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The impacts of the built environment on health outcomes

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Abstract

Purpose – The purpose of this paper is to present a conceptual framework that categorises the features and characteristics of the built environment that impact on health outcomes.

Design/methodology/approach – An extensive literature review was carried out. A total of 1,163 abstracts were assessed, leading to 92 papers being reviewed.

Findings – There is a considerable amount of evidence linking healthcare environments to patients' health outcomes, despite the lack of clarity in relation to cause-effect relationships.

Originality/value – The paper proposes a theoretical framework linking different built environment characteristics to health outcomes. This framework provides a structure to group causal effects according to their relation with design features, materials and ambient properties, art and aesthetic aspects and use of the built environment.

Keywords Environmental health and safety, Environmental psychology, Facilities, Design

Paper type Conceptual paper

Introduction

Everyday thousands of people experience the pressure of being in a hospital environment. Growing levels of anxiety, depression, stress, agitation, emotional exhaustion, among others, can occur if the surroundings are not appropriate. Thus, it is crucial to investigate and understand how characteristics of healthcare environments impact on health to enable us to improve and create environments that can enhance or at least not disturb the healing process.

In this paper, healthcare environments include any facility where healthcare is delivered and its surroundings (e.g. hospitals, primary care centres, hospices and nursing homes). Discussions about the importance of the built environment for healthcare delivery extend at least as far back as Hippocrates (400BC). More recently, theories explaining the relationships between the built environment and human behaviour have been proposed, with a starting point in the field of environmental psychology (Proshansky, 1976; Mehrabian and Russell, 1974). In the 1990s, the research interests upon healthcare environments and patient health outcomes increased considerably with myriad characteristics of the built environment investigated (e.g. Devlin and Arneill, 2003, Ulrich *et al.*, 2004, 2008). In addition, several studies present and compile evidence that can support design decisions (Evans and McCoy, 1998; Lawson and Phiri, 2003; Ulrich *et al.*, 2004; Joseph, 2006; Joseph and Ulrich, 2007).

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However, there is poor clarity in the area, as research findings have been presented using different theoretical frameworks and a multitude of methods have been used to investigate the effects of the built environment on health outcomes (Daykin and Byrne, 2006). Some of the existing studies can be classified as:

- setting-related studies (e.g. single versus multi occupancy bedrooms – Chaudhury *et al.*, 2005) and waiting areas (Leather *et al.*, 2003);
- systems' performance-related studies (e.g. ventilation systems – Chow and Yang, 2003), air conditioning (Charles, 2003; Hwang *et al.*, 2007);
- illness-related studies (e.g. Alzheimer – Zeisel *et al.*, 2003), substance misuse (Grosenick and Hatmaker, 2000) stress (Evans, 1984);
- problem-solving studies (e.g. increasing safety of patients (Clarkson *et al.*, 2004) and improving way-finding (Baskaya *et al.*, 2004); and
- built environment features and characteristics (e.g. light – La Garce, 2004; Alessi *et al.*, 2005; Joseph, 2006), noise (Topf, 2000; Wallenius, 2004, Evans *et al.*, 1995), colour (Jacobs and Suess, 1975), temperature (Lu and Zhu, 2006).

Although contributions have been made in different fields, from medical to engineering research, it can be argued that there is not a unified theoretical foundation which would support the compilation of research findings. Also, theoretical propositions that conceptualise the effects of built environment characteristics on humans (e.g. Thayer, 1989; Hall, 1968) were developed under an instrumentalist approach (i.e. cannot be proven truth of false). Consequently, there is confusion regarding cause-effect relationships.

Therefore, this research aims to better understand and identify which characteristics, features and aspects of the built environment impact on patients' health outcomes. A conceptual taxonomy of built environment settings, features and characteristics has been developed, and is presented below.

Research method

This paper presents results from a two-year research project investigating evidence-based design and how evidence can be used to inform designers (see Codinhoto *et al.*, 2008). Results are also drawn from a one-year UK foresight research project that investigated the impacts of the physical environment on mental capital and wellbeing (see Cooper *et al.*, 2008). In order to achieve the research objectives, a literature review was carried out that was both multi-disciplinary in focus – including the natural, social, physical and health sciences – and diverse in scale – i.e. from overall functioning of hospitals to specific equipment such as air-conditioners. Quantitative and qualitative evidence was gathered through an extensive review of academic research about the physical environment and its direct and indirect impacts on health outcomes. The review adopted some aspects of systematic literature reviews, recommended by Boaz *et al.* (2002) and Tranfield *et al.* (2003) as presented below.

The review started with the identification of previous state of the art reviews including: Devlin and Arneill (2003); Ulrich *et al.* (2004); and NHS Estates (2005). Jointly, these three publications refer to 293 academic journals and provided an overview of the areas of interest.

The second step was to identify and select databases and keywords to support the search for existing research results. Seven databases (ASSIA, CINAHL, DAAI, OCCL, HMIC, MEDLINE and "The Safer Environment" Database – NHS Estates, 2005) and 50 keywords were used. In total, 1,163 abstracts were evaluated against pre-defined quality parameters, including the provision of appropriate background, research method, findings applicability and generalisation. As a result, 92 papers were included in this study.

Subsequently, a conceptual taxonomy for data collection was developed to map cause-effects relationships between built environment variables and health outcomes. In the resulting framework, built environment features and characteristics are defined as causal elements, whereas psychological, physiological and physical outcomes are defined as the effects.

The theoretical framework

Definitions

It is extremely difficult to establish clear boundaries for what a health outcome is. 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). The concepts of well-being and health related quality of life (HRQL) differ from the concept of health, however as argued by Wilson and Cleary (1995) these concepts are extremely related to each other. Therefore, in this research, health outcomes include measures of well-being and HRQL as these are relevant to inform patient management (Guyatt *et al.*, 1993).

The same difficulties apply in relation to distinguishing what belongs to the built environment as opposed to belonging to the natural environment. The built environment consists of a combination of features and characteristics. Thus, in this research the built environment is considered to relate to the surroundings or conditions designed and built through human intervention, where a person, animal or plant lives or operates.

Description of the framework

Health outcomes, according to Wilson and Cleary (1995), can be grouped in different ways. These authors propose a five level classification including: biological and physiological factors, symptoms, functioning, general health perceptions and overall quality of life. This classification covers a vast set of health outcomes, however it was considered complex for the objectives of this research. Therefore, health outcomes were grouped according their relation to the mind or the body. The resulting classification includes: physical outcomes (relating to the body), physiological outcomes (relating to body) and psychological outcomes (relating to the mind) as shown in Figure 1. Physiological outcomes where included as a different category because, as argued by Wilson and Cleary (1995), these can be triggered by changes in the physical and/or psychological state.

The boxes in Figure 1 were organised in no particular order, and do not imply well-defined boundaries in the taxonomy used (e.g. music can comfortably be classified as arts as well as acoustics). Also, the absence of arrows between built environment characteristics and health outcomes does not imply that there are not such relationships. Moreover, the list of health outcomes presented is not exhaustive.

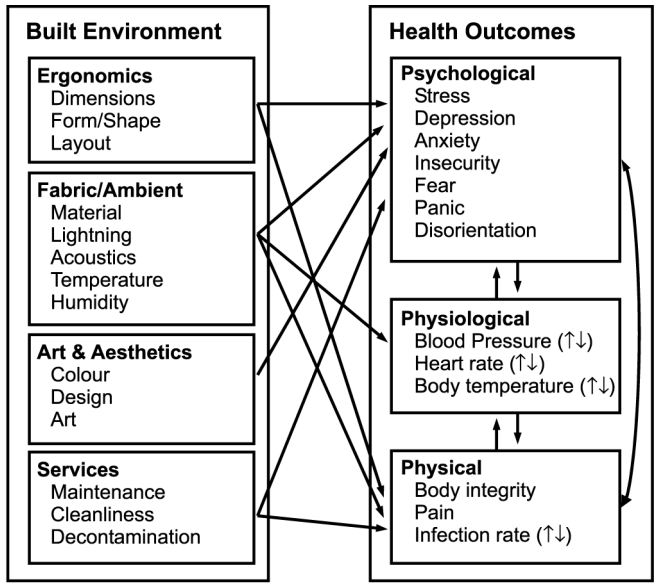

Figure 1.
Relationships between built environment characteristics and health outcomes

The developed framework consider four dimensions of the built environment: ergonomics, fabric and ambient, art and aesthetics, and services. These relate to Vitruvius definition of structure's qualities, i.e. firmitas (strong and durable – materials and ambient), utilitas (useful – services) and venustas (beautiful – ergonomics, art and aesthetics). It is important to stress that the boundaries of framework cannot be strictly defined (ergonomics, for instance, may fall in the realm of firmitas and venustas). The main objective of the framework is to distinguish among causal variables (the built environment) and measures of health outcomes.

Several perspectives and levels of analysis can be applied to the built environment, representing a continuum. At one end of the continuum are materials that can stimulate positive and negative impacts on health. At the other are complex combinations of, for example, forms, textures and ways of organising the environment that, in association with ambient environment characteristics such as temperature and noise, delineate the built environment. The following sections describe each of the four built environment levels.

Ergonomics

The areas of ergonomics investigate how the human body and mind work and behave when interacting with the built environment. It includes not only dimensions and shapes of objects and spaces but also the way these are and distributed and organised (Pahl and Beitz, 1996). Examples of health outcomes investigated in ergonomics include body injuries due poor design and use of objects (Hignett and Masud, 2006), mistakes in medication administration due to poor design of medicine labels (Hellier *et al.*, 2006). Other examples can be found in the layout of rooms and human behaviour (Zimring *et al.,* 2005), wayfinding in hospitals (NHS Estates, 2005) and also in the way patients and staff react to the environment (e.g. Leather *et al.*, 2003a). Room occupancy

and privacy leading to better well-being seem to be one of the most investigated areas. It is argued that single occupancy bedrooms increase privacy, due to reduced noise levels and consequently improved sleep rates and reduced stress and lower risk of contracting infections. However, problems of single occupancy bedrooms like more staff time need and a feeling of isolation are also highlighted. Studies in this area include the investigation of advantages and disadvantages of adopting single and multiple occupancy bedrooms (Chaudhury *et al.*, 2005), occupancy and privacy associated with the development of the social environment (Evans and McCoy, 1998) and with improved healthcare experience (Douglas and Douglas, 2004, 2005), aspects of layout related to wayfinding (Passini *et al.*, 2000; Baskaya *et al.*, 2004) and the relevance of privacy for patients of substance use (Grosenick and Hatmaker, 2000).

Fabric and ambient

The fabric and ambient are characteristics that determine the envelope which set the boundaries of the physical space. It includes materials (e.g. the use of copper to reduce the spread of multiple-resistant *Staphylococcus aureus* – MRSA – Noyce *et al.*, 2006), lighting (e.g. the exposure to bright light and its effects on depression – Kripke, 1998), acoustics (e.g. noise and recovery rates – Bayo *et al.*, 1995) and temperature (e.g. temperature and levels of stress – Hickam *et al.*, 2003). The range of possibilities in terms of cause and effect relationships related to the fabric and ambient is high.

In general, the existing literature about lighting (natural or artificial) shows that light can be associated directly and indirectly with physical, physiological and psychological health outcomes. In excess or shortage, light may cause damage. However, if provided appropriately, light can have (healing) stimulating properties that can affect our metabolism and our mind. Some issues investigated include:

- the exposure to fluorescent light and the risk of developing of melanoma in adults (Beral *et al.*, 1982);
- high levels of ambient illumination and the incidence of oxygen-induced retinopathy of prematurely infants (Glass *et al.*, 1985, Ackerman *et al.*, 1989);
- cycled light increasing 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 beneficial impacts of bright fluorescent light on seasonal depression (Kripke *et al.*, 1992; Kripke *et al.*, 1983; Yerevanian *et al.*, 1986; Kripke, 1998);
- light in intensive care units affecting patients' sleeping patterns (Richards and Bairnsfather, 1988; Girardin, 1992);
- ultra-violet radiation (in daylight) and the stimulation of the metabolism and the production of vitamin "D" (Veitch and McColl, 1993); and
- natural and artificial light associated with the reduction of the levels of contamination by Haemolytic Streptococci bacteria (Nuffield Provincial Hospitals Trust, 1960).

In addition, the effects of acoustics on health were investigated. Existing studies state that music and/or music therapy can enhance health (e.g. Cabrera *et al.*, 2000; Devlin and Arneill, 2003; Ikonomidou *et al.*, 2004; CABE, 2004). In healthcare environments,

noise is generated mainly by the operation of machines, equipment and tools, staff conversation and transportation of patients and equipment (Christensen, 2004). It is argued that noise negatively affect patient's recovery (Bayo *et al.*, 1995) and satisfaction levels among patients and staff (Douglas and Douglas, 2005). Noise is also associated with patient's sleep disturbance (Richards and Bairnsfather, 1988; Haddock, 1994; Topf *et al.*, 1996; Ersser *et al.*, 1999) and increased levels of stress (Topf, 2000). Negative psycho-physiological effects due to noise exposure (such as decreased wound healing, sleep deprivation and cardiovascular stimulation) were found by Christensen (2004). In the operating room, high levels on noise produced negative noise-induced cardiovascular and endocrine effects (Liu and Tan, 2000).

In relation to temperature, Nagano and Mochida (2004) investigated the control conditions of ceiling radiant cooling systems and concluded that some measures and parameters that have been used to design should be reviewed. In this respect, Lu and Zhu (2006) proposed physiological temperature limit values at exposure limits based on their investigation about heat stress tolerance. Variation in stress levels due to temperature has been investigated by Bell and Green (1982) and Hickam *et al.* (2003). Finally, the dissemination of waterborne infections due to warm temperature conditions is presented in Joseph (2006).

Lastly, health outcomes have been related to the exposure and access to gardens and green spaces. Some of outcomes include the reduction of stress and levels of anxiety, increased social interaction, and improved healthcare experience. Researchers investigating this issue include Ulrich (1981, 1984, 1991); Marcus and Barnes (1999); Kaplan (2001); Whitehouse *et al.* (2001); Milligan *et al.* (2004); and Marcus (2000).

Art and aesthetics

In the existing literature, health outcomes can occur due to the active and/or passive exposure or engagement of patients to any type of artistic expression such as painting (e.g. the maintenance of creativity in Alheimer's patient – Espinel, 1996), music (e.g. the exposure to music and the reduction of pain and anxiety perception – Taylor-Piliae, 2002) or drama (e.g. drama as therapy for patients with communication impairment – Snow *et al.*, 2003).

Art and health have been investigated from myriad 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 reviews, such as Devlin and Arneill (2003) and Ulrich *et al.* (2004), also consider the impacts of art on health. However, these 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), arts can help mitigate mental health conditions, such as depression, anxiety and low self-esteem as well as to improve social integration and isolation. A study conducted by Ulrich (1991) revealed that inappropriate visual art

styles are related to the disturbance of mental health conditions. McGarry and Prince (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.

Researchers 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).

There are different assumptions about how colour affects humans (Dalke *et al.*, 2006). For instance, there is anecdotal evidence speculating that red, orange and yellow in shine and polished surfaces stimulates 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 excluded from the palette of colours of designers designing hospices and psychiatric hospitals. Scientific evidence about colour includes the effects of colour on stress and arousal levels (Dijkstra *et al.*, 2006); the influence of colour in the performance of mentally and physically demanding tasks (Etnier and Hardy, 1997), the impact of colour on respiration and heart rates (Jacobs and Hustmyer, 1974) and rates. Jacobs and Suess (1975) found that different colours impact positively and negatively on anxiety levels.

Services

Services refer to non-clinical operations and continuous maintenance of characteristics and performance of the built environment. This category is also very relevant as the lack of appropriate equipment or maintenance of sub-systems may have extreme consequences (CDC, 2003).

Ventilation systems have been associated with the dissemination of infectious disease. For instance:

- contamination by Acremonium Kiliense through the humidifier water used in the ventilation system (Fridkin *et al.*, 1996);
- contamination by MRSA through the ventilation system in combination with natural ventilation (Cotterill *et al.*, 1996);
- the 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);
- increased risk of airborne bacteria contamination from the surgical team on the patient, and vice versa through the ventilation system (Chow and Yang, 2003); and
- the comfort generated by the use of localised air distribution systems is presented by Charles (2003), Chow and Yang (2003), and Hwang *et al.*(2007).

Discussions and conclusions

The role of healthcare facilities is to provide stable environment conditions that would avoid disturbance to the healing process of the patients. The major objective of this study was to propose a framework that categorises the attributes of the built environment and relates them to health outcomes. In this framework, characteristics of the built environment are grouped under four levels including: ergonomics, materials and ambient, art and aesthetics, and services. This classification provide us a structure which allows relating causal elements to design features (ergonomics), to the physical characterisation of the environment (i.e. its materials and ambient characteristics), to the artistic content (art and aesthetics) and finally to the use and maintenance of the built environment (services). Health outcomes were grouped under three levels, i.e. psychological, physical and physiological. At each level, there is a number of variables which impacts on health independently or in combination with other variables. Besides, both direct and indirect evidence have been used to demonstrate health outcomes and there is a lack of explicit cause-effect relationships. Moreover, there are too many relationships between the built environment and health outcomes to be empirically tested. In other words, one health outcome can be affected by more than one built environment characteristic (e.g. stress levels being affected by noise, music, temperature, lack of contact with green/gardens and colour). Also, one built environment characteristic may affect several health outcomes, e.g. light affecting depression, melanoma and retinopathy. In terms of limitations, the studies presented in this paper do not cover all the built environment characteristics and health outcomes and the relationships among those variables that have been reported in the literature. Also, they do not mention the relevance of measured health outcomes to the overall health conditions of the patients. However, the compilation of these studies provides readers an overview of the research that has been conducted in this area and emphasises the importance of maintaining the quality of healthcare environments for patients.

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