criteria
01 – Hospital or Clinic setting (healthcare environment)
02 – Qualitative or quantitative
03 – Theoretical or empirical
N – Exclusion Criteria
01 - Nothing pre-1980 (except for recommended papers)
02 – Not literature reviews
03 – Not related to offices

Table 4. Quality assessment criteria

Quality assessment criteria					
Element	Level				
	0-Absence	1-Low	2-Medium	3-High	Not applicable
Background	The article does not provide enough information to assess this criterion	Poor awareness of existing literature and debates. Under or over referenced Low validity of theory.	Basic understanding of the issues around the topic being discussed. The theory weakly is related to data.	Deep and broad knowledge of relevant literature and theory relevant for addressing the research. Good relation theory-data	This element is not applicable to the document or study.
Method	The article does not provide enough information to assess this criterion	Data inaccuracy and not related to theory. Flawed research design.	Data is related to the arguments, though there are some gaps. Research design may be improved.	Data strongly support arguments. Besides, the research design is robust: sampling, data gathering, data analyses is rigorous.	This element is not applicable to the document or study.
Findings use	The article does not provide enough information to assess this criterion	The ideas are difficult to implement or consider as an input in designing the building.	It's possible to use the information available in the paper, but data needs to be deployed.	Data is ready for designers' consideration in designing the building.	This element is not applicable to the document or study.
Generalisation	The article does not provide enough information to assess this criterion	Only to the population studied.	It is possible to generalise to population of similar characteristics.	High level of generalisation.	This element is not applicable to the document or study.

The following step of the literature review was to establish the framework for data collection. Therefore, a first framework was developed with the objective of mapping cause and effects relationships (Figure 1). The framework considered built environment features and characteristics as causal elements and physiological and physical outcomes were considered as effects. The framework also considered physical outcomes caused by psychological effects stimulated by the built environment.

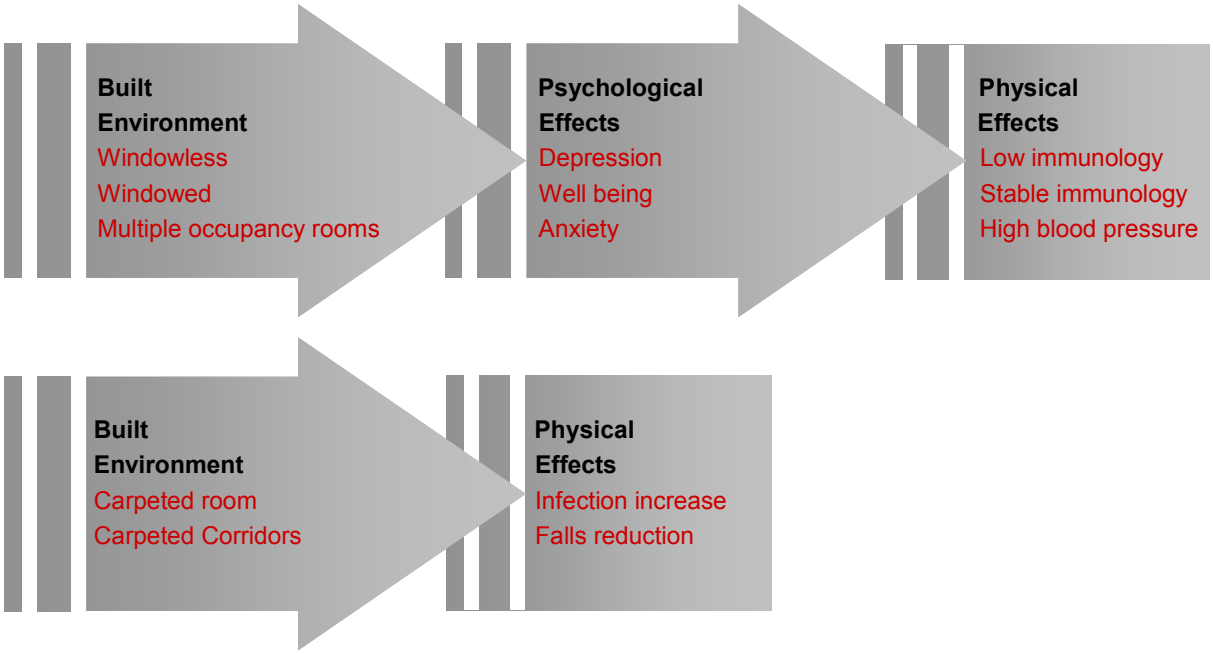

Figure 1 - Framework of cause and effects relationships

After a few attempts at using the framework, it was considered inappropriate. The main reasons were:

- Cause and effect relationships were not clear. For instance, research has been conducted looking at indirect evidence. Examples of indirect evidence are: the built environment causing stress on staff and consequently affecting the delivery of healthcare and impacting on patients' satisfaction (e.g. Ulrich *et al.*, 2004). Another example is noise, which is caused by the use of the built environment and causing sleeplessness of patients (e.g. Ersser *et al.,* 1999).

- The definition of 'built environment' and 'health outcomes' varies in the literature. The impact of features related to the built environment (such as noise, wayfinding and temperature) on health outcomes have been investigated (Altman, 1993). However, the connections between these features with the physical characteristics of the built environment have not been addressed – making it difficult and sometimes impossible to identify the root cause;

- Different research methods have been used to measure similar outcomes. For example, Lawton (2001) conducting research about environments for people with Alzheimer highlights that data can be gathered from surveys, questionnaires and direct observations. According to Lawton (2001) the debate about research method remains opened because there are too many design variations to be empirically tested and also because "*…the interface of person and environment in real situations may be simply too complex to capture in a linear experimentally controlled test*."

As a consequence, a second framework was developed (Figure 2). The objective of this framework was to group the studies according to their knowledge area rather than the built environment characteristics. The framework considered four different areas of knowledge (ergonomics, fabric and ambient investigated, aesthetic and services) and three categories of patients' outcomes (psychological, physical and physiological outcomes).

The second theoretical framework was also considered inappropriate because many relevant aspects presented in the selected abstracts and papers were not considered (e.g. patients' condition, which includes: age, gender and acquired illness or injury). Patients' condition was considered as a third group of variables to be integrated in the framework because it has been shown that the outcomes from a specific built environment characteristic may vary according to patients' configuration. For instance, artificial light may cause damage in preterm babies' vision, but not in adults (Miller *et al.* 1995; Joseph, 2006).

Two other frameworks with different emphasis emerged during the research process. For instance, frameworks considering problem-solving paradigm, problem-orientation and cause-sub-cause and effect relationships were developed and considered inappropriate. These frameworks are presented respectively in the Appendix 4 and 5.

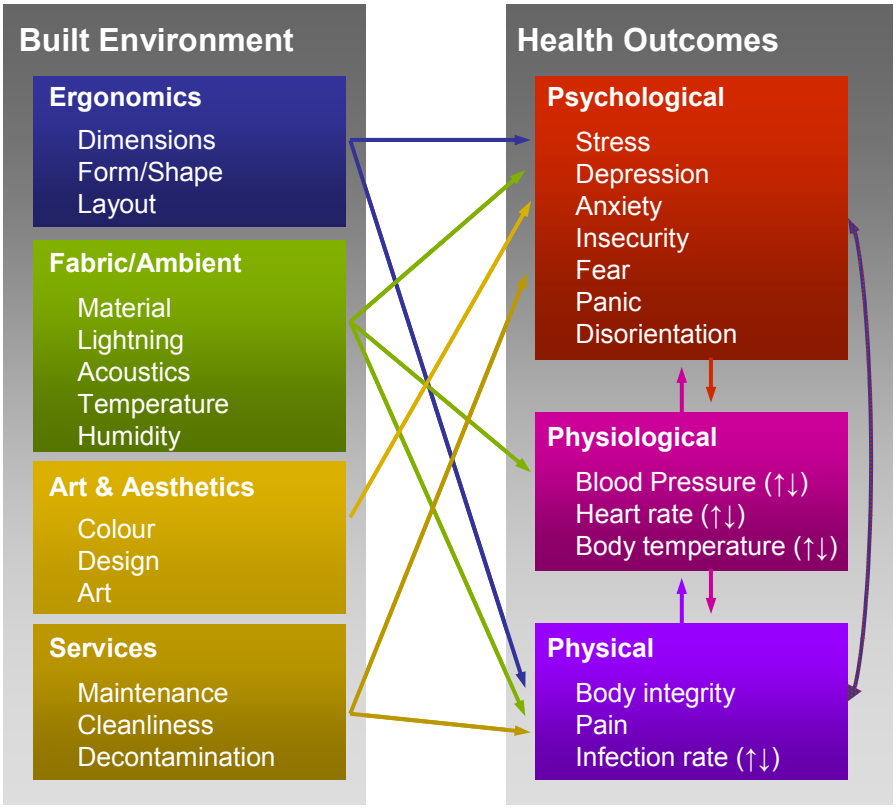

Figure 2. Knowledge areas and health outcomes framework

At this stage, the research took a different direction due to the impossibility of establishing causal relationships. As a consequence, instead of looking at how the built environment impacts health outcomes, the research objective began to map out the variables that have been made explicit in the existing literature. This map was developed using a MS Excel spreadsheet (Appendix 13). The variables were classified as follows:

- Patients' condition, which included the illness, age, gender, and pre or post clinical intervention;
- Built environment setting, characteristics and features;
- Health outcomes, considering direct (e.g. depression and blood pressure) and indirect measures (e.g. length of stay and the reduction of the use of medicines).

To denote relationships between variable, a smiling face (☺) was used to show a positive impact, a sad face (☹) was used to show negative impact, (☺/☹) was used to show both positive and negative impacts, and the empty (∅) sign was used to show no positive or negative impact (neutral). The relevance of the outcome was not considered;

- An additional item related to publication quality was added based on the quality assessment criteria presented in Table 4.

Variables connecting the built environment and patient health outcomes were mapped in different levels of analysis. The analysis considered the elements and features identified in the selected abstracts and papers. In total, 176 features, elements and variables of built environment, health outcomes and patients condition were identified. The identified variables are presented in the sections 6.1, 6.2 and 6.3.

With a pre-understanding about variables and relationships linking the built environment to health outcomes, the next step of the research was to understand how evidence could be used to inform decision makers. Thus, a review about evidence-based practice was conducted and it is presented in the next following section.

3 EVIDENCE-BASED POLICY AND PRACTICE

The objective of this section is to highlight aspects related to evidence-based policy and practice. These include the definition of evidence-based policy and how evidence has been used to inform designers.

The 'evidence-based' approach has been used in different fields of research. In medical research, for example, it has been developed to determine which methods are most effective for treating health conditions (Cook *et al.* 1997a). The evidence-base may provide enough information for a clinician to safely change from a traditional treatment to a new, more effective one. Any cause and effect relationships must be clearly stated and all variables involved in the investigated phenomenon should be made explicit.

The approach has also been used within other areas including education (e.g. Reed *et al.* 2005), economics (e.g. Pignone *et al.* 2005) and the development of healthcare facilities (e.g. Ulrich, 2000). The investigation of the effects of building design on humans resulted in an approach called evidence-based design (Malkin, 2003). According to Fischl (2006) this approach aims to provide scientific evidence to fill the designer's knowledge gap about humans' social and behavioural attitudes. In this sense, the researcher works as an interpreter investigating and describing human behaviour, wants and needs (Fischl, 2006).

The construction of an evidence-base (in medical research) is usually based on systematic literature reviews. In brief, systematic literature reviews have the objective of compiling existing research looking at specific scientific studies which address similar issues (according to the subject's relevance and/or the researchers' interest), using similar methodological approaches and measuring equivalent variables. Systematic literature reviews are further described in the following section.

3.1 The use of evidence to support design decisions

In the context of healthcare projects, evidence-based design has been used by designers in different ways. According to Hamilton (2007), architects can use the evidence- based approach on four levels. At level 1, practitioners make an effort to stay up to date with the existing literature and design specification is based on current available information. At level 2, practitioners go further hypothesising the outcomes and measuring them. The results are used to evaluate their design proposals and improve future proposals. At level 3, additionally to the previous steps, practitioners publish their findings in the public arena. Finally, at level 4, practitioners also publish their findings in quality journals that require review by qualified peers. Hamilton (2007) has also mentioned the existence of a level 0, which relates to the misuse of the evidence-based approach. In this sense, practitioners use disconnected pieces of evidence to support the bias in their design proposals.

Regarding the role of designers, it is clear that the process of translating research into useful designs is crucial. The verification of whether these translations deliver the intended outcomes is equally important (Hamilton, 2007). The evidence-based approach has been used to support design decisions in early stages of the product development process (e.g. in the concept generation). At the concept generation stage, scientific information has been used to help designers and stakeholders to establish the building program configuration (i.e. the number of bedrooms, wards, waiting areas and their characteristics). Evidence has been also used in later stages such as project evaluation to assess the design solutions (DOH, 2007).

Although evidence-based design has been promoted as an approach to support design decisions, there is little information about the process of how evidence has been collected and used. One of the few tools

that have been developed in the UK to deal with concept development is IDEA (Inspiring Design Excellence & Achievements) (DOH, 2007).

IDEA is a tool which compiles evidence-based information that is presented in terms of examples and recommendations to architects and design consultants. This tool consists of presenting pictograms and pictures of healthcare environments within nine categories: arriving, bath, beds, circulating, consulting, shopping, sanctuary, social and waiting. In each category key recommendations are presented with a basis on scientific evidence. Figure 3. shows the user interface of IDEA.

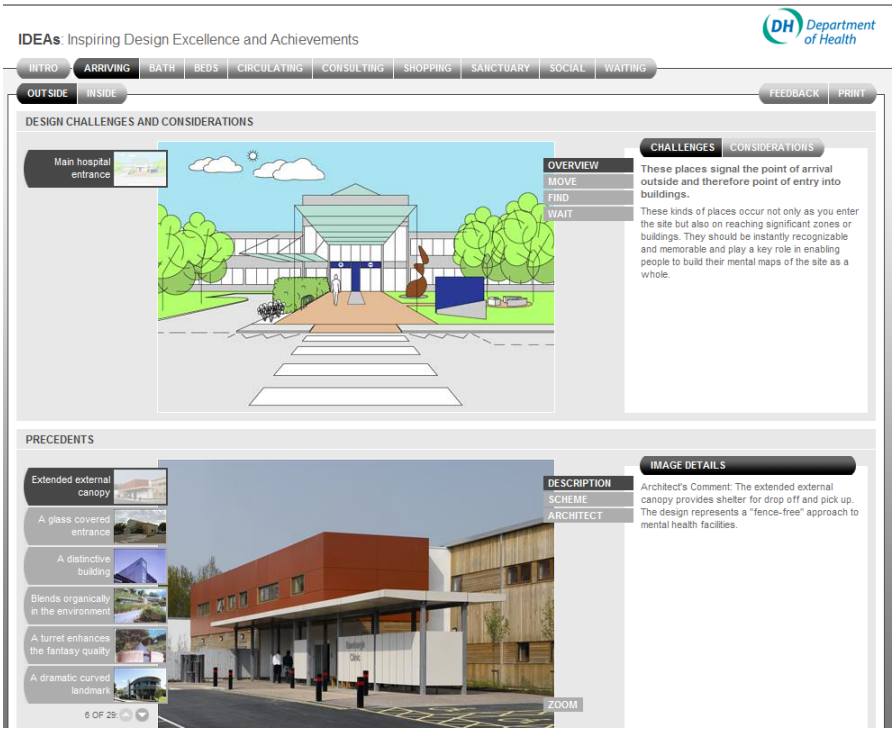

Figure 3. Sample of the IDEA's interface (available at www.ideas.dh.gov.uk/places.asp?m_id=a1)

In relation to project evaluation, scientific information has been used to provide the parameters for building and project assessment. The main objective of the assessment is to improve existing healthcare facilities or design proposals through the identification of weaknesses (NHS Estates, 2005).

In the context of healthcare projects in the UK, there are two evidence-based tools developed by the NHS to evaluate design solutions: AEDET (Achieving Excellence Design Evaluation Toolkit); and ASPECT (A Staff and Patient Environment Calibration Tool).

AEDET was developed to evaluate the building performance and the relationship between the facility and its surrounding urban area. The objective of AEDET is to assist Trusts and the NHS in determining and managing their design requirements from initial proposals through to post project evaluation. Generally it has been used as a benchmarking tool, and forms part of the guidance for ProCure21, PFI (Private Finance Initiative), LIFT (Local Finance Initiative Trust) and conventionally funded schemes (NHS Estates, 2005). AEDET uses ten key criteria in the evaluation process (NHS Estates, 2007). These criteria are summarised below.

- USES: Service philosophy, functional requirements and relationships, workflow, logistics, layout, human dignity, flexibility, adaptability and security.
- ACCESS: Vehicles, parking, pedestrians, disabled people, wayfinding, fire & security.
- SPACES: Space standards, guidance and efficient floor layouts.
- CHARACTER AND INNOVATION: Excellence, vision, stimulation, innovation, quality and value.

- CITIZEN SATISFACTION: External materials, colour, texture, composition, scale, proportion, harmony, and aesthetic qualities.
- INTERNAL ENVIRONMENT: Patient environment, light, views, social spaces, internal layout and wayfinding.
- URBAN AND SOCIAL INTEGRATION: Sense of place, sitting, neighbourliness, town planning, community integration and landscaping.
- PERFORMANCE: Daylight, heating, ventilation, air conditioning, acoustics, passive thermal comfort.
- ENGINEERING: Emergency systems, fire safety, engineering standardisation and prefabrication.
- CONSTRUCTION: Maintenance, robustness, integration, standardisation, prefabrication, health & safety.

Using the same approach, the use of scientific evidence to support and evaluate design solutions, the NHS has also developed ASPECT. This tool has been used as a complement to AEDET and focuses on the quality of the healthcare facility for staff and patients. Generally, the evaluation is based on the impact of eight aspects of the built environment into client satisfaction, health outcomes and staff work effectiveness (NHS Estates, 2005).

To assess facilities and design proposals both AEDET and ASPECT use a score system based on the scoring and weighting of statements extracted from an evidence-base. The statements are grouped according to different aspects related to the facility. Each aspect has an average of 5 evaluating statements. Figure 4 and Figure 5 illustrate an output from AEDET and ASPECT respectively.

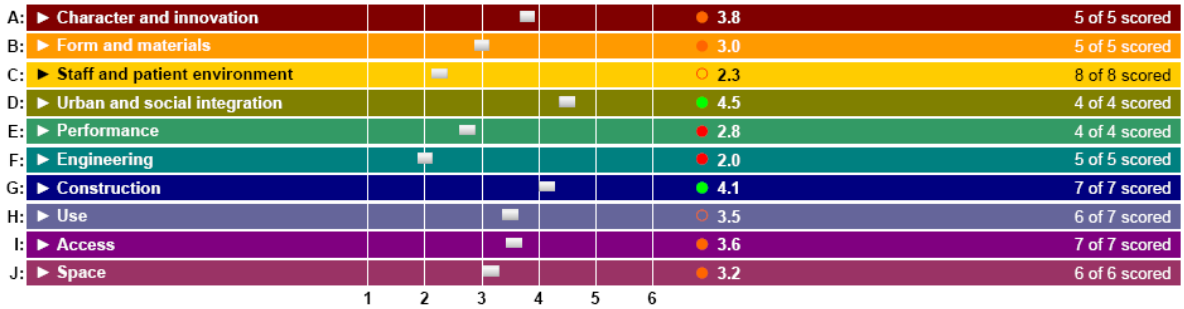

Figure 4. AEDET example output from the Microsoft Excel spreadsheet version (NHS Estates, 2005)

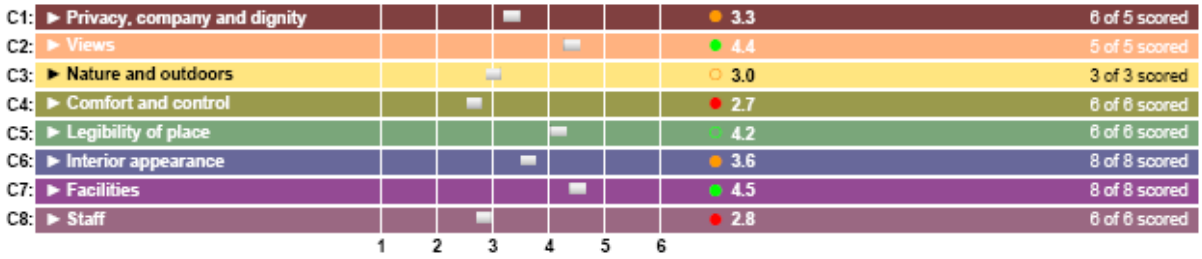

Figure 5. ASPECT example output from the Microsoft Excel spreadsheet version (NHS Estates, 2005)

The difference between AEDET and ASPECT is the focus of evaluation. In AEDET this is on architectural, engineering and urban features. ASPECT has a focus on the qualitative features of the facility. Although IDEA, AEDET and ASPECT tools are available, the process of how designers are using evidence to support design decisions is not clear in the literature. For example, design solutions in general are associated with performance specifications rather than health outcomes.

There is a lack of knowledge on how evidence can be deployed in design performance specifications. Also, the design process may involve thousands of decisions and it is not clear to what extent evidence can support design decisions. Finally, the evidence-based approach seems suitable for repetitive processes where evidence is used to justify change

from a standard practice. However, does building design need to be so repetitive? It has been shown that there is a demand for more flexible spaces in hospitals. Is it not contradictory to specify a design solution with a predicted outcome?

4 SYSTEMATIC LITERATURE REVIEW

This section presents an overview of systematic literature reviews (or systematic review) in the process of developing an evidence-base. The aim of this section is to clarify the main aspects of systematic literature reviews and to highlight the differences between using systematic reviews in medicine and design research. The main source of information is the Annals of Internal Medicine (Academia and Clinic – Systematic reviews series) and the ESRC series on Systematic Reviews.

Systematic literature review is an approach that has been used in different areas of knowledge (e.g. medicine, education and design) with the aim of dealing with the difficulties of integrating the results of different pieces of research. In medical research, the method was developed to help physicians to treat rare illnesses where very little information about possible treatment routes was available. In this sense, something was considered as evidence if at least two pieces of similar empirical research (e.g. treatment trials) demonstrated equal or similar outcomes. Difficulties associated with the identification of very similar studies triggered the development of a systematic approach.

The difference between systematic reviews and traditional narrative literature reviews relies on the adoption of a replicable, scientific and transparent reviewing process. The rigour related to systematic reviews aims to minimise bias through exhaustive literature searches of published (e.g. journal papers and books) and unpublished information (e.g. from e-mails and conversations with experts) and by providing an audit trail of the reviewer's decisions, procedures and conclusions (Cook *et al.* 1997b; Tranfield *et al.* 2003).

The use of systematic literature reviews has been associated with the creation of an evidence-base. An evidence-base should be consistent; therefore, the use of a systematic approach is important in establishing whether scientific findings are reliable and can be generalised across populations, within different settings, and under different treatment (Mulrow 1994).

Mulrow (1994), for instance, presents several reasons why to adopt systematic literature reviews, which include:

- To reduce large quantities of information into smaller batches;
- To integrate critical pieces of available information;
- To conduct the review in a systematic and replicable base;
- To increase the possibility of establishing generalisation;
- To assess the consistency of the studied relationships;
- To explain data inconsistencies and conflicts in data;
- To increase the statistical strength of the review through the use of quantitative methods (e.g. sensitive-analysis and meta-analysis);
- To increase precision in estimates of risk or effect size;
- To increase accuracy and improve reflection of reality.

CRAG (1996) summarise the benefits of using systematic literature reviews in two main points. The first relates to the limitations of traditional reviews and the second relates to the added strength obtained by synthesising the results of smaller studies.

It is evident that the use of a systematic approach to review the literature increases the possibility of generating good results. However, to conduct a systematic review is not an easy task. In the literature (e.g. Mulrow *et al.* 1997b, Mulrow and Cook, 1997, and Boaz, 2002) there are important issues that arise when developing systematic literature reviews, including: the definition of the research question, the selection of the cases and the integration of heterogeneous research.

First, according to Mulrow *et al.* (1997b) and Mulrow and Cook (1997), the definition of the research question is one of the most important and crucial issues. According to these authors, the first point is to establish the relevance of the subject to be investigated. The assessment of relevance can be done by submitting the first "draft" idea of the research question to a panel of experts. The feedback might be important to give focus and direction to the investigation. Subsequently, the research question should be sharply defined and include all variables to be investigated. Mulrow *et al.* (1997a) recommends the development of integrative frameworks to map out cause and effect relationships to understand the whole issues involved in the research to be done.

Once the research question is defined, the second part of conducting a systematic literature review is the definition of the criteria for case(s) selection. Meade and Richardson (1997) establish six main features which should be considered in including and appraising cases:

1. The definition of the research question;
2. The selection of the variables to be considered, for instance, the patient and his/her characteristics such as treatment (intervention) and outcome;
3. The type(s) of study design (e.g. case studies, experiments, interviews);
4. Type and form of publication (e.g. peer reviewed journal (ideally), abstracts), avoiding duplications and including papers published in different languages;
5. Appraisal of the variables, for instance, the kind of patient, i.e. low, medium or high risk; the periodicity of the treatment, i.e. frequency, degree and duration; and the outcome, i.e. definitions, degree and surveillance;
6. The quality of the research method, considering for instance, sample sizes, methods used to measure outcomes, appropriate description of the patient and his/her diagnosis. The methodology is most important because, according to (Meade and Richardson 1997), the methodological features of different investigations have been shown to influence the results of studies about therapy;

Meade and Richardson (1997) recommend the use of a protocol which can be considered as a check list to remember the inclusion and exclusion criteria and also to keep track of the decisions made during the research process. In medical research, for instance, the consideration of these features is very important because any difference may be an important source of variation among study results. There are also important issues related to the integration of the research results. According to Mulrow *et al.* (1997a), regardless of whether reviewers are synthesizing direct or indirect evidence[1], many factors can modify etiologic and prognostic associations, diagnostic accuracy, and therapeutic effectiveness. This is because study participants are often drawn from various settings and have a wide spectrum of baseline risk[2], disease severity, and socio-demographic and cultural characteristics.

Mulrow *et al.* (1997a) also emphasises that exposures, diagnostic strategies, interventions, and comparison groups have varying formulations and intensities. Also, different outcome measures are used in different studies, and similar outcomes are measured or reported differently. Various study designs are used, and heterogeneity of methodological features occurs within a given design. Although such heterogeneity may stimulate confidence by allowing assessment of general consistency and applicability, it may also increase uncertainty (Mulrow *et al.* 1997a).

The heterogeneity that can be found among studies is an important issue. For instance, the omission of population or setting details may generate a false idea of similarity amongst the selected cases. However, some heterogeneity is permitted in systematic reviews and there are methods to deal with heterogeneous pieces of research. These include the development of frameworks establishing cause and effect relationships or, in the case of rare single bodies of evidence, the use of narrow inclusion criteria (Mulrow *et al.* 1997a). Thus,

[1] Direct evidence in medical research links an exposure, diagnostic strategy, or therapeutic intervention to the occurrence of a health outcome. On the other hand, evidence is indirect if two or more bodies of evidence are required to link the exposure, diagnostic strategy, or intervention to the health outcome Mulrow *et al.* (1997b).

[2] Baseline data: The set of data collected at the beginning of a period of study. ("baseline data" A Dictionary of Public Health. Ed. John M. Last, Oxford University Press, 2007. Oxford Reference Online. Oxford University Press. University of Salford. 11 September 2008 http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry=t235.e352)

statistics are used for validation and generalisation. In medical research, meta-analysis is a method that has been largely used to integrate research results.

Meta-analysis is a statistical method used to combine results from different studies into a single summary estimate. In medical research, the use of meta-analysis can increase power and precision of estimates of treatment effects and exposure risks (Mulrow, 1994; CRAG, 1996). However, Pignone *et al.* (2005) states that in some types of research the use of meta-analysis may not be possible, leading researchers to adopt other methods to analyse research results.

Independent of the field or area of research the challenges of conducting systematic literature reviews are related to five main issues including: formulating the right question, identifying studies related to the investigated topic, selecting the studies that are related to the investigation, assessing the studies and synthesising the results (Bravata *et al.* 2005; Chou and Helfand 2005; Hartling *et al.* 2005; Pignone *et al.* 2005; and Reed *et al.* 2005).

In summary, systematic literature reviews have been used for research with a well-defined, narrow question. All variables affecting cause and effect (i.e. outcomes) must be made explicit. There are issues related to the integration of heterogeneous pieces of research, which have been tackled through the use of statistical methods such as meta-analysis. This approach has been mainly used in medical research; however it has been also used in research on the effects of the built environment into health outcomes (e.g. Hickam *et al.,* 2003 and Dijkstra *et al.*, 2006). The systematic literature review should follow a well established procedure in terms of keeping track of the decisions made throughout the research process. An example of steps of systematic literature reviews is presented in the following section.

4.1 Steps of a Systematic Reviews

The following section describes generic steps to be followed in a systematic literature review (Cochrane Collaboration 2001; NHS 2001; Tranfield *et al.* 2003) which include: a) planning the review, b) conducting the review and c) reporting and disseminating. These stages are further described below.

Planning the Review

According to the Cochrane Collaboration (2001), the NHS (2001), and Tranfield *et al.* (2003) planning the review involves three main steps: a) the identification of the need for a review; b) the preparation of a proposal for a review; and c) the development of a review protocol.

Prior to beginning the review, a review panel should be formed including experts in the areas of theory and methodology, as well as practitioners. In addition, in some fields as management, it is necessary to conduct scoping studies to assess the relevance and size of the literature and delimit the subject area or topic. This also includes a brief overview of the theoretical, practical and methodological debates surrounding the field.

Further recommendations are based on the definition of the review question and organisation of a review protocol. The review question is important to systematic reviews as other aspects of the process flow from it. The protocol will be the document that contains the information concerning the specific questions addressed by the study, the sample that is the focus of the study, the search strategy for identification of relevant studies, and the criteria for inclusion and exclusion of studies in the review (Davies and Crombie, 1998). An example of a protocol is presented in Appendix 7.

Conducting the Review

According to Cochrane Collaboration (2001), NHS (2001), and Tranfield *et al.* (2003) the next stage is when the literature review is done (i.e. the papers, books and other sources of information are collected and selected and information is extracted from them). This stage involves the following steps: a) the identification of the research; b) the selection of studies; c) the study quality assessment; d) data extraction and monitoring progress; and e) data synthesis.

Firstly, a systematic search should begin with the identification of keywords and search terms acquired from the scoping study, the literature and discussions within the review team. The search strategy should be reported in sufficient detail to ensure that the search could be replicated. Searches should include published journals, bibliographic databases, unpublished studies, conference proceedings, industry trials and even personal requests to known investigators. The output of the search will be a list of papers that met all the inclusion and exclusion criteria.

Today, literature resources are available in databases, the researcher can perform complex searches using Booleans operators such as “and”, “or” and “not” and possible truncations in some

words (e.g. behavi*r retrieving behaviour and behavior or percept* retrieving perceptual, perception, perceptional and perceptive).

Secondly, the researcher should conduct a review of all potentially relevant citations identified in the search. Relevant sources should be retrieved for a more detailed evaluation of the full text and from these some can be included in the systematic review. Any inclusion and exclusion should be reported in the research protocol including the reasons for exclusions (Cochrane Collaboration 2001; NHS 2001; Tranfield *et al.* 2003).

Third, a quality assessment should be carried out. The quality assessment refers to the appraisal of a study for internal validity and the degree to which its design, conduct and analysis have minimized biases and errors (Cochrane Collaboration 2001; NHS 2001; Tranfield *et al.* 2003). Individual studies in systematic review are judged against a set of predetermined criteria and checklists to assist the process (Oxman, 1994). Dealing with qualitative research, the researcher should consider a range of criteria that might be used to appraise and evaluate studies such as the presentation of the theoretical background (Cochrane Collaboration 2001; NHS 2001; Tranfield *et al.* 2003).

Fourth, the researcher should start the data extraction and monitoring progress. To reduce human error and bias, systematic literature reviews must employ data-extraction forms. These forms often contain general information (title, author, publication details), study features and specific information (population characteristics, context of the study and an evaluation of the study's methodological quality) and notes on emerging themes coupled with details of synthesis. Links to other concepts, identification of emerging themes, and key results and additional notes also need to be included on the data-extraction form (Cochrane Collaboration 2001; NHS 2001; Tranfield *et al.* 2003).

Finally, the research synthesis is the collective term for a family of methods for summarizing, integrating and, where possible, cumulating the findings of different studies on research topic (Mulrow 1994; Tranfield *et al.* 2003). Research synthesis can vary between narrative reviews and meta-analysis. In medical research, meta-analysis has been used to aggregate the research results (Mulrow 1994). In management research interpretive and inductive approaches have been used to synthesise results. Tranfield *et al.*, 2003 argue that interpretive and inductive methods, realist synthesis and meta-synthesis and derived methods have been developed to fill the gap between narrative reviews and meta-analysis.

Reporting and Dissemination

This stage involves not just reporting the findings, but also the establishment of recommendations based on the findings and the use of the evidence-base into practice.

A good systematic review should make easier for the practitioner to understand the research by synthesizing extensive primary research papers from which it was derived. The researcher should be able to provide a broad ranging descriptive account of the field with specific exemplars and an audit trail, justifying his/her conclusions (Cochrane Collaboration, 2001; NHS, 2001; and Tranfield *et al.* 2003).

Researchers also need to report the findings of a 'thematic analysis' whether or not the results were derived through an aggregative or interpretive approach, outlining that which is know and established already from data-extraction forms of the core contributions (Cochrane Collaboration 2001; NHS 2001; Tranfield *et al.* 2003).

It can be also recommended that an extensive report including a description of the research process should be produced. This is because the development of an evidence-base stands on the accumulation of knowledge. Therefore, a detailed report of a systematic review should save time and give direction to researchers interested in extending the research. Other issues related to the conduct systematic literature reviews are described in further references included in Table 5.

Table 5. Sources of further information on Systematic Literature Reviews [08/03/07] (Boaz *et al.* 2002)

Campbell Collaboration http://www.campbellcollaboration.org/ Building on the experience of the Cochrane Collaboration, Campbell will carry out reviews of interventions in the fields of education, criminal justice and social work. The website currently includes guidance on protocol construction, specimen protocols and other information.
Cochrane Collaboration http://www.cochrane.org The Cochrane Collaboration prepares, maintains and disseminates the results of systematic reviews of research on the effects of health care. The Cochrane Library is a quarterly updated electronic database of reviews. The Cochrane manual and the reviewer's handbook are available on-line.
Evidence for Policy and Practice Information and Co-ordinating Centre http://eppi.ioe.ac.uk The Centre was originally commissioned by the DfEE to provide a resource for those wishing to undertake systematic reviews in the field of education. It will also develop and maintain a database of reviews and other educational research. Useful publications on systematic review methodologies are accessible via this site.
ESRC UK Centre for Evidence Based Policy and Practice http://www.evidencenetwork.org The Centre's Evidence Network website is designed to act as a starting point for accessing key literature and information resources on evidence based policy and practice.
Health Development Agency Evidence Base http://www.hdaonline.org.uk/evidence/eb2000 Evidence Base pulls together health promotion and health improvement evidence from a wide variety of sources. The evidence is searchable via the site which also includes quality criteria for appraising evidence.
Health Education Board for Scotland http://www.hebs.org.uk The HEBS Health Promotion Library Scotland is a free national information resource for health promotion and behavioural sciences. The site offers on line access to a range of databases. There is also a specialist site (http://www.hebs.com/research/) that aims to disseminate HEBS research to practitioners, policy makers and researchers.
Health Technology Board for Scotland http://www.htbs.org.uk The HTBS works to improve Scotland's health by providing evidence based advice to NHS Scotland on the clinical and cost-effectiveness of new and existing health technologies. Reports are available on-line.
Health Technology Assessment http://www.hta.nhsweb.nhs.uk This is a national programme of Department of Health funded research designed to produce user-friendly, high quality research information on the costs, effectiveness and broader impact of health technologies. Research reports are accessible on-line.
Interactive primer on systematic reviews http://www.comp.leeds.ac.uk/comir/people/eberry/sysrev/sysrev.htm This interactive site explains what a systematic review is and explores how and why they are carried out. The site includes a quiz to test your knowledge of systematic reviews.
National Institute for Clinical Excellence http://www.nice.org.uk NICE commissions reviews and provides guidance on current 'best practice' for patients, health professionals and the public. Publications are accessible through the website.
NHS Centre for Reviews and Dissemination http://www.york.ac.uk/inst/crd CRD carries out systematic reviews on selected topics in the health care field and maintains a database of reviews (DARE). A number of useful documents, including *Undertaking systematic reviews of research on effectiveness: CRD report no 4,* are accessible on-line.
Netting the Evidence http://www.shef.ac.uk/~scharr/ir/netting/ Netting the Evidence is intended to facilitate evidence based healthcare by providing support and access to helpful organisations. It also provides access to useful learning resources, such as an evidence based virtual library, software and journals.
Social Care Institute for Excellence http://www.scie.org.uk SCIE is a newly established organisation. It will commission reviews of research and practice, and of the views, experience and expertise of users and carers. These reviews will be available on the website.

4.2 Systematic Literature Reviews on the effects of the built environment into health outcomes

Systematic literature reviews related to the impact of the built environment on health outcomes have been grouped into two main categories: built environment and patient's health outcomes and built environment and the improvement of healthcare staff work effectiveness. The built environment and infection control can be considered as a third category which has not been addressed in this report.

Studies related to how the built environment influence patient's health outcomes are focused mainly on identifying the factors, elements or components of the built environment that have an impact on patients' health. The research methods generally consider the results from exposure of the patient to a specific condition in the built environment e.g. noise, colour or light (Beauchemin and Hays, 1996b; Devlin and Arneill, 2003; Lawson, 2003; Zeisel, 2003; Altimier, 2004; Joseph, 2006; Dijkstra *et al.*, 2006). Physical, physiological and psychological effects are then observed. However, it should be noted that there are many other factors which may affect health outcomes e.g. time in hospital, healing time, and use of drugs (Evans, 1984; Block and Garnett, 1989; Haggard and Werner, 1990; Werner *et al.*, 1992; Grosenick, 2000; Day, 2002; Baskaya *et al.*, 2004; Batljan and Lagergren, 2004; Clarkson 2004; and Daykin and Byrne 2006). Therefore, causal relationships cannot be established.

Research on the built environment and the improvement of staff work effectiveness focuses on the characteristics of built environment that affect staff performance. The underlying premise is that the built environment should be supportive not just to patients, but also to staff. It is believed, for instance, that reducing levels of staff stress contributes to improved health services and increased work effectiveness. One study in this field relates improved building layout to reduction of staff walking distances. This may contribute to improved health outcomes by increasing the proportion of time staff dedicate to patients (Gralton, 2001; Ulrich, 2000; Leather *et al.*, 2003a; and Ulrich *et al.* 2004).

Studies related to the built environment and infection control focus on reducing infection levels through design solutions. An example of the research in this category is the investigation of the relation among sunlight, windows dimensions and the reduction of contamination levels (Ann Noble Architects, 2003; DOH, 2004b; Sehulster *et al.,* 2004; DOH, 2005; Bencko and Schejbalova, 2006; General Health Protection and DOH, 2006).

Table 6 presents where to find more information about the impact of the built environment on health outcomes. A list of specialist journals focused on design, psychology, medicine and nursing is provided on Appendix 2.

Table 6. Sources of evidence on how the built environment impacts health outcomes

Safer Environment Database (NHS Estates) EFM-evidence Authors: B. Lawson and M Phiri The University of Sheffield
The Center for Health Design Through research, education, advocacy and technical assistance, The Center for Health Design supports healthcare and design professionals all over the world in their quest to improve the quality of healthcare through evidence-based building design. www.healthdesign.org
Centre for Healthcare Architecture & Design CHAD is dedicated to improving the design of the built environment of the NHS. We are committed to delivering excellence in the healthcare estate, by maintaining, developing and delivering the extensive design programme currently in place to support the largest building programme in the history of the NHS. http://195.92.246.148/nhsestates/chad/chad_content/home/home.asp

International Academy for Design and Health

The International Academy for Design and Health (Design & Health) is a non-profit organization with an inter-disciplinary network dedicated to stimulate research and the application of research concerning the interaction between Design, Health and Culture.

http://www.designandhealth.com/

Healing by Design

On September 20-21, 2000, the McGill University Health Centre (MUHC) hosted a landmark event in its progress toward building a new home for its hospitals and research facilities. Healing by Design: Building for Health Care in the 21st Century, brought together leading experts in health care design from across Canada and the United States to share information, ideas, and the experience of other facilities in creating the new environments for healing, teaching and discovery of the 21st century.

http://muhc-healing.mcgill.ca/english/E_home.html

21st Century Hospital Design

The Robert Wood Johnson Foundation (RWJF) offers a web cast of a national conference, "Designing the 21st Century Hospital: Serving Patients and Staff."

http://www.rwjf.org/newsroom/activitydetail.jsp?id=10069&type=3

Healthcare Architecture (AAH) - The Academy of Architecture for Health – The American Institute of Architects

The Academy of Architecture for Health (AAH) improves the quality of healthcare through design by developing, documenting, and disseminating knowledge; educating healthcare architects and other related constituencies; advancing the practice of healthcare architecture; improving the design of healthcare environments; affiliating and advocating with others that share our vision and promoting research.

http://www.aia.org/aah/

The Academy of Neuroscience for Architecture

The mission of the Academy of Neuroscience for Architecture is to promote and advance knowledge that links neuroscience research to a growing understanding of human responses to the built environment.

http://www.anfarch.org/

Although these three categories provide a general overview of the research field, there is more. For instance, a parallel can be drawn between healthcare environments and offices. Characteristics of offices and how they impact on work effectiveness is a subject that has been investigated (e.g. Block and Garnett, 1989; Veitch, 1990; Leather *et al.*, 2003b; Stone, 2003).

The effect of the built environment on health has also been investigated by theorists, mainly from the field of psychology. These investigations are considered in the following section.

5 THEORETICAL, PRACTICAL AND METHODOLOGICAL DEBATES

There are many theories explaining how the built environment affects human life and behaviour. The objective of this report is not to cover all of them.

Sundstrom *et al.* (1996) stated that despite the progress in theory development, environmental psychologists remained far from consensus. Amongst the theories that have been guiding research, six appeared more influential in recent research developments (the following paragraphs were extracted from Sundstrom *et al.*, 1996).

- Arousal: Psycho-physiological arousal is well established as a process that mediates influences of environmental features such as sound and temperature. The arousal hypothesis predicts optimum performance and satisfaction under conditions of moderate arousal, depending on task complexity and other factors (Thayer 1989). Biner *et al.,* (1989) found students' preferences for lighting scenarios consistent with predictions of the arousal hypothesis. Extensions of the hypothesis suggest that through arousal, high temperature increases the likelihood of violence, though the nature of the relationship remains in debate (Anderson 1989; Bell 1992).
- Environmental load: The overload hypothesis assumes that humans have a finite capacity for processing stimuli and information and predicts that we cope with sensory or information overload through (among other responses) selective attention and ignoring low-priority inputs. Consistent with the hypothesis, a laboratory experiment by Smith (1991) showed that 78dB (A) noise led to reduced performance by college students in a letter writing task but not in a letter-search task. Loewen and Suedfeld (1992) found that masking sound mitigated the performance deficit produced by office noise but added to arousal. Veitch (1990) extended the arousal hypothesis to individual differences and reported better reading comprehension in noisy conditions by individuals with internal locus of control, and better reading comprehension in quiet conditions by individuals with external locus of control.
- Stress and adaptation: Previous research and theory associated extremes of temperature, sound, and other environmental variables with physiological and psychological stress and with coping and adaptive behaviours that reduce stress or its impact. Environmental stress research examined prolonged exposures (e.g. Hedge, 1989) and post-traumatic outcomes (Rubonis and Bickman, 1991) including chronic illness and psychological impairment. Such findings reinforce the need for theoretical distinction of acute and chronic environmental stress (e.g. Baum *et al.,* 1990; Hobfoll, 1991; and Baum and Fleming 1993).
- Privacy-regulation: Research on privacy, spatial behaviour, crowding, and territoriality together suggests a human tendency to seek optimum social interaction, partly through use of the physical environment (Altman, 1993). Privacy regulation theory suggests that when a person fails to achieve the subjective, optimum level of social contact for the situation, the resulting stress motivates coping behaviour, which may rely on the physical setting (Brown, 1992). Consistent with the theory, Haggard and Werner (1990) found that students who temporarily occupied a laboratory setting rejected intrusions more often when the chair arrangement delineated their work area than when it did not. Block and Garnett (1989) reported higher satisfaction among college students who worked on complex tasks in private rather than non private settings.
- Ecological psychology and behaviour setting theory: This theory analyses environments in terms of behaviour settings: "small scale social systems composed of people and physical objects configured in such a way as to carry out a "*routinised*" program of activities with specifiable time and place boundaries" (Wicker, 1992). The July 1990 issue of Environment and Behavior reviews the history of ecological

psychology. Analysis of a recent worker survey supported the predictions of behaviour setting theory (e.g. Wicker and August, 1995). Extensions of the theory have focused on specific settings (e.g. Schoggen, 1989), such as gas stations (e.g. Sommer and Wicker, 1991), and on what Wicker (1992) called a "sense-making" model—based on naturalistic research that addresses occupants' understandings of the context.

- Transactional approach: In a substantial extension of privacy regulation theory, Altman (1993) and colleagues (e.g. Brown *et al.,* 1992; and Werner *et al.,* 1992) elaborated their transactional approach, which treats the physical environment as a potential context for social interaction that can support, constrain, symbolize, and confer meaning upon various aspects of social relationships. This holistic, systems-oriented analysis incorporates multiple levels and facets, variation over time, and cyclical processes. It describes social relationships and physical settings in terms of dialectics, or tensions between opposing influences.

Proxemics is another theory related to humans and their behaviour in the built environment. Proxemics, relates to peoples' use of their perceptual apparatus in different emotional states during different activities, in different relationships, settings, and contexts (Hall, 1968). Examples of studies include Cook (1970) and Raybeck (1991) who investigated privacy and territorial boundaries. Although these studies were not conducted in healthcare environments, they provide insights about human behaviours under stressful conditions.

Considering research in architecture, Lawson (2001) states that the built environment has signs and specific characteristics which can be 'read' by its users. Therefore, it is the language of the space and its 'readability' which will influence human behaviour. In general, the behaviour is guided by the users' most important needs first and basically it varies from conscious to unconscious behaviours, as well as from controlled to uncontrolled ones (Lawson, 2001).

Lawson's classification of behaviour (controlled, uncontrolled, conscious and unconscious) leads to the generation of matrix which combine the different behaviours. According to Lawson (2001) the combination of unconscious and uncontrollable behaviours relates to what we call instinct (e.g. the blink of eyes). The combination of conscious and controllable behaviours relates to what is called cognitive activity (i.e. includes intellectual thought and the solving problems). The combination of conscious and uncontrollable is named conative behaviour and includes feelings and emotions. Finally, the combination of unconscious and controllable is related to what Lawson calls skills. Behaviours in this category include praying or singing a lyric of a song without realising the content (doing it mechanically). Lawson (2001) recognises that this is a simplistic model and there are other types of behaviour that can be included within this model. Lawson (2001) additionally quotes Proshansky *et al.* (1976) in relation to the fact that the physical (built) environment also involves a social phenomenon which can not be isolated. In other words, not just buildings affect the way humans behave, but also humans, in an attempt to develop their social relationships, affect other humans.

Additionally, research about the design and use of healthcare facilities for people with mental disorders (e.g. Lawton, 2001) has been conducted also by specialist healthcare designers, health professionals and the NHS Estates (e.g., NHS Estates 1996). These reviews aim to bring to light the broad set of theoretical and epistemological issues related to mental illness and its connection with the physical environment.

To summarise, the phenomenon under investigation, i.e. changes in humans reactions due to the stimulus caused by characteristics or different configurations of the built environment can be explained through different ways according to the observed outcome. The Table 7 presents a summary of the presented theories related to this phenomenon, making explicit the observed effect, its possible cause and the dependency (or relation) between both.

Table 7. Existing theories about the effects of the environment on humans' reaction

Theory	Effect	Cause	Explanation
Arousal (Thayer 1989)	Optimum performance and satisfaction	Moderate arousal	There is a universal environmental balance/ equilibrium that impact us if disturbed
Environmental load (Cohen 1978)	Humans coping through selective attention	Human's finite capacity for processing stimuli and information	Humans ignore low-priority inputs because human's capacity for processing information is limited.
Stress and adaptation – Environmental stress (Evans 1984)	physiological and psychological stress and coping and adaptive behaviours that reduce stress or its impact	Extremes of temperature, sound, and other environmental variables	There is a universal environmental balance/ equilibrium that impact us if disturbed
Privacy regulation (Brown *et al.* 1992)	Coping behaviour stimulated by the stress caused by the lack or excess of social contact	Failure to achieving the subjective, optimum level of social contact.	There is a universal social balance/ equilibrium that impact us if disturbed
Ecological psychology and behaviour (Barker 1969)	Humans carrying out "*routinised*" program of activities with specifiable time and place boundaries	Specific small scale social systems configuration	Not clear
Transactional approach (Altman 1993)	The stimulation of social interaction	Specific arrangements and characteristics of the physical environment.	The physical environment provides the context for social interaction that can support, constrain, symbolize, and confer meaning upon various aspects of social relationships.
Language of the space (Lawson 2001)	Stimuli in humans' behaviour	'Readability' of physical environments intentions.	Built environmental characteristics have specific meanings (which are associated with socio-cultural aspects) and may have an inductive role in humans behaviour.

From the presented theories it can be concluded that:

a) The built and social environment can not be considered as separate environments. This is aligned with the concept of the built environment adopted in this report (presented in the next section), which consider physical (human made) environments as places where humans operate;

b) The built environment is perceived (or 'read') through the use of our senses, which stimulate our cognition in the first place;

c) Cognition can be stimulated when the 'natural' environmental balance is disturbed, through the 'readability' of the features of the built environment or through humans' priorities.

However, the parameters which establish balance, readability, and priorities and whether they vary from person to person were not identified in the literature.

d) The psychological impacts caused by the built environment may lead to subsequent physical or physiological consequences.

The following section presents variables related to the built environment and health outcomes identified within the literature.

6 VARIABLES RELATING THE BUILT ENVIRONMENT AND HEALTH OUTCOMES

The following section presents the aspects, features and variables used to build an evidence-base about the impact of the built environment into health outcomes.

6.1 The Complexity of the Built Environment

The term built environment can be defined in many different ways. For instance, according to the Wikipedia Contributors (2007) the built environment refers to the human made surroundings that provide the setting for human activity, ranging from large-scale civic surroundings to personal places. The Concise Oxford English Dictionary (2006) defines environment as the surroundings or conditions in which a person, animal, or plant lives or operates. These two definitions have complementary aspects which help to define what the built environment is. From the former it is the fact that the built environment refers to the human made surrounding. From the latter it is the surrounding which a person, animal or plant lives or operates. Hence, in this report, the built environment is considered to include the surroundings or conditions designed and built through human intervention, where a person, animal or plant lives or operates.

Considering this definition, the questions to be asked are: a) “Is it possible to adopt a reductionist approach to research and isolate and observe a specific feature of the built environment and its impact on patients’ health?” and b) “Is it possible to adopt a holistic approach to research and assure that a specific outcome is the result of the continuum that constitute the built environment rather than from a specific variable?” These are key questions because the built environment is composed by a complex mix of different features. For instance, the arrival of non-elective patients at hospitals is unpredictable as to the duration of their stay. Many patients have their own specific needs and therefore the built environment should be flexible enough to provide the right range of support for their treatment.

Building characteristics related to healthcare environments have been investigated within different knowledge areas. In architecture, for instance, considerable attention has been given to design solutions that improve the quality of healthcare environments (e.g. CABE, 2006). In engineering, research has been focused on the investigation of systems and the improvement of systems’ performance (e.g. ventilation, illumination and air conditioning) and how the improvement of these systems affects healthcare delivery (e.g. Chow and Yang, 2003).

Additionally, rather than considering the result achieved by analysing different characteristics, it is also important to consider the different outcomes produced by a single characteristic. This problem is well described in Nuffield Provincial Hospitals Trust (1960) in relation to the design of a window. According to the Nuffield Provincial Hospitals Trust (1960) sunlight is a characteristic which may have both a good and bad impact on health. On one hand, it is effective in killing haemolytic streptococci bacteria, but if the design does not consider the amount of glare generated, it may cause discomfort to the patient.

Another characteristic of the field relates to multi-levels of analysis. This is due to the fact that the built environment can be observed in different levels of detail, i.e. from the whole building or a specific setting to a group or individual elements or characteristics (e.g. a chair, a colour or even texture on a wall). Consequently, the same element or characteristic can be observed under different levels of analysis and be associated with different expected outcomes, making it more difficult to integrate and generalise research results.

From what was noted in the literature, a building can also be observed through its physical (e.g. temperature, ventilation), architectural (e.g.

symmetry and balance) or functional characteristics (e.g. privacy and maintainability). These three constructs can be measured in different ways and therefore amplifying the possibilities of establishing relationships between the built environment and health outcomes. Table 8 presents different levels of analysis, variables and variants used to conduct research in healthcare facilities. This table was built during the literature review based on investigated environments and based on the first author's experience as an architect.

Table 8. Examples of levels of analysis, variables and variants in healthcare facilities

Levels of analysis	Hospital Speciality: primary care, secondary care, mental care, hospices. etc Care Units: intensive care, coronary care, dental care, neonatal care, etc Settings: ward, bedroom, operation theatre, corridor, waiting area, hospital entrance, kitchen, bathroom, garden, haemodialysis room, etc Components: furniture, equipments, installations, ceiling, window, floor, partitioning walls, etc Furniture and equipment: sink, bed, alcohol-rub, television, over bed table, bed privacy curtain, door handle, curtains, blinders, bedside rail, shower, chair, computer, etc Systems: ventilation, heating, sound proofing, information and communication, etc
Variables	Physical characteristics: temperature, humidity, ventilation, luminosity (natural and artificial light), acoustics, colour, dimensions, texture, material Architectural characteristics: symmetry, balance, rhythm, movement, composition Functional characteristics: usability, safety, privacy, accessibility, functionality, maintainability, comfort, stability, locomotion
Variants	Lightning: natural light, artificial light, different types of artificial light Colour: yellow, orange, red, black, white, blue, green, grey Pattern: stripes, dots, chequerboard, plain Textures: smooth, rough, silky Ventilation: natural ventilation, artificial ventilation Temperature: cold, hot Dimension: size, height, width, depth Material: carpet, copper, steel, aluminium, plastic

From the literature review it is possible to conclude that both holistic and reductionist approaches have been adopted. Examples of the holistic[3] approach are presented in Qatari (1999) and Leather *et al.* (2000). In both studies specific areas within hospitals were investigated in relation to clients' satisfaction and improved well being. Examples of the reductionist approach can be found in Wilson, (1966) Nourse and Welch (1971), Jacobs and Hustmyer Jr. (1974), and Jacobs and Suess (1975) in relation to colour and its psychological impacts. Another example can be found in Chow and Yang (2003) which investigated the performance of ventilation systems in relation to temperature control in a non-standard operating room. Chow and Yang (2003) concluded that the appropriate ventilation and temperature (in terms of effectiveness in 'washing'

[3] In this report no judgment of value was made in relation to the use of a holistic or reductionist approach.

bacteria during an operation) might cause discomfort for staff.

It can be also concluded that some features of the built environment can be combined affecting other features and consequently increasing the complexity of research in the field. One example drawn from this situation is the relation between artificial light, windows size and ventilations systems with temperature.

The number of levels of analysis, variables and variants related to a hospital is enormous and in combination with variables related to patients and outcomes may provide a considerable number of research scenarios. Variables related to patients and health outcomes are further described in the next sections.

6.2 The Patient Configuration

Research linking the built environment and health outcomes usually involves participants with varied characteristics and needs (Mulrow *et al.* 1997a). Thus, an important question that should be considered when analysing the impact of the built environment on patient's health is: "Would patients of and under different conditions (e.g. age, gender, illness, treatments, and interventions) perceive and react similarly to the environment?"

Patients with different illnesses have different needs. For some, the need might be a stimulating environment, whereas for others the priority would be to provide a quiet and private place in which to rest. Also, it has to be considered that the need might change for a person over time during the healing process (e.g. pre- and post-operative patients).

The number of variables which characterise the patient is considerable. For example, the condition of the patient (illness and severity), the level of stress caused by previous experiences in hospitals and age seems to change the way that they are affected by the built environment. For example, patients with mental illnesses seem to perceive the built differently to other patients (e.g. Laditka *et al.*, 2005). Also, artificial light may damage the vision of premature babies but not that of adults (e.g. Glass *et al.*, 1985).

Table 9 presents variables and variants describing patient's conditions which may affect the way patients perceive and react to the environment. Table 2 is not exhaustive as it does not include all variants and does not consider patients' cultural, social and economical aspects.

Considering the number of possible individual characteristics which may affect patient reaction, another question emerges: how to integrate research results from heterogeneous groups of patients? This is an important issue related to building an evidence-base. Adding to this problem, the number of outcomes that can be measured increase the difficulty of building up an evidence-base. Variables and variants which represent health outcomes are presented in table 9.

Table 9. Variables and variants related to patients' condition

Variables	Variants
Illness or injury	Infectious diseases: respiratory infections, HIV/AIDS, tuberculosis, meningitis, etc. Injuries: burns, fractures, wound, etc. Physical diseases: cancer, heart diseases, Parkinson, kidney dysfunctions, etc. Psychological diseases: Alzheimer, dementia, depression, chemical dependency, etc.
Age	Infant Adolescent Adult Elderly

Gender	Female Male
Condition	Pre-operative Post-operative Pregnant Post-Stroke / CVA Post-Heart Attack Post-Stop Breathing
Treatment	Dependent on illness

6.3 The Variety of Outcomes

Improved health and well-being are the desired outcomes of a patient visit or stay in a built environment for healthcare (e.g. hospital or clinic). Health is broadly defined as a "state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (WHO, 1946). Psychological well-being is a mental condition characterised by pleasant feelings of good health, exhilaration, high self-esteem and confidence, often associated with regular physical activity (The Concise Oxford English Dictionary, 2007).

Although both concepts are essential, these definitions do not set what exactly is meant by health outcome. Thus, considering that health outcomes can be associated with a large number of variables and variants, the construction of an evidence-base should clearly establish what was measured and how, providing as much detail as possible.

In the literature, there are a variety of models, typologies and theories of health outcomes (e.g. Bergner, 1985; Patrick and Bergner, 1990; and Johnson and Wolinsky, 1993). Wilson and Cleary (1995) proposed a conceptual model of health-related quality of life that integrates both biological and psychological aspects of health outcomes (Figure 6). According to these authors, there are at least five different levels of health outcomes including: biological and physiological factors, symptoms, functioning, general health symptoms, and overall quality of life. Although Wilson and Cleary (1995) argue that molecular and genetic factors are the most fundamental determinants of health status, their model begin with biological and physiological factors because they are more commonly conceptualised, measured, and applied in routine clinical practice.

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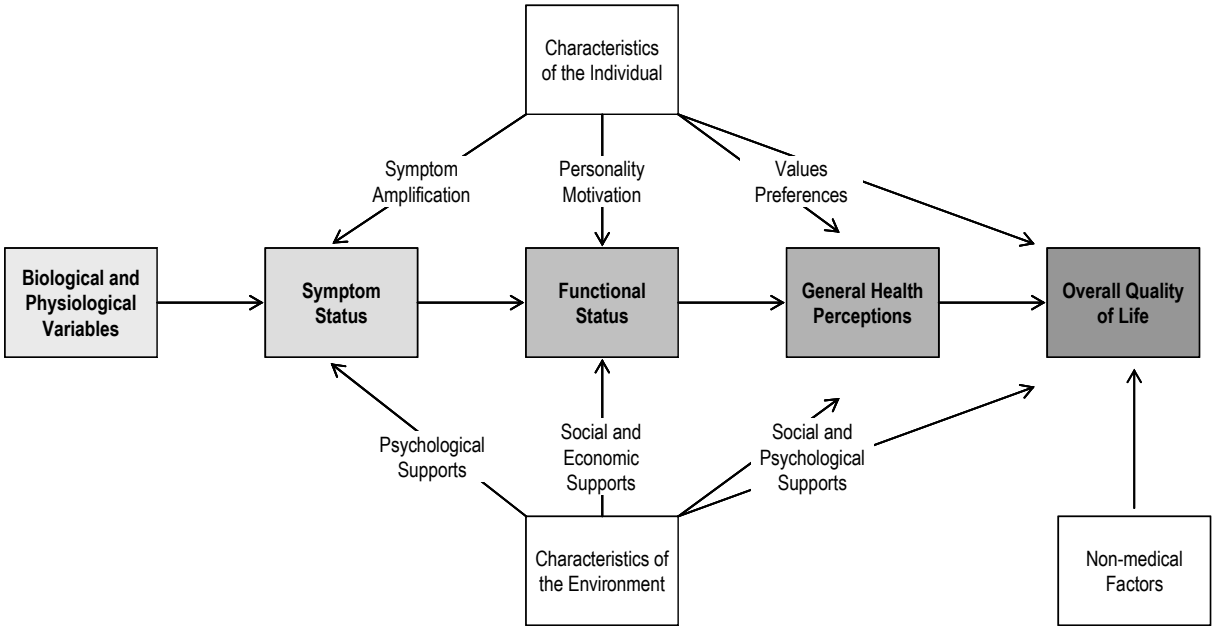

Figure 6. Relationships among measures of patient outcomes in a health-related quality of life conceptual model (source: Wilson and Cleary, 1995)

Health outcomes can be presented in terms of positive and negative results. Moreover, both positive and negative outcomes can also be measured to different degrees, e.g. relevant or irrelevant to health enhancement or decline. Thus, the question to be asked is: is the resulting outcome measured in research relevant to health improvement and decline?

Considering all these aspects, in this report both concepts are considered as constructs and therefore should be measured through the use of a set of different variables.

Table 10 presents some of the variables that have been used to measure health outcomes.

Table 10. Variables related to health outcomes

Classification	Variables
Psychological	Depression, anxiety, stress, insecurity, fear, panic, mood, confusion, satisfaction, attentional capacity, arousal, sleeplessness, delirium
Physical	Heart rate, pain, hypothermia, blood pressure, infection, body integrity, broken bones
Physiological	Respiration, coordination, excretion, circulation, reproduction
Others	Length of stay, healing time, well being, medicine use reduction, staff errors, substance use decrease, physical health improvement, social interaction improvement, psychological well being, health care independency, setting infection level, work effectiveness, staff time per patient, injury caused by falls, privacy
Relevance	Clinically relevant, surrogate, beneficial

Additionally, health outcomes can be both direct and indirect. According to Mulrow *et al.* (1997a) direct evidence in medical research links an exposure, diagnostic strategy, or therapeutic intervention to the occurrence of a health outcome. On the other hand, evidence is indirect if two or more bodies of evidence are required to link the exposure, diagnostic strategy, or intervention to the health outcome. In the medical area, Eddy (1990) in (Mulrow and Cook 1997) considers that the outcomes to be assessed should be clinically relevant to the patient. According to (Fleming and DeMets 1996) and (Mulrow *et al.* 1997a), relevant outcomes are symptoms, loss of function, and death. They must consider the perspective of the patient because physicians and patients often do not agree on what issues are important (Goodare and Smith, 1995; Smith, 1996 in (Mulrow and Cook 1997). Indirect or surrogate outcome measures, such as laboratory or radiological results, should be avoided or interpreted with extreme caution because they rarely predict clinically important outcomes accurately.

6.4 The Impact of the Built Environment on Health Outcomes

The aim of this section is to present a list of studies which investigated the characteristics of the built environment impacting on patients' health outcomes. Prior to this, a few aspects should be considered:

1. From the previous sections it was concluded that research can be either holistic or reductionist. The studies presented in this report follow the reductionist point of view. It was considered that the lack of clarity about cause and effects relationships in the holistic view generates confusion;
2. The existence of different levels of evidence strength (Figure 7) was considered. Anecdotal evidence was the lowest level and the Cochrane Collaboration standards the highest. The Cochrane standards was considered the highest because for this group evidence is found when, at least, two pieces of clinical trials (two cases) with very similar characteristics demonstrate the same results. Evidence about the built environment and its impact on health outcomes which qualifies as the Cochrane standard were not found. Therefore, the list of studies in this report was classified as general standard of evidence i.e. which considers only one unique case;
3. The list presented in this report is organised according to physical characteristics (e.g. lightning, temperature, humidity). It was considered that all settings within a healthcare environment are composed of these characteristics. In this sense, it is understood that settings might operate following specific, controlled and normative physical performance parameters (e.g. operation theatres, intensive care units). Therefore, generalisation is limited;
4. In relation to different patients' configuration (e.g. age, gender, condition), it was considered that each possible combination of characteristics constitutes a case for evidence. Therefore, each patient might have a different need and general patterns of behaviour may not apply. Therefore, generalisation is limited;
5. In this report, it was considered impossible to verify if health outcomes were actually caused by a specific (group of) characteristic(s) of the built environment or by the effectiveness or failure of the treatment and/or intervention that patients (the unit of analysis) were submitted. Therefore, generalisation is not possible.

The list of studies relating the built environment and health outcomes is presented in the following, discussing lighting, ventilation, temperature, arts and acoustics individually. The effects of other environmental variables are summarised.

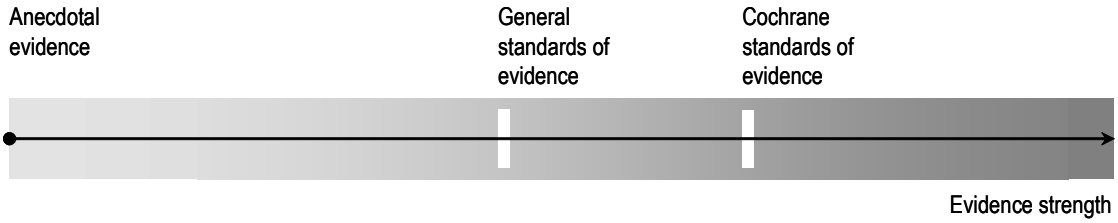

Figure 7. Different evidence strength levels

Lighting

The literature highlighted that light (either natural or artificial) can be associated directly and indirectly with physical, physiological and psychological health outcomes. In excess or lack thereof, light may cause physical damage which is not restricted to the eyes (e.g. the development of skin problems). On the other hand, if provided appropriately, light is considered to have a (curative) stimulating property that affects our metabolism and our mind. The list of studies is presented below:

- The increased duration of exposure to fluorescent light was associated with the rise of the risk of development of melanoma in adults (Beral *et al.* 1982);
- High levels of ambient illumination contributing to the incidence of oxygen-induced retinopathy of prematurely infants (Glass *et al.* 1982). Controversially, a study conducted by Ackerman *et al.* (1989) concluded that there was no difference in the incidence and severity of retinopathy of premature infants. Ackerman *et al.* (1989) also identified that shielding infants in isolation from incidental lighting has no effect on the development of retinopathy of prematurely infants;
- The exposure to cycled light was associated with infants' superior rates of weight gain, faster development of the capability of being fed orally and enhanced motor coordination when compared with non-cycled light (Miller *et al.* 1995);
- The exposure to bright fluorescent light was associated with beneficial effects on seasonal depression. The same effects were not verified on non-seasonal depression (Kripke *et al.*, 1982; Kripke *et al.*, 1983; Yerevanian *et al., 1986;* Kripke *et al.*, 1998);
- Light in intensive care units was associated with variability of patients' sleeping patterns (Richards and Bairnsfather, 1988);
- The exposure to ultra-violet radiation in daylight was associated with the stimulation of the metabolism and consequently production of D vitamin (Veitch and McColl, 1993);
- Natural and artificial light was associated with the reduction of the levels of contamination by haemolytic streptococci bacteria (Nuffield Provincial Hospitals Trust, 1960);
- Low frequency (red) light waves were associated with less sleep-wake frequency and more sleep thereby contributing to night-sleeping. High frequency (blue) light waves were associated with greater sleep-wake frequency and more waking and may contribute to day-waking or be useful for undesirably sleepy neonates (Girardin, 1992).

Ventilation

Ventilation can be promoted by both natural and artificial routes. From the literature review it was observed that research on artificial ventilation and its impact on health outcomes are mainly associated with the dissemination of infectious disease. Research about natural ventilation is mainly related to windows types and sizes. However it can be associated with different levels of pressure between adjacent rooms (e.g. bedroom and corridor). The identified issues are presented below:

- Contamination by Acremonium kiliense through the humidifier water used in the ventilation system (Fridkin *et al.,* 1996);
- Contamination by staphylococcus aureus (MRSA) through the ventilation system in combination with natural ventilation (Cotteril *et al.,* 1996);
- Reduction of Nosocomial infections through the adoption of negative pressure in settings occupied by infected patients (Anderson *et al.,* 1985);
- Tuberculin conversion among healthcare workers was strongly associated with inadequate ventilation in general patient rooms (Menzies *et al.,* 2000);
- Recommendations for the use of heat and moisture exchangers in patients with acute respiratory failure (Pelosi *et al.,* 1996);
- Increased risk of airborne bacteria contamination from the surgical team on the patient, and vice versa through the ventilation system (Chow and Yang, 2003).

Temperature

Not much was found about the impact of temperature on patient's health. The literature demonstrates that many parameters are used by designers to specify the temperature performance of indoor environments. These parameters rely on both subjective and objective indicators (Frasson *et al.,*

2007) and may vary as they are provided by different organisations such as ANSI/ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) and ISO (International Standards Organisation).

- Nagano and Mochida (2004) investigated the control conditions of ceiling radiant cooling systems. The study concluded that some measures and parameters that have been used to design should be reviewed;
- Lu and Zhu (2006) investigated the heat stress and heat tolerance of 148 male. The study proposed physiological limit values at exposure limits;
- Bell and Green (1982) investigated the impact of temperature on physiological stress;
- A compilation of studies looking at comfort generated by the use of localized air distribution systems is presented by Charles (2003). Comfort was also studied by Chow and Yang (2003), Hwang *et al.* (2006);
- Results of the impact of thermal stress is presented in Hickman *et al.*(2003);
- The dissemination of waterborne infections due to warm temperature conditions is presented in Joseph, (2006b);

Acoustics

The investigation of acoustics characteristics is mainly related to noise and its effects on health. It was found that music and music therapy (e.g. Cabrera *et al.,* 2000, Devlin and Arneill, 2003; Ikonomidou *et al.,* 2004 and CABE, 2004) can enhance health. In the literature, noise is associated mainly with sleeplessness and stress. Also, that the route causes of noise varies and is associated with the operation of machines, equipment and tools, staff conversation and transportation (Christensen, 2004). The papers related to noise are presented below.

- Noise disturbance produced by the operation of the facility can affect patient's recovery (Bayo *et al.*, 1995);
- Noise produced by the operation of the facility was associated with patients bad experience of healthcare service (Douglas and Douglas, 2005);
- Noise produced by the operation of the facility was associated with sleep disturbance (Richards and Bairnsfather, 1988; Haddock, 1994; Topf *et al.,* 1996; Ersser *et al.,* 1999);
- Noise produced by the operation of the facility was associated with stress (Topf, 2000);
- Psycho-physiological effects (such as decreased wound healing, sleep deprivation and cardiovascular stimulation) due to excessive noise exposure was investigated by Christensen, (2004);
- Noise levels above the international recommendations where found in operation theathers. The measured noise levels exceed the thresholds to produce noise-induced cardiovascular and endocrine effects (Liu and Tan, 2000).

Art[4]

Art and mental health has been investigated from a myriad of perspectives. These include the use of music with particular attention paid to different types of instruments; the use of live, video or recorded performances; drawings and paintings, and; traditional and contemporary art (Staricoff 2004). The existing literature also distinguishes between art therapy (i.e., the effect of actively getting involved in the development of an art work) and the passive exposure to art in a specific environment, for instance, healthcare settings (Daykin and Byrne 2006). These authors argue that few controlled and randomised studies of the therapeutic effects of art in mental health have been carried out. Literature reviews specifically looking at art and mental health include ones by Staricoff *et al.* 2003, Staricoff 2004 and Daykin and Byrne 2006. Other literature reviews, such as Devlin and Arneill (2003) and Ulrich *et al.* (2004) also consider the impacts of art on health; however, these reviews are focused on the impact of the physical environment on health, and art is considered as a feature of the physical environment.

According to Philipp (2002), the arts can help mitigate mental health conditions, such as depression, anxiety and low self-esteem as well as to improve social integration and isolation. There is a diverse range of art activities that are incorporated into the study of art and mental health care. A study

[4] This sub-section was extracted from Cooper, R., Boyko, C., Codinhoto, R. (2008) State-of-Science Review: The Effect of the Physical Environment on Mental Wellbeing, London, Foresight project, Office of Science and Innovation.

conducted by Ulrich (1991) revealed that inappropriate visual art styles are related to the disturbance of mental health conditions. McGarry (1998) and Korlin *et al.* (2000) argue that creative arts programmes induce significant improvements in the communication of psychiatric patients. Mornhinweg (1992) found significant reduction of stress levels by using patients' pre-selected music in the background. Gerdner (2000) showed that classical music can reduce the levels of agitation of patients with Alzheimer's disease.

Research results presented in literature reviews, such as Staricoff (2004) and Daykin and Byrne (2006), suggest that the arts can have a therapeutic effect on people suffering with mental disorders. However, Staricoff (2004) draws attention to the fact that the introduction of creative arts, such as dance, drama, music, visual arts and creative writing in mental health can also bring with them potential risk factors. These are associated with the psychological effects of being engaged in these activities, which could become too demanding for the patient (Staricoff, 2004).

Other variables

This session discusses three further variables, i.e. colour, layout, and gardens, presented as follows.

There are different assumptions about how colour affect humans (Dalke *et al.*, 2006). For instance, there is anecdotal evidence speculating that red, orange and yellow in shiny and polished surfaces stimulate appetite and anxiety (these would explain why these colours are very often used by fast-food chains). Grey, purple and red have been associated with depression and are excluded from the palette of colours of designers designing hospices and psychiatric hospitals. Generally speaking, it seems that the impact of colour in humans is psychological. Studies on colour include:

- The effects of colour on stress and arousal levels in healthcare environments (Dijkstra *et al.*, 2008);
- The effects of colour in hospital design are discussed in Dalke *et al.* (2006);
- Kaya and Crosby (2004) investigated individuals' colour associations with different building types;
- Etnier and Hardy (1997) studied colour influence on performance of mentally and physically demanding tasks.
- Respiration: the study about the effects of red, yellow, green and blue concluded that there is no significant effect of these colours on respiration (Jacob and Hustmyer, 1974).
- Heart rate: the study about the effects of red, yellow, green and blue concluded that there is no significant effect of these colours on heart rates (Jacob and Hustmyer, 1974).
- Anxiety: the study about the effects of red, yellow, green and blue (in non-healthcare environment) concluded that red and yellow can be associated with high levels of anxiety levels and that blue and green can be associated with low levels of anxiety (Jacob and Suess, 1975).

Layout is another aspect affecting the way humans behave (Zimring *et al.*, 2005) specifically the way patients and staff react to the environment (e.g. Leather *et al.*, 2003a). There are several aspects associated with the layout of the facility or the setting under investigation (NHS Estates, 1999). Privacy seems to be one of the most investigated outcomes, which has been mainly associated with occupancy. There are a variety of studies stating that single occupancy bedrooms increases privacy, and therefore, it is better for patients and staff because it reduces noise levels and consequently improves sleep rates and reduces stress, and reduce the risk on infections. Studies looking at these issues are presented bellow.

- Chaudhury *et al.,* (2005) present a review of the vantages and disadvantages of adopting single and multiple occupancy bedrooms;
- Evans and McCoy (1998); Altimier, (2004) associate occupancy and privacy with the development of the social environment, which is relevant to patients recovery;
- Improved healthcare experience associated with privacy and occupancy is presented by Douglas and Douglas, (2004); Douglas and Douglas, (2005);
- Baskaya *et al.*, (2004) discusses the aspects of layout related to wayfinding.
- Passini *et al.*, (2000) explores layout and wayfinding in a nursing home for advanced dementia of the Alzheimer's type
- Grosenick and Hatmaker (2000) associate privacy with one important building characteristic to be considered in the treatment of substance use treatment;

- Finally, positive health outcomes related to the exposure to gardens and other green spaces have been scientifically investigated. Some of outcomes include the reduction of stress and levels of anxiety, increased social interaction, and improved healthcare experience. Researchers looking at this issue include Ulrich, (1981); (1984); (1992); and (2004); Marcus and Barnes, 1999, Kaplan (2001), Whitehouse *et al.,* (2001); Milligan *et al.,* (2004); and Marcus, (200x).

7 THE CHALLENGES FOR RESEARCH

This report presented variables related to the built environment, patient characteristics and health outcomes as identified through a literature review. Healthcare environments have been studied within different research fields and viewed from different perspectives. Therefore, there is a variety of information that can be added to the evidence-base. However, due to the complexities described above, it is difficult to identify cause-effect relationships between variables. The lessons learnt during the research process are presented below.

Considerations on the built environment and health outcomes

- In general, the impact of the built environment on health outcomes is indirect rather than direct. In this sense, the role of the built environment is to provide stable environmental physical conditions and to avoid disturbance among patients. Operational and maintenance aspects have an important function in relation to this issue;
- More clarity is needed in terms of the relevance of research findings (i.e. measured health outcomes) to the improvement of the patient or patient groups being investigated;
- Existing built environments were designed following parameters which allow prediction of environmental physical performance (e.g. temperature, lighting, ventilation). Any research looking at the impact of the built environment into health outcomes should first look at the parameters used to design the facility and check if they conform to existing norms. Subsequently, the performance should be measured to compare it with the performance specification. Finally, if the actual performance is as predicted and any negative health outcome is observed, the parameters used to inform designers should be reviewed.
- Hospital environments are complex. Thus, experiments conducted under laboratory conditions should not be considered as definitive as they do not consider the interactions which occur in real situations;

Lessons related to the use of systematic literature review

In this section, shortcomings of using systematic reviews in broad areas are presented:

- The research question “how the built environment impact into health outcomes” is too broad being the focus divergent rather than convergent. Systematic reviews should be used for research with convergent focus as recommended by Mulrow *et al.* (1997b) and Mulrow and Cook (1997.
- Difficulties related to integrating research results and lack of clarity in this research field include :**a)** the multidisciplinary characteristic of the subject and the lack of a shared theoretical view explaining the phenomenon. **b)** the use of different terminologies amongst different areas of knowledge to refer to the same concept; **c)** the use of similar terminology amongst different areas of knowledge to refer to different concepts (e.g. health can be very broadly defined –e.g. incorporating well being – or sharply defined as the state of being free from illness or injury) ;

All things considered, the use of a systematic approach for “searching” the literature in this report was no more or less efficient than other ways of conducting reviews. However, the use of a systematic way to “analyse” research findings brought transparency and reliability to the process.

Lessons related to the development of an evidence-base

- Generally, the principle of induction is not stated/presented or clear in research about the impact of the built environment to health outcomes. Evidence-based design has been consistently based on the use of empirical evidence. As argued by Popper (1968) empirical sciences can be characterised by the use of inductive methods and therefore truth is established by the use of the logic of induction. , i.e. “*…the movement from the empirical observation of data by means of experiments to*

the inference of theories and general laws verified by the causal relations exhibited by that data (Johnson and Duberley 2004)". However, there are shortcomings in the use of an inductive approach, such as whether inductive inferences are justified (Russell, 1948; and Popper 1968). Popper (1968) argues that in justifying an inductive inference, researchers must first establish the principle of induction (an explanation of the logic expressing the cause-effect relationship). However, in general, research about the built environment and the impacts on health outcomes seems not to address such issues. Additionally, as stated by (Popper, 1968) rather than trying to prove a theory through empirical observation the researcher should also considerer the possibility of falsifying it.

- The type of evidence that have been used within the field lacks clarity in relation to cause and effect relationships and connection with theory. Therefore, there is a knowledge gap about research methodology. In this regards, the relationships are too complex to be studied under reductionist approaches that try to isolate variables.

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9 APPENDICES

9.1 Appendix 1 – Glossary of terms

Behaviour

Behaviour n. The physical activity of an organism, including overt bodily movements and internal glandular and other physiological processes, constituting the sum total of the organism's physical responses to its environment. The term also denotes the specific physical responses of an organism to particular stimuli or classes of stimuli. US behaviour (Colman, 2001).

Built Environment

The surroundings or conditions, created and built through human intervention, where a person, animal or plant lives or operate.

Characteristic

Characteristic [countable usually plural]: a quality or feature of something or someone that is typical of them and easy to recognize (Longman, 2000).

Component

Component n. A part or element of a larger whole, especially a part of a machine or vehicle (Soanes; Stevenson, 2004).

Element

Element [countable]. One part or feature of a whole system, plan, piece of work etc, especially one that is basic or important (Longman, 2000).

Ergonomics

Ergonomics n. A branch of industrial/organizational psychology or occupational psychology concerned with fitting jobs to people rather than people to jobs. Ergonomists design jobs, equipment, and work places to maximize performance and well-being and to minimize accidents, fatigue, boredom, and energy expenditure. Also (especially in the US) called biotechnology, human factors psychology, or engineering psychology. See also knobs-and-dials psychology, personnel psychology. ergonomic adj. ergonomist n. One who practises ergonomics.[From Greek ergon work + nomos management, from nemein to manage] (Colman, 2001).

Function

Function noun 1. an activity that is natural to or the purpose of a person or thing: bridges perform the function of providing access across water | bodily functions. [mass noun] practical use or purpose in design: building designs that prioritize style over function. A computer operation corresponding to a single instruction from the user (Soanes; Stevenson, 2004).

Health

Health is broadly defined as a “state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity” (WHO 1946).

Health Outcomes

Mental health seems to be achieved when the patient changes its behaviour as demonstrated in (Higgs, gabb, christenfeld in Groos 1998)

Physical

Physical adj. 1. Relating to the body as opposed to the mind. Involving bodily contact or activity: a physical relationship. 2. Relating to things perceived through the senses as opposed to the mind; tangible or concrete. 3. Relating to physics or the operation of natural forces generally (Soanes; Stevenson, 2004).

Physiological

Physiological: Pertaining to functions in a normal, healthy person (Oxford University Press, 1998).

Physiological functions

physiological functions Processes carried out by organs, tissues, and cells to maintain health. Major physiological functions include respiration, coordination, excretion, circulation, and reproduction (Oxford University Press, 1998).

Physiology

physiology n. The study of the functioning of organisms; also the working of a particular organism or one of its organs or parts (as in the physiology of the human ear).[From Greek physio- of or relating to nature or natural processes, from physis nature, from phyein to cause to grow + logos word, discourse, or reason] (Colman, 2001).

Setting

Setting [countable]: 1 the place where something is or where something happens, and the general environment (Longman 2000).

System

System noun 1. A set of things working together as parts of a mechanism or an interconnecting network; a complex whole: the state railway system | fluid is pushed through a system of pipes or channels (Soanes; Stevenson, 2005).

Well Being

Psychological well-being (mental well-being) is a mental condition characterised by pleasant feelings of good health, exhilaration, high self-esteem and confidence, often associated with regular physical activity (The Concise Oxford English Dictionary, 2007).

9.2 Appendix 2 – List of Journals

No.	Name of the Journal	NOPQ
1	ACCID. ANAL. & PREC.	1
2	ACHEMS (ABSTRACTS)	1
3	ACTA PAEDIATR SCAND	3
4	ADDICTION	1
5	ADDICTIVE BEHAVIORS	1
6	ADVANCES IN ENVIRONMENTAL PSYCHOLOGY	1
7	AEROSPACE MEDICINE	2
8	AGE AND AGEING	2
9	AGE AND BEING	1
10	AGNP SYMPOSIUM	1
11	AMERICAN ASSOCIATION OF NURSE ANESTHETISTS (AANA)	1
12	AMERICAN INDUSTRIAL HYGIENE ASSOCTION JOURNAL	1
13	AMERICAN JOURNAL OF ALZHEIMER'S CARE AND RELATED DISORDERS AND RESEARCH	1
14	AMERICAN JOURNAL OF ALZHEIMER'S DISEASE AND OTHER DEMENTS	1
15	AMERICAN JOURNAL OF CLINICAL HYPNOSIS	1
16	AMERICAN JOURNAL OF CRITICAL CARE	2
17	AMERICAN JOURNAL OF EPIDEMIOLOGY	2
18	AMERICAN JOURNAL OF HEALTH PROMOTION	1
19	AMERICAN JOURNAL OF HOSPITAL PHARMACY	1
20	AMERICAN JOURNAL OF INFECTION CONTROL	10
21	AMERICAN JOURNAL OF MEDICINE	2
22	AMERICAN JOURNAL OF OBSTETRIC GYNAECOLOGY	1
23	AMERICAN JOURNAL OF PSYCHIATRY	1
24	AMERICAN JOURNAL OF PUBLIC HEALTH	3
25	AMERICAN JOURNAL OF ROENTGENOLOGY	1
26	AMERICAN SOCIETY OF INTERNAL MEDICINE	1
27	ANAESTHESIA	3
28	ANAESTHESIA AND ANALGESIA	1
29	ANAESTHESIA AND INTENSIVE CARE	1
30	ANAESTHETIST	1
31	ANNALES FRANCAISES D'ANESTHESIE ET DE REANIMATION	1
32	ANNALS OF EMERGENCY MEDICINE	1
33	ANNALS OF INTERNAL MEDICINE	3
34	ANNALS OF THE NEW YORK ACADEMY OF SCIENCES	1
35	ANNUAL REVIEW OF NURSING RESEARCH	1
36	AORN JOURNAL	10
37	ARCH. GERONTOL. GERIA TR.	1
38	ARCH. INTERN MED.	1
39	ARCH. SURG	2
40	ARCHIVES OF DISEASE IN CHILDHOOD	7
41	ARCHIVES OF ENVIRONMENTAL HEALTH	2
42	ARCHIVES OF OPHTHALMOLOGY	1
43	ARCHIVES OF PSYCHTRIC NURSING	1
44	ARCHIVES SURGERY	1
45	ATMOSPHERIC ENVIRONMENT	1
46	BEHAVIOR AND THE NATURAL ENVIRONMENT	1
47	BEHAVIOR THERAPHY	1
48	BEHAVIORAL MEDICINE	1
49	BIO NEONATE	1

No.	Name of the Journal	NOPQ
50	BIOLOGICAL PSYCHIATRY	1
51	BIRTH	2
52	BJM	1
53	BMC PSYCHIATRY	1
54	BMC PUBLIC HEALTH	1
55	BRITISH JOURNAL OF MUSIC EDUCATION	1
56	BRITISH JOURNAL OF PSYCHIATRY	1
57	BRITISH JOURNAL OF RHEUMATOLOGY	1
58	BRITISH MEDICAL BULLETIN	1
59	BRITISH MEDICAL JOURNAL	8
60	BRITISH MEDICAL JOURNAL	1
61	BUILDING AND ENVIRONMENT	1
62	BUILDING SCIENCE	3
63	BURNS	1
64	CANADIAN INSTITUTE OF MINING AND METALLURGY (CIM)	1
65	CANADIAN INTERIORS	1
66	CANADIAN JOURNAL OF ANAESTHESIA	1
67	CANADIAN MEDICAL ASSOCIATION JOURNAL (CMAJ)	1
68	CANCER NURSING	2
69	CHEMICAL SENSES	5
70	CHEST	5
71	CHILD DEVELOPMENT	1
72	CIFR TECHNICAL REPORT (GRANJi) VALLEY STATE UNIVERTY)	1
73	CIRCULATION	2
74	CLINICAL EFFECTIVENESS IN NURSING	1
75	CLINICAL INFECTIONS DISEASES	1
76	CLINICAL INFECTIOUS DISEASES	1
77	CLINICAL NURSE SPECIALIST	2
78	CLINICS IN PERINATOLOGY	1
79	CONSULTING PSYCHOLOGY JOURNAL: PRACTICE & RESEARCH	1
80	CRITICAL CARE MEDICINE	5
81	CRITICAL CARE NURSING QUATERLY	7
82	CRITICAL CARE NURSING QUATERLY	1
83	CRITICAL NURSING QUATERLY	1
84	DESIGN	1
85	DESIGN DK	1
86	DESIGN MANAGEMENT JOURNAL	4
87	DESIGN STUDIES	3
88	DESIGN WEEK	5
89	DIALYSIS & TRANSPLANTATION	3
90	DIMENSIONS OF CRITICAL CARE NURSING	7
91	EARLY CHILD DEVELOPMENT AND CARE	1
92	EARLY HUMAN DEVELOPMENT	2
93	EBM	1
94	ELECTROENCEPHALOGRAPHY AND CLINICAL NEUROPHYSIOLOGY	1
95	EMERGING INFECTIOUS DISEASES	1
96	ENVIRONMENT AND BEHAVIOR	34
97	ENVIRONMENTAL HEALTH: A GLOBAL ACCESS SCIENCE SOURCE	1
98	ENVIRONMENTAL INTERNATIONAL	2
99	ERGOCON 95	1
100	ERGONOMICS	4

No.	Name of the Journal	NOPQ
101	EUROPEAN JOURNAL OF CANCER CARE	2
102	EUROPEAN JOURNAL OF PHYSIOLOGY	1
103	FX	1
104	GERIATRIC NURSING	1
105	GRAPHICS INTERNATIONAL	1
106	GROUP PRACTICE JOURNAL	1
107	HEALTH AND LUNG	15
108	HEALTH CARE MANAGEMENT REVIEW	2
109	HEALTH PHYSISCS	2
110	HEALTH PSYCHOLOGY	2
111	HEALTH SERVICE JOURNAL	2
112	HEART & LUNG	1
113	HOLISTIC NURSING PRACTICE	1
114	HOSPITAL AND COMMUNITY PSYCHIATRY	4
115	HUMANS FACTORS	3
116	I.D. (USA)	2
117	IMMUNOLOGY AND ALLERGY CLINICS OF NORTH AMERICA	1
118	INDOOR AIR (SUPLEMENT)	3
119	INFANT BEHAVIOR AND DEVELOPMENT	1
120	INFECTION CONTROL	4
121	INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY	5
122	INFECTIOUS DISEASE CLINICS OF NORTH AMERICA	1
123	INTENSIVE CARE MEDICINE	3
124	INTERIORS	3
125	INTERNATIONAL ARCHIVES OF OCCUPATIONAL ENVIRONMENTAL HEALTH	1
126	INTERNATIONAL JOURNAL BIOSOCIAL RESEARCH	2
127	INTERNATIONAL JOURNAL OF HEALTH CARE QUALITY ASSURANCE	1
128	INTERNATIONAL JOURNAL OF MENTAL HEALTH NURSING	1
129	INTERNATIONAL JOURNAL OF NURSING STUDIES	1
130	INTERNATIONAL JOURNAL OF PSYCHOANALYSIS	1
131	J RES MUSIC EDUC	1
132	JAHA	2
133	JAMA	4
134	JOGNN	1
135	JOURNAL OF ABNORMAL PSYCHOLOGY	1
136	JOURNAL OF ADOLESCENT HEALTH	2
137	JOURNAL OF ADOLESCENT HEALTH CARE	1
138	JOURNAL OF ADVANCED NURSING	12
139	JOURNAL OF ADVERTISING	1
140	JOURNAL OF AFFECTIVE DISORDERS	3
141	JOURNAL OF AMERICAN GERIATRICS SOCIETY	1
142	JOURNAL OF AMERICAN MEDICAL ASSOCIATION	2
143	JOURNAL OF APPLIED BEHAVIOUR ANALYSIS	1
144	JOURNAL OF APPLIED PSYCHOLOGY	3
145	JOURNAL OF APPLIED SOCIAL PSYCHOLOGY	2
146	JOURNAL OF ARBORICULTURE	1
147	JOURNAL OF ARCHITECTURAL AND PLANNING RESEARCH	4
148	JOURNAL OF BIOLOGICAL RHYTHMS	1
149	JOURNAL OF BUSINESS RESEARCH	1
150	JOURNAL OF CANCER NURSING	1
151	JOURNAL OF CLINICAL ANESTHESIA	1

No.	Name of the Journal	NOPQ
152	JOURNAL OF CLINICAL MICROBIOLOGY	1
153	JOURNAL OF CLINICAL MONITORING & COMPUTING	1
154	JOURNAL OF CLINICAL NUTRITION	1
155	JOURNAL OF COMMUNITY HEALTH NURSING	1
156	JOURNAL OF CONSUMER RESEARCH	3
157	JOURNAL OF COUNSELING PSYCHOLOGY	1
158	JOURNAL OF DESIGN HISTORY	1
159	JOURNAL OF DEVELOPMENTAL & BEHAVIORAL PEDIATRICS	1
160	JOURNAL OF ENVIRONMENTAL PSYCHOLOGY	17
161	JOURNAL OF GENERAL PSYCHOLOGY	1
162	JOURNAL OF GERIATRIC PSYCHIATRY	1
163	JOURNAL OF GERONTOLOGICAL NURSING	4
164	JOURNAL OF GERONTOLOGY	1
165	JOURNAL OF HEALTH CARE INTERIOR DESIGN	1
166	JOURNAL OF HEALTH CARE MARKETING	1
167	JOURNAL OF HOSPITAL INFECTION	5
168	JOURNAL OF HOUSING FOR THE ELDERLY	1
169	JOURNAL OF HUMAM STRESS	1
170	JOURNAL OF HYGIENE-CAMBRIDGE	2
171	JOURNAL OF INFECTION	1
172	JOURNAL OF INFECTIOUS DISEASES	1
173	JOURNAL OF INTERIOR DESIGN	1
174	JOURNAL OF LIGH AND VISUAL ENVIRONMENT	2
175	JOURNAL OF MARKETING	3
176	JOURNAL OF MUSIC THERAPY	10
177	JOURNAL OF NURSING ADMINISTRATION	4
178	JOURNAL OF NURSING CARE QUALITY	1
179	JOURNAL OF NURSING PRACTICE	1
180	JOURNAL OF NURSING RESEARCH	1
181	JOURNAL OF NURSING STUDIES	1
182	JOURNAL OF OCCUPATIONAL AND HEALTH PROFESSIONALS	1
183	JOURNAL OF PERIANESTHESIA NURSING	1
184	JOURNAL OF PERINATOLOGY	1
185	JOURNAL OF PERSONALITY AND SOCIAL PSYCHOLOGY	4
186	JOURNAL OF POST ANAESTHESIA NURSING	2
187	JOURNAL OF PSYCHIATRY	1
188	JOURNAL OF PSYCHOSOCIAL NURSING AND MENTAL HEALTH SERVICES	1
189	JOURNAL OF PUBLIC HELATH MANAGEMENT & PRACTICE	1
190	JOURNAL OF REHABILITATION COUNSELING	1
191	JOURNAL OF RESPIRATORY CRITICAL CARE MEDICINE	1
192	JOURNAL OF RETAIL BANKING	1
193	JOURNAL OF RETAILING	2
194	JOURNAL OF RHEUMATOLOGY	1
195	JOURNAL OF SAFETY RESEARCH	4
196	JOURNAL OF SOCIAL ISSUES	2
197	JOURNAL OF SOCIAL PSYCHOLOGY	1
198	JOURNAL OF THE AMERICAN GERIATRIC SOCIETY	1
199	JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY	1
200	JOURNAL OF THE JAPANESE INSTITUTE OF LANDSCAPE ARCHITECTS	1
201	JOURNAL OF THE ROYAL COLLEGE OF PHYSICIANS OF LONDON	1
202	JOURNAL OF THE ROYAL SOCIETY OF MEDICINE	1

No.	Name of the Journal	NOPQ
203	LANCET	1
204	LANDSCAPE AND URBAN PLANNING	4
205	LANDSCAPE RESEARCH	1
206	LIGHTING DESIGN + APPLICATION	1
207	LIGHTING RESEARCH TECHNOLOGY	7
208	LIPPINCOTT'S CASE MANAGEMENT	1
209	MARKETING LETTERS	1
210	MARKETING NEWS	1
211	MEDICAL CARE	1
212	MENTAL HYGIENE	1
213	METROPOLIS	3
214	MILLIEU THERAPHY III	1
215	MODERN HEALTHCARE	1
216	MODERN HOSPITAL	2
217	NAACOG'S CLINICAL ISSUES IN PERINATAL AND WOMEN'S HEALTH NURSING	1
218	NATNEWS	1
219	NEONATAL NETWORK	1
220	NEW DESIGN	1
221	NEWBORN AND INFANT NURSING REVIEWS	1
222	NHS REPORT (ENGLAND)	1
223	NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH	1
224	NURSING ADMINSTRATION QUATERLY	2
225	NURSING MANAGEMENT	2
226	NURSING RESEARCH	13
227	NURSING STANDARD	1
228	NURSING TIMES	4
229	ONCOLOGY NURSING FORUM	6
230	OTOLARYNGOLOGIC CLINICS OF NORTH AMERICA	2
231	OTOLARYNGOLOGY HEAD AND NECK SURGERY	3
232	PAIN	1
233	PATIENT EDUCATION AND COUNSELLING	2
234	PEDIATRICS	5
235	PERCEPTUAL AND MOTOR SKILLS	6
236	PERFUMER AND FLAVORIST	1
237	PHARMACOTHERAPHY	1
238	PLACES	1
239	PREVENTION IN HUMAN SERVICES	1
240	PROQUEST NURSING JOURNALS	1
241	PSYCHIATRY RESEARCH	1
242	PSYCHOLOGICAL MEDICINE	2
243	PSYCHOLOGICAL REPORTS	2
244	PSYCHOPHARNACOLOGY BULLETIN	2
245	PSYCHOSOM. MED. PSYCHOL. (PPmP)	1
246	PSYCHOTERAPY: THEORY, RESEARCH, PRACTICE, TRAINNING	1
247	PUBLIC HEALTH NURSING	1
248	QUALITATIVE HEALTH RESEARCH	2
249	QUALITY IN HEALTH CARE	1
250	RADIOLOGY	1
251	RESEARCH IN NURSING AND HEALTH	5
252	RESEARCH NURSING HEALTH	2
253	SCANDINAVIAN JOURNAL OF CARING SCIENCES	1

No.	Name of the Journal	NOPQ
254	SCANDINAVIAN JOURNAL OF INFECT. DIS.	1
255	SCANDINAVIAN JOURNAL OF PSYCOLOGY	1
256	SCHOLARLY INQUIRY FOR NURSING PRACTICE: AN INTERNATIONAL JOURNAL	2
257	SCIENCE	1
258	SCIENTIFIC AMERICAN	1
259	SLEEP	1
260	SOCIAL SCIENCE MEDICINE	4
261	SOCIOMETRY	1
262	SPACE '90 (PROCEEDINGS)	1
263	SURVEY OF OPHTHALMOLOGY	1
264	TECHNICAL BULLETIN OF THE FACULTY OF CHIBA UNIVERSITY	1
265	TEXTILE RESEARCH JOURNAL	1
266	THE AMERICAN JOURNAL OF ALZHEIMER'S CARE AND RELATED DISORDERS & RESEARCH	2
267	THE AMERICAN JOURNAL OF HEALTH-SYSTEMS PHARMACY	2
268	THE AMERICAN JOURNAL OF MEDICINE	3
269	THE AMERICAN JOURNAL OF PSYCHIATRY	1
270	THE AMERICAN SURGEON	1
271	THE ANPHI PAPERS	1
272	THE CANADIAN MEDICAL ASSOCIATION JOURNAL	1
273	THE CENTER FOR INNOVATION IN HEALTH FACILITIES	1
274	THE DESIGN JOURNAL	1
275	THE GENERAL PSYCHOLOGY	1
276	THE GERONTOLOGIST	6
277	THE HEALTH CARE SUPERVISOR	1
278	THE JOURNAL OF AGING AND HEALTH	1
279	THE JOURNAL OF ARCHITECTURAL & PLANNING RESEARCH	2
280	THE JOURNAL OF BONE AND JOINT SURGERY	2
281	THE JOURNAL OF INFECTIOUS DISEASES	2
282	THE JOURNAL OF PEDIATRIC NURSING	1
283	THE JOURNAL OF PEDIATRICS	6
284	THE MEDICAL CLINICS OF NORTH AMERICA	2
285	THE MODERN HOSPITAL	2
286	THE NEW ENGLAND JOURNAL OF MEDICINE	10
287	THE PRACTITIONER	1
288	THE WESTERN JOURNAL OF MEDICINE	1
289	TRANSPORTATION RESEARCH RECORD	1
290	US OFFICE OF TECHNOLOGY ASSESSMENT, ALZHEIMER'S DISEASE AND ASSOCIATED DISORDERS	1
291	WESTERN JOURNAL OF NURSING RESEARCH	2
292	WORK & STRESS	1
293	WORLD ARCHITECTURE	1

NOFP: Number of papers quoted.

9.3 Appendix 3 - Electronic databases

The following databases were assessed for relevance and were selected for use in the study. The cells highlighted in grey refers to the accessed data bases.

Data base	Description
ASSIA – Applied Social Sciences Index nd Abstracts (via CSA*)	Indexing and abstracting database covering health, social services, psychology, sociology, economics, politics, race relations and education. Updated monthly, ASSIA provides a comprehensive source of social science and health information for the practical and academic professional. Contains over 255,000 records from 650 journals in 16 different countries, including the UK and US.
CINAHL – Cumulative Index to Nursing Allied Health (via Ovid)	Bibliographic database which covers over 900 nursing, allied health and biomedical journals. Of particular use for physiotherapy and occupational therapy.
DAAI – Design and Applied Arts Index (via CSA)	A comprehensive database of design and craft journals covering 450 titles. It contains over 100,000 annotated references, as well as information on over 40,000 designers, craftspeople, studios, workshops, firms etc.
Article First, ECO, Worldcat (via First Search - OCCL)	
HMIC - Health management information Consortium (via Ovid)	Health Management Information Consortium – Consists of 3 databases, DH-Data, HELMIS, and Kings Fund Database. Abstracts are available on the following subject areas health service and hospital administration and management, public health, community care, service development and NHS organisation.
HEALTH MANAGEMENT LITERATURE	
IBSS – International Bibliography of Social Sciences (via BIDS)	Access to over 1.5 million records from over half a century of social science research. Current data is taken from over 2400 selected international social science journals and around 7000 books per year. Updated weekly.
MEDLINE (via Ovid)	Contains bibliographic citations of biomedical literature, including all foreign languages. Covers the whole spectrum of medicine, referencing over 3700 journals from 70 countries.
PRO-QUEST	
SCIENCE DIRECT (via Elsevier B.V.)	Full text of all the journals published by Elsevier Science.
SWETSWISE (via Swets Information Services)	Electronic Journal Aggregator providing access to full text publications from several major academic publishers.
WEB OF KNOWLEDGE (via Mimas)	A collection of databases covering all subjects.
ZETOC (via British Library	British Library's Electronic Table of Contents service, covering 20,000 current journals and 16, 000 conference proceedings published each year. 15 million articles and conference records, covering most subjects.
NHS Estates – Safer Environment Database, efm-evidence, Bryan Lawson and Michael Phiri	Data base developed University of Sheffield

*CSA – Cambridge Scientific Abstracts

Selected database are shaded in grey.

9.4 Appendix 4 - Theoretical Framework: Cause and Effect

The original idea of this framework was identify health outcomes and track their rout causes.

Cause (lack or excess)	Underlying cause	Effect
Noise	Machines (e.g. haemodialysis machine); Wheelchairs and stretcher locomotion; Conversation between roommates or visitors; Noise from outside;	Sleeplessness; Heart rate increase; Blood pressure increase; Anxiety; Difficult in gain weight (infants); Stress increment;
Light	Artificial light; Natural light;	Anxiety; Depression; Delirium;
Occupancy	Multiple x Single patient room; Ward organization	Stress increase; Problems related to noise;
Falls	Flooring material (carpet, hard, glossy vinyl or linoleum)	Depression; Insecurity;
Furniture arrangement	Lack of social interaction;	Depression Lack of appetite;
Other environmental factor	Windowless; Music Paintings Landscape view Air quality	Anxiety; Stress; Pain reduction; Infections control;

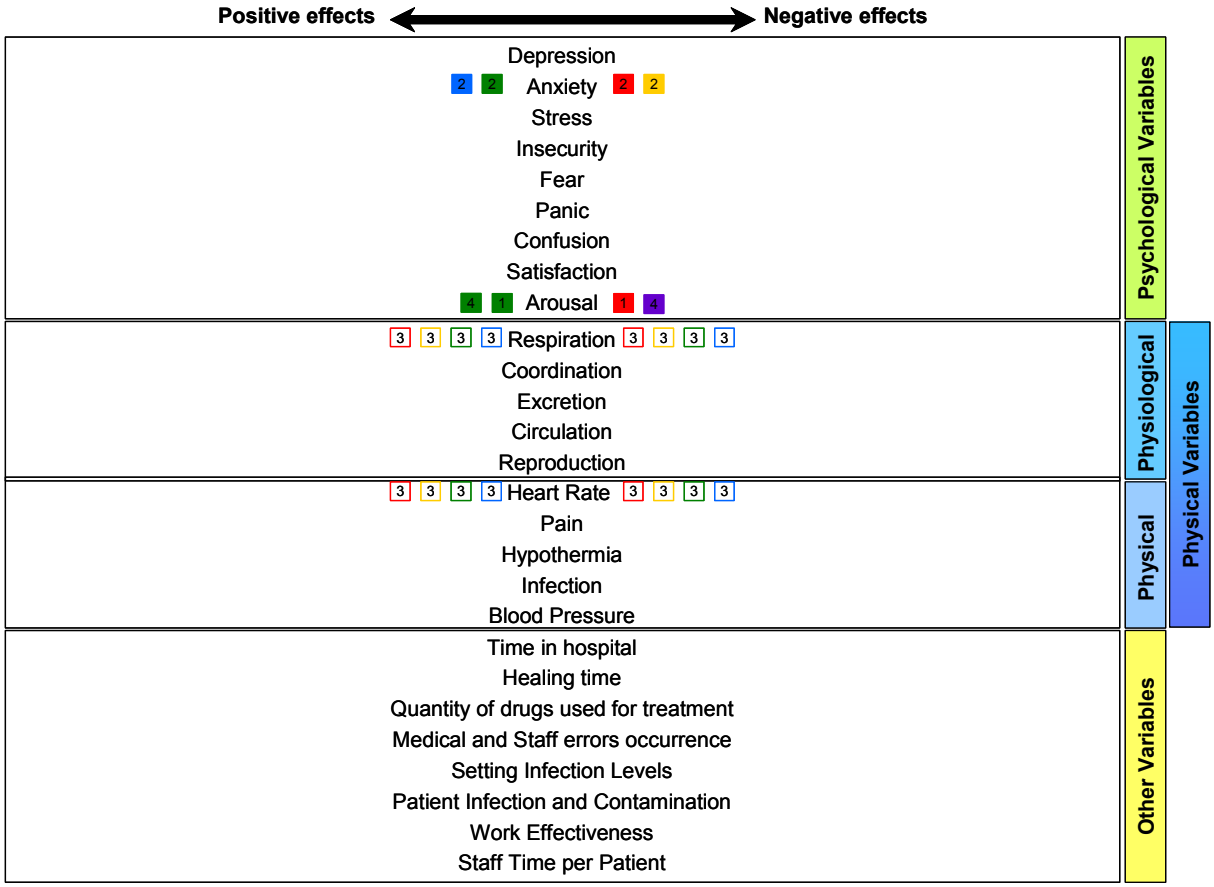
9.5 Appendix 5 – Framework: Problem-oriented description

The original idea of this framework was to identify targets for the improvement of health outcomes and the proposed solutions to achieve the targets.

Objectives	Solutions		
To reduce the numbers of errors make by staffs, doctors, nurses, etc.;	Windows near tasks type; Visual communication improvement Reduce the noise level Improve wards conditions (space organization, facilities, etc);		
To reduce the level of contamination;	Air conditioning – ventilation quality Hand washing Humidity control – humidifier water Private rooms (burned patients)		
To reduce the level of inpatient STRESS, ANXIETY, BLOOD PRESSURE and HEART RATE;	Reduce noise	from equipments from conversation (in and out side) from floor snoring at night	
	Improve patient control	Noise level Light level Communication Temperature control Social interaction Ventilation control	
	Improve sleep quality	Noise control	Earplugs (failed for some) Sound conditioner (failed)
	music	introduce music periodically	
	social interaction	furniture sizes furniture layout private x social bedrooms	
To reduce the patients accidents;	Type of floor (carpet x vinyl)		
To reduce treatment time and drugs necessities	Windows with landscape view Well furniture that promote social interaction		
to control body temperature	Temperature control Humidity control		
To improve sleep quality			

9.6 Appendix 6 – Framework: Impact of Colour on Humans

This framework was developed with the objective of compiling information about different colours on humans. The variables presented in the middle are related to the health outcomes identified in the literature review. Positive outcomes were listed on the left side and negative outcomes on the right side. Coloured squares were used to represent the investigated colour. Filed squares meaning that colour has an impact and empty squares meaning that no effect was identified. The number in the middle of the squares is related to the source of information which is listed below.



1. Wilson, G., D., Arousal properties of red versus green Perceptual and Motor Skills, Vol. 23 1966 942-949;
2. Jacobs, K., W., and J., F., Suess Effects of four psychological primary colors on anxiety state Perceptual and Motor Skills, Vol. 41 1975 207- 210
3. Jacobs, K., W., and F., E., Hustmyer, Jr., Effects of four psychological primary colors on GSR (galvanic skin response) heart rate and respiration rate Perceptual and Motor Skills, Vol. 38 1974 763- 766
4. Nourse, J., C., and R., B., Welch Emotional attributes of color: a comparison of violet and green Perceptual and Motor Skills, Vol. 32 1971 403- 406

9.7 Appendix 7 – Framework: Patient related investigation

This framework was developed with the aim of associate the perception canals (5 senses), patients' health outcomes and the route causes of the outcomes.

Patient-related						
			Underlying Cause	Effect on building	What have been done	Effect on patient
SENSES	Vision	Light	Lack of sun light	Shadows, exaggerated images and sensory distortion	Skylights, solariums, atriums and courtyards	Reduction of suffering, reduction of drug confusion
			Light wave frequency		Use of different light wave frequencies	LF (red): less sleep-wake frequency and more sleep; HF (blue) greater sleep-wake frequency
		Window preference	Small dimensions and few transparency	Lack of light and ventilation	Transparency and dimensions improvement	
		Window	Lack of landscape view	-	Care with hospital design in sense of provide a natural view	Shorter hospitalizations , less need for pain medications
		Art	Modern art (abstract images)	depression	Substituted by landscape paints	
	hearing	Noise	Conversation and environment (+70dBA), machines on ICU (90dBA); heavy footsteps	Sleeplessness, heart rate and blood pr essure increase, perturbation,	Time planning for interaction with staffs and family, reduction of patients and machines per room, acoustic building treatment, soft shoes for nurses, maintenance of squeaky beds and trolleys, dripping taps, plastic urine bottle instead glass, telephones relocation;	Reduction of pain medication;
		Music			Controlled exposure	Infants weight increase, stress reduction, shorter hospitalization;
			Machines (e.g. haemodialysis machine);			
	Touch					
	Taste					

9.8 Appendix 8 – Framework: Illness related investigation

This framework was developed with the aim of associate health outcomes with illness.

Illness-related					
	Illness	What have been done	Effect on building	Underlying Cause	Effect on patient
	Alzheimer and dementia	Visual access stimulation through signage (e.g. floor patterns)	Use of signposts and signage in the building	Way finding desorientation	Personal autonomy and quality of life increase
	Geriatric rehabilitation	Changes on the type of flooring (vinyl substituted for carpet)	Reduced housekeeping floor maintenance		Satisfaction related to safety, access and aesthetics were improved
	Children with psychiatric problems	density per room h ave been controlled	resize the bedrooms	Density psychological condition on patients	Improve behaviour
	Psychiatric related	Room size	Private rooms substituted multiple occupancy		Multiple rooms increase isolated passive behaviour

9.9 Appendix 9 – Framework: Performance related investigation

This framework was developed with the aim of associate the performance of physical built environmental characteristics with health outcomes.

Performance-related				
	problem	Underlying Cause	Effect in health	What have been done
Ventilation	Quality of air in rooms	Windowless or poor dimension	Non commented	Windows size increase
	Quality of air in wards	Design's criteria are non reliable (43)	Non commented	Ventilation standards have been reviewed
	Infections by aspergillosis	Lack of infection control during construction phase	During construction the level of infection by aspergillosis increase	Use of Portable High-Efficiency Particulate Air (HEPA) filtration
	Infections by Staphylococcus (48)	Conduction through exhaust ducting and opened window	Before to solve exhaust problem patients were continuously infected	Orientation for ITU designers that architectural design should take into account the position of external and internal ventilation structures such as ventilation exh aust grilles and windows wich can be opened
	Infections by Acremonium in surgical centre	Ventilation system were switched on once a week and allowed Acremonium development in the humidifier water	Before to solve the problem, patients in surgical centre were infected mainly after to turn on the ventilation system	Implementation of established hospital infection control practises in the outpatient setting.
	Air quality in surgical centre	Bad air conditions	Sepsis development	Operation in surgical centre with ultraclean air associated with prophylactic use of antibiotics (50,58)
Humidity	Humidity in infants incubator	Lack of humidifier or humidity control	Loss of water in infants at low level humidity	Utilization of vapour pressure
	Relation between humidity and body temperature	Increase of humidity level	Body temperature increase	Systems to control humidity
	Humidity level definition		Between 80 -90% rapid respiratory rates, higher body temperature and lower death rate	

9.10 Appendix 10 – Framework: Setting related investigation

This framework was developed with the aim of associate health outcomes to specific settings within hospitals.

Setting-related				
Unit of treatment	Environment	Population Studied	Research	Health outcome or finding
Heart Treatment	CICU (Cardiac Intensive Care Unite)	628 first attack of myocardial infarction (66)	Sunny versus dull rooms	Patients stayed short time in sunny room; Mortality was higher in dull rooms;
	Coronary care units	11 patients treating myocardial infarction (70);	Effects of environment in delirium	People moved to environment of nearly normal surroundings presented less delirium and anxiety.
		75 patients with suspected myocardial infarction (84)	Effect of music and synthetic silence in anxiety and physiologic parameters (heart rate, blood pressure and skin temperature)	Significant improvement in physiologic parameters
Babies treatment	Neonatal Intensive Care Unit (NICU)	41 preterm infants (67)	Lighting (cycled and non -cycled lighting) in infant growth and development	In lighting conditions: great rate of weight gain; less time on the ventilation and on phototherapy; enhance motor coordination.
		290 infants (91)	Lighting 55 foot - candles and 15 foot-candles in incidence of retinopathy	No difference was observed in the incidence and severity of retinopathy of prematurity or visual damage.
	Non specified	96 babies (69)	Exposes infants under 90 foot - candles and 10 foot-candles	Infants under high level of illumination showed reduced levels of hyperbilirubinemia or prematurity
	Nursery	41 infants (85)	Light and noise in infants	Longer time sleeping, less time feeding and weight gain on infants in controlled light and noise environment
		Non specified (65)	Effects of high level illumination in retinopathy of	Contribute for oxygen - induced retinopathy of prematurity

9.11 Appendix 11 – Framework: Non-building related investigation

This framework was developed with the aim of compiling research results related to devices, treatments and therapies associated to health outcomes.

Non-building related			
subject	Population Studied	Research	Health outcome and or findings
drugs		Perceived effect end effectiveness in drugs with different colours	Green and blue may have more sedative effect; red and orange may have more stimulant effect (68);
music	Non specified (78)	Effects of music therapy on anxiety	Reduction of anxiety level
	20 subjects (83)	Pain reduction through music listening and imagery stimulation	Significant time effect for heart rate, systolic and diastolic blood pressure. No signifi cant results were found in pain reduction;
earplugs	Non specified (79)	Effect of earplugs on sleep	Helped patients to sleep but may not be suitable for every patient.

9.12 Appendix 12 – Framework: Non-health outcomes related

This framework was developed with the objective of compiling information from studies presenting non-health related impacts of the built environment on humans.

Non-health related			
environment	Population Studied	Research	Findings
office	36 paid subjects (71)	Examine the effects of red versus a blue office environment on a typing task and mood	Red: more anxiety and stress scores; blue: more depression score; people who switched showed more arousal score.
	70 employees (93)	Privacy and it correlation with the degree of physical enclosure	There is correlation between privacy and physical enclosure and satisfaction. Masking sound system, carpeting and semi -sound absorbing panels do not create speech privacy enough
	Non specified	Task performance in windowed and windowless offices	Non conclusive
Non-specific environment related	20 subjects (72)	Arousal level under red and green colour	Red induces to a higher arousal level;
	14 subjetcs (76)	Arousal level under violet and green light	Violet to green showed more arousal level than green to violet.
	48 subjects (73)	Colour (red, green and achromatic) environment effect on activities requiring psychomotor and judgmental functions	Subjects exposed showed hand tremor and motor inhibition;
	40 subjects (74)	Effects of colours (red, yellow, green a nd blue illumination) in anxiety.	Red and yellow showed higher scores than blue and green;
	Non specified (75)	Effects on Galvan skin response (heart rate and respiration)	Non significant results in heart and respiration rates.
	80 subjects (87)	Effects of noise under active task involvement as opposed to passive exposure	The ability to engange and improve in task performance under noise conditions does not change
	Non specified (92)	Effects of illumination in noise (generated by conversation) stimulation.	Low levels of noise were measured in low - illumination conditions

Non-building-related studies:

Hospitalization increase stress – cause: financial problems and lack of information related to illness and their consequences (59);

Stressed patients developed respiratory infection, clinical colds and infection more than those non-stressed (60);

People exposed to fluorescent light showed relative excess of melanoma lesions on the trunk (63);

Non-healthy related:

Sunlight: window size did not affect the occupant emotional state or degree of satisfaction, but increase the feeling of relaxation (61);

Sunlight: significant effect for sunlight penetration on job satisfaction, intention to quit and general being (64).

9.13 Appendix 13 – Framework: Map of Variables

This open framework was developed with the aim of map explicit variables within different studies. The framework for controlling the literature review and for the identification of similar cases (i.e. considering similar variables) making possible to build an evidence-base.

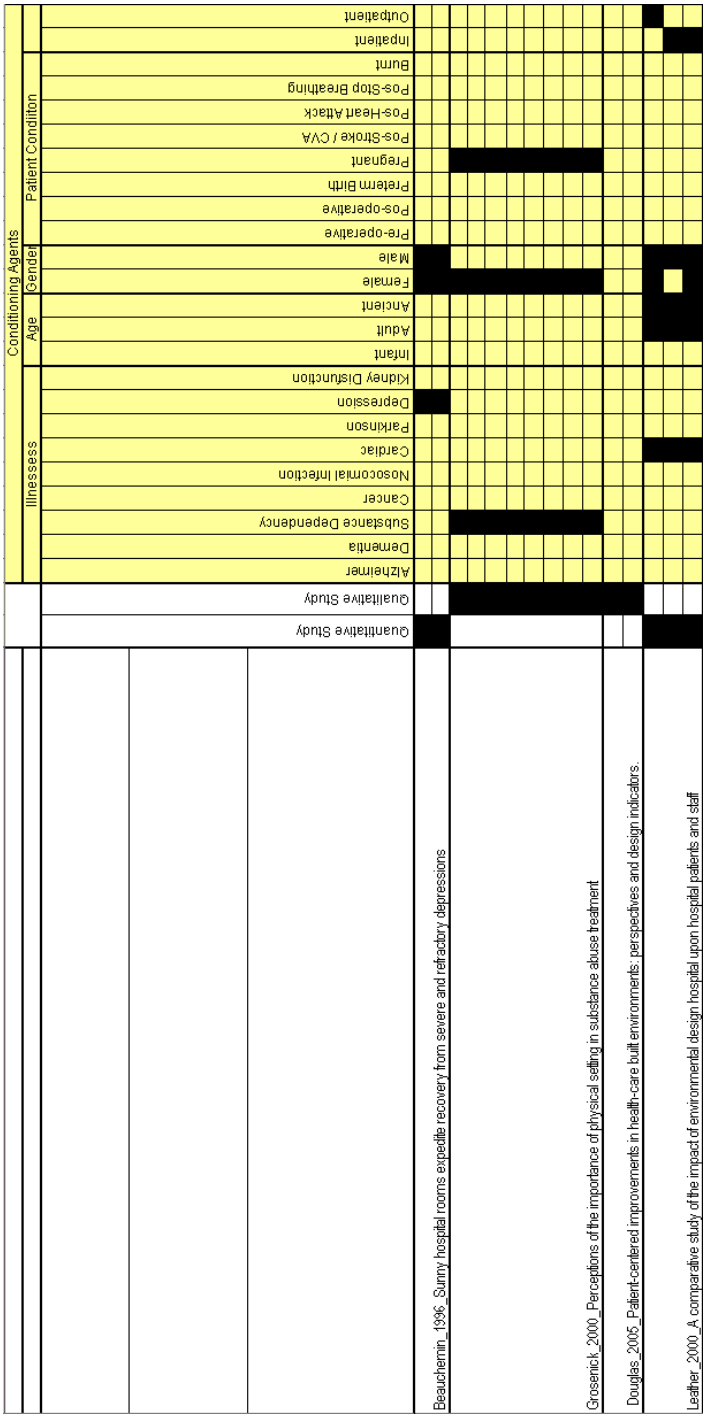


Figure 8. Reference and Patients' Condition

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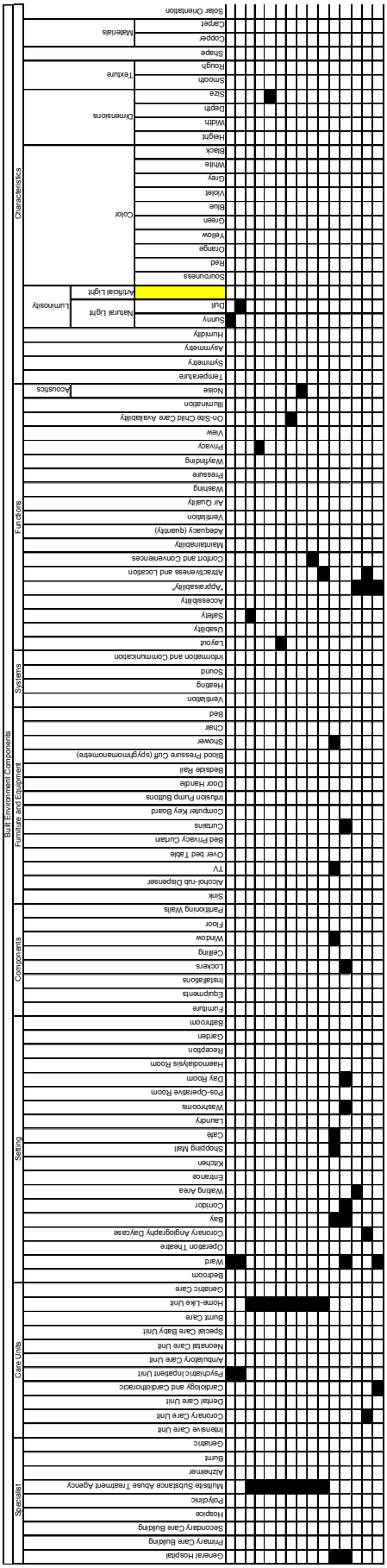

Figure 9. Built environment setting, characteristics and features

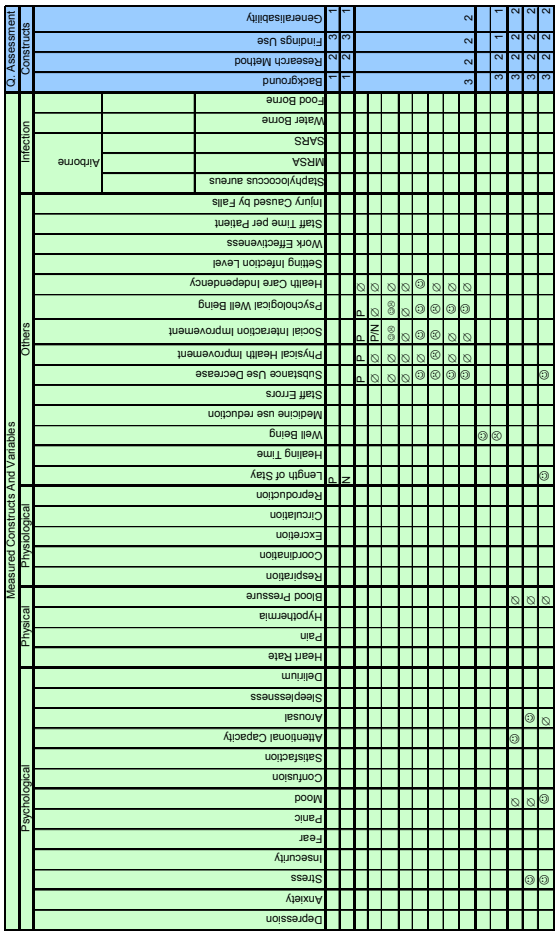

Figure 10. Health outcomes and quality assessment criteria

9.14 Appendix 14 – Research Protocol

Table 11. Protocol for data extraction (adapted from Boaz *et al.* 2002)

Data Extraction Tool
Details of Publication
Author(s):
Title:
Source (e.g. journal, conference etc.)
Year/volume/pages/country of origin:
Institutional affiliation:
Research Details
Research question:
Aims:
Objectives:
Study design (e.g. case study, action research, literature review):
When was the fieldwork conducted?
Participation in the study:
Target population:
Exclusion criteria:
Recruitment procedures:
Characteristics of participants (e.g. age, sex, social class, ethnicity, geographical location, health status, income status, other information):
Research tools
Which research tools were used?
Where were they piloted?
Was a specific attitude scale used? Which?
Theory
Was any theory referred to in the research?
Give details:
Ethics
Was ethics committee approval obtained?
Analysis
Statistical techniques used:
Qualitative analysis techniques used:
Computer analysis tools used:
Reviewers decision
Is the study methodologically sound (see decision tools)?
Is it relevant to the review topic?
Is it to be included?