



# HEALTH AND WELLBEING IN HOMES

JULY 2016

GLOBAL CAMPAIGN SPONSORS:





# CONTENTS

EXECUTIVE SUMMARY	4
INTRODUCTION	10
DESIGNING HEALTHY HOMES	15
DESIGNING HEALTHY NEIGHBOURHOODS	37
RETROFIT	47
PROCUREMENT	51
VALUE	55
HEALTHY HOMES INDICATORS AND METRICS	61
ACKNOWLEDGEMENTS	67
REFERENCES	68

CASE STUDIES	
Multi-generational House, Chobham Manor (PRP)	16
Loudoun Road (Levitt Bernstein)	28
SHARPER (Arup)	30
Wild West End (ARUP)	40
Pea Soup House (Fielden Clegg Bradley Studios)	41
Kirkstall Forge Masterplan (FCBS/Planit-IE/Hoare Lea Sustainability)	42
Vaudeville Court (Levitt Bernstein)	45
Design for Future Climate (Innovate UK/Good Homes Alliance)	46
Crossways Estate, Bow (Crossways, PRP)	47



## BACKGROUND

Our home, both the location and the physical building itself, influences almost every aspect of our lives – from how well we sleep, to how often we see friends, to how safe and secure we feel. If we want to improve the health and wellbeing of individuals, families and communities, there can hardly be a more important place to start than the home: it is where most people spend most of their life.

Much work has been carried out on establishing the links between poor housing and ill health, and increasingly on the links between sustainable, well-designed homes and better health and wellbeing in residents. However, this evidence has not yet had an impact in the market.

This report is about beginning a concerted effort to shift the market towards a focus on the mental, social and physical health and wellbeing of the people who occupy the homes we build and retrofit.

It is aimed at all those with a role in developing, designing, delivering or managing housing, and is focused on general needs homes in the UK housing sector. We aim to gather and distil the most compelling evidence and advice about building and neighbourhood design features which can enhance the health and wellbeing of residents.

The report also explores the 'value' case for action. Through a combination of a literature review, dialogue with housing providers and dedicated consumer research undertaken by one of our task group members, Saint-Gobain, we demonstrate that there is a compelling business case for the industry to focus on health and wellbeing in residential property.

### What is health and wellbeing?

The World Health Organisation defines health not as merely the absence of ill-health but as "a state of complete physical, mental and social wellbeing". Therefore, we have interpreted "health and wellbeing" to include social, psychological and physical factors.

Physical health can be described as the absence of disease, as well as optimal functioning of our body. Mental health is about much more than just the absence of mental illness: it encompasses positive issues such as peace of mind, contentment, confidence and social connection. Social wellbeing is determined by the strength of an individual's relationships, and the way in which they function within their community.

It is important to note that health and wellbeing is influenced by a complex combination of genetics, behaviour and environmental factors. The built environment, and professionals who work in this sector, do not have an influence on all of these factors, but they do play a crucial enabling role.



# KEY FINDINGS

1) **Construction and property professionals have an opportunity to dramatically enhance the lives of the people they design and build for.**

Whilst built environment professionals may not have direct control over the wide ranging determinants of health and wellbeing, the evidence highlighted in this report shows that the design and quality of a home and neighbourhood is a key contributor to the health and wellbeing of the people who live there.

2) **It is vital to consider all three aspects of health and wellbeing equally – mental, social and physical.**

The industry is, perhaps, more used to dealing with the environmental design parameters associated with physical occupant health, and while these aspects are critically important, they are only one part of the picture. In order to provide the most favourable environments in which people can flourish, it is vital to consider all three aspects of health and wellbeing equally.

3) **The emerging solutions to minimising the impact of the built environment on mental health are, largely, the same as those required to minimise the impact on physical health.**

Evidence shows that a single design feature, such as good daylight levels, good ventilation or the provision of open space, can have a simultaneous positive impact on mental wellbeing and physical health: therefore, these need to be considered early in the design process.

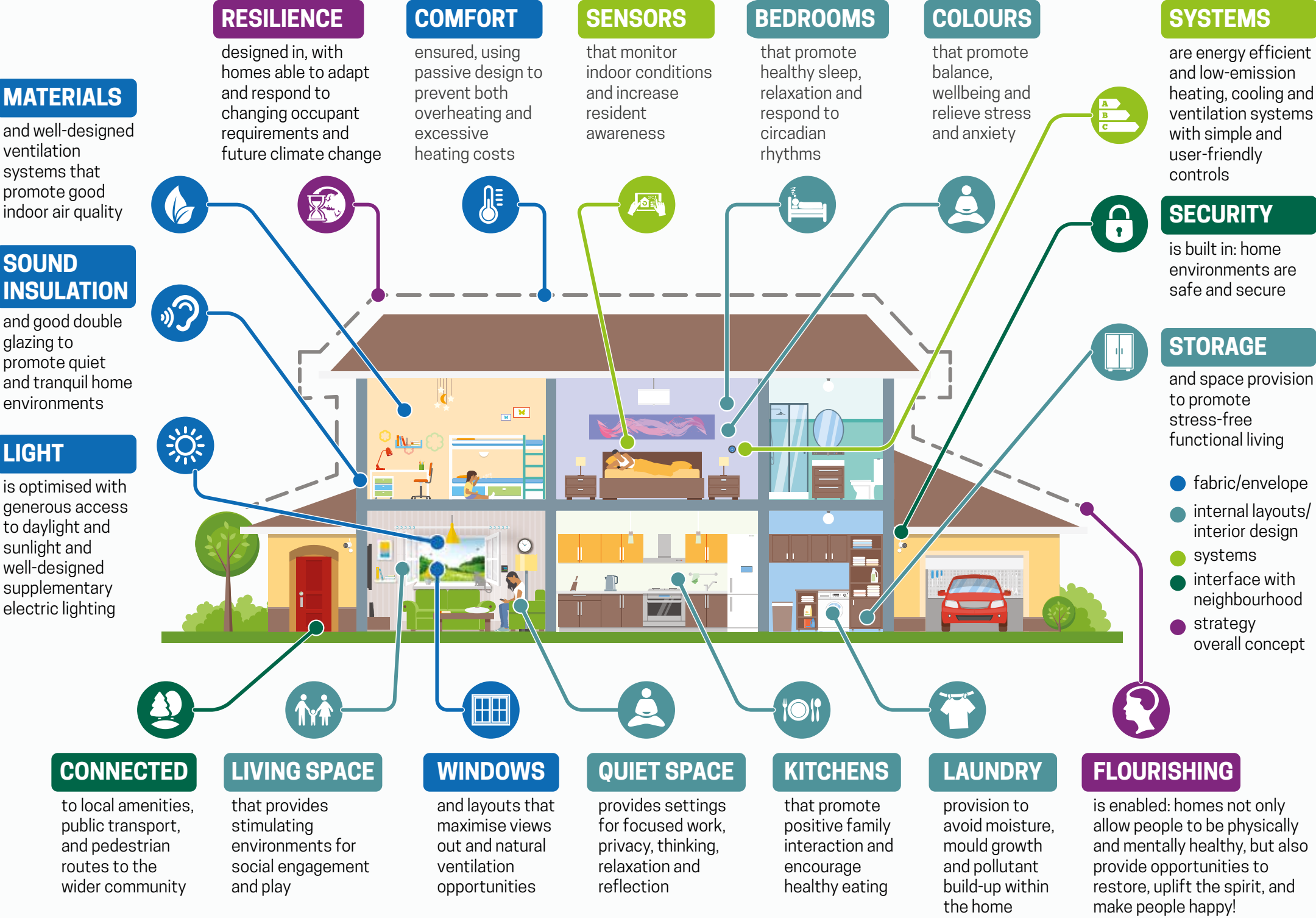
4) **Many of the design features which enhance health and wellbeing also bring positive environmental benefits.**

For example, better daylighting can also reduce energy consumption and carbon emissions, and the provision of green space can enhance biodiversity. However, we need to be aware of and address possible tensions – such as balancing the need for more energy efficient homes with the need for improved air quality through adequate ventilation and air filtration.

5) **Consideration of health and wellbeing is increasingly influencing consumers' buying and decision-making processes, spanning generations and consumer demographics.**

The results of our consumer research clearly demonstrate that UK consumers want a home that contributes to their health and wellbeing. Over 30 per cent of home owners would be willing to pay more for this, with nearly as many renters prepared to pay higher rent for such a home

# WHAT IS A 'HEALTHY' HOME?





## KEY ACTIONS REQUIRED

Reaching a tipping point in the demand for and supply of healthy homes requires action across all parts of the housebuilding value chain:

### For clients, developers and housing associations

- Engage designers early in the development process, to undertake assessments and analysis of opportunities to promote health and wellbeing for residents
- Factor in ability to deliver health and wellbeing objectives in to selection of construction team and ensure that construction monitoring services are engaged
- Provide residents with easy-to-understand operational and maintenance information so that they are able to maximise the health and wellbeing benefits of their home
- For mixed-use and multi-residential developments engage property management services to ensure the development is well maintained and safe, helping to enable social interaction, and active use of outdoor spaces
- Undertake post occupancy evaluation, ideally with the design and construction team, to learn and share lessons

### For designers and contractors

- Act as an advocate for healthy, sustainable design and challenge the client to be as ambitious as possible
- Put residents' health and wellbeing at the heart of building and neighbourhood design, including consideration of changing future needs
- Select materials and systems that are robust, low maintenance, low emission and resource efficient
- Commit to strategies for testing and commissioning the construction so that the homes meet the intended functionality and performance

### For agents and advisors

- Ensure all staff have appropriate knowledge on key trends, design standards and changing householder aspirations on health and wellbeing
- Act as an advocate to developer clients on consumer trends, and the importance of health and wellbeing
- Reflect health and wellbeing of developments in pricing and marketing strategy

## WHAT IS A 'HEALTHY' NEIGHBOURHOOD?



# INTRODUCTION



“Understanding occupant behaviour is vital when designing buildings for health and wellbeing...”

## Why are healthy homes important?

In the USA and Europe we spend around 90 per cent of our time indoors, with 65 per cent of this spent at home<sup>[1]</sup>. Our homes are where we eat, sleep and relax, and where our children have many of their most formative experiences.

We often become very emotionally attached to our homes, investing our time, money and effort in making them comfortable, secure, and personalised places. Not only that, but for the majority of us, whether owner occupiers or tenants, housing is our biggest financial outlay each month. Therefore we tend to have a particularly powerful connection with residential buildings – something which differentiates homes from other building types.

However, many people are unaware of how their internal home environment can have significant impacts on their health and wellbeing. Factors ranging from the quality of the internal air, to how much space and light there is, even how much storage space is available, can have measurable impacts on health and wellbeing. Furthermore, the design of the neighbourhood around a home is critical: it provides opportunities for social interaction, exercise, access to nature, local amenities and schools. All of these have a bearing on how much residents will enjoy living in their community, and therefore on their own personal health and wellbeing.

## Scope

Health and wellbeing clearly comprises a very wide range of issues. Besides genetic factors, our health and wellbeing are affected by a combination of environmental factors which impact upon us differently, depending on individual characteristics including age, gender, pre-existing health conditions or genetic susceptibility. In addition, our lifestyle and behaviours also impact our health and wellbeing, either directly (e.g. smoking) or indirectly (e.g. opening windows to ventilate homes). Socio-economic factors also have a role to play: our lifestyles are not entirely determined by choice, but are in fact heavily influenced by income, education and social connectedness.

Whilst built environment professionals may not have direct control on the wide ranging determinants of health and wellbeing, a broad awareness is extremely important: risk factors rarely act in isolation. Understanding occupant behaviour is vital, not only because building design will affect behaviours and lifestyles in many ways, but also because building performance is heavily dependent upon the assumptions that housing designers, clients/developers and managers make about occupant behaviours.

The first two sections of this report are aimed more at the new build sector, with most of the guidance being applicable to new developments. Many of the same underlying issues apply in retrofit projects, but the lack of a blank canvas means a different approach is required: this is discussed in [Section 3](#). This report therefore focuses on what built environment professionals can influence through the design, construction, management and refurbishment of homes.





“Social interaction is a key factor in determining both the physical and the mental health and wellbeing of an individual from childhood through adult life”



### Mental health

In the UK, mental health problems constitute 28 per cent of the total burden of disease, compared to 16 per cent each for cancer and heart disease<sup>[2]</sup>. One in four people (25 per cent) in the UK will experience a mental health problem in any given year<sup>[3]</sup> and nearly one in five people show symptoms of anxiety or depression<sup>[4]</sup>. The scale of the problem is significant, but often when we think about or consider health the focus is on physical or dietary issues rather than the promotion of a healthy mental state.

However, mental wellbeing is much more than just the absence of mental illness. It represents a more positive side to mental health, incorporating more aspirational concerns such as peace of mind, contentment, confidence, social connection, self-realisation, and happiness. The built environment can influence mental health and wellbeing by strengthening mental resilience, helping to heal from mental illness, and promoting a general feeling of happiness and empowerment. As described, the home is where people spend most of their time, and in particular where they spend time with family members. Therefore the issue of happiness in residential design is vital: emotions are more powerful here when compared to office or retail settings.

Finally, design quality has also been strongly linked to mental health. People living in better quality housing have fewer psychological issues, including decreased anxiety and depression<sup>[5,6]</sup>.

### Social wellbeing

Social connectedness can have a very positive influence on our mental wellbeing. Having positive relationships, control over your own life and a sense of purpose are all attributes of functioning well. International evidence has recently been gathered to measure wellbeing, demonstrating that this field has now emerged as a rigorous discipline<sup>[7]</sup>.

Social interaction is a key factor in determining both the physical and the mental health and wellbeing of an individual from childhood all the way through to adult life. It takes place within various environments: starting at home, continuing within the neighbourhood, evolving in school, expanding in the professional environment and flourishing with social activities. The majority of these interactions emerge within our homes and immediate surroundings, which we intuitively value more as a result of their long-lasting presence.

According to the World Health Organisation (WHO) “the main action on social determinants of health ... come from outside the health sector”<sup>[7]</sup>. The WHO defines health not as the absence of ill-health but as “a state of complete physical, mental and social wellbeing”<sup>[8]</sup>. The definition of health thus includes an awareness of the interrelationships between social and psychological as well as medical factors. The way in which an individual functions at home, within the family and the wider community is seen as part of the health definition, alongside biological and physiological symptoms. Health is determined by a range of factors related to the quality of our homes and the wider neighbourhood<sup>[9,10]</sup>.

“...neighbourhoods which are well connected to walk and cycle paths, and comprised of homes with adequate storage for bicycles, will enable their residents to live active lifestyles”

### Physical health

We rely on metabolic processes to maintain our health. This has helped us to adapt to and thrive in a variety of different climates and environments. However, exposure to unfavourable environmental conditions will have a negative impact on our health and wellbeing: such stresses affect the performance of our body, in particular our productivity, and mood. Babies, young children, older people, adults with long-term health conditions and obese people are more vulnerable to these issues.

Home and neighbourhood design features can affect many different aspects of physical health, both positively and negatively. For example, neighbourhoods which are well connected to walk and cycle paths, and comprised of homes with adequate storage for bicycles, will enable their residents to live active lifestyles. Many other examples are explored in the report.

This report has been made possible by efforts of the Task Group. We are very grateful for their hard work, knowledge and expertise. All of those involved are fully credited in the acknowledgements at the end of the report.







**VIEWPOINT**  
**FREEDOM TO FLOURISH** (DEREK CLEMENTS CROOME, UNIVERSITY OF READING)

Seligman in his book *Flourish* proposes the PERMA model – Positive Emotion; Engagement; Relationships; Meaning; Achievement for leading a way to a more enriched life. This, alongside work by Diener and Biswas-Diener<sup>[11]</sup> perhaps covers the most comprehensive range of attributes that can contribute to happiness and wellbeing by including in their research a psychological flourishing scale which add some aspects on accomplishment, moral character and citizenship.

Diener's model for wellbeing<sup>[11]</sup> is based on three issues – the environmental factors, the perceptions and feelings people have in various environmental settings and the economic consequences of the environments created<sup>[13]</sup>.

The first is a normal layer featuring standard comfort health and safety guidelines for temperature, sound, light, ventilation for the waking and sleeping states. A number of Codes, Guides and Handbooks prescribe these.

The second layer is one which recognises there is a relationship between health and some of the factors we are dealing with in a proportional way. There is not a single number or narrow band to choose for design like temperature for example but rather an Individual Layer in which a choice has to be made. Often the decision is made on low energy and cost but

this has to be offset by the savings accrued by better health and wellbeing as evidenced by decreased stress or an increase in satisfaction and self-reported happiness.

Thirdly, there is the Sparkle or 'wow' layer which includes things like views of nature, daylight, colour, décor, layout, aesthetics, green space around the building. These features are mainly non-quantifiable but important. These seemingly small factors can suddenly make one feel better in spirit---a bit like getting up in the morning and feeling a

little sluggish then opening the curtains on to a beautiful sunny morning and feeling quivers of happiness. Some of the research is beginning to give some design data like for biophilic design<sup>[14]</sup> but in general it is things we should do even though these factors are 'soft' metrics and do not have numbers. We do know however for example that homes with sea or country views fetch premium prices. Buildings in cities are particularly challenging but with careful creative thought they can be lovable joyful and soulful places for people to live and work.



Adapted from Seligman's PERMA Framework:<sup>[12]</sup>

# SECTION 1: DESIGNING HEALTHY HOMES

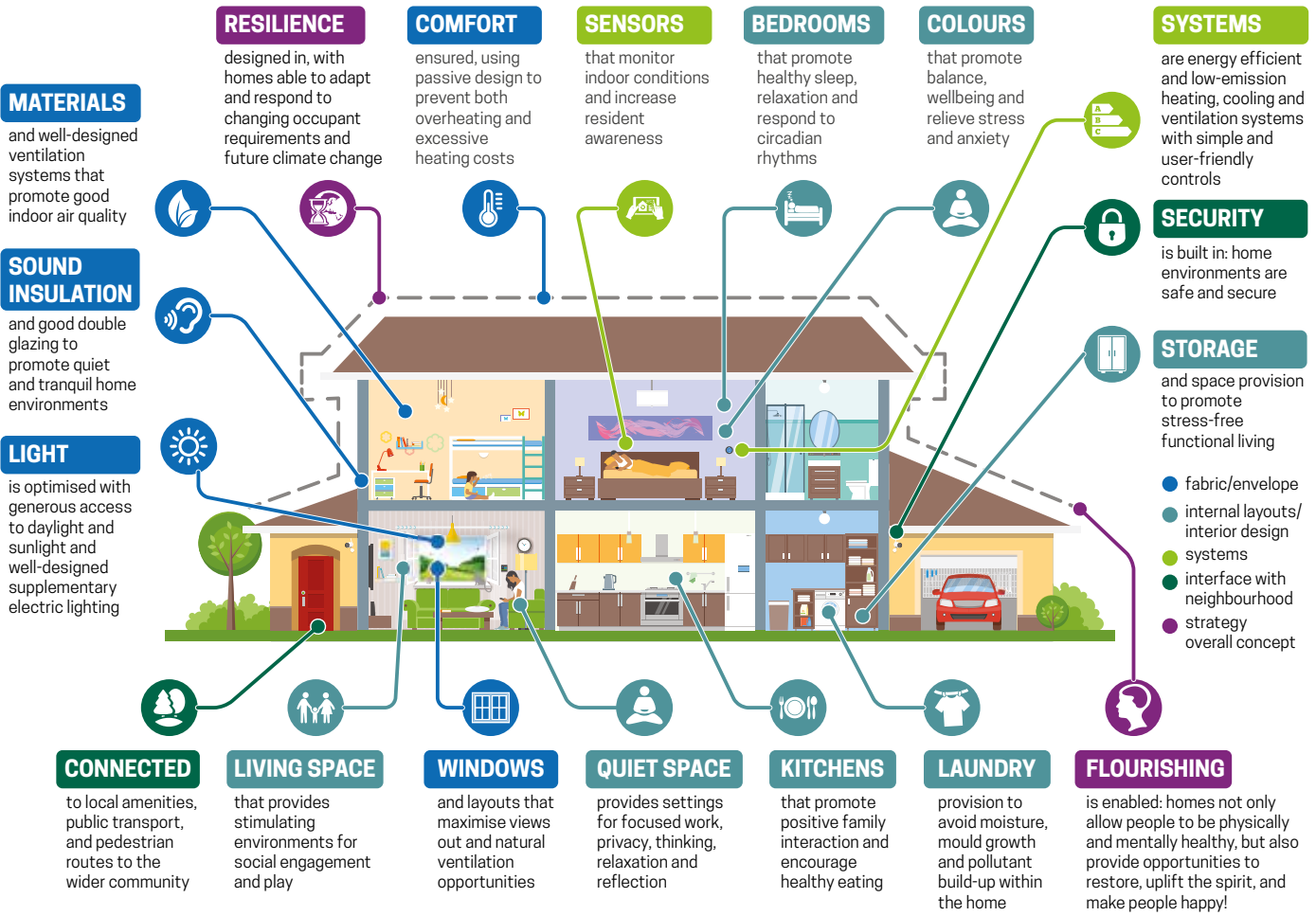
## Introduction

When asked about the issue of health in homes, the thing that first springs to mind for most people is the physical: being too cold in the winter, or too hot to sleep on warm nights; the irritation of neighbour noise transmitted through walls; mould growth and slow drying clothes. However, the relationship between health and the home is far more complex than this.

Not only should a home provide an indoor environment which enables physical wellbeing, it should also promote mental wellbeing, providing its residents with a general feeling of happiness and empowerment. There is much overlap between the design features required for these two aspects.

This chapter deals with health and wellbeing issues within the building itself.

## What is a healthy home?



Infographic developed for UK-GBC by PRP



## Social interaction

### Why is it important?

The quantity and quality of social connections (e.g. talking and listening to family or strangers) correlate with reported wellbeing as well as physical health<sup>[15]</sup>. The domestic environment provides the context for this, and the design of our homes and neighbourhoods can facilitate positive social interactions.

Of course social interaction cannot be guaranteed by domestic design. An individual can choose whether or not to participate<sup>[16]</sup>. However, denying individuals or groups the opportunity of participation, whether they actually desire to participate or not, will result in their exclusion<sup>[17]</sup>. Stress – such as that associated with socio-economic factors – can become more manageable where there is the support of family, friends and the community, which can be facilitated through design by creating an environment for social interaction<sup>[18]</sup>.



### CASE STUDY

#### MULTI-GENERATIONAL HOUSE, CHOBHAM MANOR (PRP)

There are increasing pressures on families throughout the cycle of life. The housing shortage, the rising cost of childcare and an ageing population are all contributing to the figures, which are at their highest in four decades. With bank lenders requiring increased deposits on purchases of homes, and rents in London getting higher day by day, these issues led PRP to review what the contemporary family needs beyond basic Lifetime Homes requirements.

Chobham Manor is the first of five neighbourhoods to be developed at the Queen Elizabeth Olympic Park in Stratford, East London. In order to encourage long-term social, as well as economic, investment in the area, the communities are designed as 'Lifetime Neighbourhoods'. Chobham Manor's East London location is home to a number of ethnic groups who require large dwellings to accommodate extended families. PRP has designed houses with up to eight bedrooms to satisfy this need on previous projects, however, it found that due to issues of affordability, availability and changing family dynamics, along with the desire for each generation to have some degree of privacy rather than all live under one roof, another typology needed to be explored. Hence the 'multi-generation

house', an interconnected assembly of dwellings for a large family with members across three or four generations who can live side by side yet maintain their own independence.

The multi-generation home consists of a main house and an annexe. The main house is a 3-storey, three bedroom house. The annexe is a self-contained studio with the sleeping area on a gallery over the living space. The house and the annexe share a courtyard garden, which also includes areas for refuse bins and bicycles. The house has an allocated on-street parking space right outside the front doors.

The flexibility of the layout allows for various arrangements of the home. It can accommodate a family with a grandparent living together, or a returning student coming back to live with their family. The annexe can also be used as an office space, offering opportunities for working from home. Corner configuration in terraced housing is a common problem, yet the multi-generation home turns this problem into an opportunity. The arrangement of the two dwellings and the garden result in a typology which is successful at turning street corners and it has been incorporated on all three street corners where housing terraces meet.



### VIEWPOINT - OVERCROWDING (KOEN STEEMERS, UNIVERSITY OF CAMBRIDGE)

Overcrowding is detrimental to positive social interactions and family relationships<sup>[19]</sup>. It affects health and wellbeing, the spread of illness, increasing stress and the quality of relationships. Using the Bedroom Standard as a measure, there are more than half a million overcrowded households, affecting one child in ten in England, with over one third in London<sup>[19]</sup>. There is thus, a need to provide more affordable, family-sized homes that meet recommended space standards for size of rooms, storage and outdoor space. The size and type of affordable homes in a development, rather than simply the number of units, should match the need. Although adaptability (discussed elsewhere in this report) is not a direct proxy for more space, it is a design characteristic that can ameliorate some of the problems associated with overcrowding.

A constraint on providing diverse and stimulating conditions for social engagement in the home is a lack of internal and outdoor space. Children need space to play, develop, and do their homework. They also need privacy. Adults need space too, to foster healthy relationships with their partners and enable them to care for their families<sup>[19]</sup>.

### Design guidelines

- Spaces should be created for different activities<sup>[20]</sup>. Designing homes with diverse settings for playing, cooking, talking, etc., provides positive opportunities for social interaction. This could involve the design of small retreat spaces (e.g. a window seat or niche) for quiet exchange as well as larger more adaptable areas for group activities.
- Being able to control the environment can offer conditions to suit social interactions: e.g. noise (to reduce it for quiet exchange, or to enable the making of noise by good sound insulation); lighting (to make a space darker, focused and more intimate, or admit more daylight); thermal conditions (to cool it for physical play or keep it warm for sedentary activities). A diversity of spaces coupled with adaptive controls enables occupants to create settings that suit their needs<sup>[21]</sup>.
- Preparation of food can be a social activity. Cooking can be collaborative if the kitchen is designed to facilitate this (e.g. sufficient space, so children can join in, adjacent seating for onlookers, worktops facing the room rather than a wall, etc.).
- According to research, eating together as a family on a regular basis has some surprising effects. When sharing a meal together family bonds become stronger, children are better adjusted, family members eat more nutritional meals, they are less likely to be overweight, and they are less likely to abuse alcohol or drugs<sup>[22]</sup>. Eating together can be encouraged by making the dining area pleasant (e.g. with views out and good daylight) and more accessible from the kitchen (compared to the living area) in order to nudge people to sit around the table rather than in front of the TV.
- Circulation spaces can become locations of social interaction. Making circulation an enjoyable experience (with daylight and views), and offering spatial variation, can create opportunities for encounters. Ensuring that dimensions make circulation suitable for the physically less able (contributing to a more generous experience for all) with accessible thresholds (for wheelchair users and prams) is a critical parameter to consider when designing such spaces.
- Ceiling height can play a role in social engagement and ability to focus. Findings show that when people are in a space with low ceilings, they are better at focused tasks, such as studying or reading, whereas high ceilings are thought to encourage creative thinking, and are more appropriate for social gatherings<sup>[23]</sup>.
- Homes should promote a connection to the outside through windows and intermediate spaces (e.g. window seats, porches or entry ways, balconies etc.) with views of and aural contact with neighbourhood or communal (green) areas.



### Light

#### Why is it important?

Good quality and well-designed lighting contributes to the appearance and identity of a home, as well as, of course, to the wellbeing of its occupants.

Natural light makes us aware of the passage of time: the specific mechanisms of this interaction are not entirely understood, but our bodies are naturally in tune with external light levels and characteristics. As well as the photoreceptors responsible for vision, the eye contains sensors which detect the blueness of daylight. Therefore, the colour and intensity of the light that we experience influences the secretion of hormones, including melatonin and serotonin, which regulate our circadian rhythms.

Research at the University of Oxford<sup>[26]</sup> links mental illness to abnormal circadian rhythms. This has led to the development of a “Circadian House” concept that promotes design that harmonises with nature and the seasons, has variety and stimulation, and has a particular focus on the role of light in supporting circadian rhythms<sup>[27]</sup>.

There are opportunities for design to both embrace daylight and sunlight, as well as to supplement it with electric lighting. The design of electric lighting in homes should be flexible, and provide comfort as well as practicality and efficiency.

#### Daylight and sunlight

There is widespread research on the health benefits of daylight and sunlight, although this work has rarely been focused on the home. In offices, natural light has been shown to improve quality of life measures, quality and quantity of sleep, and reduce sick leave<sup>[28,29]</sup>. In healthcare settings, it has been shown to improve recovery times of long-stay patients and reduce anxiety and medication<sup>[30,31]</sup>. The relevance of these studies to an environment in which we sleep, work, rest and play should be self-evident.

On an emotional level, people enjoy and feel a sense of wellbeing in daylight and sunlight. Prolonged lack of daylight can have psychological effects: for example, at the extreme end of the spectrum, some people are affected by conditions such as seasonal affective disorder (SAD) during dark winters.

Sunlight can also improve the appearance and feel of a home. But this has to be carefully considered, as there are also times when sunlight will feel too intense or hot, and can be a cause of discomfort and glare. Sunlight is a source of heat, which is helpful in the winter when we are heating our homes, but can be a nuisance in the summer when we are not (see Window Design box on [page 21](#)).

Daylight has excellent colour quality. The full spectrum light it produces ensures that objects lit by daylight appear natural, with their true colours, which is good for the appearance of art, food, clothing etc.

Last but not least, it should be remembered that daylight is a free and zero carbon source of light – good daylighting of our homes means less energy is used for electric lighting during daylight hours.

#### Electric light

Electric lighting allows us to carry out tasks safely and/or comfortably – such as cooking or reading a book. The specifics of an electric lighting installation will have a significant impact on the appearance and experience of a dwelling at night, and can create different moods and atmospheres. In particular, too much illumination can be negative – causing feelings of oppression or over exposure.

The colour appearance of light in a dwelling is also an important consideration. People have evolved over millennia with warm light at night – first flame for much of human history and then, more recently, incandescent lighting.





**Design guidelines**

- The design of homes should aim to provide good daylight first. Careful design of building form, orientation, and space planning is key.
- Higher level glazing admits significantly more daylight than low level. Therefore, glazing primarily for daylight ought to be as high as possible on the wall (or skylights in the ceiling), but this needs to be balanced with the need for a view out, including windows at a level suitable for less able residents and for children.
- In planning the daylighting of a space, the designer should consider the use and layout of the space – where will daylight and sunlight be most useful or desirable. Of course this is in addition to other factors such as views, comfort and privacy. See Technical Appendix for further detail: <http://bit.ly/HomesHealthy>
- Shading in the form of blinds or curtains is recommended on any window or skylight that requires it, to avoid glare from sunlight; to provide privacy at night when the interior electric lighting is on; and to block daylight and sunlight when required to darken a space. (See window box on [page 21](#))
- Electric lighting is very much driven by residents' needs, depending upon their preferences and activities, so flexibility is vital.
- Controllability of lighting is a key design issue. Lighting control needs to be simple, or it will be a cause of annoyance and/or won't be used. However, occupants will need enough control to allow for comfort, minimise energy use and for adaptability (the different uses of spaces at different times).
- The colour of electric lighting is important in a domestic environment: people prefer warmer light. Unless there is a strong reason why it works better architecturally, it is recommended to avoid cooler sources as the lighting may feel less 'natural' to occupants at night. This is especially important for cooking, dressing and make-up etc., to ensure a natural appearance of the lit objects and faces.
- External lighting should be designed to ensure safe access to the entry points of a dwelling at night, keeping to paths and avoiding potential hazards. The lighting should be controlled to ensure it is only on when required (after dark, when the space is in use), and should be designed to avoid light trespass (into windows of properties) and light pollution, as well as with local ecology in mind.



**CROSS CUTTING: WINDOW DESIGN**

Windows are 'machines', in the sense that they combine multiple properties: they should be considered not just as transparent sections of wall, but as important multi-functional elements of the home. Good window design can enhance occupant wellbeing, both physically and psychologically. However, there are a number of common pitfalls which do quite the opposite. Too much glazing can negatively impact privacy, furniture layouts, amount of solar gain and heat loss.

**Daylight**

From a purely daylighting perspective, windows are better wide and high in the wall. Window sizes should be carefully considered and be fit for purpose. Large glazed areas can lead to the requirement for solar control coatings and triple glazing which will reduce light transmission.

**Views**

A connection to the outside is important for occupants, and determines the window height required for views. This can be an issue where the preference for floor to ceiling glazing for views conflicts with the need for privacy, furniture layouts, solar gain and heat loss. Coatings or shading can impact the quality of views.

**Solar gain**

Too much glass can lead to internal overheating. Use of solar control coatings is a valuable way to offset this but will reduce light transmission and can impact the colour rendering of glass. Solar control coatings can also reduce the amount of passive solar gain in winter, which would normally contribute to reducing heating loads. Moveable external shading provides the best balance between winter and summer needs.

**Heat loss**

Large areas of glass will increase heat loss. This leads to an argument to only use glass where it is useful for daylight or views. Use of triple glazing to offset large glazed areas will reduce light transmission, increase cost and increase weight/thickness of opening elements.

**Openings**

Natural ventilation is usually desirable in homes. To be successful, ensure the following is considered:

- Cross ventilation provides the most ventilation, so place openings on opposite sides of the home.
- Residents should have the ability to open smaller windows in spring/summer, or at night, and larger ones in summer. Security can be an issue with night time ventilation.
- Security and safety: any restrictors applied to openings will often need to be removable to meet purge ventilation requirements<sup>[32]</sup> If windows cannot be fully opened, alternative means of ventilation may need to be considered.
- Wind, draughts and height: at height, wind pressures become much higher and change the drivers for window design. Designers of high rise apartment blocks should consider how windows can be fixed open in small apertures against wind.
- Providing openings at higher levels will allow ventilation without drafts.
- External noise levels can be problematic, especially at night. This must be assessed in the design process to ensure health and wellbeing is not compromised (see "Noise" on page 33).
- Blinds/curtains/external shade: the ability to open windows while shading or privacy devices are used should be provided.
- Cleaning: it is preferable if possible that windows can be safely cleaned from inside, in line with guidance<sup>[33]</sup>. In addition, BS 8213 – defines the extent of external cleanable reach when cleaned internally for windows in dwellings. Refer directly to the Housing Standard Handbook for the safety and cleaning elements.
- Education: There is evidence<sup>[34]</sup> that people don't understand why they should open their windows. There appears to be a case to educate people that they need to get rid of pollutants and moisture by occasionally opening their windows. This has a large impact on basic health (refer to "Internal air quality" on page 24).





**VIEWPOINT**  
**COLOUR** (ANNA WHITEHEAD, ANNA WHITEHEAD DESIGN CONSULTANCY,  
FOR BIID (BRITISH INSTITUTE OF INTERIOR DESIGN))

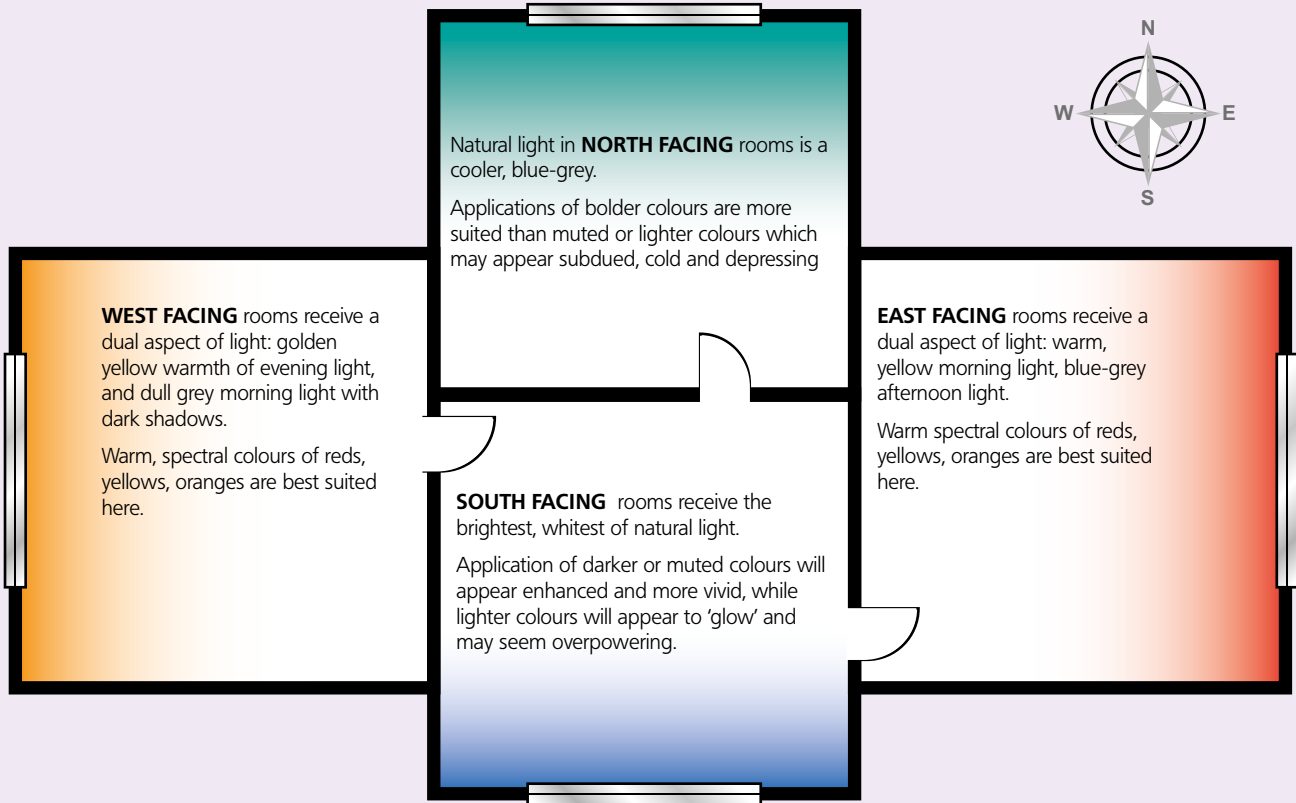
Colour is the most dominant and visible aspect of interior design, and studying its impact on our health and wellbeing is a complex subject. Many research experiments over decades have concluded that we are indeed influenced by colour in our interior environments, which evokes both a physiological and psychological response within us. However, colour is often the easiest aspect of an interior to change, altering the feel and characteristic of an interior environment, so understanding something of this topic is invaluable.

Firstly, our perception of colour is strongly influenced by the type of light being used to illuminate it.

**Natural light and sunlight** vary in colour temperature and brightness throughout the day, as well as being dependent on geographical location, season and the direction of light entering a room. For example, the UK's location in the northern hemisphere, and often cloudy weather, result in a grey-blue light quality. This can make lighter colours look subdued, and have a muting effect on saturated bright colours that might appear vivid in a southern European setting.

The way we see colour under **artificial light** will depend on the type of light fitting used<sup>[35]</sup>:

- The warm yellow light of **incandescent bulbs** enhances reds, oranges, and yellows, making them appear more vivid, but provides a muting effect on cool blue-green colours;
- The flat, cool, bluish light of **fluorescent bulbs** enhances blues and greens, while muting warm spectral colours;
- The 'whiter' light of **halogen bulbs** enhances all colours and by more closely resembling daylight, makes a smoother and less jarring transition from a day lit to an artificially lit room;
- **LEDs** are highly versatile and are available in both the cool and warm spectral ranges. Currently, they do not enhance the vividness of colours in the way that an incandescent or halogen bulb can, but they are a rapidly developing technology so this is likely to improve soon..

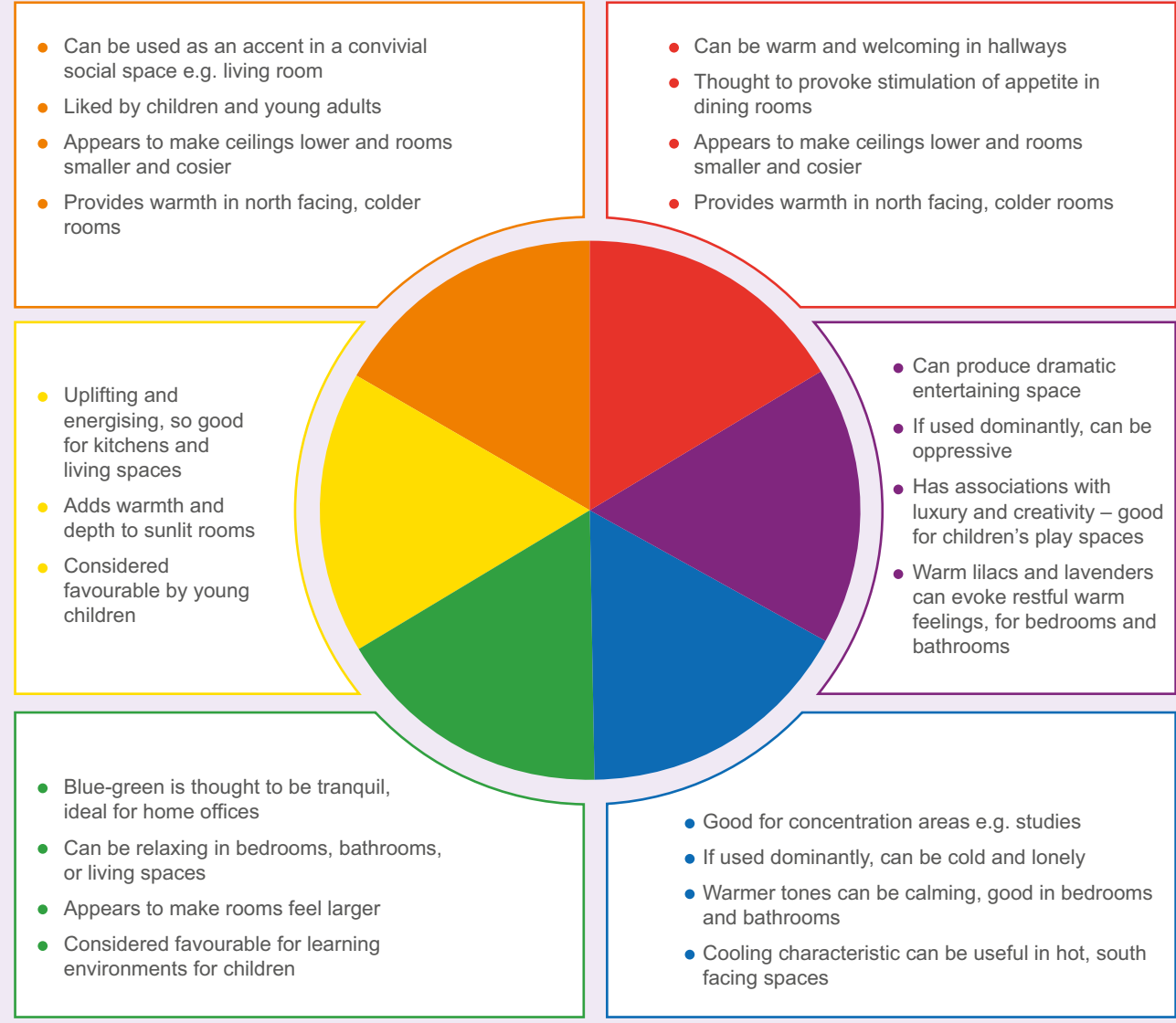


Once colour is received and processed by the brain, there is the additional complexity of our **individual** relationship to colour: the impact of our childhood, culture and environment, all inform our unique colour relationship throughout our life. For example, cultures interpret and experience colours differently: red is interpreted as danger in the UK, is the colour for mourning in South Africa, but is seen as a symbol of good luck in China<sup>[36]</sup>.

**General principles**

- A tonally homogenous, monotonous colour scheme may result in under-stimulation, which can lead to restlessness, irritation, aggression and difficulty in concentration.

- A coloured environment of extreme complexity and contrast can lead to over-stimulation, causing physiological responses of increased pulse rate, blood pressure and muscle tension.
- As with natural environments, interior spaces require some variety of colour hues, saturation, contrast, light and texture to provide balance, stress relief and enhance a sense of wellbeing.
- The degree of colour saturation will affect the way a space is perceived: paler tints make a surface recede and make rooms appear larger, or ceilings higher, and vice versa<sup>[37,38,39,40]</sup>.





“We need to ensure that new homes are not only energy efficient, but also provide optimal ventilation rates for good internal air quality”



## Internal air quality

### Why is it important?

It is obvious that the quality of the air we breathe is vital, but much discussion of air pollution tends to be in relation to our external environment – e.g. pollution from cars when we are in the street. Less obvious perhaps, is that the internal air quality in our homes can be very poor, and have a serious effect on our health. There are two main issues associated with indoor air quality: the build-up of internal pollutants inside the home, and the ingress of external pollutants into the home.

The two major external pollutants that find their way into our homes are nitrogen dioxide (NO<sub>2</sub>) and particulate matter emitted from vehicles, along with construction dust and industrial pollution. Internally, the passive drying of laundry within homes can cause moisture and volatile chemicals from fabric softeners to build up within the air, with further contaminants coming from paint, building materials, furnishing, and cleaning products. Cooking too generates significant spikes in particulate matter and moisture that adds to the overall burden of indoor air quality.

High moisture levels encourage dust mites and mould growth; this leads to an increased risk of asthma and can also increase the risk of skin conditions such as eczema<sup>[41]</sup>. Furthermore, it has been shown that the risk of asthma can increase with the energy efficiency of a building, mainly due to a lack of sufficient ventilation<sup>[42]</sup>. Various building materials and finishing products emit Volatile Organic Compounds (VOCs) and formaldehyde which can have health impacts such as skin and mucous membrane irritation. Some VOCs (such as benzene) are known carcinogens<sup>[43]</sup>.

Occupied spaces with insufficient ventilation can also experience significant build-up of carbon dioxide, which increases with occupancy density, and can have an impact on cognitive functional ability<sup>[44]</sup>. Various studies have shown the importance of air quality for learning and behaviour in schools and productivity in offices. The impact in homes is less clear, but the desirability of good air quality is without doubt.

However, it is possible to provide sufficient clean, cool, outside air without allowing the ingress of external pollutants, whilst at the same time providing an adequate air change rate to remove these various pollutants. One major challenge we face in the UK is that of balancing the need for more airtight, energy efficient houses with the need for adequate ventilation outlined above. We need to ensure that new homes are not only energy efficient, but also provide optimal ventilation rates for good internal air quality.



### Design guidelines

- Consider the location of homes and the existing external air quality: are they located within an Air Quality Management Area (AQMA), or close to a major source of pollution (e.g. a busy road)?
- Can homes be orientated with openings and outdoor spaces away from pollution sources? Or can landscaping, internal courtyards, ‘green screening’, or other measures be used to reduce the impact of the poor external air quality? Only once these options have been considered should additional measures such as filtration be considered: the ideal is to bring large quantities of good quality, clean air into the home.
- Strive to avoid the internal build-up of pollutants wherever possible: construction materials, fittings and finishes with a low air quality impact should be used, (consult various British and European standards regarding VOC and formaldehyde emissions from products).
- Provide a Home User Guide to help occupiers understand how to establish and maintain good internal air quality. The first two years of a building’s operation are the most important in terms of VOC emissions, when the effect of fittings and finishes is strongest.
- Homes should be designed with dedicated, well ventilated, low energy drying spaces such as covered outdoor areas, indoor drying cupboards or communal drying facilities, in order to alleviate health risks from moisture. See [page 31](#) for more information on moisture in homes.
- Ensure windows are accessible and have varying degrees of opening so they can be partially opened for trickle ventilation, or opened wide for purge. In order to provide adequate ventilation overnight, it is recommended that a window is left open: if this is not possible due to local security issues, other means of secure night-time ventilation should be provided. See window box on [page 21](#) for more details.
- If the provision of fresh air at a sufficient rate to dilute and remove airborne pollutants is not possible via natural means, mechanical ventilation with heat recovery (MVHR) or mechanical extract ventilation (MEV) could be considered: guidelines<sup>[49]</sup> are available describing when this is considered to be necessary. However, there needs to be a robust maintenance plan in place for mechanical systems, in particular those containing filters which require regular cleaning and replacement.
- When specifying mechanical systems, air intakes should be located as far as possible from sources of external air pollution, and from exhaust points, to avoid recirculation. Guidelines<sup>[50]</sup> for good practice relating to outdoor air quality considerations and the use of air filters are available: these should be followed when specifying heating, ventilation and air conditioning (HVAC) systems to ensure that they incorporate suitable filtration to prevent external air pollutants from entering the building.





**VIEWPOINT:**  
**DIY SUSTAINABILITY: HOW PERSONAL TECHNOLOGY IS BUILDING NEW MARKETS**  
(RICHARD FRANCIS, THE MONOMOY COMPANY)

A home is the most expensive item most of us will ever buy. Yet compared to other purchases it is also the one we often know least about. Consider this: a 50 pence pot of yoghurt will tell you what it is made of and how it is good for you. The average Londoner will spend a million times more than this for a home without knowing any of this information.

This is about to change. In the last couple of years, new technology that measures environmental conditions in and around the home has blossomed. Low cost indoor environmental quality (IEQ) monitors and free mobile phone apps now put important health and wellbeing information at everyone's fingertips. Wearable sensors allow children walking to school to do the work once reserved for scientists. The flow of real-time, granular, actionable health intelligence is exploding. Much of it is free.

Want to know the real-time air quality on the street where you are buying a home? There's a free app for that. Want to know the quality of air inside your home, or one you are considering buying? There's a low cost consumer device for that, too. Coming to market are inexpensive products that plug into smartphones and instantly reveal all kinds of critical information: the quality of water coming from the tap, the amount of dampness in the walls, the level of chemicals in your cleaning products, the amount of pesticides in your food. These products are new and not without limitations, but over time they will improve, and could, like the phones they plug into, become normal, indispensable parts of our lives.

As more and more sensors get placed in everyday items like mobile phones and wearables, it is clear that ordinary people will have extraordinary new capabilities. With no additional expense

or equipment, they will be able to measure, benchmark, map and reveal to the entire world environmental conditions at a specific postal code. The risks and opportunities from this are astounding.

This is already beginning to happen, as the number of open source monitors increases and social media becomes the chief repository of information about building performance, including homes. The companies that have the most information about conditions in buildings and people's impressions of them are less than 10 years old. They are not construction and real estate companies, they are technology and service providers.

Technology is disruptive, but it is also constructive. Think of the opportunities for ordinary individuals to make healthier choices based on information they never had before. Think of how new knowledge will create changing expectations from government and industry. Think of the new-found capabilities for professionals of all kinds to profit personally by benefitting everybody.

Real estate has been called the last imperfect market in the world, but this label may soon become obsolete. Technology has and will continue to empower consumers to make better, more informed choices about how houses (and other buildings) impact them and their families. This is already affecting the attractiveness of some homes, which will no doubt be reflected in the prices they command.

In other consumer markets, products that promote health and wellbeing outperform conventional products by a mile. Although the market for healthy homes is just emerging, why would we expect anything else?

“Well insulated, warm homes can drastically reduce winter mortality and illness”

**Thermal environment**

**Why is it important?**

Well insulated, warm homes can drastically reduce winter mortality and illness: the incidence of heart attacks, strokes, and other respiratory diseases is directly increased by excess cold. In fact, on average around 24,000 deaths per year in the UK are attributable to excess cold<sup>[51]</sup>, and the impact of cold housing specifically was estimated to cause a fifth of these excess deaths in winter 2014-15 in England and Wales<sup>[52]</sup>.

At the other end of the scale, during the summer months, we need to avoid overheating: our ability to continue normal function relies on our bodies maintaining a temperature of around 37 degrees Celsius. Exposure to warm conditions in excess of approximately 25 degrees is associated with increased health risks<sup>[53,54]</sup>, with thermal stresses affecting the performance of our body, productivity, and mood.

In recent years, we have seen a marked rise in the incidence of overheating<sup>[55]</sup>, particularly in the new build sector. As the frequency and severity of heatwaves is predicted to increase due to climatic changes, addressing this issue is vitally important<sup>[56]</sup>. Although most evidence on the impacts of overheating on health is based on outdoor temperatures, with less information regarding safe indoor temperatures<sup>[57]</sup>, a dwelling's location and building characteristics no doubt have a significant impact<sup>[9]</sup>. See cross cutting box on overheating on [page 30](#).

NHS guidance suggests homes should be at least 18°C in winter for people with reduced mobility, those 65 years old or over, or those with a health condition such as heart or lung disease<sup>[58]</sup>. While it is possible that younger, healthier people may be able to cope with lower temperatures, the WHO suggests that 'healthy indoor temperatures' for healthy individuals should be in the range 18-24°C<sup>[59]</sup>.





## CASE STUDY

### LOUDOUN ROAD (LEVITT BERNSTEIN)

#### The benefits of a fabric first approach

Loudoun Road, completed in 2013 for Origin Housing, provides 42 mixed tenure apartments on a prominent site adjacent to the South Hampstead Overground station. The development contains a mix of smaller one bedroom homes through to larger four bedroom family homes. With Origin Housing's support we developed a sustainability approach which sought to significantly reduce the energy demands through a highly efficient building envelope, designed to Passivhaus levels of super-insulation and air-tightness, but without the financial implications of seeking full certification.

A high performance building fabric was specified with low u-values and high levels of airtightness matching the Passivhaus requirement of 0.6 ACH-1 @50Pa in post-completion testing. Mechanical ventilation with heat recovery (MVHR) was installed to provide ventilation whilst retaining the majority of heat in the homes. Communally fed heater batteries provide top up heat through the MVHR system should the homes need it.

We have since returned post-completion to carry out monitoring and evaluation of the homes in use. This included the monitoring summer and winter temperatures in select homes over the course of a year and comparing this with energy consumption and occupant satisfaction levels.

The winter temperature monitoring highlighted the benefits of high levels of insulation and the installation of mechanical ventilation with heat recovery (MVHR). These features are thought to have significantly contributed to the stability of internal temperatures and warmth of the living spaces, with a constant and flat 20-23°C measured despite external temperatures dropping as low as 5°C.

Whilst in summer, despite the external temperature peaking at 32°C, all living spaces measured remained at a constant 25-27°C internally without the need for cooling. This highlights the ability of the insulated fabric to keep out the heat in summer as much as it keeps in the heat in winter.

These design decisions have resulted in a low heating demand in winter and high reported levels of comfort, with more than two thirds of residents using less than 15 kWh/ m<sup>2</sup>.yr in-use. Consequently residents' average heating and domestic hot water consumption combined was 4 times smaller than the UK average for a similar size home.

It is through careful orientation, high levels of insulation, appropriate shading, air tightness levels and system design that the heating consumption of the homes has been reduced. The most striking discovery is the validation that the building fabric and MVHR systems have the ability to stabilise internal temperatures and humidity levels despite large external temperature fluctuations.

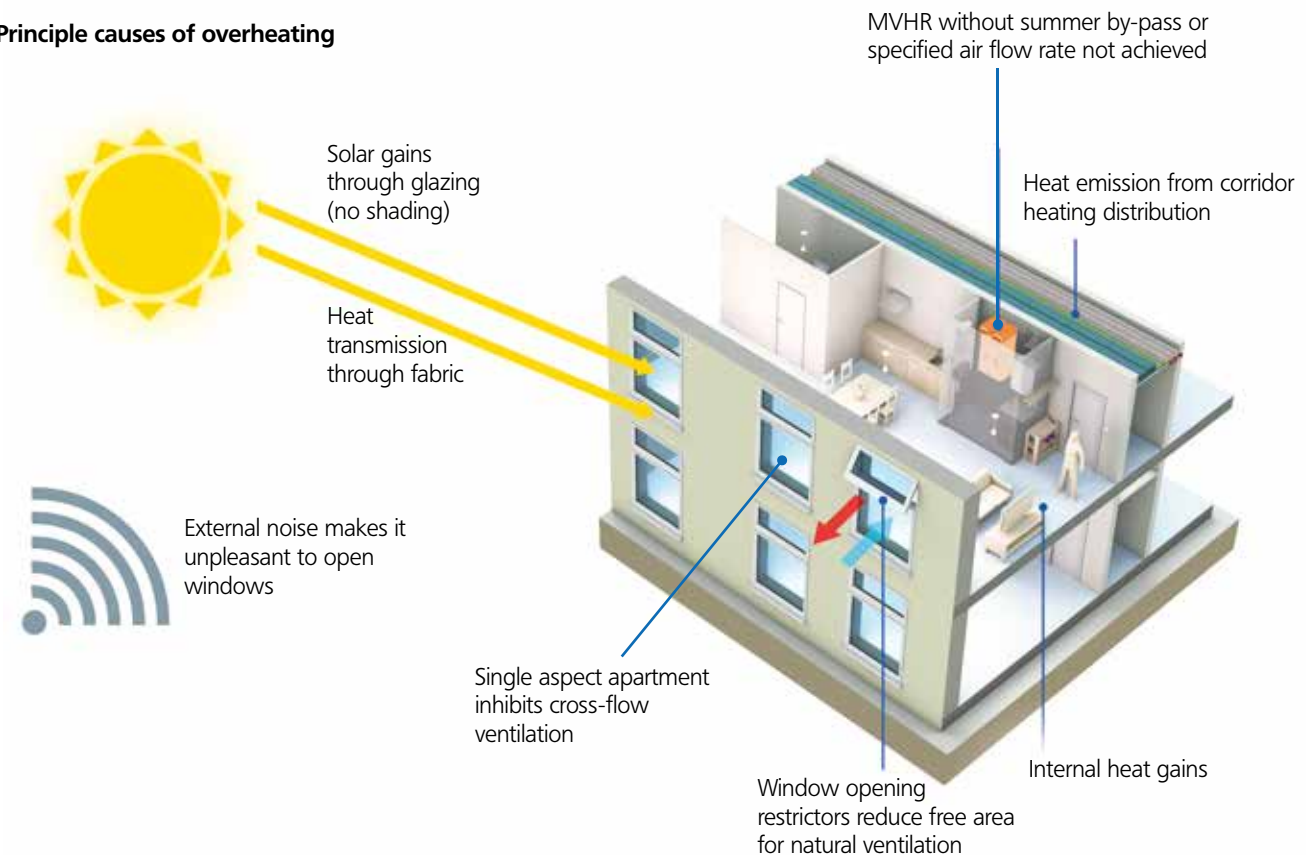


Image © Levitt Bernstein

#### Design guidelines

- Orientate homes to allow for a balance of sun and shade: ideally homes would be designed to receive low level sun in winter and block out high level sun in summer.
- Consider the size and specification of windows in relation to orientation and thermal comfort. Large windows facing south or west will have high heat gains unless measures such as external shading or solar control glazing are used to reduce the impact. Conversely large windows on north facing elevations will contribute to additional heat loss. See [page 21](#) for more on windows.
- Natural ventilation through openable windows can be used to help cool homes, or at least provide a pleasant breeze on a hot summer's day. The most effective form is cross ventilation, with openable windows on opposite sides of the building (dual aspect homes). See window design box on [page 21](#).
- Utilising thermal mass (heavyweight materials such as brick, stone, block and concrete) inside homes can help regulate internal temperatures, especially in summer. This should be combined with night time ventilation to cool the thermal mass overnight ready to absorb heat the following day, although security must be considered.
- Design for a well-insulated building fabric, including enhanced insulation (improved u-values, which keep heat out in summer as well as keeping heat in during winter), reduced heat loss at element junctions (thermal bridging) and improvement in air leakage (air tightness) beyond that required by Building Regulations.
- Carry out overheating analysis at an early stage in the design process, to determine how to best design out overheating. Include future weather scenarios to futureproof designs.
- Where mechanical ventilation with heat recovery (MVHR) is used to efficiently retain heat in winter, it should be installed with a summer bypass mode to ensure internal heat is expelled rather than recirculated in the hotter months.
- Heating and ventilation controls should be easy to use and understand, allowing occupants to adjust temperatures and ventilation rates to suit their preferences.
- Avoid unnecessarily adding heat internally from hot water storage or poorly insulated heating pipes. Insulate pipework to a high standard of workmanship.

#### Principle causes of overheating





“Over recent years, concern over energy costs and carbon emissions have led to increasingly airtight, thermally insulated homes.”

### CROSS CUTTING: OVERHEATING

In June 2015, the Zero Carbon Hub (ZCH) reported extensively on the issue of overheating in homes.

Historically in the UK, with its relatively mild climate, heat was allowed to escape our homes in a fairly uncontrolled manner: our older houses are leaky and draughty. Over recent years, concern over energy costs and carbon emissions have led to increasingly airtight, thermally insulated homes. It is now possible to live in a UK home and not use a heat source other than solar and internal gains during the winter months: quite a change from our Victorian homes.

However, without careful design, there is a risk of overheating in highly insulated homes. The ZCH suggests that overheating could be an issue in up to 20 per cent of our current housing stock. This looks set to worsen if we do not address the issue, as the climate warms, and heatwaves become more frequent and more intense. In a 10 day heatwave in August 2003, over 2,000 excess deaths were thought to be attributable to overheating.

In this report we have outlined some design principles which can be implemented to reduce overheating risk. Full guidance is available from the Zero Carbon Hub<sup>[60]</sup>.



### CASE STUDY SHARPER (ARUP)

SHARPER (Seasonal health, ageing and resilience in urban populations and environments) is a collaborative research project that focuses on three major global cities: London, New York and Shanghai. Its aim is to help inform policy and practice relating to creating healthy and resilient cities in the context of ageing populations.

#### The risk of extreme weather events

Climate change related extreme weather events are posing increasing risks to public health and property in cities around the world. This is especially the case in major global cities which are home to growing numbers of elderly people who are potentially more vulnerable.

#### Establishing priorities

As a part of the research, a method to estimate heat vulnerability in cities was developed and a Heat Vulnerability Index map was created for London, identifying which areas in each city are most exposed, and where vulnerable populations such as the elderly live. The Heat Vulnerability Index, combined with climate hazard maps, can be used to prioritise measures to increase resilience in London and other cities.

#### Ensuring wider benefits

The priority measures cover strategic, operational, social and physical considerations, and are tailored to decision makers and developers in each city. There is an emphasis on ‘win-win’ measures that have wider sustainability and resilience benefits for the city and its people as a whole.

#### An enduring legacy

SHARPER provides an evidence base and methodology for further work in London, New York and Shanghai and other cities around the world. It has also raised awareness of the need to prioritise investment and action to increase the resilience of vulnerable people to climate change.



“It is important to control moisture levels because too much moisture in homes can increase growth of bacteria, house dust mites, and mould”

### Moisture

#### Why is it important?

Moisture in our homes is generated by activities such as cooking, drying, washing, bathing, and breathing. It is important to control moisture levels because too much moisture in homes can increase growth of bacteria, house dust mites, and mould, all of which represent health risks. Furthermore, dampness could also cause degradation of materials, further polluting the air in buildings. All of these can result in problems with respiratory systems, for example infections or exacerbation of asthma<sup>[61]</sup>.

However, as with all of these things, a balance needs to be struck. While elevated levels of moisture in the air can inhibit sweating which in turn can increase the impact of high temperatures on thermal comfort, dry air can result in irritated mucous membranes of the skin, eyes, nose and throat which could lead to greater risk of infections.

#### Design guidelines

- Good levels of background ventilation, whether natural or mechanical, combined with the ability to purge ventilate through large openable windows will significantly reduce internal moisture levels.
- Provide good levels of ventilation in problematic areas such as kitchens and bathrooms, with facilities for residents to dry their clothes externally where possible.
- Prevention and/or rapid remediation of water damage are key to avoiding excess humidity in the air, condensation on surfaces and excess moisture in materials.
- Avoid and reduce the impact of thermal bridges to minimise condensation forming on cold junctions, which can lead to the formation of mould on ceilings and walls.





“We spend about a third of our life sleeping and the built environment can affect the quality of sleep”

### CROSS CUTTING: SLEEP

Poor sleep quality affects both physical and mental health. We spend about a third of our life sleeping and the built environment can affect the quality of sleep. Regular poor sleep can lead to serious medical conditions such as obesity, heart disease and diabetes, and has been shown to shorten life expectancy, weaken your immune system, and even affect fertility. Sleep duration and quality has been linked to the risk of anxiety and depression<sup>[62,63]</sup> and poor sleep can cause fatigue, irritability and lack of concentration, which in turn can lead to a risk of injury and accidents. The National Sleep Foundation<sup>[64]</sup> sets out some good guidelines for how to promote good sleeping patterns, in terms of both the sleeping environment and lifestyle habits. Some of these recommendations include the following strategies, which are within the sphere of influence of building design.

- Light and darkness are powerful cues that tell your body to rest, or get you ready for a productive day. Artificial light after dark wakes up your brain and makes it harder to fall asleep. Warmer light is better for bedrooms, and dimmable light fixtures facilitate better lighting control to enable people to control indoor lighting requirements to mimic natural light levels. ‘Blue light’ from electronics has the potential to disrupt sleep and should be kept out of sleeping areas, as they have been shown to delay the release of melatonin.
- Cool rooms make for the best sleep – generally an optimal temperature of 18°C<sup>[65]</sup> Prevent summertime overheating by providing blinds or curtains and educating residents on their proper use. Employ night-time ventilation to facilitate a cross-breeze and open windows where it is feasible to do so. Use the home’s ‘cool zones’ on the lower floors for locating bedrooms. Cross ventilation in dual aspect homes can be facilitated through a network of internal doors if they are left open. For more on overheating see “Overheating” on page 30 and “Thermal environment” on page 27.
- External air pollution has been linked to the incidence of sleep disordered breathing. Studies have shown that people are at a 13 per cent higher risk of having shallow breathing or experiencing sleep apnoea if pollution goes from the lower range to the higher range of pollution for a particular city<sup>[66]</sup> Another study showed that sleep quality and perceived air quality improved significantly with lower CO<sub>2</sub> levels, along with next-day reported sleepiness and the ability to concentrate<sup>[67]</sup> Improve indoor air quality by maintaining good ventilation levels, and possibly the use of air purification systems for homes in areas with poor neighbourhood air quality. For more information see “Internal air quality” on page 24 and “External air quality” on page 41.

“The distress caused by neighbour noise issues and poor sound insulation between homes is well documented, although noise complaint statistics generally underestimate the extent of dissatisfaction”

## Noise

### Why is it important?

Unwanted noise in homes can be at best a nuisance, but at worst can cause longer term health issues. In the short term, unwanted noise can cause activity disturbance, speech interference and disturb rest, relaxation and sleep. In the longer term there is evidence of more insidious health effects, because the presence of noise can cause increased levels of stress hormones, increasing the risk of cardiovascular effects (heart disease and hypertension). The distress caused by neighbour noise issues and poor sound insulation between homes is well documented, although noise complaint statistics generally underestimate the extent of dissatisfaction. A national survey reported in 2000 that an estimated 37 per cent of the population were bothered, annoyed, or disturbed to some extent by neighbour noise<sup>[68]</sup>.

Acoustic design and noise control is another key element for the design of stress-free restorative environments. Noise has been shown to elevate blood pressure and stress hormones in children<sup>[69]</sup> and it can contribute to feelings of helplessness. It can also lead to cognitive issues, including impaired cognitive development and lack of concentration.

A key element of achieving mental wellbeing is the element of control. When people feel in control of their surroundings and environment, they feel empowerment and stability<sup>[70,71,72]</sup>. ‘Learned helplessness’ is a medical theory that links clinical depression with the absence of control, and this can include the inability to cope with repeated exposure to noise<sup>[73,74,75]</sup>. Acoustical improvements in schools have been shown to improve task persistence in children<sup>[76]</sup>.

Neighbourhood noise is a key factor in influencing the performance and concentration of children. In one study, children residing in noisier neighbourhoods attending schools with high ambient noise levels showed lower reading scores compared to children at the same school, but residing in quieter neighbourhoods<sup>[77]</sup>.

However, the effects of sounds are highly context-dependent. Noise associated with inconsiderate behaviour, or with an unwelcome development, is likely to cause annoyance or distress. On the other hand the urban soundscape, for example, can be a normal – even comforting – presence in inner-city developments.

This means that available guidance on suitable acoustic standards needs to be intelligently interpreted in the context of the overall setting of developments, and carefully set against potentially conflicting design aims or constraints.







### Design guidelines

- Masterplanning and landscaping: National planning guidance ensures that the potential effect of external noise is acknowledged. Acoustic considerations should be considered at the outset. The aim should be to maximise the amenity of external areas and the ability of occupants to open windows and / or have fixed natural ventilation paths without unacceptable noise. These aims are reinforced in industry guidance currently at draft stage<sup>[78]</sup>.
- External noise ingress: The WHO<sup>[79]</sup> has produced recommendations for external noise, supported by British guidance<sup>[80]</sup>, which vary according to room type. In general, bedrooms need to be quieter, particularly at night, whereas living spaces can be slightly noisier.
- Ventilation: There can be a direct conflict between achieving adequate ventilation and appropriate internal levels of noise. Minimum background rates of ventilation can be achieved by employing acoustic trickle vents, but many building occupants will wish to open windows, particularly in the summer. This is not a condition which has always been taken into account in planning, since there has not been a requirement to assess noise levels with the windows open.
- Opening windows: Close attention needs to be paid to internal temperature gains, the number of days in a year when windows may need to be open for comfort reasons, and the magnitude of the resulting acoustic compromise. A case can be made for mechanical ventilation and comfort cooling where the frequency of window opening is not desirable. Where circumstances allow, passive cooling systems could provide more desirable and sustainable solutions.
- Sound transfer between adjacent dwellings: Minimum standards for sound insulation between dwellings are a requirement of the Building Regulations. Many developers seek to achieve significantly better than the legal minimum standards required to avoid occupant dissatisfaction with sound travelling between dwellings.
- Internal sources of noise: All mechanical or electrical system components must be selected with great care to ensure not only that the internal noise criteria are met, but also to avoid any tonal or other attention-catching features. It is beneficial for occupants to be have a simple manual control so that they can set back systems to be sure of reduced noise levels in bedrooms at night.
- Internal acoustics: Other than the Building Regulations requirement for control of reverberation in common parts, there are no required nor generally followed measures to provide particular internal acoustic characteristics. It is desirable to avoid for excessive reverberance, and in practice soft furnishings will provide a significant degree of acoustic control. However, in areas with primarily hard finishes, consideration should be given to the use of sound absorbent finishes to reduce noise build-up, and also to help reduce transmission of sounds to other parts of the dwelling.

Further guidance is provided in Technical Appendix: <http://bit.ly/HomesHealthy>



### Functional homes

#### Why is it important?

The design of a home for functionality has the ability to reduce the everyday stress in our lives whilst also protecting our physical health. However, functionality is often an afterthought or even worse considered a luxury outside that of standard home layout designs.

Key issues include:

- Storage and space for drying clothes are often the first to go when space is tight. Storage of basic but large items such as vacuum cleaners is proving tight in new homes, especially in apartments where loft spaces and under stair cupboards are non-existent. Whilst the recently introduced Nationally Described Space Standard for England<sup>[24]</sup> contains minimum built-in storage requirements for varying size homes, this standard is only applicable where Local Planning Authorities have evidence of need and viability for adopting and enforcing it, or previously had space standards in its adopted Local Plan.
- Where occupants have been presented with complicated heating, lighting or ventilation controls they may struggle to maintain internal temperatures, fresh air rates and appropriate light levels – all of which can have health impacts. The consequences of residents not feeling in control of their systems can lead to homes becoming too hot or too cold, reduced energy efficiency, and in some cases it can then lead to exacerbated levels of fuel poverty.
- With the amount of technology we own growing, occupants are often faced with a distinct lack of plug sockets in which to power and charge their gadgets. Overloading sockets can lead to plugs overheating and causing a fire<sup>[25]</sup>.

#### Design guidelines

- There should be at least two stores in every home containing a mix of full height, deep, shallow, shelved and open options. In addition, placing more than 50 per cent of storage in bedrooms should be avoided.
- Ideally, all homes should have a utility room for their laundry needs, however, failing this some form of external space to dry their clothes, whether a washing line in a garden or a dedicated space on a balcony.
- To avoid the risk of fire from overloaded power sockets, or needing to retrofit additional sockets at a later date, a generous number of sockets spread across every room in the home should be provided.
- Simple and effective controls that give residents the freedom to adjust their home controls, increase the opportunity for meeting comfort requirements while allowing self-regulation of health and wellbeing.

Adaptable homes

Why is it important?

Developers and designers should consider the impact of future events on their designs which may relate to changing lifestyles, or technologies. Designs should be appropriately resilient, investing a reasonable amount in being able to meet changes that are foreseeable but not precisely predictable.

The ageing population is just one example of the need for flexible design. The Office for National Statistics projects that the number of people aged 80 and above will more than double, to 6 million, by mid-2037; the number aged between 70 and 80 will grow from 4.5 million to 7.5 million<sup>[81]</sup>. It is expected that 60 per cent of total household growth in England up to 2033 will come from households headed by someone aged 65 or over<sup>[82]</sup>.

It is important to improve the quality of life of our ageing population, and those suffering from disability or illness. Being forced to move home or into care can result in increased loneliness. This is bad in its own right, but also has health consequences<sup>[83,84]</sup>. Injuries due to falls among older people have been estimated to cost the state over £1 billion a year – 1 in 4 falls involve stairs and the majority take place in the home<sup>[85]</sup>; postponing entry into residential care by one year could reduce non-care costs by £26,000 per person<sup>[86]</sup>.

Studies have shown health outcomes to be just as good where people are able to be treated or rehabilitated at home compared to a hospital or care home<sup>[87,88,89]</sup>. People naturally prefer to remain at home where they can and so happiness and patient satisfaction is generally higher<sup>[90]</sup>.

Some developments are specifically designed for residents without children and when couples in those developments have children, the home is not adaptable to their needs. It is important that thought is given to this scenario at the design stage (e.g. the provision of safe play space for children, even if the target market do not yet have children) to encourage residents to stay, thereby improving communities.

Design guidelines

- Low-level and low-cost interventions to improve the adaptability of houses were researched in great detail by the Joseph Rowntree Foundation, in its Lifetime Homes design guide<sup>[91]</sup>. This provides 16 criteria that ensure homes remain flexible to the changing needs of their occupants, including recommendations for the design of parking spaces, windows, toilets, halls (with appropriate turning radii), etc. This has been widely adopted within the house building industry and as of 2015 many of the principles have been incorporated into Approved Document Part M's new "Category 2 – Accessible and adaptable dwellings", use of which should be encouraged.
- The design and adaptability of housing specifically for older people is covered by the 2009 report "Housing our Ageing Population: Panel for Innovation (HAPPI)"<sup>[92]</sup>, which makes ten key design recommendations for designing housing for older people. The 2012 follow up report HAPPI 2<sup>[93]</sup> provides further recommendations for delivery.
- Requirements of children should be incorporated into every development, or a plan made for future provision. External safe car-free play space should be provided for and storage requirements should be carefully considered.

SECTION 2:  
DESIGNING HEALTHY NEIGHBOURHOODS

Introduction

It is not just the home which is important when it comes to health and wellbeing; the surrounding neighbourhood also has a vital role to play.

There is a correlation between communities where people are physically active and are able to interact with other community members and communities that are more prosperous, have lower crime rates and greater overall community cohesion. However, there are a whole range of factors at the neighbourhood scale which contribute towards health and wellbeing, as the graphic shows.

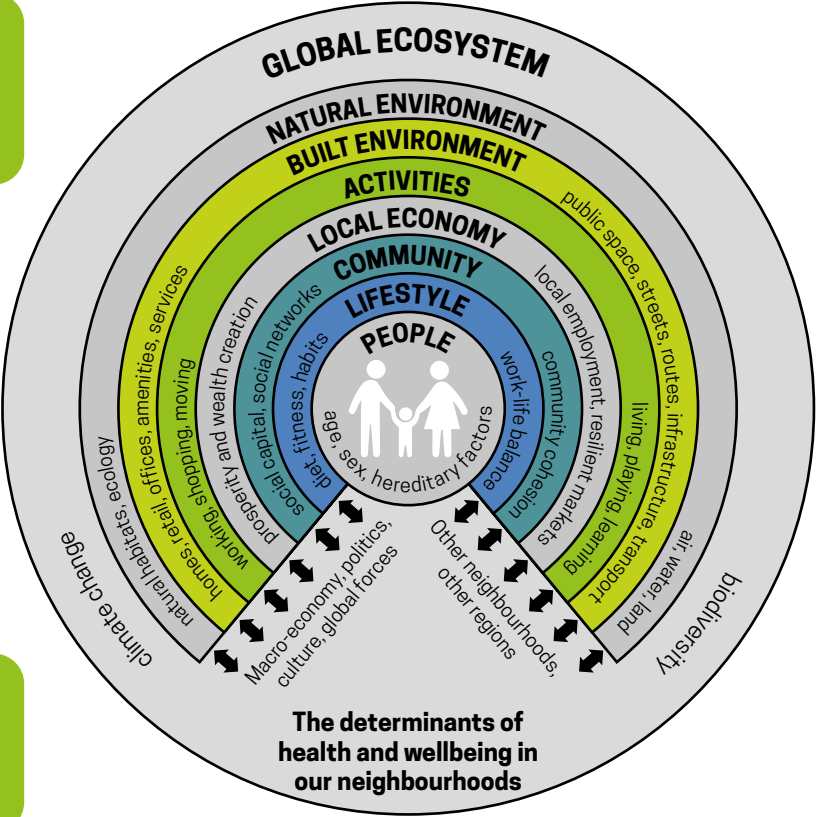
What is a healthy neighbourhood?



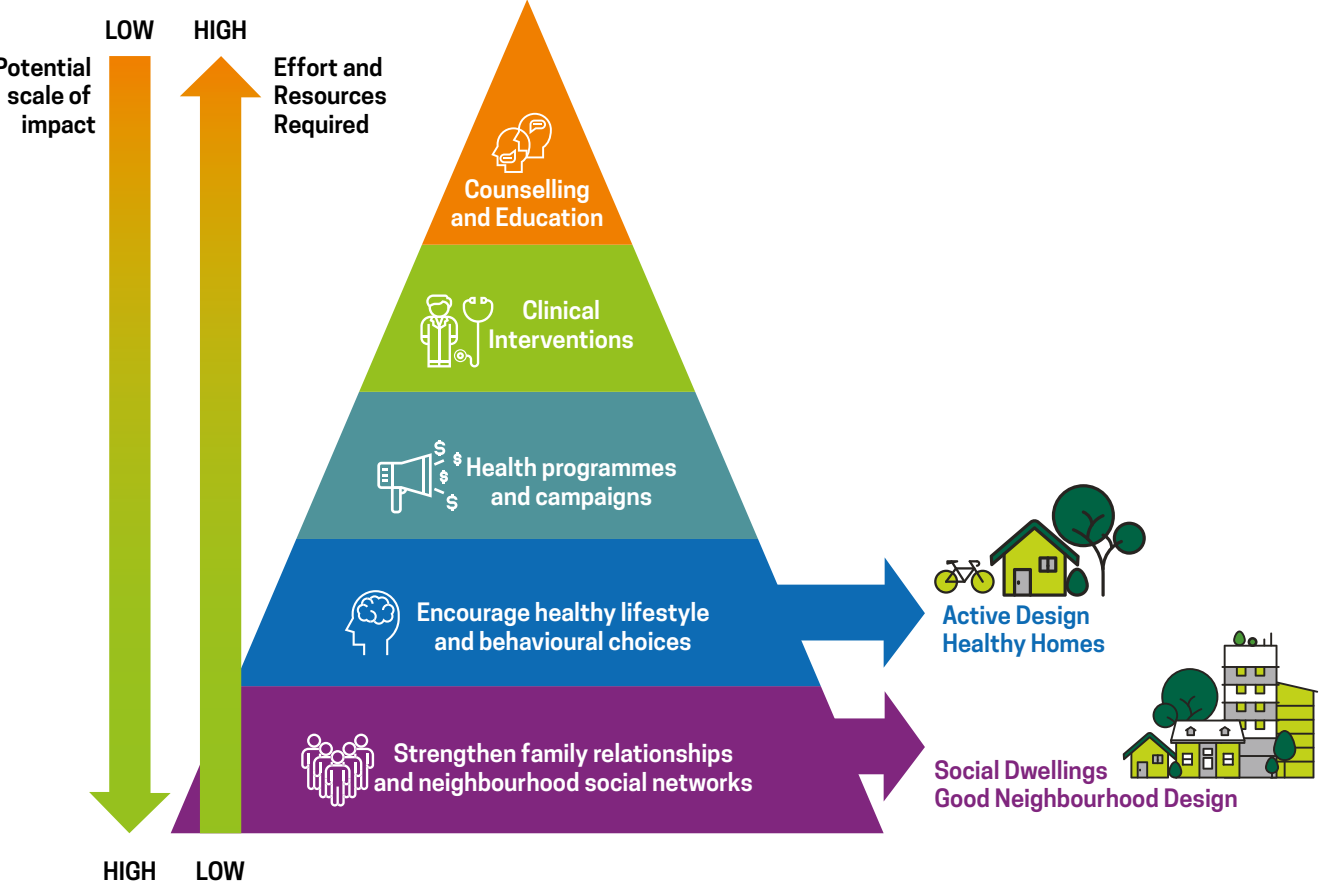


The wide range of issues impacting health and wellbeing from social, environmental and economic perspectives have been portrayed in the “Settlement Health Map” created by Barton and Grant.

Areas in colour indicate the primary scope influence of the recommendations set out in this report. Adapted from Barton and Grant (2006) A health map for the local human habitat, The Journal for the Royal Society for the Promotion of Health, 126 (6):252-253.



Good design of our homes and neighbourhoods can have a positive impact on a very large number of people. When compared to individual clinical interventions, it is a relatively resource efficient route to improved public health.



### CROSS CUTTING: DENSITY

As urban populations grow, and the environmental impact of cities expands, cities necessarily need to be high density. High density living, including mixed uses and efficient public transport links can have a number of health and wellbeing benefits, including promoting physical activity and encouraging social activity.

However, some studies show that poorly designed high density housing can be detrimental for wellbeing, in part because of a lack of privacy and natural space. Where possible, a small garden can offer a buffer between the private and the public, maintaining the privacy of the home, while providing a sense of community. The 'greening' approach with planting, roof terraces, garden allotments and/or living walls can also help promote healthy and happy environments.

A challenge for high density is ensuring that homes and outdoor spaces achieve access to sunlight, daylight, quiet and clean air. Careful massing can achieve sunlight and daylight provision<sup>[94]</sup> and create diverse microclimatic conditions to enhance outdoor comfort for different seasons and activities (e.g. a sunny space to sit on a cool autumn day, or a shady, breezy spot for the summer).

If designers take these issues into account, high density housing developments can provide healthy neighbourhoods which support strong communities.

### Green spaces

#### Why are they important?

As well as the numerous environmental benefits associated with the provision of green spaces and green infrastructure in housing developments, such as increased biodiversity and opportunities for sustainable urban drainage, studies show that contact with natural environments can be directly linked to people's health and wellbeing<sup>[95]</sup>.

Connection with nature can affect cortisol levels, pulse rates, blood pressure, glucose levels, and the serotonin-melatonin balance which in turn can affect mood and energy levels. In a cross sectional study in four European cities, it was found that more hours of visiting green spaces was linked to higher self-reported mental health and vitality<sup>[96]</sup> and lower levels of perceived stress<sup>[97,98]</sup>, and for women, lower odds of depressive symptoms<sup>[99]</sup>. Other studies have also found that access to a garden or green areas a short distance from a dwelling are associated with less stress, depression, and a lower likelihood of obesity<sup>[100,101]</sup>. Furthermore, people experiencing stress prefer natural environments that feel safe, provide access to nature and promote serenity and calm as opposed to busy open spaces and squares that are focused on leisure activity and social interaction<sup>[102]</sup>. Symptoms of ADHD have also shown to be reduced by exposure to nature<sup>[103]</sup>.

Biophilia means a love of life or living systems<sup>[104]</sup> and biophilic design in neighbourhoods can help to improve the health and wellbeing of people who live there<sup>[105,106]</sup>. Biophilia plays an important role in achieving feelings of empowerment. In a study of Chicago public housing, residents living in architecturally identical buildings with or without nearby trees and grass, it was found that self-reported procrastination with regards to dealing with major life challenges was higher for residents with no access to vegetation<sup>[107]</sup>.

Children living in greener environments have been shown to have a greater capacity for paying attention, and are able to inhibit impulses and delay gratification better than children living in buildings surrounded by concrete<sup>[108]</sup>. Access to or views out to natural environments have been linked to improved cognitive function in adults<sup>[109]</sup>, children<sup>[110]</sup> and young adults<sup>[111]</sup>.

Burton (2015) concludes that for human flourishing there should be well-defined open green spaces with plenty of trees and green verges, gardens, green living walls and terraces; walkways; roadways with slow traffic; housing with plenty of fresh air, daylight, effective heat and sound insulation and easy access to cultural activities<sup>[112]</sup>. All these factors help to avoid loneliness and illness by encouraging walking and play and this adds to the communal value of the neighbourhood.





**CASE STUDY**  
**WILD WEST END**  
(ARUP)

Wild West End is a partnership between large property owners in London, aiming to: increase connections to green space and nature for residents, workers and visitors; enhance biodiversity and ecological connectivity; and raise awareness and promote the benefits of green space in urban areas.

As the technical partner, Arup plays a supporting role to the partnership, helping the Estate's to develop a objectives, implement proposals and monitor progress against the targets set.

*"There is absolutely no doubt that parks and green spaces in urban areas improve people's wellbeing and quality of life. Through the Wild West End we look forward to transforming a part of the city for thousands of residents, workers and tourists to enjoy even more."*  
**Mayor of London**

**Partners:**

The Crown Estate  
Grosvenor Britain & Ireland  
The Howard de Walden Estate  
The Portman Estate  
Shaftesbury

**Strategic Partners:**

The London Wildlife Trust  
Greater London Authority

**Design guidelines**

- Providing a variety of local recreation areas, gardens, parks, trails and playgrounds is essential for healthy neighbourhoods, as they encourage active transportation and exercise among all age groups.
- In addition to traditional recreation areas, adding green walls and green roofs to developments brings benefit to an area. Similarly, even 'pocket parks' are beneficial in increasing the greenness of the public realm.
- Community gardens and allotments are a further type of green space, discussed further in the 'healthy food' section but also relevant here.
- Green spaces should be rich in biodiversity for maximum psychological benefit, with a variety of plant types combined with open spaces for play.
- Management and long-term maintenance of public spaces and facilities should be carefully considered during the early design phase of any new development. The design intent of such places should be focused on ensuring maintenance to a high standard, protecting initial investment, encouraging continued use and adapting to changing needs<sup>[113]</sup>.
- Ensuring that local communities are involved in the ongoing management of their local facilities encourages a sense of ownership<sup>[113,114]</sup>.



**CASE STUDY**  
**PEA SOUP HOUSE**  
(FIELDEN CLEGG BRADLEY STUDIOS)

Pea Soup House is an installation promoting awareness about external air quality, as part of the RIBA exhibition "At Home in Britain – Designing the House of Tomorrow". It runs from 21 June 2016 – 4 August 2016.

In 1820, the artist John Sartain coined the term Pea Soup to describe the thick yellow fog drowning London during the industrial revolution. Londoners became known as Pea Soupers, and in 1952 the great smog of London (attributed to 12,000 deaths) prompted the 1956 clean air act. Today, pollution levels remain extremely high in London; toxic to the communities living there.

Playing on the origins of the 'Pea Soupers', Pea Soup House serves specific soups reflecting the daily air quality index (DAQI), encouraging locals to congregate and voice their concerns over the lunch hour. By engaging the local community through food, Pea Soup House raises public awareness of London's air quality through architecture, education and event. The servery is clad in a richly coloured enclosure representing Euston Road's historic air quality data. At night the installation will become a coloured LED illuminated landmark between two of the most polluted roads in London: Oxford Street and Euston Road.



**External air quality**

**Why it is important?**

In order to be really healthy and comfortable within our homes, we also need healthy external environments in our neighbourhoods. Obviously we need to be able to safely inhabit the spaces between buildings, but also, we use external air to ventilate our buildings.

In built up areas such as cities and towns, and by busy roads, the air can have very high levels of pollutants that are not good for human health. These pollutants include particulates, nitrous oxide (NOx), sulphur dioxide (SO<sub>2</sub>), and ozone, and are produced by vehicles, industry, and building heating systems. Due to the rise in use of diesel vehicles, NOx emissions have become particularly high in many cities and in London, the levels are higher than the EU limits in places. However, although this is an issue, a recent study showed that the health benefits of walking and cycling can in fact outweigh the risks of poor urban air quality<sup>[115]</sup>.

Effects such as cardiovascular diseases, respiratory diseases, including asthma, and lung cancer are well documented. However, researchers are now finding that air pollution may be also be associated with diabetes and neurological diseases, and that exposure during pregnancy may be associated with low birth weight and pre-term births. The annual mortality burden in the UK from exposure to outdoor air pollution is equivalent to around 40,000 deaths, according to the Royal College of Physicians<sup>[116]</sup>. The health problems resulting from exposure to air pollution also have a high cost to society and business, our health services and people who suffer from illness and premature death. In the UK, these costs add up to more than £20 billion every year – so an improvement in this area would have huge, positive repercussions.

**Design guidelines**

- Trees and plants can have some effect on reducing local air pollution, e.g. by planting lines of birch trees along street between homes and roads. Pollutants can stick to the leaves, before being washed away by rain, and some pollutants are processed by plants.
- Providing good public transport links, walkable amenities, good cycling infrastructure, electric vehicle charging points, and car clubs, will reduce private car use, which could improve air quality locally. Increasing walking and cycling opportunities will increase physical health and will counteract some of the health disadvantages of air pollution.
- The effect of external air quality on indoor air pollution can be further reduced by using mechanical ventilation systems with filters rather than natural ventilation in areas where pollution is high. Ordinary filters on a ventilation system will remove some particulates. A standard mechanical ventilation with heat recovery (MVHR) unit for a home would normally have a panel filter, which would filter coarse dust particles and insects, but not pollen or fine dust.
- NOx emissions produced by buildings come from heating systems. Gas boiler systems normally have low NOx emissions. Combined heat and power (CHP) systems typically have higher NOx emissions locally, although they displace the use of grid electricity, which has very high NOx emissions, so at a larger scale they perform well. Their NOx emissions can be reduced by using catalytic converters.



## CASE STUDY KIRKSTALL FORGE MASTERPLAN (FCBS/PLANIT-IE/HOARE LEA SUSTAINABILITY)

The 20 hectare site to the North East of Leeds is planned to include about 1050 houses and apartments, 28,000m<sup>2</sup> of commercial space, 3,000m<sup>2</sup> of retail and leisure, and a primary school. Sitting in a wooded valley and straddling the River Aire, the site offers a sense of rural seclusion; yet a new train station being built as part of the masterplan and due to open in summer 2016 will make the development just a 6 minute train journey from central Leeds.

Capitalising on the natural surroundings, the masterplan retains the wooded perimeter within the site for use as an exercise trail, connects to existing woodland walks, and extends the river footpath. The scheme includes a gym, playgrounds, an open meadow, and a bridge across the railway to connect to the fields and canal towpath beyond.

Excellent public transport connections also allows for development to be dense and to discourage car use: Car clubs are to be provided on site, car parking is more limited than normal, and extensive local amenities are provided within walking distance.

The masterplan promotes healthy lifestyles through both planned exercise and the incidental physical activity associated with reduced car usage.

## Promoting physical activity and social interaction

### Why it is important?

Facilitating physical activity and providing healthy foods helps to reduce risk of respiratory disease, developmental disorders, obesity and chronic illnesses<sup>[117]</sup>. In developed countries a lack of physical activity and reliance on convenience food are identified as major causes of heart disease, heart attacks, strokes and death<sup>[118]</sup>.

Research shows that in places with direct pathways connecting homes with multiple destinations, people are more likely to engage in moderate physical activity for 30 minutes or more per day<sup>[119]</sup>. Moreover, the number of people who get regular exercise (i.e. 3 days a week) increases by 25 per cent in neighbourhoods with parks, trails, and playgrounds<sup>[120]</sup>. Residents living in a neighbourhood with at least one grocery store are 1.5 times as likely to be physically active than residents living in an area with no grocery store<sup>[121]</sup>.

However, physical activity does not just help to improve physical health, it also helps to promote mental health and improves social interactions between individual members of a society<sup>[122]</sup>.

Integrating basic amenities within a well-planned, sustainable neighbourhood encourages frequent interaction between the community members throughout their daily life. Walkability to amenities not only reduces the use of individual cars, but also minimises air and noise pollution that contribute to health problems such as lung diseases, asthma, sleep disturbance and annoyance.



Image © Fielden Clegg Bradley Studios

## “Physical activity helps to promote mental health and improves social interactions between individual members of a society”



Different age groups need different opportunities for exercise and social interaction. Children spend the greatest amount of time outside: space to interact with friends and peers is vital for child development, and leads to the most effective exercise in this age group. Their independent use of spaces close to home, unsupervised by adults, can be provided by a network of shared spaces that are safely connected by footpaths. These spaces should be well overlooked in order to be useable, and should offer a variety of play and seating to attract other members of the community.

Alongside the network of safe spaces for children to play and roam, more formal playgrounds and other social spaces should be created; for example allotments, resident maintained gardens, ball parks and other games areas. These measures will design-in the opportunity for neighbours to both exercise and form stronger community ties and can be developed later with more structured programmes. Such spaces should be usable in all climatic conditions, not limited to certain times of the year.<sup>[123]</sup>

### Design guidelines

- Providing mixed-use developments, in which key uses, such as employment, amenities, green spaces and services are located near or among residential areas<sup>[124]</sup> can encourage walking and cycling. Furthermore, co-locating complementary functions such as health centres and gyms, and sports and recreational facilities, can also allow for efficient shared management facilities<sup>[113]</sup>.
- Walking and cycling should be prioritised over other modes of transport to encourage physical activity<sup>[113]</sup>. Providing safe, walkable and easily accessible pedestrian paths and cycling routes should be integral to any large development's design. Traffic calming features should be used to minimise hazard to pedestrians and improve their safety. Improving the quality of pavement surfaces, and creating visually attractive pavement can create a more enjoyable experience for pedestrians.
- There is a direct link between physical activity, safety and security<sup>[125]</sup>. Lower levels of physical activity have been reported in neighbourhoods which are not perceived as safe and secure by occupants<sup>[126]</sup>. Therefore creating a safe and secure environment is the key feature to promote physical activity.
- Clustering homes together and keeping noisier uses, such as public, retail and commercial spaces away (potentially separating one from the other with a green space as a buffer) can enhance residents' mental and social wellbeing.
- Enough lighting should be provided to enhance the safety and security<sup>[127]</sup>.
- The design of play space should take into account a changing climate. Children and young people should be protected from risks such as exposure to the sun, hot weather, poor air quality or noise. Measures could include the incorporation of canopy trees and shading structures/canopies to provide shade and refuges from the heat/weather. Where practical, water fountains should be provided nearby, along with biodiverse vegetation or food growing opportunities to enhance the outdoor experience.
- Play should be seen as a central component of green and blue infrastructure. This ties the safe active routes to school and around the neighbourhood, hedges for foraging and improved biodiversity/climate resilience all together.
- Stairs and ramps inside a building, or ones that connect different buildings to a public ground and social areas, such as gardens, playgrounds and community centres can encourage active design and promote physical health, as well as ensuring inclusivity.



“The provision of safe, accessible growing spaces means that children can get actively involved in food growing from an early age”

### Healthy food

#### Why is it important?

The results of a 2002 study<sup>[128]</sup> showed that availability of healthy foods encourages people to eat healthier foods more frequently. Providing opportunities for residents to grow their own food can have a positive impact not only on their physical health but also improve mental health and wellbeing. Other benefits include minimising food miles and waste.

The provision of safe, accessible growing spaces means that children can get actively involved in food growing from an early age, with research showing that the more a child is involved in growing vegetables, the more likely they are to want to consume them<sup>[129]</sup>.

For adults, research shows that the availability of growing space helps to minimise risk of stress and depression<sup>[130]</sup>.

#### Design guidelines

- Courtyards, gardens, terraces, and roofs can be used as areas to encourage physical activity, as well as providing food growing spaces. Providing adequate water is another key issue which should be considered in design of garden and growing spaces.
- The garden should be designed in a way to provide safe and secure environment for residents.
- Preferably in garden areas which have been used as playground some forms of shading should be provided in order to protect residents from direct sunlight during summer.
- Fruit trees and hedges are a good way to combine play, food, contact with nature and education through foraging.

### CASE STUDY VAUDEVILLE COURT (LEVITT BERNSTEIN)

Vaudeville Court began life as Levitt Bernstein’s winning entry in an open design competition, held by the London Borough of Islington. The competition sought to provide new high quality homes for council tenants and to explore what affordable family housing in the borough could look like in the 21st century

Inspired by the market gardens of Islington’s past, and the popular gardening clubs of its present, we imagined the scheme as a holistic, healthy and productive landscape, where every single surface – public or private, indoor or outdoor – is designed to be useful and can be enjoyed by all.

A major element of the design is the communal gardens which surround the scheme. These are shared with residents of the existing tower block, and will be run by the tower’s gardening club. As such, they’ll create a means to ‘grow’ two neighbouring communities together.

As the community gardeners come together it is hoped that residents will begin to benefit from their growing space which provides the opportunity for:

- Enjoyment of fresh seasonal vegetables as part of a healthy diet.
- Additional physical activity that can also help to relieve stress and improve mental wellbeing.
- A stimulating learning experience for families and children.
- A sense of community with increased social interaction and neighbourhood pride.







Image © Fielden Clegg Bradley Studios

### CASE STUDY DESIGN FOR FUTURE CLIMATE (INNOVATE UK/GOOD HOMES ALLIANCE)

In 2011 the Technology Strategy Board (now Innovate UK) put out a call for research into adapting buildings to future climate change. Good Homes Alliance received funding to study how the One Brighton housing scheme would cope under future climate scenarios and what could be done to adapt it in the future so that management strategies could be planned in advance if necessary.

Apartments are single or corner aspect, with exposed concrete soffits providing thermal mass, MVHR systems, openable windows, and high levels of insulation. Initial modelling showed worrying potential for overheating when the windows were assumed to be left on restrictors. Key conclusions:

- Removing the restrictors for purge ventilation provided the greatest drop in potential overheating of all the passive strategies tested, and is also the simplest and cheapest.
- Because the proportion of glazing is within recommended ranges, there was little benefit shown from adding solar shading.
- The MVHR helped reduce overheating because it improved air flow through the apartments.
- The same apartments with a lightweight construction would have overheated more.
- Optimal use of natural ventilation, including at night time, should keep overheating within recommended limits until 2050 on a 'medium' climate change scenario.

### Adapting to a changing climate

#### Why is it important?

Higher temperatures for longer periods, particularly when combined with warmer night time temperatures due to urban heat island effects can lead to unhealthily warm homes. In the absence of any approaches to address urban heat risk, heat related deaths in London could more than double by the 2050s<sup>[131]</sup>. In the UK, heat-related stress currently accounts for approximately 1,100 premature deaths and 100,000 hospital patient-days per year<sup>[132]</sup>.

This primarily involves anticipating changes in future weather. In terms of new-build and retrofits, all developments should be stress-tested using future climate data in dynamic simulation software<sup>[133]</sup>.

#### Design guidelines

- Risk can be assessed at a building level through overheating analysis, as described in the thermal comfort section. Future climate weather files are available from CIBSE to project future weather, including CIBSE TM49 for London, which is particularly useful as takes account of Urban Heat Island. These files allow heat wave scenarios to be tested.
- Future weather years and heat wave scenarios allow testing to assess how people might be able to modify behaviour to remain comfortable in a future climate. Alternatively, future retro-fit solutions could be tested and allowed for in the base build, which might extend to provision for the installation of future external shading or future cooling.
- It is recommended that developments have a heat wave plan to deal with an extreme heating event, particularly where residents are vulnerable. This should include a communications plan to help residents modify behaviour, access to tools, a means of identifying risk groups and liaison with emergency services<sup>[134]</sup>.
- The development should from the earliest stage plan to incorporate as much multi-functional green and blue infrastructure as possible to reduce urban heat island, to increase resilience to flood risk and to harness health benefits associated with improved air quality, access to nature, recreation and sustainable transport connections.
- Avoid dark coloured external surfaces to reduce the heat island effect.
- Promote community-led actions to enhance preparation and response to extreme weather events.
- To design against future water scarcity and increased prices, resilient residential developments should consider including infrastructure, or allowing space for non-potable water pipework routing, and set aside space for future treatment and storage equipment.

## SECTION 3: RETROFIT

“Work on an existing dwelling is an opportunity to improve its internal environmental conditions, enhance security, reduce running costs and improve the internal layout and the external appearance”

### Introduction

Much of the content and recommendations contained within this report equally apply to existing dwellings when they are being refurbished, adapted, extended or retrofitted to reduce energy consumption. Work on an existing dwelling is an opportunity to improve its internal environmental conditions, enhance security, reduce running costs and improve the internal layout and the external appearance; all of which can contribute to the health and wellbeing of the residents.

There is however one considerable difference when we consider existing dwellings in isolation from new build dwellings, and that is the residents, who will be very likely living in their homes during any building work. We address this need for sensitivity below.

### CASE STUDY CROSSWAYS ESTATE, BOW (CROSSWAYS, PRP)

Built in the early 1970s Crossways Estate in Bow was a high-rise development in the London Borough of Tower Hamlets (LBTH) that suffered serious physical and social decline due to poor investment and physical isolation from its surroundings. Cut off from the local street pattern and bounded by railways and changes of level on all sides, the estate was in one of the worst conditions in the Borough. It became a flagship project of the LBTH Housing for Choice programme and SRB funding was committed to the comprehensive regeneration of the estate, which originally comprised three 22-storey tower blocks and stacked maisonettes on the periphery, with open space and community facilities at a sunken lower-ground-floor level.

The masterplan retained the three towers and demolished the few low rise buildings. A new street layout now integrates the estate with its surroundings, enabling pedestrian and vehicular movement through the area, featuring urban blocks with front doors to maisonettes and flats at street level, all contributing to improved neighbourhood security. Creation of communal courtyards and a detailed landscaping strategy, ground remodelling and a new road and bridging structures over the adjacent railway, break down the perceptions of the area as an enclosed estate.

The community were involved throughout the process once the masterplan to retain the towers was conceived. Existing residents were rehoused in the new development or newly refurbished flats. The retention of the community was of primary importance and the regeneration project has expanded and strengthened that community.

The new development provides a total of 397 new homes and 273 refurbished homes in the three tower blocks. The housing comprises a mix of tenures including social rent and shared ownership for the existing tenants and leaseholders and new housing for sale to cross-subsidise regeneration. The retained

towers have been comprehensively improved and the existing residents who have been rehoused in the refurbished flats on a rolling decant programme have much reduced energy bills due to the retrofit upgrade works. The location of the site close to a transport hub, the improved quality of the homes and surrounding environment and the balanced social and economic outcomes have all influenced improved health and wellbeing amongst the residents.

The residents have much respect for their neighbours and the homes in which they live as a consequence of the high quality design and levels of maintenance. The regeneration project has been a huge success in terms of social sustainability and the improvement it has made to the lives of the residents.



Image © PRP



### Design strategies for retrofit

#### Daylight

Internal daylight levels can be improved by the removal of internal partitions to open up spaces, the introduction of additional windows or light pipes and replacement of windows to reduce frame areas and improve glass quality. When installing external wall insulation, care should be taken to keep any loss of daylight through deeper reveals to an absolute minimum, and to compensate for that wherever possible.

#### Ventilation

Indoor air quality has largely not been considered by recent retrofit programmes in the UK, but energy efficiency measures simply cannot be considered in isolation without a ventilation strategy. Without adequate ventilation, a refurbished or retrofitted dwelling which is now more sealed may well be at risk of condensation occurring and potential mould growth, especially if thermal bridging has not been addressed. Materials and finishes should be selected which minimise off-gassing, which would be exacerbated by poor ventilation.

Any ventilation system should be easy to use. Where systems with filters are used a management process must be put in place so these are changed regularly or at least residents (and landlords in the case of rented homes) are warned that the filter will soon need changing, akin to a smoke alarm beeping when its battery is nearly drained.

Care should be taken when locating mechanical ventilation systems without filters, so as not to increase pollutants such as vehicle emissions into the home<sup>[135]</sup>.

#### Overheating

A retrofitted home can be cooler in the summer months, particularly if external wall insulation is installed and solar reflective glass is incorporated into new windows. Resilience to future climate change needs to be considered, and the opportunity to incorporate or enable easy future installation of shading devices and the use of lighter coloured façade and roof material should be considered, as should the incorporation of oversized rainwater gutters.

#### Acoustics

Replacement windows, external doors and new façades can reduce external noise transfer into the home if the specification is carefully considered and the items are installed correctly. Internal works may offer the opportunity to reduce sound transfer through party structures and partitions within the home through the installation of acoustic insulation and finishing boards or isolated partition structures.

#### Usability

Designers should consider the opportunity for improving layout to meet the needs of contemporary lifestyles, introduce new storage and improve accessibility. Internal or external wall insulation are highly desirable from a carbon and energy perspective, but care must be taken to ensure that accessibility and usability are taken into account..



#### Security and safety

Replacement windows and doors are likely to have improved security fixtures, smoke/ fire and burglar alarm systems can be installed or enhanced (the former may be required under Building Regulations depending on the type and extent of work being undertaken) helping to make residents feel safer in their home.

#### Controls

Any new controls for heating, ventilation or lighting systems should be easy to use for all members of the household, with easy to understand instructions preferably using simple graphics. Complicated systems or lack of resident understanding of a control system could lead to the internal environmental conditions not being at the optimum, energy bills being higher than they should be and residents being frustrated.

#### Ownership

A refurbished home can instil pride in its residents who in turn take greater care of it. The refurbished home can also be a social catalyst for further improvement works to surrounding homes or the public realm if a large stock improvement programme is considered. This can lead to wider investment in the community, higher property values, a safer environment and overall happier residents. This is demonstrated by the very many successful regeneration projects in the UK which are home to happy and content communities.

#### Monitoring and sensors

Ideally, the internal conditions in homes which are to be refurbished should be monitored before the work is undertaken. The collected data can be used to inform the design proposals and ideally compare with monitoring post-refurbishment. Furthermore, it is now possible for embedded sensors to be installed which link to ventilation and heating systems and can be monitored or controlled via smart phones etc.

#### User guidance

When a refurbished or retrofitted home is handed over, the residents must be taught how to operate any new controls and how to regulate the internal conditions, including when to open windows. It has been found that the best method to do this is using clear and simple language and diagrams in a digital or filmed form of communication such as a video or animation. Guidance relating to seasonal operational must be provided.

### Minimising disruption

#### Communication

Good communications with residents before, during and after any works is imperative to ensure a good working relationship and to reduce the impact on the residents. Residents will want to know when the work will commence and end, and during the programme what will they need to do (clear rooms, driveway etc.) and what amenity they will lose (TV signal, use of a room, heating etc.)





### Impact on lives

Taking time off work to allow access to the home for the works can cause inconvenience, stress, anxiety and loss of income. Not being able to park one's car due to contractors vehicles, skips or material storage on the drive or outside the house can be a source of frustration. Not being able to access rooms in the house for cooking, bathing or sleeping can affect the health of residents no matter the extent of the duration. Work should be programmed to minimise disruption and the residents must be kept fully informed of work which will impact directly on their lives.

### Possession storage

Where required, secure onsite or offsite storage should be provided which the residents can get access to if required. Not being able to get access to their possessions easily can be a source of frustration and worry to residents. The interiors of homes must be adequately protected; all too often carelessness can lead to interior finishes being covered in material splashes or dust. Issues such as these can cause tension between the installation team and the residents leading to reduced levels of trust and increased stress levels for both parties.

### Site conditions

The site should always be kept tidy, dust and noise levels must be kept to a minimum as if not these can be issues that can upset residents and neighbours (and pets) and potentially lead to health problems.

### Prolongation

Delays associated with problems due to inadequate surveys, poor design or installation can lead to enhanced stress levels and if costs increase which are to be borne by the resident this can further contribute to reduced wellbeing as a result of stress.

### Safety and privacy

Residents worry about privacy and safety, with unknown people in the house and potentially dangerous work being carried out. Contractors should make every effort to ensure their employees wear identification and have the appropriate safety and customer liaison training.

## SECTION 4: PROCUREMENT

“The way a home is procured, from brief setting all the way through to detailed design and on to construction, handover and occupancy is fundamental to the quality of the building”

### Overview of the procurement process

The way a home is procured, from brief setting all the way through to detailed design and on to construction, handover and occupancy is fundamental to the quality of the building. Ultimately, this affects those living in and maintaining homes. This chapter provides guidance on best practice throughout this process, to maximise health and wellbeing outcomes. It is primarily written with new build in mind.

#### Briefing stage

The briefing stage is the earliest point in time in which the client can set good quality technical standards that are comprehensive but not overly prescriptive, whilst ensuring that the focus is on value for money rather than cost. At this point the following priorities should be determined:

- Occupation by a specified date, limiting flexibility on design and construction programme
- Budget: are there strict limits to budget, after which the project cannot be afforded?
- Quality of finished work, impacting durability and functionality of the finished building

It is rare to avoid compromising on one or more of these. Awareness of where concessions appear, and how they will impact the project and therefore the people who will live in the homes is vital.

#### Selection of contractor

The selection of the construction contract determines who shoulders risk (employer or contractor), and therefore the level of control over cost, programme and quality. Design and Build contracts offer more guarantee on price but can compromise on quality through value engineering, and can also squeeze construction programmes. In particular commissioning works tend to be compromised here. Traditional contracts focus on quality but have a higher risk of exceeding tight budgets.

#### Pre-planning

At design stage, particularly pre-planning, specialists should be appointed early in order to influence the design of homes. It is usually much cheaper to design out issues with space planning, building services, overheating, air quality, thermal comfort, and noise, than to mitigate them further down the line. Once a scheme has received planning permission it is likely to be too late to meaningfully improve the environmental conditions in a building. The knock on effect of this on health and wellbeing can be substantial, especially for concerns like overheating.

Another important aspect to consider pre-planning is the involvement of local communities and stakeholders, as early as practically possible. Local residents understand how their community operates: many of them will have lived in neighbouring homes for a long time, or may be looking to move in to one of the new homes. New development in an area can upset local residents and businesses where consultation is not carried out appropriately. Teams should seek to consult rather than dictate and avoid making promises that cannot be kept.

Specification

Later in detailed design, robust specifications with close control of products and materials that offer value and functionality are key. These specifications may well be subject to value engineering during construction, when financial burdens tend to outweigh decisions on quality. Good detailed design will help achieve more for less, whilst protecting against unsuitable, cheaper substitutions, which result in a range of issues that may well only appear once the home is occupied.

Commissioning and handover

Very often, unavoidable pressures on the build programme lead to an overrun on site, but handover and completion dates remain unchanged. Typically, this results in rushed testing and commissioning of building services, and therefore inefficient or rapid breakdown of heating and ventilation systems. As described earlier in this report, these systems are vital to resident health and wellbeing.

Providing occupants with an in-person handover on moving in, a follow-up session a month or two later, and easy to understand information on how to use their home, are simple but effective ways of improving the residents experience. When complex building systems and controls are not explained clearly or in enough detail, the residents experience can be variable or disappointing<sup>[136]</sup>.



A note on cost

While we have not investigated the costs of the design guidelines outlined in this report in detail, our working assumption is that better quality, healthier homes and developments need not cost any more. As with almost all sustainability issues, the key to reducing costs is to design in health and wellbeing features right from the start of the procurement process, rather than adjusting designs at a later date to respond to health and wellbeing criteria. Project delivery should consider the outcomes of design and procurement choices from the outset. Performance gaps can arise if key stages are not implemented properly, with consequences to wellbeing and building operation. Some of these are highlighted in the project timeline diagram.

Summary of key actions required

For clients, developers and housing associations

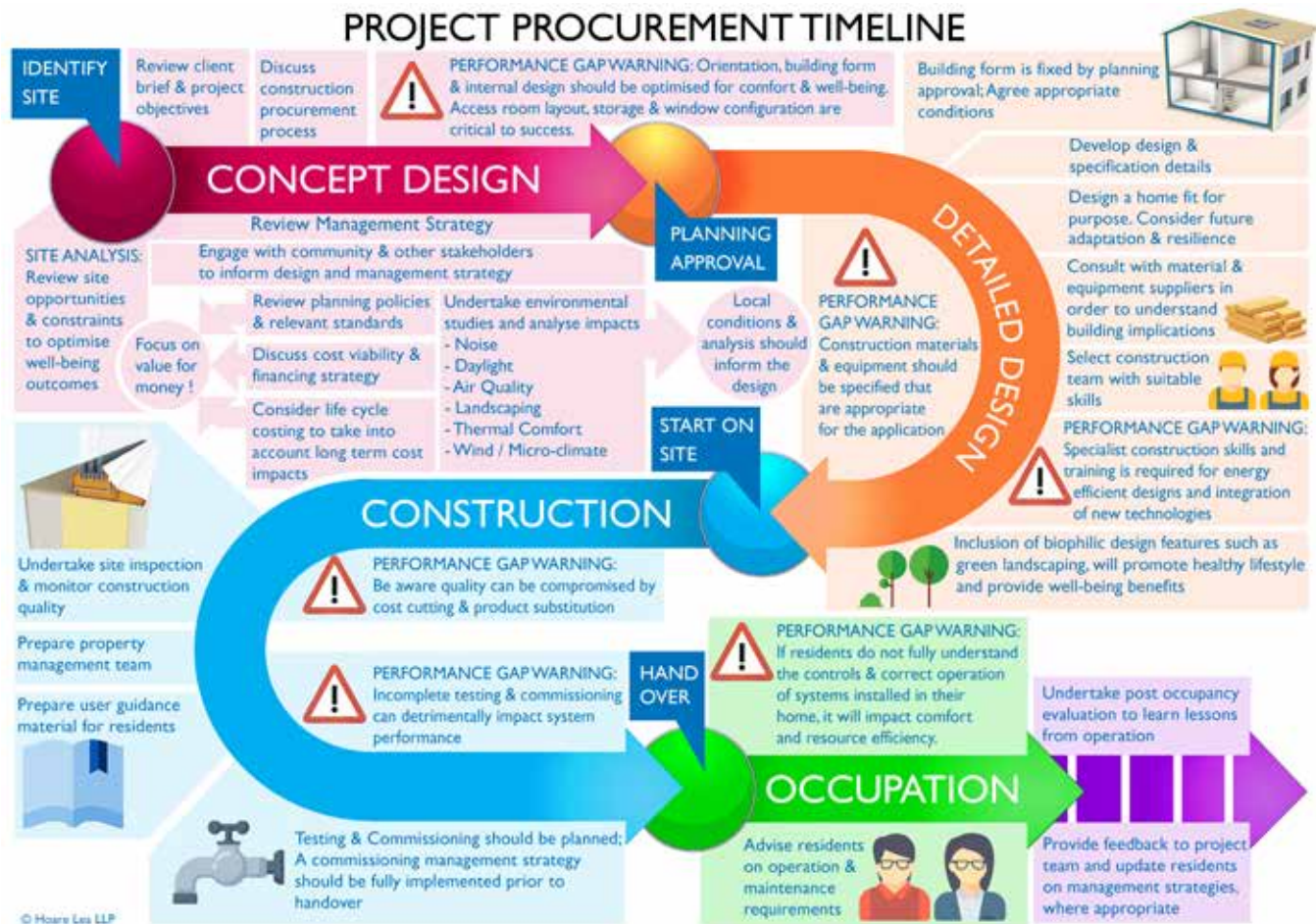
- Engage designers early to analyse opportunities and constraints for the proposed site, and undertake assessments, as necessary, to evaluate impacts.
- Review the needs of the residents with the design team
- Engage with the planning authority to understand policy and regulatory issues
- Select a construction team based on ability to deliver the intended quality of construction and ensure that construction monitoring services are engaged
- Provide residents with easy-to-understand operational and maintenance information so that they can get the best use of the systems provided
- For mixed-use and multi-residential developments engage property management services to ensure the development is well maintained, safe and enables social interaction.
- Consider opportunities to undertake post occupancy evaluation, ideally with the design and construction team, to learn lessons from the procurement and operational stages to inform improvements in future projects.

For architects/designers

- Review the needs of the residents with the client.
- Optimise the building form and home design to meet the requirements of the residents and consider resilience/adaptation opportunities to meet future needs
- Select materials and systems that are robust, low maintenance, low emission and resource efficient
- Engage with constructors and material/equipment suppliers to review buildability and installation methods
- Provide drawings and specifications suitable for the procurement route to control quality and buildability
- Propose strategies for testing and commissioning the construction so that the homes meets the intended functionality and performance

For agents and advisors

- Ensure all staff have appropriate knowledge on key trends, design standards and changing householder aspirations on health and wellbeing
- Act as an advocate to developer clients on consumer trends, and the importance of health and wellbeing
- Reflect health and wellbeing of developments in pricing and marketing strategy





## MANAGEMENT

The following is focused on properties which are managed, for example by freeholders or housing associations.

### Why is it important?

Homes and neighbourhoods require suitable management in order to sustain the health and wellbeing of residents. Management should include appropriate planned maintenance, servicing and repair. The performance of buildings can deteriorate if they are not looked after, which can result in increased costs in the long term and detrimentally affect comfort and functionality.

Management should cover the building itself, including the external fabric and systems within it, and the wider development, including common areas, shared facilities, external spaces between buildings and landscaping.

### Home management and maintenance

Building materials and building installations, to a varying degree, require servicing and maintenance. Building fabric generally requires little regular maintenance but may require major occasional repairs over long periods, for example the replacement of roof tiles or cleaning of rainwater drainage systems. Indoor mechanical and electrical installations generally require more regular attention. Indoor air quality, for example, can be compromised if ventilation rates are not maintained. It is important therefore, that mechanical ventilation systems with filters are maintained so that dirty filters don't reduce ventilation rates. Unfortunately, recent evidence has shown that many residents are not aware that filters need to be replaced or don't know to replace filters in domestic ventilation units<sup>[137]</sup>.

### Neighbourhood management and maintenance

Proactive property management of multi-residential developments will demonstrate to the residents that the development organisation cares about the residents, which can improve the perception of safety, security and social interaction between residents. Making the external space attractive will also facilitate more healthy lifestyles by encouraging more outdoor activity. A study of adolescents found that they are less likely to engage in outdoor physical activity if a neighbourhood was unattractive, such as being littered with refuse and graffiti<sup>[138]</sup>.

### Occupant behaviour

The behaviour of residents can strongly influence comfort and air quality conditions, with potential impacts on health and wellbeing.

It's important that professionals responsible for the delivery and operation of housing recognise how their designs and management strategies can influence occupant behaviour in order to encourage positive outcomes.

An example of how occupants can influence air quality is highlighted by recent research undertaken by the University of Strathclyde's Mackintosh Environmental Research Unit<sup>[139]</sup>. It was found that many residents don't know how to operate trickle vents or windows to optimise ventilation. This can have an impact on the build-up of humidity within the home which can result in dampness and mould. As a result of the research residents are now being advised to keep vents or windows open when cooking, showering and cleaning; dry laundry near an open window; and open windows at night.

From a design perspective this highlights the need to provide window configurations that occupants feel are safe to open at night and from a management perspective residents need appropriate guidance.

Another example of the impact of occupant behaviour on comfort is in the mitigation of overheating risk. Heat from electrical appliances that are left on or in stand-by mode, and the failure to open windows or close blinds/curtains on sunny days can cause internal temperatures to build up and contribute to overheating. People in cultures that have been used to hot summers for many centuries, such as in Mediterranean climes, have learnt the importance of closing shutters during the day when they go to work to reduce solar heat gains. This is something the British may have to learn to follow.

### For housing managers

- The design of homes should consider suitable access provision for all the maintenance and repair necessary during the life of the building – for example windows should be designed to allow easy cleaning.
- Easy-to-understand guidance should be provided for occupants so that homes can be operated and controlled optimally. Guidance should include information on maintenance requirements and operational issues.
- Plan for maintenance of heating and ventilation systems (filters in mechanical ventilation units and cooker hoods should be checked at least twice a year).
- Check that building fabric (including insulation and plaster) is not damaged by cold bridging and mould etc. Repair any damage from water leakage and check air tightness features such as sealants.



## SECTION 5: VALUE

“There is growing interest in health and wellbeing. It is increasingly influencing consumers’ buying and decision making processes, spanning generations and consumer demographics”

### Introduction

As explored throughout this report, there is a growing bank of evidence linking the design and quality of housing to the health and wellbeing of residents. However, this evidence is not yet translating into widespread action in the market. In this chapter we explore the reasons behind this inaction, and examine the value case for action.

Value can be defined as the importance, worth, or usefulness of something<sup>[140]</sup>. However, what constitutes value in the context of health and wellbeing in housing varies for different stakeholders, for consumers, for the construction and property sector and at the macro-economic level – i.e. the value to the country.

### Value to residents

*“It may have crept up on us, but the UK population appears to be following in LA's glamorous footprints. Large swathes of the population are on a health kick. This is reflected in the way that members of the public have embraced different types of fitness regimes, from yoga to CrossFit; their aversion to fast food brands and women's unprecedented participation in competitive sporting activity. Cumulatively, this indicates a genuine evolution in UK consumer lifestyles.”<sup>[141]</sup>*

### 2015 Crimson Hexagon, Consumer Trends Report

There is a growing interest in health and wellbeing. It is increasingly influencing consumers’ buying and decision making processes, spanning generations and consumer demographics.

### Existing research

Despite the growing level of consumer interest in health and wellbeing in general, the amount of research done on consumer attitudes in relation to health and wellbeing in the home specifically is surprisingly small.

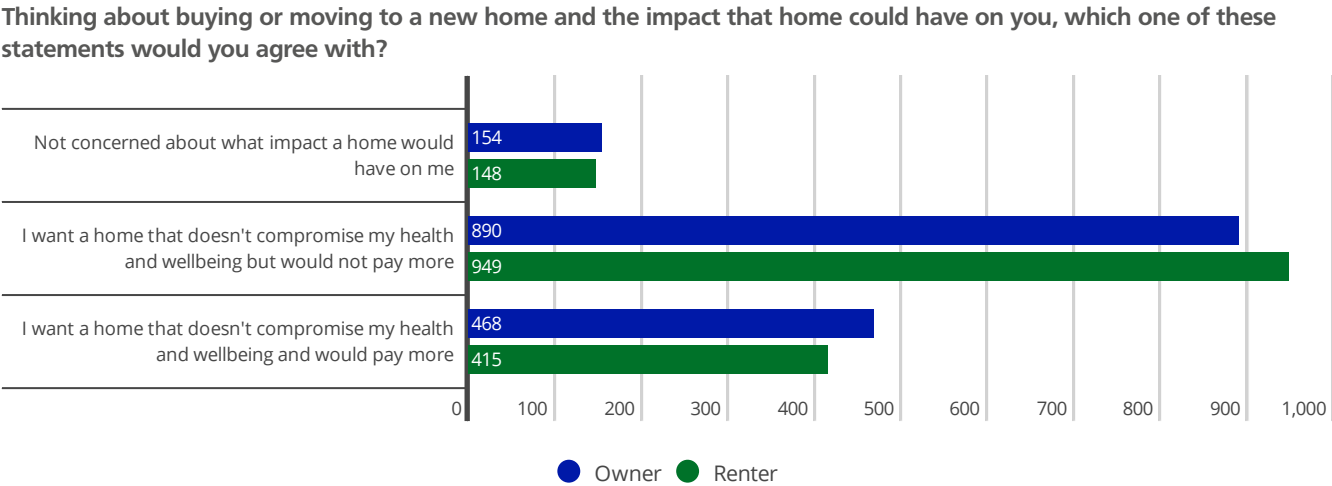
- Berkeley Group's 2012 research into social sustainability dealt with a wide range of topics, including wellbeing issues, and highlighted the importance, for example, of peace and quiet and safety for residents’ feelings of neighbourhood wellbeing in UK developments<sup>[142]</sup>.
- A consumer survey from the US in 2014 suggested that comfort, exposure to chemicals and exposure to germs were the most important internal features of the home that influenced consumer perception of health and wellbeing<sup>[143]</sup>.
- In 2015 the Velux Group published the Healthy Homes Barometer<sup>[144]</sup>, reporting on consumer attitudes across 12 European countries. Asked to rank issues in order of impact on their health, Europeans placed sleeping well at night and ventilating their homes at the top. 83% of those surveyed were reported as “highly” or “above averagely” concerned about unhealthy indoor air quality: remarkably, a similar ranking to financial or job security<sup>[145]</sup>.

Saint-Gobain’s Consumer Attitudes survey

In order to help bridge a gap in existing research, during May 2016, Saint-Gobain commissioned a survey of just over 3000 UK homeowners and renters on health and wellbeing in the home. The research was carried out via an online survey, by Research Now, and took participants 15-20 minutes to complete.

Key findings

- 90 per cent of those surveyed would like a home that does not compromise their health and wellbeing. Almost 30 per cent of all those surveyed (buyers and renters combined) would be willing to pay more for such a home. The figure is slightly higher for buyers as opposed to renters.
- Although 95 per cent of survey respondents claimed to make some effort (e.g. through diet and/or exercise) to look after their health and wellbeing, less than 10 per cent identified “concern about the health and wellbeing impacts of the buildings where I spend my time”. This probably reveals a lack of awareness about the influence of buildings compared to more everyday things like exercise and diet.
- When people were asked to select features of their ideal home, in order to reveal ‘relative importance’, safety and security topped the list. This was closely followed by running and maintenance costs, and a home environment with no condensation, dampness or mould. Remarkably, “a home that will improve in value and will have desirability when sold” came 17th in a list of relative importance, behind issues such as views of nature, daylight and lack of noise.
- There is a reasonably high appetite for home improvement. Only a small minority of respondents could not highlight any issues within the home to improve. The most common needs were around redecoration, and new kitchens or bathrooms. Being cold in the winter, high energy bills and lack of insulation all featured strongly.
- The issue of homes that are too cold in the winter was twice as important for renters as opposed to homeowners. Nuisance noise and high energy bills were also bigger problems for renters rather than homeowners.



Features of the “ideal home” according to respondent preferences

Rank	Feature	Relative importance (%)
1	A home where I feel safe and secure	11.5%
2	A home that I can afford to run and maintain	10.5%
3	A home environment with no condensation, dampness or mould	7.1%
4	An area that has low or no crime	4.7%
5	A home that has off-street parking/garage	4.4%
6	A home that helps you relax and unwind	4.4%
7	A home where I have views of nature and greenery	4.2%
8	A home that is energy efficient with low utility bills	4.2%
9	A home that's warm indoors without the need for excessive heating in the Winter	4.0%
10	A home with plenty of natural light, no need to turn lights on during the day	3.5%
11	A home where you're not disturbed by noise from neighbours or outside	3.4%
12	A home that is not overseen and looked in to by neighbours	3.1%
17	A home that will improve in value and will have desirability when sold	2.2%

Note: MaxDiff is a form of trade-off analysis used in market research to obtain preference/importance scores for multiple statements. The sum of scores across all the statements in the exercise (not all are shown here) is 100 per cent.

What, if at all, are the top three issues you have with your home that you would like to change?

Needs decorating	26%
Would like to improve it internally	18%
Needs new kitchen	17%
Needs new bathroom	16%
Too cold in the Winter	12%
Windows need to be replaced	12%
It is too small for our needs	12%
In need of repair / outstanding repairs	11%
Noise from adjoining neighbours	11%
We have high energy bills	10%
Lack of insulation and so cold and draughty	8%
Don't like the area / neighbourhood / neighbours	6%
Lack of natural light	6%
Noise from outside	6%
Access to amenities (e.g. shops and services)	5%
Badly built / poor quality workmanship / finishing	5%
Too much external noise	5%
It is too large for our needs	5%
Too warm in the Summer	4%
Need to move to cheaper accommodation	4%

Note: Top 20 issues only.



A note on affordability

As outlined earlier in the report, we maintain that delivering healthier homes and neighbourhoods need not cost any more, and that with good design from the start, simple and cost effective measures can bring significant health and wellbeing benefits. This means that healthier homes and neighbourhoods can and should be available to all - not just those who can afford to pay higher sales or rental prices.

Having said that, the research we carried out with homeowners and renters demonstrates that there is a demand for healthier homes and neighbourhoods. It is important to acknowledge that in a market economy, in the private sector, more desirable homes are likely to sell or rent for higher prices, and this of course can be a driving force in changing developers’ and landlords’ attitudes to design quality.

It is beyond the scope of this report to comment on the UK’s current housing affordability crisis and the rights and wrongs of the market economy. However we do maintain that the evidence compiled in this report shows that designing for healthier homes and neighbourhoods makes economic (as well as moral) sense across different all tenure types given the potential for societal benefits, savings to the healthcare system, greater national productivity, and an increase in overall population health and wellbeing.

For more information on the survey results, go to <http://www.multicomfort.co.uk/>





Wellbeing Valuation Approach

This relatively new approach to valuation attaches monetary value to more intangible goods and services like health and social relationships by estimating the amount of money required to keep individuals just as happy or satisfied with life in the absence of such things.

The approach has been included in the HM Treasury Green Book, the Government guide for public sector bodies on how to appraise proposals before committing funds to a policy, programme or project, and is being considered by a number of housing associations.

Value to business

As part of our research, we surveyed a number of housing developers, housing associations and landlords in the Private Rented Sector in order to better understand their Key Performance Indicators (KPIs). Although it was a small sample, there was consistency in the most frequently used KPIs across business types:

Typical key performance indicators by business type

Developer	Landlord (PRS sector)	Housing Association
• Rate of sale	• Lower void rates	• Average void costs
• Sale price	• Increased rent	• Current rent arrears
• Profit	• Capital value	• Percentage of rents collected

We also uncovered additional KPIs, which may be less common, or less consistently tracked, but nevertheless were of interest to developers and housing providers:

Additional key performance indicators by business type

Developer	Landlord (PRS sector)	Housing Association
• Brand recognition & equity	• Brand recognition & equity	• Tenant satisfaction overall
• Client satisfaction	• Client & managing agent satisfaction	• Tenant satisfaction with repairs & maintenance
• Community investment	• Community engagement	• Number of people helped into employment
• Post occupancy evaluation measures	• Number of complaints	• Average time to complete non-urgent repairs

The more health and wellbeing can be shown to impact on some of these KPIs, the greater the business case for it.

There is some evidence linking factors that support health and wellbeing to commercial value. For example, research by Savills in 2013 found that homeowners attached more value to the environment their home is in – for example, availability of green and open spaces, safety, and proximity to amenities – than the home itself. The Landscape Institute published a report in 2014 which built on these findings, highlighting the value of ‘placemaking’ and high quality outdoor environments to housing developers<sup>[146]</sup>.

It is our assessment that the results of the consumer research above demonstrate that there is appetite amongst UK householders for homes that support health and wellbeing. The fact that almost 30 per cent say that they would be willing to pay more for such a home, whether buying or renting, is very significant. Naturally we need to be cautious in interpreting this data, and recognise that there can be a significant difference between what people say they will do, and what they will actually do in practice (known as the ‘value/action gap’).

Nevertheless, we conclude that there is a strong case for developers to inform their customers about the impacts that housing can have on health and wellbeing, and how their housing promotes better health and wellbeing. If developers did this, they could expect a growing number of customers to be interested, which over time, could positively impact speed of sales or even sale price.

Similarly, for landlords, the growing interest in health and wellbeing, and evidence from the consumer research suggests that property differentiated on health and wellbeing attributes could enjoy lower void rates and even increased rental and capital value. In the case of Housing Associations, healthy homes could rent faster and for longer periods, with increased tenant satisfaction.

Improvements in homebuyer or resident satisfaction as a result of healthier, more comfortable homes can support or improve a business’s brand recognition and equity. Word of mouth referrals and recommendations stemming from positive occupant experiences are powerful.

Looking ahead, the business case for health and wellbeing in homes would appear to be supported by anecdotal evidence from London estate agents, reported in the Evening Standard in 2016. It is claimed that homebuyers are increasingly concerned about local air pollution when choosing where to buy. At the current time, this is a concern about outside air quality, but we might anticipate interest spreading to internal air quality over time, as awareness grows<sup>[147]</sup>.

Value to the economy

This report has already identified the numerous health benefits housing can create, as well as its role in preventing health problems, ranging from respiratory issues to winter deaths from cold homes. We know that instinctively this all has value for “UK Plc”, but quantifying that is a different matter.

A lot of work has been done in the healthcare sector which recognises the importance of design in the healing environment<sup>[148]</sup>, but this has not yet been extended to the design of homes, despite this being where we spend the majority of our time. This means that the evidence showing specific links between housing, its impact on health and wellbeing, and the financial value to the UK is limited.

The clearest evidence illustrates the financial cost of poor housing to the NHS directly. For example, costs have been estimated to be as high as £2.5bn per year to the NHS in terms of primary care services, treatment, hospital stays and outpatient visits for issues resulting from inadequate housing, including respiratory and circulatory diseases<sup>[149]</sup>.

Costs to the NHS specifically due to cold homes have been reasonably well documented. There is evidence to suggest that for every £1 spent on reducing fuel poverty, 42p can be expected in NHS savings<sup>[150]</sup> and Age UK estimates the annual cost of cold homes to the NHS in England is £1.36 billion<sup>[151]</sup>. Yet this still largely reflects the cost to the country of the physical health problems created by cold homes and only those borne by the NHS; the Age UK figure doesn’t include the cost of social care, for example. This is despite evidence showing that fuel poverty can result in poor mental health and low productivity, particularly among children and adolescents<sup>[152]</sup>.

Although NHS costs (and therefore potential savings) do demonstrate the value of healthy homes, there are arguably wider benefits to the UK economy. For example, the full financial cost to the UK of mental ill-health is an estimated £70bn per year through lost productivity, social benefits and health care<sup>[153]</sup>. Whilst the full costs to the country of obesity and physical inactivity are £2.5 billion and £8.2 billion respectively<sup>[154]</sup>. If we consider the resilience of healthy homes and neighbourhoods, the value case grows. The cost to public health of the 2007 floods were as much as £287 million, £260m of which was associated with the mental health costs to those affected<sup>[155]</sup>.

These are substantial figures, and the potential role that health and wellbeing in homes could play in reducing them has on the whole been overlooked.



## VIEWPOINT

### THE VALUE OF INDEPENDENT CERTIFICATION (GWYN ROBERTS, BRE)

There are many areas where achieving standards above minimum requirements leads to positive outcomes for home occupiers. It is important to ensure these standards are realised in construction (not just in planning and design) and are also communicated to the home occupier to ensure that they understand the full potential of their home.

Independent, accredited certification provides a number of benefits for different stakeholders to help give them confidence in what is better, as well as to allow for robust and credible comparisons to be made. This applies to most certification schemes, whether it be BREEAM, HQM, Passivhaus, LEED or WELL. While they measure varying aspects and in differing ways, they provide a degree of rigour and comparability in evidence and methodology. This makes them credible.

We all want to have confidence in the goods and services that we receive, whether it's the car we drive, the schools and hospitals we use or the homes we live in. Certification enables us to make a more informed choice and take less of a gamble: for example, EuroNCAP has not only become a trusted stamp of approval, but has also significantly improved the safety in modern cars beyond what regulations require.

#### Home Occupiers

Certification provides reassurance, trust and the ability to compare clearly between different homes. With a certificate in place the home occupier can have much greater confidence in the performance of their home, knowing that claims about quality, savings and benefits have been independently verified. This empowers home owners to make better choices: If two apparently identical houses are available but one has an independent certificate backing up the claimed performance and the other doesn't – which would you choose?

#### Developers

The main benefit to developers for using independent certification is differentiation of product against competitors. It can become a key marketing tool in drawing out the benefits of their particular home.

Consumers are starting to value certification: Passivhaus gains over 90% approval ratings by occupiers and in a survey carried out for HQM over 70% of respondents said they would be happy to pay over £750 extra (on a home valued at £300k) for a certificate demonstrating its overall quality and sustainability.

#### Financial sector, health sector, land owners, planners, and beyond

Certification also provides evidence for many other sectors. For example, it provides the financial and insurance sector with an additional tool for determining and therefore managing risks. In turn this provides additional reassurance for investment decisions: if such a decision is to be made between two developers, who are building outwardly identical homes, but one is certified, accreditation is likely to add confidence

With a growing cost, and reducing budgets in the health sector, certification can help give reassurance around what developments and communities are best to encourage in the local area, helping to reduce the future burden on the health sector.

#### Construction Industry

Certification and standards also provide the construction industry and its supply chains as a whole with a number of benefits. Firstly standards that improve on minimum requirements provide a framework to drive forward the quality and performance delivered by industry.

As many certification schemes are linked to research bodies, the income generated from certification helps to fund further research. BREEAM, HQM (and in the past the Code for Sustainable Homes) provide funding to the BRE Trust, which in turn helps fund research that leads to many of the reports referenced in this document.

Furthermore, certification can help pave the way to future regulation, or in many situations make it clear that regulation is not appropriated. It can help build the case, by providing evidence and also ways in which it can be measured. If leading developers in industry are already building to higher [voluntary] standards, this learning and product development makes it much cheaper for the rest of industry when (and if) higher standards are integrated into regulations.

## SECTION 6: HEALTHY HOMES INDICATORS AND METRICS

“This section is all about a how we might begin a collaborative industry effort to gather more data about these linkages, and about the value of these outcomes, in order to inform practice and policy about the future of homes designed to promote health and wellbeing in particular”

### Why measure?

In the previous section we have made the case for the value of health and wellbeing in homes. However, the industry would benefit from more data and a richer body of quantitative evidence, in order to inform best practice and the business case.

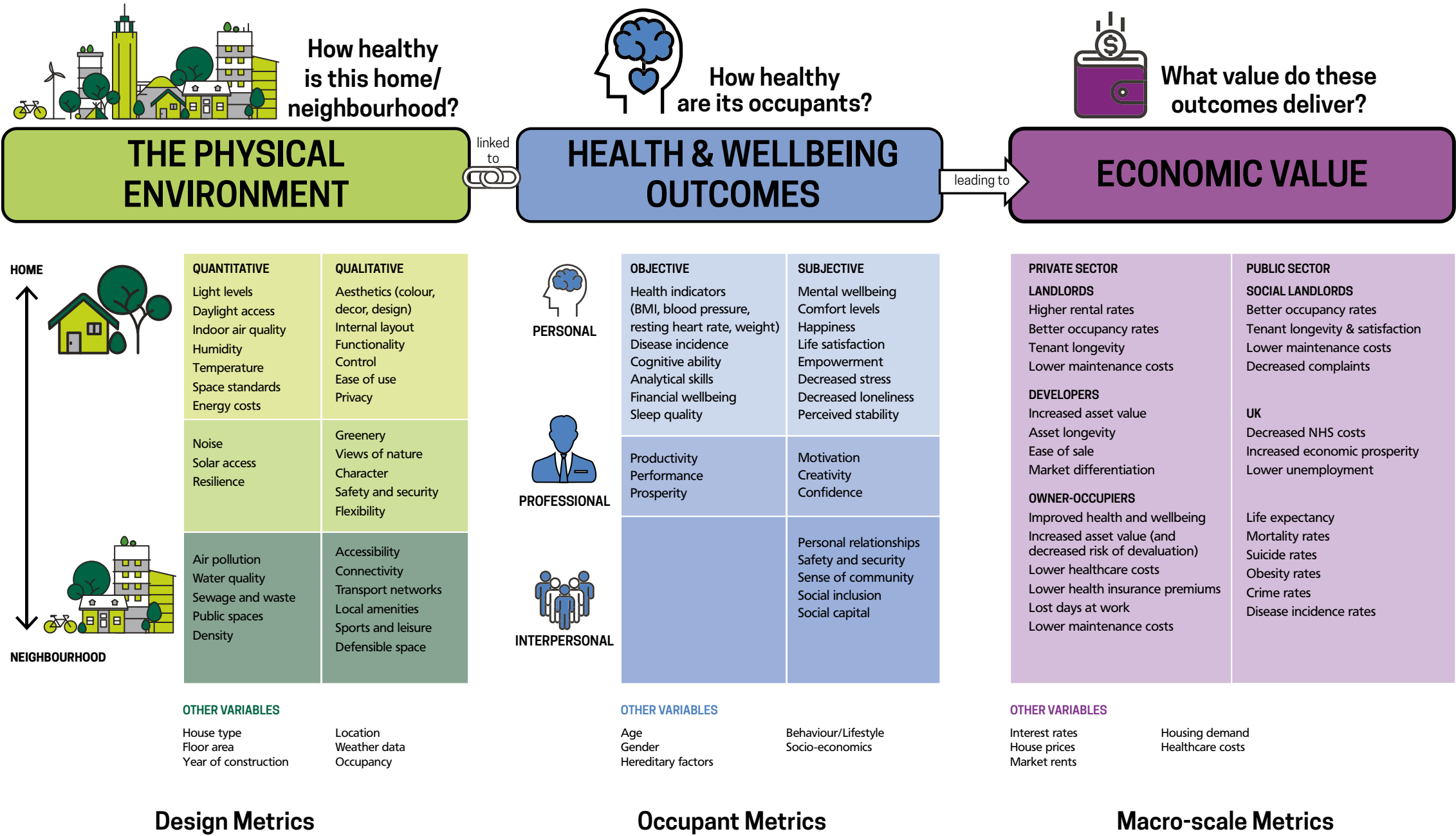
For developers, better data can provide an insight into perceptions of value and facilitate meaningful discussions within design teams about what features can cost-effectively deliver the highest impact in terms of resident health and wellbeing. Housing managers can use data to better understand how residents are living in their homes, enabling them to pro-actively implement strategies for improving the health and wellbeing of the communities that they manage. And data, if made openly available, can help policymakers and their advisers deliver better outcomes through policy levers.

Common metrics can support cohesive and consistent gathering of data, so that results can be interpreted across datasets. The following diagram is a flow chart that highlights some key design and occupant metrics for homes, health and wellbeing outcomes, and the potential economic value. The diagram also sets out at what stage those outcomes might be measured, and what type of measurement techniques could be used.

The overall structure is based on the theory that environmental parameters (green) have the potential to influence tangible health and wellbeing outcomes (blue) and that these outcomes in turn, have the potential to lead to economic value for both the private and public sectors.

We are not presenting this as a fully formed 'framework', but hope it can inform the ways in which key stakeholders consider measurement, and that organisations begin to pilot some of these metrics in their own projects. We will continue to work with partners through WorldGBC's campaign Better Places for People to build on these foundations.





“Our framework also attempts to highlight the fact that the measurement of health and wellbeing has two dimensions – there are measures available for ill-health, but it is also equally important to measure wellbeing or flourishing”



### Health and wellbeing outcomes

These range from metrics that are experienced at an individual personal level through to outcomes that affect social relationships (going from top to bottom, with metrics related to productivity sitting somewhere in between), and are divided into objective and subjective metrics.

Objective metrics are quantifiable indicators, often applied to physical health, but also includes established tests for cognitive functioning. Subjective metrics cover self-reported or perceptual issues, for which, despite their more ‘fuzzy’ nature, there are some well-established data gathering techniques.

The flowchart also attempts to highlight the fact that the measurement of health and wellbeing has two dimensions. The measures for ill-health sit alongside measures of wellbeing or ‘flourishing’ as well: absence of illness does not necessarily mean that a person is happy and well.

There are a range of measurement techniques for these issues, including post-occupancy evaluations, personal fitness devices, smartphones, large-scale surveys, medical tests, aptitude tests, environmental monitoring devices and sensors.

- Smartphones and wearable devices are able to record many things from movement and location, to number of hours of deep sleep. These devices, along with environmental sensors, are catalysing a move to greater data visibility, providing real-time feedback on how well indoor environments are meeting people’s needs. In the near future, we can expect devices capable of carrying out far more advanced analysis of everything from your sweat to your mood – maybe even from inside your body.
- The public health sector has many measurement techniques for measuring both physical and mental health outcomes. A typical full NHS health check would include carrying out a rigorous personal history interview including questions on smoking status, alcohol intake, family history and level of physical activity.
- The Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) is one of the most commonly used subjective wellbeing measurement methods in the UK. Its shortened form is a good way to find out about perceptions of different environmental settings, which can act as a background indicator of whether the environment is a factor in wellbeing.

There are of course many other measures of health, qualitative and quantitative, available, measuring things such as sleep quality, anxiety levels, and depression, but listing them all is beyond the scope of this report.

### Economic Value

These measures of value are divided into private and public sector value, ranging from metrics that influence personal financial outcomes, such as decreased healthcare costs or insurance premiums, to ones that relate to the sale or rental value of a property or development. We also include national societal outcomes, such as decreased public health costs and increased economic prosperity, through to mortality rates and life expectancy. This reinforces the idea that measurement can be carried out at all scales and by all stakeholders, and that the benefits of designing homes and neighbourhoods for health and wellbeing can make a difference on so many levels.

## POST-OCCUPANCY EVALUATION



A post occupancy evaluation (POE) is an evidence based study that seeks to find out how well a building performs and/or how well the occupants feel about their building. It is most commonly undertaken after a refurbishment, or when new accommodation has been recently occupied. The study can help designers, developers and managers understand whether a building is satisfactory from an occupant’s perspective and whether environmental and comfort objectives are being met.

The key elements of a well-designed POE study include both quantitative and qualitative aspects: built environment measurements (using monitoring devices and sensors) and a resident behaviour component (as a minimum, questionnaires and surveys). The timing of the study is important: if it is undertaken too early the occupants may not have had a chance to settle down and fully appreciate their accommodation. The study is therefore best undertaken after the occupants have become familiar with their new environment, and ideally experienced both summer and winter conditions.

The best studies include both pre-and post-occupancy evaluation, allowing direct assessment of any changes. Using validated questionnaires and scales for subjective wellbeing, such as those in WEWMBS and BUS not only ensures comprehensive analysis, it also provides the opportunity for national or regional benchmarking. However, whatever the questionnaire format, any study should aim to be independent in terms of asking occupants how well they rate comfort, daylight and design layout etc. The BSRIA Soft landings framework shows how POE can fit into an integrated approach to project procurement strategy that aims to deliver buildings that meet intended outcomes<sup>[165]</sup>.

The parameters for the study should be clearly set out from the beginning, to ensure consistency of the data and to provide a clear brief to all stakeholders and researchers. There is plenty of excellent guidance available on this topics, but as a starting point the following aspects should be considered:

- What links are you trying to establish or understand? What health and wellbeing outcomes are you interested in?

- What is the budget for the POE exercise? What resources will be required from the organisation carrying out the survey, and how much client and/or resident time will also be required?
- What needs to be measured, and at what intervals?
- What is the protocol for sensor calibration, and what is the mechanism for data download and sensor maintenance?
- During what seasons and for how long will the study take place?
- What dwelling typologies need to be covered? What resident types need to be covered?
- How will the residents be recruited? What incentives will be offered for participation? How will their privacy and data be protected?
- What rooms will be measured and where will the sensors be located?
- How will the data be analysed?
- What outputs are expected and how will this data be used?





**VIEWPOINT**  
**WHAT DOES THE FUTURE HOLD?**  
(STEVE BURR, BLACK ARCHITECTURE)

Predictions for the year 2050 permeate this report: our society is likely to be more diverse, obese, and populous, with natural resources such as water becoming scarce in our cities. But what does the future hold for our homes and neighbourhoods? And as professionals in the built environment industry, what trends should we be aware of?

Looking back a similar time span to the late 1970's may offer some insight to the level of change that we should expect. Technology has advanced and our dietary habits shifted, but our housing stock remains fundamentally unchanged, with residential developments in the intervening period becoming less experimental and more formulaic. Perhaps we are now more risk adverse in our provision and selection of housing?

In order to accelerate change, can we learn from other sectors, in particular the workplace? Part of the success has been to challenge the pre-conceived ideas which are reinforced by those who market the space and seek to minimise risk. The balance has shifted from desks and chairs to social space, aided by the introduction of technology and the re-adoption of basic design principles which champion the quality of light, delivery of well-tempered environments and create places which encourage interaction.

Why should the home in 2050 contain the array of spaces of the model house of today? Will we need much storage if we are sharing things more: the success of car clubs and companies like Airbnb<sup>[163]</sup> may be a pointer to the willingness of younger generation to adopt new ideas. B&Q, an established retailer, has stated it could no longer be selling power tools, but could become a lender, radically rethinking their business model and challenging capitalism to *focus on wellbeing rather than growth*<sup>[164]</sup>.

**What might the home of 2050 look like?**

- The shell of an existing Victorian stock building or a robust new build frame, its external envelope optimised to ensure clean air and natural light are available on demand – parametric design tools, rather than aesthetics defining the glazing to solid wall ratio.
- Static internal walls re-provided to suit the occupants' changing needs. The sleeping area the size of a 4m<sup>2</sup> bed, one third of the area defined in the current national housing standards – regulatory storage and circulation space used more creatively in lessons learnt from the hotel sector.
- Raised floors adopted from the workplace environment offer flexibility for the delivery of power, data, water and fresh air across the floor plate – sourced from centralised communal energy centres.
- Redundant highway surfaces replaced with landscaped amenity and communal allotments, now that urban traffic speeds having dropped to levels which necessitate smarter forms of transportation – streetlamps cut down and remodelled as bollard lighting.
- The Victorian coal hole originally designed to receive a weekly supply of fuel, is adapted to accept internet home deliveries and the return of recycled resource. The letterbox is similarly near redundant – demonstrating the cyclical nature of residential design and responding to the needs of the period.

# ACKNOWLEDGEMENTS

**UK-GBC TEAM**

Joanne Wheeler  
Elinor Huggett  
John Alker

**SECTION AUTHORS**

**Ashley Bateson (workstream chair)** Hoare Lea  
**Mark Bauer** Forbo  
**Louise Clarke** Berkeley Group  
**Derek Clements-Croome** University of Reading  
**Mina Hasman** SOM  
**Katherine Holden** Grontmij  
**Narguess Khatami** Hilson Moran  
**Tassos Kougionis** Building physics consultant  
**Simon Major** AkzoNobel  
**Andrew Mellor** PRP  
**Clare Murray** Levitt Bernstein  
**Sukumar Natarajan** University of Bath  
**Kate Paxton** Hodgkinson Consultancy  
**Ritu Rajashekar** Waterman Group  
**Marylís Ramos (workstream chair)** PRP  
**Koen Steemers** University of Cambridge  
**Becci Taylor** Arup  
**Stacey Temprell (workstream chair)** Saint-Gobain  
**Marcella Ucci** University College London

**WORKING GROUP AND ADDITIONAL CONTRIBUTORS**

**Charlotte Benjamin** The Crown Estate  
**Rory Bergin** HTA  
**Steve Burr** Black Architecture  
**Robert Delius** Stride Treglown  
**Barney Evans** WSP Group  
**Alan Fogarty** Cundall  
**Richard Francis** Monomoy Company  
**Antonio Irranca** Homes and Communities Agency  
**Jeremy Kape** Affinity Sutton  
**Jay Lee** Stride Treglown  
**Jade Lewis** Saint-Gobain  
**Miles Lewis** Lendlease  
**Andrew Macintosh** Fielden Clegg Bradley Studios  
**Sofie Pelsmakers** University College London  
**Claire Racine** JLL  
**Gwyn Roberts** BRE  
**Jane Wakiwaka** The Crown Estate  
**Anna Whitehead** Anna Whitehead Design Consultancy  
**Alexandra Willey** Affinity Sutton

**THANKS TO OUR SPONSORS**

**UK PROJECT SPONSORED BY:**



**GLOBAL CAMPAIGN SPONSORS:**



# REFERENCES

- 1 <https://www.ashrae.org/resources-publications/free-resources/10-tips-for-home-indoor-air-quality>
- 2 Ferrari A, Charlson F, Norman R, Patten S, Freedman G, Murray C, Vos T and Whiteford H. (2013). Burden of Depressive Disorders by Country, Sex, Age, and Year: Findings from the Global Burden of Disease Study 2010. *PLoS Med*, 10(11)
- 3 McManus S, Meltzer H, Brugha T, Bebbington P, Jenkins R (eds), (2009). Adult psychiatric morbidity in England, 2007: Results of a household survey. [online] NHS Information Centre for Health and Social Care, pp.1-274. Available at: <http://www.hscic.gov.uk/catalogue/PUB02931/adul-psyc-morbres-hou-sur-eng-2007-rep.pdf> [Accessed 25 Aug. 2015]
- 4 Office for National Statistics, (2015). Measuring National Wellbeing, Life in the UK, 2015. [online] Available at: <http://www.ons.gov.uk/ons/rel/wellbeing/measuring-national-wellbeing/life-in-the-uk--2015/index.html> [Accessed 25 Aug. 2015]
- 5 Evans et al (2000) Housing quality and mental health. In *Journal of Consulting and Clinical Psychology* 68:526-530
- 6 Halpern (1995) *Mental health and the built environment*, Taylor and Francis, London
- 7 World Health Organization (WHO). (2008). Closing the gap in a generation – Health equity through action on the social determinants of health. Geneva: World Health Organisation Commission on Social Determinants of Health
- 8 World Health Organization (WHO). (2001). Fifty-fourth World Health Assembly. Geneva: World Health Organization
- 9 Steemers, K. (2015). Architecture for Well-being and Health. *Daylight & Architecture* (23), 1-22
- 10 Chartered Association of Building Engineers (CABE). (2009). *Future Health, Sustainable Places for Health and Well-being*. London: Commission for Architecture and the Built Environment. <http://webarchive.nationalarchives.gov.uk/20110118095356/http://www.cabe.org.uk/files/future-health.pdf>. Accessed 16 March 2016
- 11 Diener, E., Biswas-Diener, R., 2008, *Happiness: Unlocking the mysteries of psychological wealth* (Malden, MA: Free Press)
- 12 Seligman M, Flourish, 2011
- 13 Health, Wellbeing & Productivity in Retail: The impact of green buildings on people and profit, WorldGBC, 2016, and Health, Wellbeing & Productivity in Offices: The next chapter for green building, WorldGBC, 2014
- 14 Browning, W., 2012, *The Economics of Biophilia*, Terrapin Bright Green
- 15 (Foresight, 2008) (Dolan, Peasgood & White, 2008) (Helliwell & Putnam 2004)
- 16 Burchard, T., Le Grand, J., & Piachaud, D. (2002). Degrees of exclusion: developing a dynamic, multidimensional measure. In J. Hills, J. Le Grand, & D. Piachaud (Eds.), *Understanding Social Exclusion* (pp. 33-43). Oxford: OUP
- 17 Barry, B. (2002). Social exclusion, social isolation, and the distribution of income. In J. Hills, J. Le Grand, & D. Piachaud (Eds.), *Understanding Social Exclusion* (pp. 13-29). Oxford: OUP
- 18 Egerter, S., Braveman, P., & Barclay, C. (2011). Stress and Health. *Exploring the Social Determinants of Health Series* (3), 1-14
- 19 Shelter. (2005). *Full house? How overcrowded housing affects families*. London: Shelter
- 20 Burton, E. (2010). *Wellbeing and Design*. Coventry: Warwick Institute of Health. <http://www2.warwick.ac.uk/newsandevents/features/what-makes-us-happy/libby-burton/>. Accessed 1 March 2016
- 21 Steemers & Steane, *Environmental Diversity in Architecture*, (2004)
- 22 Forthun, L. (2008). Family Nutrition: The truth about family meals. University of Florida (UF), Family, Youth and Community Sciences Department. Gainesville: Institute of Food and Agricultural Sciences (IFAS)
- 23 Meyers-Levy, J., & Zhu, R. (2007). The influence of ceiling height: The effect of priming on the type of processing that people use. *Journal of Consumer Research*, 174-186
- 24 <https://www.gov.uk/government/publications/technical-housing-standards-nationally-described-space-standard>
- 25 Electrical safety first – <http://www.electricalsafetyfirst.org.uk/guides-and-advice/electrical-items/overloading-sockets/>
- 26 <http://blog.ted.com/the-connection-between-sleep-and-mental-health-a-qa-with-circadian-neuroscientist-russell-foster/>
- 27 Velux (2013). *The Circadian House: principles and guidelines for healthy homes*
- 28 Chueng I. (2013) Impact of workplace daylight exposure on sleep, physical activity, and quality of life. *American Academy of Sleep Medicine* 36 30
- 29 Elzeyadi I. (2011) Daylighting-Bias and Biophilia: Quantifying the Impact of Daylighting on Occupant Health
- 30 Dr. Richard Hobday, 1999, *The Healing Sun: Sunlight and Health in the 21st Century* (Findhorn Press)
- 31 David Strong, *Daylight Benefits in Healthcare buildings* (a literature review), TSB & BRE. Available at: <http://www.designingbuildings.co.uk/>
- 32 Approved document F: Ventilation (2010 edition incorporating 2010 and 2013 amendments). Department for Communities and Local Government, 2010
- 33 [www.planningportal.gov.uk/uploads/br/BR\\_PDF\\_AD\\_K\\_2010.pdf](http://www.planningportal.gov.uk/uploads/br/BR_PDF_AD_K_2010.pdf)
- 34 <http://stv.tv/news/west-central/1351955-poor-ventilation-in-new-homes-may-lead-to-health-problems/>
- 35 “Choosing Paint Colours: How Light Affects Colour.” Lisa Kaplan Gordon. [www.houselogic.com](http://www.houselogic.com). 2016
- 36 The Psychology of Colour in an Interior Space. Britanni Anderson. Virginia Tech School of Architecture and Urban Studies. 2011
- 37 CPD 17 Specifying Colour. Dulux Trade. *Building Magazine*. 04.09.2015
- 38 The Psychology of Colour. Valerie Latona. [www.Motherearthliving.com](http://www.Motherearthliving.com) June 2016
- 39 Colour Psychology and its Role in Promoting Health & Wellbeing. Simon Major. May 2016
- 40 Colour for the Seven Ages of Man. TEDx Talk Brighton. Lori Pinkerton-Rolet. 16.11.2012
- 41 Menon, R. & Porteous, C., 2011. *Design Guide: Healthy Low Energy Home Laundering*, s.l.: Mackintosh Environmental Architecture Research Unit
- 42 Sharpe, R. A., Thornton, C. R., Nikolaou, V. & Osborne, N. J., 2014. Higher energy efficient homes are associated with increased risk of doctor diagnosed asthma in a UK subpopulation. *Environment International*, Volume 75, pp. 234-244
- 43 World Health Organisation, 2010. WHO Guidelines for indoor air quality: Selected pollutants, s.l.: s.n
- 44 Vehvilainen, T. et al., 2016. High indoor CO<sub>2</sub> concentrations in an office environment increases the transcutaneous CO<sub>2</sub> level and sleepiness during cognitive work. *Journal of Occupational and Environmental Hygiene*, 13(1, 19-29), pp. 1545-9632
- 45 Bakó-Biró, Zs., Clements-Croome, D.J., Kochhar, N., Awbi, H.B. and Williams, M., (2012), Ventilation Rates in Schools and Pupil's Performance, *Building and Environment*, 48, 215-223
- 46 Satish, U., et al., (2012), Is CO<sub>2</sub> an Indoor Air Pollutant? Direct Effects of Low-to-Moderate CO<sub>2</sub> Concentrations on Human Decision-Making Performance. *Environmental Health Perspectives* 120: 1671–1677
- 47 by Allen et al (2015) in a study from the Harvard T H Chan School of Public Health
- 48 The term ‘green’ in this case refers to environments with improved air quality, which in turn, affects brain performance
- 49 Approved document F: Ventilation (2010 edition incorporating 2010 and 2013 amendments). Department for Communities and Local Government, 2010, and CIBSE Guide A: Environmental Design, 2015
- 50 British Standard BS EN 13779:2007 Annex A3
- 51 National Institute For Health and Care Excellence (NICE), 2015, Excess winter deaths and illness and the health risks associated with cold homes, <https://www.nice.org.uk/guidance/ng6/resources/excess-winter-deaths-and-illness-and-the-health-risks-associated-with-cold-homes-51043484869> (accessed 23 Feb 2016)
- 52 Allen J et al., (2016), featured in “BBC’s Panorama ‘Too Poor to stay warm’”, March 2016
- 53 Public Health England (PHE), 2015, Heatwave plan for England. Making the case: the impact of heat on health – now and in the future. [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/429572/Heatwave\\_plan\\_Making\\_the\\_case\\_-\\_2015.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/429572/Heatwave_plan_Making_the_case_-_2015.pdf) (accessed 26 Feb 2016)
- 54 Department for Communities and Local Government (DCLG), 2006, Housing Health and Safety Rating System. Guidance for Landlords and Property Related Professionals, [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/9425/150940.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/9425/150940.pdf) (accessed 23 Feb 2016)
- 55 Zero Carbon Hub. <http://www.zeroarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingInHomes-TheBigPicture-01.1.pdf>
- 56 Vardoulakis S, Dimitroulopoulou C, Thomes J, Lai K-L, Taylor J, Myers I, Heaviside C, Mavrogianni A, Shrubsole C, Chalabi Z, Davies M, Wilkinson P, 2015, Impact of climate change on the domestic indoor environment and associated health risks in the UK, *Environment International*, 85: 299-313
- 57 Anderson M, Carmichael C, Murray V, Dengel A, Swainson M., 2013, Defining indoor heat thresholds for health in the UK, *Perspectives in Public Health*, 133 (3): 299-313
- 58 National Health Service (NHS), 2016a, Keep warm, keep well. <http://www.nhs.uk/Livewell/winterhealth/Pages/KeepWarmKeepWell.aspx> (accessed 26 Feb 2016)
- 59 World Health Organisation, (WHO), 1987, Health Impact of Low Indoor Temperatures: Report on a WHO Meeting. World Health Organization for Europe, Copenhagen
- 60 <http://www.zeroarbonhub.org/current-projects/tackling-overheating-buildings>
- 61 <http://www.who.int/indoorair/publications/7989289041683/en/>
- 62 Ohayon (2003) The effects of breathing-related sleep disorders on mood disturbances in the general population. In *J Clin Psychiatry* 64(10):1195-200
- 63 Taylor et al (2005) Epidemiology of insomnia, depression and anxiety. In *Sleep* 28(11):1457-64
- 64 National Sleep Foundation (2012-2016) Inside your bedroom: Use your senses! <https://sleepfoundation.org/bedroom>
- 65 Onen et al (1994) Prevention and treatment of sleep disorders through regulation of sleeping habits. In *Presse Med* (in French) 12(10):485-9
- 66 Gold, Diane (2010) Air pollution linked to sleep breathing problems. WebMD, LLC. <http://www.webmd.com/sleep-disorders/news/20100617/air-pollution-linked-to-sleep-breathing-problems>
- 67 Strøm-Tejsen et al (2015) The effects of bedroom air quality on sleep and next-day performance. In *Indoor Air* doi:10.1111/ina.12254
- 68 National Noise Attitude Survey, 1999/2000
- 69 Evans (2006) Child development and the physical environment. In *Annual Review of Psychology* 57:423-451
- 70 Bandura (1987) *Self Efficacy*. WH Freeman, San Francisco, CA
- 71 Shapiro et al (1998) *Control Therapy*. Wiley, New York, NY
- 72 Taylor et al (1998) Illusions and well being: a social psychological perspective on mental health. In *Psychol. Bull.* 103:293-210
- 73 Glass et al (1972) *Urban Stress*. Academic, New York, NY
- 74 Hiroto et al (1974) Locus of control and learned helplessness. In *J Exp Psychol.* 102:187-193
- 75 Krantz et al (1974) Helplessness, stress level, and coronary prone behaviour pattern. In *J Exp Soc Psychol.* 10:284-300
- 76 Maxwell et al (2000) The effects of noise on preschool children's prereading skills. In *J Environ Psychol.* 20:91-97
- 77 Cohen et al (1986) *Behaviour, health and environmental stress*. Plenum Press, New York, NY
- 78 ProPG - Planning & Noise: new residential development, Association of Noise Consultants, 2015
- 79 Guidelines for Community Noise, World Health Organisation, 1999
- 80 British Standard BS 8233:2014
- 81 Office for National Statistics, National population projections, 2012-based statistical bulletin, November 2013 [http://www.ons.gov.uk/ons/dcp171778\\_334975.pdf](http://www.ons.gov.uk/ons/dcp171778_334975.pdf)
- 82 <http://www.publications.parliament.uk/pa/ld201516/ldselect/ldbuilt/100/100.pdf>
- 83 “Loneliness twice as unhealthy as obesity” – The Guardian, 2014, <http://www.theguardian.com/science/2014/feb/16/loneliness-twice-as-unhealthy-as-obesity-older-people>
- 84 Victor CR, Bowling A: A longitudinal analysis of loneliness among older people in Great Britain (2012)
- 85 Help the Aged (2007) *Preventing Falls*
- 86 Adams, S. (2006) Small things matter: the key role of handyperson services. *Care & Repair England*



- 87 Agency for Healthcare Research and Quality (AHRQ) (2012) "Long-Term Care for Older Adults: A Review of Home and Community-Based Services Versus Institutional Care", *AHRQ Publication* No. 12, (13)-EHC134-EF November 2012 [https://www.effectivehealthcare.ahrq.gov/ehc/products/369/1277/CER81\\_Long-Term-Care\\_FinalReport\\_20121023.pdf](https://www.effectivehealthcare.ahrq.gov/ehc/products/369/1277/CER81_Long-Term-Care_FinalReport_20121023.pdf)
- 88 Craig Anderson, et al (2000). "Home or Hospital for Stroke Rehabilitation? Results of a Randomized Controlled Trial". *Stroke* 31: 1024-1031. <http://stroke.ahajournals.org/content/31/5/1024.full>
- 89 Remedios, López-Liria, et al (2015) "Home-Based versus Hospital-Based Rehabilitation Program after Total Knee Replacement". *BioMed Research International*, 2015, Article ID 450421. <http://dx.doi.org/10.1155/2015/450421>
- 90 Riccio, Patricia A (2001). "Quality Evaluation of Home Nursing Care: Perceptions of Patients, Physicians, and Nurses". *Journal of Nursing Care Quality* 15 (2): 58–67
- 91 Lifetime Homes Design Guide, <http://www.lifetimehomes.org.uk/>, The Joseph Rowntree Foundation
- 92 Housing our Ageing Population: Plan for Innovation (HAPPI)
- 93 Housing our Ageing Population: Plan for Implementation (HAPPI2)
- 94 Littlefair PJ (2011) Site Layout Planning for Daylight and Sunlight: a guide to good practice, BRE Press; British Standards Institution (2008) BS 8206-2:2008 Lighting for buildings: Code of Practice for Daylighting, BSI
- 95 Frumkin (2001) Beyond toxicity: Human Health and the Natural Environment. In *American Journal of Preventive Medicine* 20:234-240
- 96 van den Berg et al (2016) Visiting green space is associated with mental health and vitality – A cross sectional study in four European cities, in *Health and Place* 38, pp 8-15
- 97 Grahn P and Stigsdotter UA (2003) Landscape planning and stress. *Urban Forestry & Urban Greening* 2, pp 1-18
- 98 Stigsdotter et al (2010) Health promoting outdoor environments – associations between green space, and health, health-related quality of life and stress based on a Danish national representative survey. In *Scandinavian Journal of Public Health* 38, pp 411-417
- 99 Relklatiene et al (2014) The relationship of green space, depressive symptoms and perceived general health in urban population. In *Scandinavian Journal of Public Health* 24: 669-976
- 100 Nielsen and Hansen (2007) Do green areas affect health? Results from a Danish survey on the use of green areas and health indicators, in *Health and Place* 13: 839-850
- 101 Louv (1005) *Last Child in the Woods*. Algonquin Books of Chapel Hill, USA
- 102 Grahn and Stigsdotter (2010) The relation between perceived sensory dimensions of urban green space and stress restoration, in *Landscape and Urban Planning* 94: 264-265
- 103 Kuo and Faber Taylor (2004) A Potential Natural Treatment for Attention-Deficity/Hyperactivity Disorder: Evidence from a national study. In *Am J Public Health* 94:1580-1586
- 104 Wilson, E.O., 1984, *Biophilia*, Cambridge:Harvard University Press
- 105 Browning,W.,2012, The Economics of Biophilia, Terrapin Bright Green
- 106 Gillis,K., Gatersleben,B.,2015, Buildings, 5, 948-963;doi:10.3390/buildings 5030948
- 107 Sullivan and Kuo (2004) The fruit of urban nature: Vital neighbourhood spaces. In *Environment and Behaviour* 36:678-700
- 108 Taylor, Kuo and Sullivan (2002) Views of nature and self-discipline – evidence from inner city children, in *Journal of Environmental Psychology* 22, pp 49-63
- 109 Kaplan and Kaplan (1983) Cognition and Environment: Functioning in an uncertain world, Ulrich's, Ann Arbor, MI
- 110 Wells (2000) At Home with Nature: Effects of 'Greenness' on Children's Cognitive Functioning. In *Environment and Behaviour* 32:775
- 111 Tennesen and Cimprich (1995) Views to nature: Effects on attention. In *Journal of Environmental Psychology*, 15:77-85
- 112 Burton, E., 2015, *Mental wellbeing and place*, Chapter 11, 150-161 in *The Routledge Handbook of Planning for Health and Wellbeing* edited by Hugh Barton et al
- 113 Sport England. (2015). Active Design: Planning for Health and Wellbeing through Sport and Physical Activity. *Public Health England*. <https://www.sportengland.org/media/3426/spe003-active-design-published-october-2015-email-2.pdf>. Accessed 1 June 2016
- 114 UK-GBC, 2015 Demystifying Green Infrastructure
- 115 Tainio et al. Can air pollution negate the health benefits of cycling and walking? *Preventive Medicine*; 5 May 2016
- 116 Royal College of Physicians. Every breath we take: the lifelong impact of air pollution. Report of a working party. London: RCP, 2016
- 117 Srinivasan S., O'Fallon LR, and Dearth A., 2003. Creating Healthy Communities, Healthy Homes, Healthy People: Initiating a Research Agenda on the Built Environment and Public Health. Time Again for Public
- 118 Frank L., Kavage S. and Devlin A., 2012, Health and the Built environment: A review, Urban Design 4 Health, Ltd (Prepared for: The Canadian Medical Association)
- 119 Parsonage, R. (2009). Creating Healthier Built Environments: Developing a tool to conduct health reviews of land use proposals. British Columbia: University of British Columbia, SPHA 590 Research Project
- 120 Mikkelsen, L. Chehimi, S, Cohen L. 2007. HEALTHY EATING & PHYSICAL ACTIVITY: Addressing Inequities in Urban Environments. Oakland: Prevention institute
- 121 [http://www.heartandstroke.com/site/c/iklQLcMWJtE/b.8045619/k.F840/Healthy\\_Communities.htm](http://www.heartandstroke.com/site/c/iklQLcMWJtE/b.8045619/k.F840/Healthy_Communities.htm)
- 122 Healthyactivebydesign, 2016, Good practice for creating healthy and active buildings. Available online at: <<http://www.healthyactivebydesign.com/design-features/buildings>> [Accessed 18.05.16]
- 123 Affordable design for affordable housing: Nicol, G., Lee, KK.,Du Bose,K.2013. Active design. Affordable design for affordable housing. NY City of New York
- 124 BC Healthy Communities Society (BCHC). Health Neighbourhood Design. British Columbia. <http://planh.ca/take-action/healthy-environments/built-environments/page/healthy-neighbourhood-design>. Accessed 1 March 2016
- 125 Frank L., Kavage S. and Devlin A., 2012, Health and the Built environment: A review, Urban Design 4 Health, Ltd (Prepared for: The Canadian Medical Association)
- 126 Krieger J and Donna L. H., 2002, Housing and Health: Time Again for Public Health Action, *American Journal of Public Health*. 92(5): 758–768
- 127 See Secured By Design for further guidance: <http://www.securedbydesign.com/>
- 128 Morland K, Wing S, Diez Roux A, Poole C. Neighborhood characteristics associated with the location of food stores and food service places. *Am J Prev Med*. 22:23–29
- 129 <http://www.csgn.org/sites/csgn.org/files/wgf-resource-guide-preschool-garden-grants.pdf>
- 130 Wiltshire, R, Burn, D. (2009). Growing in the community. London: Local government association
- 131 Arup (2016), SHARPER (Seasonal health and resilience for ageing urban populations)
- 132 [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/440728/National\\_Drought\\_Framework.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/440728/National_Drought_Framework.pdf)  
[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/69346/pb13562-future-water-080204.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69346/pb13562-future-water-080204.pdf)
- 133 The EPSRC funded COPSE and PROMETHEUS projects already provide new future climate data for these purposes. The EPSRC COLBE project will produce, by the end of 2018, new "event years" that will allow designers to test against heat waves and cold snaps of varying intensities
- 134 <https://www.gov.uk/government/publications/heatwave-plan-for-england>
- 135 Hamilton I, Milner J, Chalabi Z, et al. Health effects of home energy efficiency interventions in England: a modelling study. *BMJ Open* 2015;5:e007298. doi:10.1136/bmjopen-2014-007298
- 136 National Housing Federation, *Housing Standards Handbook*, 2016
- 137 Ref. NHBC/Zero Carbon Hub – Performance Gap Evidence, 2015
- 138 Ref. Tucker- Adolescents' Perceptions of Home, School and Neighbourhood Environmental Influences, 2008
- 139 University of Strathclyde's Mackintosh Environmental Research Unit (MERU, 2014)
- 140 <http://www.oxforddictionaries.com/definition/english/value>
- 141 2015 Crimson Hexagon, Consumer Trends Report
- 142 <http://www.berkeleygroup.co.uk/media/pdf/7/8/berkeley-reports-and-opinions-social-sustainability-reports-creating-strong-communities-part-one.pdf>
- 143 <http://info.houzz.com/rs/houzz/images/HouzzHealthyHomeStudy.pdf>
- 144 Healthy Homes Barometer, VELUX Group and B. Wegener, 2015
- 145 <http://www.velux.com/artide/2016/Energy-renovation-resonates-with-european-home-owners>
- 146 [http://www.landscapeinstitute.org/PDF/Contribute/ProfitablePlacesOctober2014\\_002.pdf](http://www.landscapeinstitute.org/PDF/Contribute/ProfitablePlacesOctober2014_002.pdf)
- 147 <http://www.standard.co.uk/news/london/londoners-increasingly-seeking-homes-in-areas-where-pollution-is-low-a3254236.html>
- 148 Future health Sustainable places for health and well-being, CABE, 2009
- 149 Friedman D. *Social Impact of Poor Housing*. London: 2010
- 150 Building the Future: The economic and fiscal impacts of making homes energy efficient, Verco and Cambridge Econometrics for the Energy Bill Revolution, October 2014
- 151 Age UK. The cost of cold: Why we need to protect the health of older people in winter. London: 2012
- 152 Marmot Review, *The Health Impacts of Cold Homes and Fuel Poverty*, May 11
- 153 *Mental Health And Work: United Kingdom* © OECD 2014
- 154 Natural England 2009: Headline Facts: The cost of obesity and physical inactivity [online]
- 155 Delivering Benefits through Evidence, The Costs of the 2007 Summer Floods in England, DEFRA and Environment Agency, 2010
- 156 Delivering Benefits through Evidence, The Costs of the 2007 Summer Floods in England, DEFRA and Environment Agency, 2010
- 157 Natural England 2009: Headline Facts: The cost of obesity and physical inactivity [online]
- 158 CIBSE LG9 Lighting for Communal Residential Buildings (2013)
- 159 CIBSE KS17 Indoor Air Quality and Ventilation (2011)
- 160 CIBSE Guide A: Environmental Design (2015)
- 161 Building Regulations Part E: Resistance to the passage of sound; the National Planning Policy Framework guidance: <http://planningguidance.communities.gov.uk/blog/guidance/noise/noise-guidance/>; also London Housing Design Guide Section 5.3, and the London Plan SPG on Sustainable Design and Construction



Front and back cover images  
© Berkeley Group

## WITH THANKS TO TASK GROUP CONTRIBUTORS:

Affinity Sutton	Lendlease
AkzoNobel	Levitt Bernstein
Arup	Monomoy Company
Berkeley Group	PRP
Black Architecture	Saint-Gobain
BRE	SOM
Cundall	Stride Treglown
Fielden Clegg Bradley Studios	The Crown Estate
Forbo Flooring UK	University College London
Grontmij	University of Bath
Hilson Moran	University of Cambridge
Hoare Lea	University of Reading
Hodkinson Consultancy	Waterman Group
Homes and Communities Agency	WSP Group
HTA	Zero Carbon Hub
JLL	

This report does not necessarily reflect the position of individual companies



UK Green Building Council  
The Building Centre  
26 Store Street  
London WC1E 7BT

T: +44 (0)20 7580 0623  
E: [info@ukgbc.org](mailto:info@ukgbc.org)  
W: [www.ukgbc.org](http://www.ukgbc.org)