A Breath of Fresh Air

The importance of air quality in aged care design

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The Dementia Centre HammondCare is committed to providing excellence in dementia care. Older and younger people living with dementia deserve services that are designed and delivered based on evidence and practice knowledge of what works. This is achieved through providing research, training and education, publications and information, consultancy and conferences.

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The Pelgromhof aged care residence in Zevenaar, Netherlands. Credit: Damian Utton

Foreword

External and internal air quality play a major role in how our physical environment supports or undermines our health and wellbeing. From Vitruvius in the 1st century BC to the modernist architecture of Alvar Aalto, air quality has been central to design for health, quality of life, reduced disease transmission and a range of other environmental issues. However, good planning and design has not always prevailed, and this is resulting in poor health outcomes in our towns, cities and buildings. Sadly, the devastating impact of COVID-19 has highlighted the role of air quality and shown the importance of good ventilation, air filtration, and the importance of outdoor spaces and fresh air for safer social interaction.

Air quality is also a universal design issue, as poor air quality can affect accessibility and usability, impairing human performance and social participation by causing lethargy and fatigue, dizziness or confusion, breathing difficulties, stress, eye irritation, voice hoarseness or headaches. Unlike physical barriers in poorly designed buildings, air quality is typically invisible, sometimes odourless and tasteless, and often very difficult to fully appreciate or monitor.

Air quality is particularly important for us as we get older, when impairments of ageing, physical and sensory difficulties, or health issues can make us more susceptible to a poor environment. Again, COVID-19 has illustrated the importance of air quality for older people who have greatly suffered during the pandemic. In addition to direct health impacts, a person with dementia may be very vulnerable to poor air quality as they may be acutely sensitive to their environment and incapable of articulating their discomfort, or simply unable to open a window, go outside, or make other adjustments to improve their situation.

Whilst poor air quality is linked to lung diseases, there is also emerging research showing a correlation between COVID-19 infection rates and pollution levels. Furthermore, there is growing evidence linking exposure to pollutants with a heightened risk of developing dementia. This reinforces the importance of sustainable and healthy planning, design and material selection, firstly to reduce air pollution, and secondly to ensure that the built environment helps to protect people against harmful emissions and any associated short- and long-term negative health outcomes.

A Breath of Fresh Air deals with these issues and challenges in a straightforward and in-depth manner.

It provides a good foundation with clear definitions of pollution and air quality and how these impact on health, with a focus on issues related to ageing and dementia. It sets out the main outdoor and indoor pollutants that we should be aware of and outlines design strategies for the various stages of a building's design, construction and maintenance.

The short case studies ground the information contained in this book within realistic and familiar contexts. These help to reinforce and explain key issues and, in some cases, illustrate simple solutions to common air quality problems.

This booklet will be useful for a wide range of readers, from those who want a better understanding of how to manage their own environment, to family members, carers, health professionals and facility managers who want to improve the health and quality of life for those in their care. It will also be invaluable to building professionals such as architects, mechanical engineers and HVAC (heating, ventilation, and air conditioning) experts.

Annie Pollock, HammondCare, and the contributors to *A Breath of Fresh Air* should be commended for this work. It provides an excellent source of information in a complex and challenging area and will help to improve the quality of life for older people and people living with dementia in a range of settings.

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Shanghai, planted wall to help combat pollution visible in the sky. Credit: Annie Pollock

Introduction

Air quality – a global issue

Poor air quality is one of the biggest global issues of the 21st century and is causing health problems for people of all ages. A report by the UK's Environment Agency,[1] updated 8th September 2020, notes that:

> *Air pollution is the single biggest environmental threat to health in the UK, shortening tens of thousands of lives each year.*
>
> *Exposure to ambient air pollution and noise is ubiquitous globally. A strong body of evidence links air pollution, and recently noise, to cardiovascular conditions that eventually may also affect cognition in the elderly.*[2]

Los Angeles pollution. Credit: steinphoto

So, the publication of this book, *A Breath of Fresh Air,* is very timely. It provides a brief introduction to the issues of internal and external air quality that affect us all.

Our aim in writing this book is to provide guidance to designers, their clients, managers of buildings for older people and those with dementia, as well as people of all ages, on how to create environments which optimise health outcomes and mitigate the effects of air pollution.

Whilst it does not provide detailed technical guidance, it aims to raise awareness of the problems of poor air quality and how to avoid them. Further sources of more detailed guidance are provided.

Specifically, it is to help readers to:

- understand the specific needs of older people and people with dementia
- reduce exposure to outdoor pollution by careful consideration of a building's location
- minimise indoor pollution by avoiding any products that can emit pollutants
- ensure the regular maintenance and cleaning of the building fabric, fittings, all forms of ventilation and heating and/or cooling appliances and outdoor landscaping too
- find out more about the trees, garden plants and indoor plants that may help to improve air quality.

The World Health Organization is an excellent source of information on this topic and has an interactive map[3] showing the DALYs (disability-adjusted life years – a measure of years in perfect health lost) attributable to ambient air pollution (per 100,000 population): in 2016.

The UK for example had 559, Australia, 289 and India, 2,547.

This book was written with the assistance of Dr Tom Russ (advice on air pollution, cardiovascular disease and dementia) and Professor Sandy Halliday (advice on mechanical ventilation and construction), experts in their particular fields, to whom I am very grateful for their contributions.

An Appendix has been added to address the ongoing implications of forest fires and the current COVID-19 pandemic.

Global problem, local solution

In 2010, Iceland's Mt Eyjafjallajökull volcano erupted, sending millions of tonnes of CO_2 into the atmosphere, and forcing the closure of airports across Europe. This catastrophic event naturally generated headlines across the world and served as a reminder of human impotence against the forces of nature.

Wikimedia Commons: Arni Friorikssson

Yet, as mused by author and environmental activist Andri Snær Magnason in the UK's *The Guardian* newspaper:[4]

> *What do we humans matter, people ask, when a volcano might blow and spew out millions of tonnes of CO_2?...[But] the impact of humans on a daily basis is equal to more than 600 of these volcanoes. Imagine all these eruptions on every continent, all day, all night; all year round and tell yourself that they have no effect on the climate.*

Such comparisons should remind us that as humans we are not helpless. We do have the ability to impact our environment positively, improve air quality and thereby enhance the quality of life for everyone, but in particular for elderly and vulnerable people such as those living with dementia. Small steps taken consistently by individuals can cumulatively prevent the environmental 'volcano' from erupting.

Vulnerability to poor air quality

Whilst everybody is affected by poor air quality, some of us are more vulnerable:

- older people and people with dementia
- adults with long-term health conditions
- pregnant women
- children.

In particular, many older people will have impairments associated with ageing. These might include poor mobility, impaired senses (including sight, hearing, smell) and impaired lung capacity. Some people will have additional health conditions, such as arthritis, asthma, chronic obstructive pulmonary disease (COPD), diabetes, multiple sclerosis, Parkinson's disease, dementia and compromised or weakened immune systems.

The risk of developing dementia increases exponentially after age 65. There are many types of dementia, the commonest being Alzheimer's, followed by vascular dementia and Lewy body dementia.

All dementias have broadly similar symptoms and for most people, these include problems with memory, sensory changes, difficulties with problem solving and challenges with planning.[5] Many people with dementia will find it hard to recognise or adjust to impairments of normal ageing and crucially, may also be unaware of the air quality around them.

Relatives and carers may attribute some of the symptoms caused by poor air quality (such as drowsiness, confusion or agitation) to the result of a person's dementia. All such health issues can result in high levels of stress. Recent research indicates that not only can stress worsen the effects of air pollution but air pollution itself causes stress hormones to spike.[6]

Designing for older people and people with dementia is therefore an important and often complex issue. Good design, management and building maintenance can help greatly.

In respect of older people and those with dementia who live in care homes, WHO Europe reported that:

'…up to 50% of COVID-19 deaths across the region were in care homes'.[7]

Air quality may be one link with this and is discussed later on in this book in Appendix 1.

Lessons from the past

The COVID-19 pandemic has reminded us that one of the key contributors to our health is something that is free and readily available to all – fresh air!

As long ago as the mid-19th century, Florence Nightingale noted the virtues of fresh air: *'Always air your room, then, from the outside air, if possible. Windows are made to open; doors are made to shut – a truth which seems extremely difficult of apprehension.'*[8]

The curative effects of fresh air were investigated at length by the physiologist Sir Leonard Hill (1866–1952) in the years following World War I. He reported favourably on the effects of the sun and air when judiciously applied, particularly for tuberculosis.[9] In 1919, he wrote in the *British Medical Journal*: *'The best way to combat influenza infection was deep breathing of cool air and sleeping in the open.'*

Modern life has seen us move away from open windows and outdoor activity, to climate-controlled spaces with sealed windows. COVID-19 has caused us to revisit some of those choices, recognising that spending time outdoors and allowing fresh air to circulate indoors is one of the easiest, and most effective, weapons against transmission of the virus.[10]

The importance of air quality, disease transmission and personal protective equipment (PPE) is a huge and constantly developing medical subject in itself – and cannot be covered in any detail in this book, but any findings are only likely to make this subject even more relevant to human health and wellbeing.

Chapter 1

Outdoor air pollution and its impact on our health

What is air pollution?

'An air pollutant is any substance in the air that could harm people'.[11]

'Air pollution is a mixture of natural and man-made substances in the air we breathe. It is typically separated into two categories: outdoor air pollution and indoor air pollution'.[12]

In 2016, 91% of the world population was living in places where the WHO air quality guidelines levels were not met.[13]

The main causes of outdoor air pollution

The most common air pollutants of ambient air include:[14,15]

- particulate matter (PM10 and PM2.5)
- oxides of Nitrogen (NOx)
- ozone (O_3)
- carbon monoxide (CO)
- sulphur dioxide (SO_2)

Also mentioned in the Department for Environment, Food and Rural Affairs (DEFRA) report are polycyclic aromatic hydrocarbons (PAHs), benzene and 1,3-Butadiene which are largely from combustion (fires, forest fires and road transport).

Particulate matter, also known as particle pollution or PM, is a term that describes extremely small solid particles and liquid droplets suspended in air. Particulate matter can be made up of a variety of components including nitrates, sulphates, organic chemicals, metals, soil or dust particles, and allergens (such as fragments of pollen or mould spores). Particle pollution mainly comes from motor vehicles, wood

burning heaters and industry. During bushfires or dust storms, particle pollution can reach extremely high concentrations.[16]

Particulate matter is classified by size. Smaller particles tend to have a greater effect on our health:

- PM10: inhalable particles, diameter 10 micrometers (microns) or less
- PM2.5: (the most studied), fine inhalable particles, diameter 2.5 micrometers or less
- UPM: (ultra-fine particles), which are possibly the most damaging.

By comparison, the average human hair is about 100 micrometers in diameter, which shows how very small these polluting particles are.

A large proportion of air pollution derives from human activity, including motor vehicles, heat and power generation, industry, incineration of municipal and agricultural waste and the use of polluting fuels in our cooking, heating, and lighting *(See Table 1).*

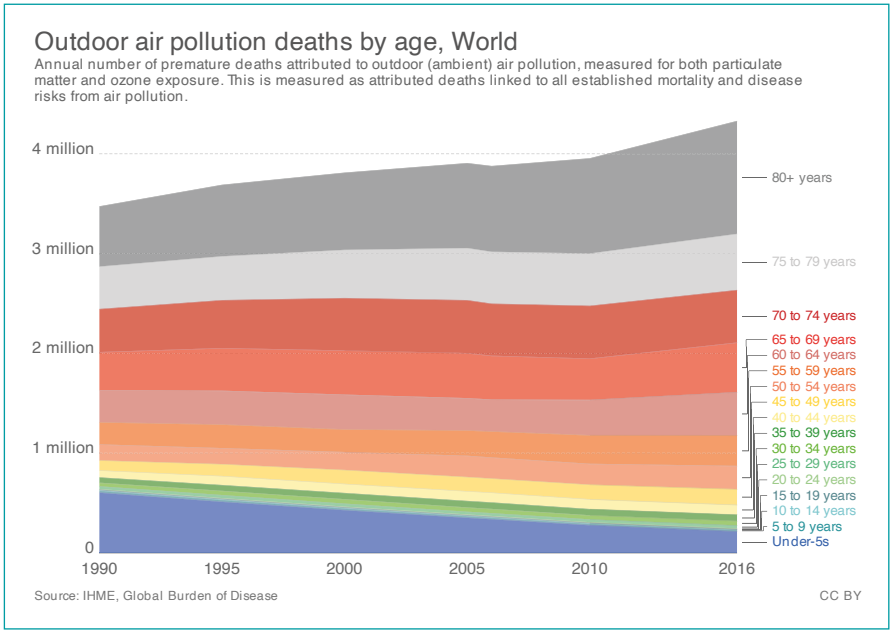
In Australia, researchers examining the impact of wood heating on health and mortality studied a regional city with high levels of air pollution each winter.[17] Approximately 40% of Armidale's households use wood heating, the main source of air pollution in the city of 24,500 people. Monitoring enabling detailed characterisation of population PM2.5 exposure by season, revealing that air pollution in Armidale exceeded the national daily PM2.5 standard (25 µg/m3) on 32 days in 2018; all exceedances were attributable to winter wood heater pollution.

The research found 14 premature deaths per year, corresponding to 210 years of life lost, are attributable to long term exposure to wood heater PM2.5 pollution in Armidale. The estimated financial cost is A$32.8 million, or A$10,930 per wood heater per year.

Recommendations to reduce wood heater pollution include:

- public education about the effects of wood smoke on health
- subsidies to encourage residents to switch to less polluting home heating
- assistance for those affected by wood smoke from other people
- regulations that reduce wood heater use (for example, not permitting new wood heaters and requiring existing units to be removed when houses are sold).

Globally, an estimated 4.2 million deaths each year are attributed to air pollution and nine in ten people live somewhere where air quality is poorer than the World Health Organization's air quality guidelines.[18]



Source: https://commons.wikimedia.org/wiki/File:Outdoor_air_pollution_deaths_by_age,_OWID.svg

On Saturday 18th May 2019, the front page of *The Guardian* newspaper in the UK proclaimed: *'Revealed: air pollution may be damaging every organ in the body.'*

The scholarly reviews on which this article was based, led by the University of Illinois at Chicago and published in the journal *Chest*, have amassed evidence for a detrimental effect of air pollution throughout the body, including the brain, eyes, heart, lungs, blood, fat, pancreas, gastrointestinal system, urogenital system, joints, bones, nose and skin.[19,20]

Gases which can cause pollution indoors and outdoors are shown in Table 1 below.

Table 1 – Gases which can cause pollution outdoors and indoors

Ammonia (NH_3)

Ammonia comes from natural and man-made sources.

It combines with other chemicals in the air to form deadly particulates PM2.5.

Sources

- Certain cleaning products
- Used in the production of plastics, synthetic fibres, dyes, explosives and pharmaceuticals
- Livestock farms, breakdown of animal waste
- Fertilisers for agriculture.

Possible health side effects

- Inhalation at low levels: eye, nose and throat irritation. High levels: burns, swelling in airways, lung damage
- Ingested: pain and burns throughout the digestive tract. In severe cases, possible damage of respiratory system, stomach and heart.
- Inhaled and ingested: possible death.
- Splashes of strong solutions: serious skin burns and damage to eyes.
- Mixing with some cleaning products may produce toxic gases.

Carbon dioxide (CO_2)

CO_2 is a trace gas occurring naturally in the Earth's atmosphere. Whilst not considered an air pollutant, it can be a major contributor to air pollution.

The concentration of CO_2 in the Earth's atmosphere is nearly 412 parts per million (ppm) and rising – an 11% increase since 2000.

Find out more: https://climate.nasa.gov/news/2915/theatmosphere-getting-a-handle-on-carbondioxide/

Sources

Outdoors: Deforestation and use of fossil fuels increase CO_2 in the atmosphere, leading to global warming.

Indoors:

- Respiration
- Combustion appliances, e.g. gas cookers, boilers, wood fires, candles, cigarettes
- Clothes dryers
- Seepage from soil under a building.

Possible health side effects

Risk to health starts at a level of 1,000 parts/million and can cause:

- Reduced concentration
- Drowsiness at relatively high levels (2,000 parts/million)
- Unconsciousness at extremely high levels (5,000 parts/million).

Nitrogen oxides

The two most common are nitric oxide (NO) and nitrogen dioxide (NO_2), referred to as NOx. They react with sunlight, causing smog and contributing to acid rain.

Sources

Outdoors and indoors:

- Vehicle exhausts
- Coal and wood burning
- Diesel fuel, natural gas, gas stoves, kerosene heaters
- Cigarette smoking
- Silos containing silage.

Possible health side effects

At high levels, causes:

- Decreased female fertility
- Genetic mutations and harm to a developing foetus
- Spasms
- Swelling of throat
- Rapid pulse, dilated heart, death
- Links with neurodegenerative diseases, including Alzheimer's. Find out more: https://pubmed.ncbi.nlm.nih.gov/15265275/

Radon (Rn)

A natural radioactive gas which comes from the decay of uranium in rocks and soil. It is colourless, odourless and tasteless. In outside air the levels of radon are low – but it collects in enclosed places, such as houses, workplaces and other buildings. A contaminant that affects indoor air quality world-wide.

Possible health side effects

Lung cancer – a clear link between this and breathing high concentrations of radon.

Ozone (O_3)

Ozone (O_3) is a highly reactive gas composed of three oxygen atoms. It is both a natural and a man-made product that occurs in both the Earth's upper and lower atmospheres. Depending on where it is in the atmosphere, ozone affects life on Earth in either good or bad ways.

Sources

Outdoors: Formed from dioxygen by the action of ultraviolet light (UV) and electrical discharges.

Indoors: Can be formed by reaction with some cleaning products (VOCs).

Possible health side effects

Smog from reaction with sunlight, which exacerbates asthma and respiratory problems.

Sulphur dioxide (SO_2)

Sulphur dioxide is the pollutant gas most commonly found in the atmosphere and is usually present in high concentrations in urban and industrial locations.

Sources

Outdoors:

- Natural emissions – volcanoes, sea spray, biological decay
- Manmade emissions – combustion of coal or other fuels with high sulphur content.

Possible health side effects

- Aggravation of existing health conditions, hastening death.
- Greater susceptibility to bacterial infections, e.g. pneumonia.

Air pollution and cardiovascular disease

There is a clear link between air pollution and cardiovascular disease. There is also evidence that a day with particularly high levels of air pollution is followed within a week by an increase in strokes.[21]

Experiments exposing volunteers to dilute diesel fumes in a controlled setting (equivalent to walking along a busy road) have shown exactly how air pollution can harm the heart and circulatory system.[22]

Given the clearly established causal link between air pollution and cardiovascular disease and associated mortality, efforts to reduce exposure to air pollution should be urgently intensified and supported by appropriate and effective legislation.[23]

Air pollution and dementia

While there are multiple studies linking air pollution and all types of impaired brain health, including cognitive impairment, brain changes observable on scans, and clinical dementia – a causal link is yet to be established.[24,25]

In recent years, research suggests that Alzheimer's disease may begin decades before dementia is observed, in middle life;[26] or even earlier.

Factors at all stages of life – and even before birth – can influence one's risk of developing dementia. Furthermore, the brain changes that ultimately lead to overt dementia – such as the amyloid and tau pathologies of Alzheimer's disease – develop several decades before the emergence of clinical symptoms. Both these facts are likely to be relevant to the link between air pollution and dementia.

> *It is never too early and never too late in the life course for dementia prevention. Early-life (younger than 45 years) risks, such as less education, affect cognitive reserve; midlife (45–65 years), and later-life (older than 65 years) risk factors influence reserve and triggering of neuropathological developments.*[27]
>
> *A systematic review of studies until 2018 including 13 longitudinal studies with 1–15 years follow-up of air pollutants exposure and incident dementia, found exposure to PM2.5, NO_2 and carbon monoxide were all associated with increased dementia risk.*[28]

We don't know at present at what stage in a person's lifespan exposure to air pollution is most harmful – and the link, if any, with dementia.

It may be that exposure to air pollution is always bad, and that associated risk accumulates with the amount of time you are exposed. However, there may also be particular periods of time – so-called sensitive or critical periods – when being exposed to air pollution is especially harmful.

We can't answer this at present because air quality monitoring only became mandatory in high income countries over the last few decades and there is a lack of reliable data.

Therefore, estimating what air quality was like in the early or middle twentieth century – when people who now have dementia were younger – is very difficult.

However, groups of climate scientists and meteorologists are working on ways of estimating what historical air pollution levels were like using existing emissions data and comparing weather patterns with more recent years which appear similar but for which more data are available.[29]

This approach, along with more detailed research in this growing area will hopefully clarify the effects of air pollution on the brain.

Chapter 2
Air pollution indoors

People with poor health are at greatest risk from indoor air pollutants. They are frequently less mobile and may spend more time indoors, often with poorer ventilation (noted as a way in which the current COVID-19 pandemic is spread). Those of us (of all ages) with respiratory diseases, allergies and asthma are particularly vulnerable to poor air quality, but the older you are, the more you will be affected.[30]

The following quotes from the Royal College of Physicians in London show the importance of being aware of and avoiding materials that can emit pollutants:

> *Being indoors can offer some protection against outdoor air pollution, but it can also expose us to other air pollution sources. There is now good awareness of the risks from badly maintained gas appliances, radioactive radon gas and second-hand tobacco smoke, but indoors we can also be exposed to NO_2 from gas cooking and solvents that slowly seep from plastics, paints and furnishings. The lemon and pine scents that we use to make our homes smell fresh can react chemically to generate air pollutants, and ozone-based air fresheners can also cause indoor air pollution.*
>
> *… the concentration indoors is as much as ten times higher than that outdoors because of the presence of internal sources. This emphasises the importance of indoor air quality – not only do we spend considerably more time indoors than out, but the range and concentration of pollutants inside buildings are often much greater than those found outdoors.*[31]

In addition, human activity can also create unpleasant odours and excess moisture; management of these can often exacerbate the problems of poor air quality.

This report, quoted above, also notes that measured levels of CO_2 or of total volatile organic compounds (VOCs) are useful indicators of indoor air quality.

1. Carbon dioxide (CO_2) and carbon monoxide (CO)

Carbon dioxide: this is the most common pollutant, the most significant and long lived greenhouse gas in the Earth's atmosphere. Inside buildings, levels of CO_2 can build up in the following ways, causing people to feel drowsy and fall asleep.

- Fuel burning appliances (e.g. open fires, wood burning stoves, charcoal BBQs, gas cookers) can use up the available oxygen resulting in an over-abundance of CO_2.
- Respiration by the occupants of a room can cause CO_2 levels to build up if the ventilation system is poor, i.e. windows and doors are shut or mechanical ventilation has been poorly maintained. This can happen with just a few people in a small room, if windows are shut and ventilation is poor.

Credit: PIKSEL

In care homes, living room windows are often shut. Residents become drowsy, which staff may attribute to their age and dementia. In reality, the CO_2 levels are likely to be far too high due to lack of fresh air and the number of occupants.

LESSONS LEARNED

For all of us and particularly older people and those with dementia, lack of fresh air can cause us to feel drowsy during the day – and then be unable to sleep at night. In a care setting, those who cannot sleep at night may be given drugs to help them sleep, when all that is needed is plenty of fresh air during the day.

Similar conditions have been reported in Australia:

> *Project lead Associate Professor Priya Rajagopalan from RMIT's Sustainable Building Innovation Lab said surveys indicated that Australians spend more than 90% of their time indoors, yet the importance of indoor air quality was often overlooked.*[32]
>
> *Why are so many aged care residents and staff becoming infected with COVID-19? New research suggests poor ventilation may be one of the factors. RMIT researchers are finding levels of carbon dioxide in some nursing homes that are more than three times the recommended level, which points to poor ventilation.*[33]

Carbon monoxide: This is known as the 'silent killer'. It can cause confusion and agitation, symptoms that in a care home setting may be ascribed to dementia.

Any appliance that burns a carbon-based fuel can potentially produce carbon monoxide – as well as carbon dioxide. These include oil and gas burners, wood or gas fires, barbecues (often used on outdoor patios beside open doors and/or windows allowing fumes indoors) and portable generators.

It is therefore vital that such items of equipment are regularly checked and serviced by a registered engineer – and faulty appliances replaced. Exhaust fumes must be directed well away from rooms used by staff, residents or visitors.

Barbecues are a part of life in the warm summer months in many countries. Many of them produce a lot of smoke, which can waft in through open windows and doors and affect older people more adversely than younger ones.

Blocked chimneys and flues can also be lethal, preventing fumes from escaping from a room.

A couple had recently moved into an 19th century Scottish tenement flat.

The living room had a gas fire connected to a flue in the chimney stack.

They both felt hot and stuffy in this room and eventually sleepy too, so decided to get the gas fire serviced.

The flue was found to be blocked by a dead bird – and a build-up of carbon monoxide had been polluting the air in the room.

LESSONS LEARNED

A person with dementia living at home may well not associate stuffy air quality and sleepiness with a faulty fire or blocked chimney. Carbon monoxide fumes can be fatal.

Credit: Annie Pollock

A major problem is that both carbon dioxide and carbon monoxide are odourless, so people can be totally unaware of their presence. How do we manage this?

Recommendations:

- Ensure regular maintenance of all gas appliances – for a more environmentally friendly option, replace gas appliances with electric appliances instead.
- Avoid open fires, but if not possible, clean chimneys at least once a year before colder weather.
- Install CO_2 and CO monitors to check levels where there are possible sources and create alarms.
- Train staff in care facilities for older people and those with dementia to be aware of the issue.
- Regularly open windows to purge any build-up of pollutants.
- Provide relatives of those living in their own homes with information so that they too can be aware.
- Consider a cleaner BBQ, e.g. an electric powered one, which will not produce fumes.

This is an area where hopefully climate change policies (COP 26, the UN Climate Change Conference in Glasgow, 12th November 2021) will lead to improvements in public health. We can only hope that the use of gas and oil is phased out as soon as possible, but we must rely on governments world-wide to achieve this…

Credit: monkeybusinessimages

2. Tobacco

This is one of the worst pollutants. Fortunately, smoking is now banned in most public places in many countries. In vehicles and private homes, it can still be a problem.

Rosie lived in Los Angeles, where outdoor air quality is known to be poor. She was asthmatic since childhood.

Over many years, she had several hospital admissions for severe breathing problems due to the city's air pollution and exacerbated by smoking. By age 80, she had mild cognitive impairment and finally suffered from a severe coughing fit, collapsed lung and cardiac arrest, from which she never recovered.

LESSONS LEARNED

Poor air quality and smoking can cause COPD and together can contribute to developing dementia.[34]

Credit: Annie Pollock

In residential accommodation, it may be hard to stop a person living with dementia from smoking if they have smoked most of their life. So how do we manage this?

Recommendations:

- Provide an outdoor smoking shelter for smoking well away from windows.
- If there is space, allow for a smoking room within the building, which has a separate ventilation system to deal with tobacco smoke.
- Encourage those living at home to smoke outside in a sheltered area.

3. Particulates and volatile organic compounds (VOCs)

Particulates: As well as cooking and open fires, particulates are also emitted by other indoor activities we might undertake, such as:

- Cleaning – e.g. dusting, vacuuming.
- Use of aerosol sprays for personal hygiene, cleaning, air freshening and painting.
- Smoking – tobacco products.
- Vaping – there has been conflicting and at times confusing information reported regarding the potential risks to bystanders and non-e-cigarette users from exhaled e-cigarette aerosol. The regulatory outlook from a public health perspective currently remains undetermined; there is a clear need for further research in this area to support the development of appropriate product standards and other science-based regulatory measures.[35]

Particulates are also produced by biological processes and include fungi and mould resulting from damp conditions and rotting vegetation.

Volatile organic compounds (VOCs): These are synthetic chemicals found in building materials and many typical household products and furnishings.

Concentrations of these are typically 10x higher indoors than outdoors.[36] They easily become vapours or gases.

Many are associated with health effects in humans and animals, e.g. cancers, tumours, irritation and immune suppression. The higher the air temperature, the more VOCs in the air – so they can pose more problems in hotter climates or overheated buildings.

The main effects on a person's health are respiratory irritation leading to coughs and/or a runny nose and also headaches and dizziness. Respiratory symptoms may be triggered at very low levels of exposure.

Sensory changes and dementia

Many VOCs smell unpleasant and some are carcinogenic, however, people with dementia and associated sensory issues may not smell them and therefore cannot tell someone or take any action.

Sometimes people with dementia smell things that are not there at all, and it's important that carers are aware of this.

Agnes Houston, the author of *Talking Sense*[37] has dementia and experiences severe sensory challenges. She frequently smells fire when there is no fire. She also often smells an unpleasant drain smell.

The main volatile organic compounds that can affect us all and particularly older people and those with dementia are shown in Table 2 below.[38] Further additional products, commonly used which contain VOCs, are also listed below.

Table 2 – Volatile organic compounds

Benzene

A clear, colourless, highly flammable and volatile liquid aromatic hydrocarbon with a gasoline-like odour. Found in crude oils and as a byproduct of oil-refining processes. In industry, it is used as a solvent, a chemical intermediate and in the synthesis of numerous chemicals. Find out more: https://pubchem.ncbi.nlm.nih.gov/compound/Benzene

Sources

Outdoor sources include

- Natural processes, e.g. volcanoes, forest fires.

Indoor sources include

- A solvent, present in paints, glues, plastics, inks and rubber.

Possible health side effects

Benzene is a known human carcinogen. Exposure causes:

- Neurological symptoms
- Affects the bone marrow causing aplastic anaemia, excessive bleeding and damage to the immune system.

Formaldehyde

A colourless, strong-smelling gas used in making building materials and many household products. It also occurs naturally in the environment. Humans and most other living organisms make small amounts as part of normal metabolic processes. Find out more: https://www.cancer.org/cancer/cancer-causes/formaldehyde.html

Sources

Outdoor sources include

- Fertilisers and pesticides

Indoor sources include

- Some building materials
- Household products, e.g. glues, paints, lacquers, paper products
- Preservatives in some medicines, cosmetics, dishwashing fluid, fabric softeners
- Byproduct of combustion and cigarette smoking
- Formaldehyde-based foam in furniture.

Possible health side effects

Exposure mainly through off-gassing:

- Skin, eyes, nose and throat irritation
- High levels: some types of cancer.

Trichloroethylene

A volatile, colourless liquid organic chemical, created by chemical synthesis. Find out more: https://www.cancer.gov/aboutcancer/causesprevention/risk/substances/trichloroethylene

Sources

- An industrial solvent
- Refrigerants
- An ingredient in several household products, e.g. adhesives, paint removers, cleaning wipes, carpet cleaners and spot removers
- Used in commercial dry cleaners.

Possible health side effects

Exposure mainly through contaminated drinking water:

- Low levels: skin/eye irritation
- High levels: dizziness to unconsciousness, even death
- Prolonged/repeated exposure: kidney cancer.
- Association with increased risk of non-Hodgkin lymphoma and possibly liver cancer.

Tolulene

A colourless liquid that is highly flammable. Sometimes used as a recreational inhalant. Find out more: https://www.chemicals.co.uk/blog/what-is-toluene

Sources

Indoor sources include

- A common solvent in, e.g. paints, paint thinners, silicone sealants, glues, lacquers, disinfectants.

Possible health side effects

Exposure through inhalation:

- Moderate levels: tiredness, confusion, loss of memory, hearing, appetite, colour vision
- High levels: light-headedness, nausea, unconsciousness, death.

Vinyl chloride

A colourless gas that burns easily. It does not occur naturally and must be produced industrially for its commercial uses. Find out more: https://www.cancer.gov/aboutcancer/causesprevention/risk/substances/vinylchloride

Sources

Outdoor sources include

- A common contaminant near landfill sites.

Indoor sources include

- Used in making PVC, pipes, wire, cable coatings and packaging materials.

Possible health side effects

Exposure through inhalation and contaminated water:

- Associated with an increased risk of a rare form of liver cancer, brain and lung cancers, lymphoma and leukaemia.

Others, including Styrene, Terpenes, Phthalate esters

Find out more: https://ec.europa.eu/health/ph_risk/committees/04_scher/docs/scher_o_026.pdf

Sources

E.g. air fresheners: many emit allergens and toxic air pollutants including benzene, formaldahyde, terpenes, styrene, phthalate esters and tuolene.

Possible health side effects

Exposure through inhalation.

Effects include allergies, skin and eye irritation, and nausea.

A UK Government report from September 2019 notes:

> *Due to their properties, VOCs are widely used in construction and building products (e.g. paints, varnishes, waxes, solvents), in household consumer products (detergents, cleaning products, air fresheners and personal care products) and are also emitted while using electronic devices such as photocopiers or printers.*[39]

VOCs from electronic devices may include hydrocarbons, ozone, and dust from paper and toner. More modern machines should have filters to minimise this, so regular maintenance is necessary.

The Scottish Ecological Design Association's (SEDA) 'Design and Detailing for Toxic Chemical Reduction in Buildings' design guide contains a more detailed list and notes in addition to those listed above:

- aerosol sprays, cleansers and disinfectants
- moth repellents and dry-cleaned clothing
- plasticisers including phthalates used in vinyl flooring, wallpapers, shower curtains, plumbing, wires, cables, sealant ribbon, adhesives, electrical equipment, textiles and coated fabrics
- glues such as used in laminate flooring and carpets
- fire retardants used in furnishings, electronics (e.g. TVs) and building materials
- stored petrol, diesel fuels and automotive products.

We all recognise the importance of keeping buildings clean to protect our health – and especially residential and health care facilities. But as we can see, many cleaning agents and air fresheners are themselves a source of toxins and the harmful effects of these are of particular concern – they can emit allergens and toxic air pollutants including benzene, formaldehyde, terpenes, styrene, phthalate esters, and toluene.

Recommendations:

- Conduct detailed discussions at design stage on natural and mechanical ventilation, which can affect the building layout.
- Minimise the use of materials which produce VOCs through off-gassing.
- Open windows where possible for ventilation in key areas, e.g. toilets and bathrooms; if not possible, ensure extraction by means of mechanical ventilation.
- Train those responsible for cleaning to:
  - Read all labels on cleaning supplies and household products before buying them. Choose products that do not contain or have reduced amounts of VOCs, fragrances, irritants and flammable ingredients. Avoid using air fresheners altogether.[40]
  - Open windows and doors to allow in fresh air – and especially when using cleaning or household products. Never use cleaning products in a small, enclosed space.
  - Never mix cleaning agents, and in particular anything containing bleach, with another cleaner containing ammonia.

4. Odours

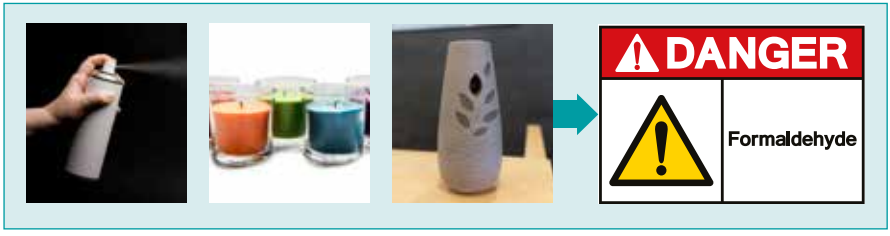
Unpleasant smells can come from many sources, both human and man-made. They may be mixtures of VOCs, water vapour and unpleasant smelling gases from sources including:

- people, e.g. sweat, urine and faeces – and less obvious, coughs and sneezes
- cooking processes
- decomposing foods
- sanitary appliances, e.g. toilets, sinks, soil and waste-water drains
- building materials, furnishings, paints.

To mask unpleasant smells, we commonly use scented candles and plug-in air fresheners to freshen the atmosphere indoors and create an ambiance, particularly when friends or relatives are visiting. People often give scented candles as gifts too, without realising that they can be harmful.

Unfortunately, most of us don't realise that these can react chemically with ozone, generating air pollutants such as formaldehyde – and the potential impact that this can have on the health of our relatives, residents and patients.

All of the scented products below can produce formaldehyde, which can irritate the eyes, skin and respiratory tract and has been linked to some types of cancer. Prolonged exposure could cause skin sensitisation and allergic contact dermatitis.[41,42]



In particular, for people with pre-existing conditions such as ischaemic heart disease, asthma and COPD, VOCs alone can increase the likelihood of more severe health effects such as cancer.[43]

So what should we do to minimise the effect of odours in our buildings?

- Train staff to check whether an odour is real or not (i.e. as experienced by Agnes Houston) and to deal with the situation appropriately and with sensitivity.
- Use air monitoring devices as the norm, where it is known that there may be pollutants that are harmful.
- Open windows where possible to purge smells and pollutants.
- Never use scented candles or air fresheners – as these simply add to the cocktail of pollutants in a room, possibly worsening the situation and causing health issues.

The *WHO Guidelines for Air Quality: Selected Pollutants* (2010) are targeted at public health professionals involved in preventing health risks of environmental exposures, as well as specialists and authorities involved in the design and use of buildings, indoor materials and products. They provide a scientific basis for legally enforceable standards. This publication contains some useful guidance – and we recommend readers to look at the pdf download.[44]

5. Excess moisture and humidity

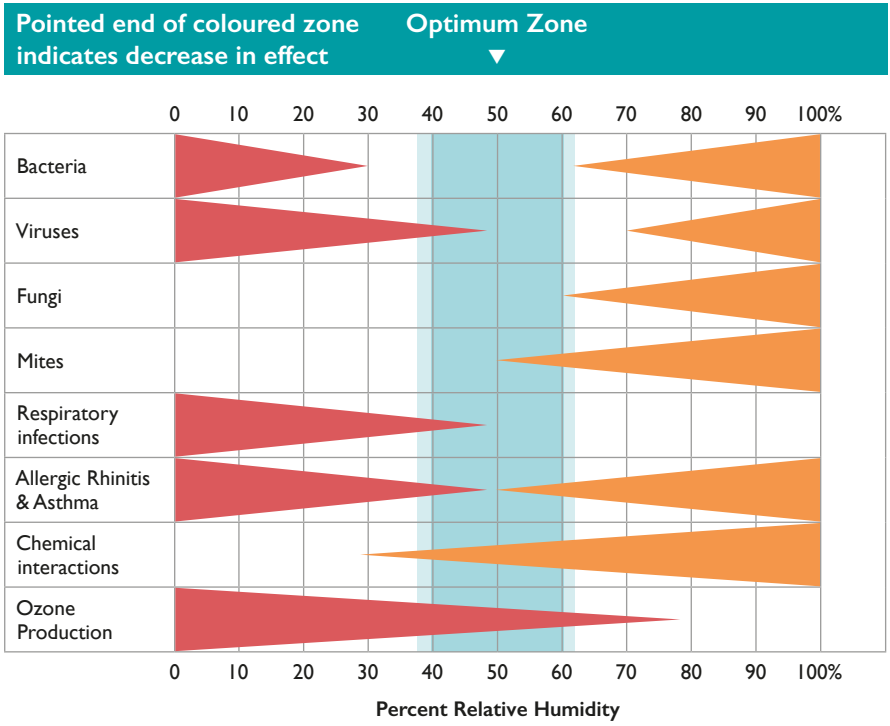
One of the greatest issues in homes in many places around the world is dampness and mould. A review by the WHO in 2009 deals with this in detail and the quote below is taken from this document:

> *In residences, day-care centres, retirement homes and other special environments, indoor air pollution affects population groups that are particularly vulnerable due to their health status or age. Microbial pollution involves hundreds of species of bacteria and fungi that grow indoors when sufficient moisture is available. Exposure to microbial contaminants is clinically associated with respiratory symptoms, allergies, asthma and immunological reactions.*[45]
>
> *Condensation occurs when moist air comes into contact with a colder surface like a wall, window, mirror etc. The air can't hold the moisture and tiny drops of water appear. It also occurs in places where the air is still, like the corners of rooms, behind furniture or inside wardrobes.*[46]

As can be seen from the generic diagram below, high humidity leads to a rise in bacteria, viruses, fungi and mites. Chemical interactions are greater and allergic rhinitis and asthma can result.

Conversely if the humidity is too low, bacteria and viruses still thrive, respiratory infections including allergic rhinitis and asthma can result, and ozone production is high.

Consequently, we should aim to achieve the optimum range for humidity (40%–60%) within private homes and residential facilities for our older people and those with dementia, as they will be far more susceptible to infections.



Source: Theodor D Sterling and Associates Ltd, Vancouver, BC

So how do we achieve these optimum humidity levels?

- Dry clothes outdoors or in separate rooms from those in which we live.
- Don't use paraffin or bottle gas heaters.
- Use saucepan lids when cooking.
- Open windows – especially in bathrooms and kitchens and switch on extractor fans in both rooms.
- Ensure good insulation and draught proofing – in some countries there may be grants available for roof insulation and secondary glazing for people in their own homes.
- Raise the heat a little more – warm houses in colder climates suffer less from condensation.
- Ensure windows in unused rooms are opened from time to time to air them.
- Provide mechanical ventilation where natural ventilation is not practical or where outdoor air quality might be changeable due to weather and season.

There are many guides on moisture management available, as noted in 'Further reading'.

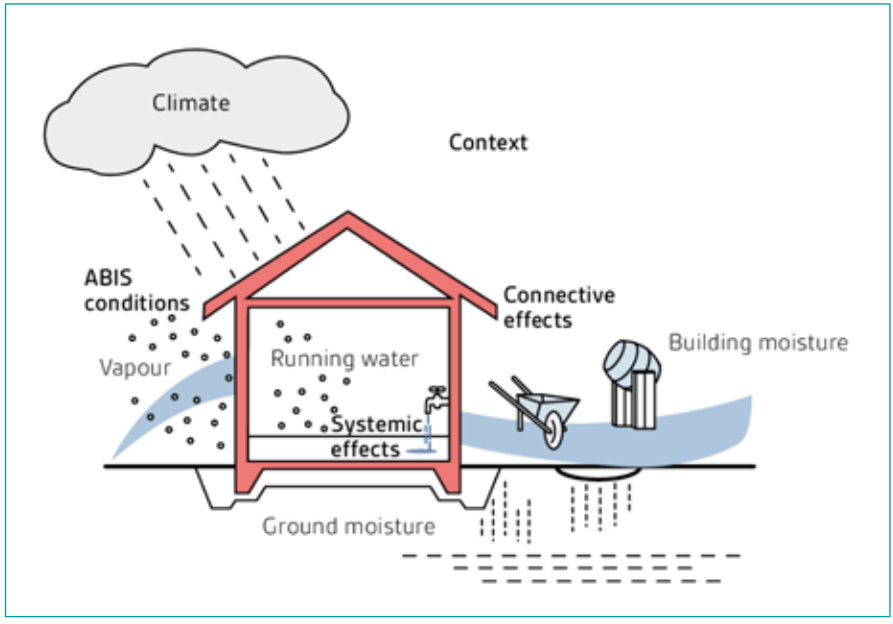
6. Moisture management by design

We can manage moisture by good ventilation and thoughtful specification of materials. There are many natural methods to ventilate, but if mechanical means are considered necessary then extreme care must be taken to avoid accumulation of dirt and particulates in ducts and filters.

Countries throughout the world will have different building techniques although the basic science is the same. The US Environmental Agency produced a detailed guide in 2013.[47]

Another later UK guide, published by the British Standards Institution (BSI),[48] notes the need for a joined-up process and understanding the context of the building.

The diagram below shows the different factors to consider in a moisture risk assessment (produced with permission of the BSI).



Note: Solutions to moisture problems must take into account 'as built' and 'in service' conditions (here called *ABIS conditions*). These are conditions which exist (in existing buildings) or which are likely to exist (in new buildings).

We add the following quotes from this document as they provide good general principles for the Design Team to note:

[Permission to reproduce extracts from British Standards is granted by BSI Standards Limited (BSI). No other use of this material is permitted. British Standards can be obtained in PDF or hard copy formats from the BSI online shop: www.bsigroup.com/Shop]

Air infiltration is a major route for energy loss in houses. However, ventilation is necessary for good indoor air quality, including the reduction of high internal humidity. Good design of ventilation systems and detailing of the building can achieve an effective balance between these potentially conflicting aims. Air leakage from the interior into the fabric can be the dominant mechanism for transporting water vapour into regions where it can cause problems. This can be minimized by detailing an airtight layer on the warm side of the building envelope.

A coherent approach is required because many moisture problems in fabric and indoor air quality are highly influenced by ventilation and heating. Ventilation and heating … are an essential component of any moisture strategy.

Usability of services (particularly ventilation and heating) is essential. The context of the user should be prioritized in the specification of services.

Both services (particularly ventilation and heating) and fabric (particularly rainwater goods and drains) must be easy to maintain.

The use of some 'hygroscopic' materials in building construction can help with moisture management as well. These are materials that absorb moisture when humidity rises and emit it when the air becomes dry. Such materials can hold quite large quantities of moisture without any special risks of biological activity or degradation.[49]

They can be used to stabilise the relative humidity inside buildings and help to prevent damp-related damage and adverse impacts on health. Clay plaster, untreated wood, water-based paints and lime-based plasters, mortars and renders are preferable to oil-based paints and finishes, plastic surfaces and cement-based surfaces.

PVC surfaces, plastic membranes and glass fibre should be avoided. On these non-hygroscopic surfaces such as these, films of moisture can form and as nutrients dissolve in the moisture, micro-organisms proliferate. As the film of water dries, spores are produced and toxins released, which can aggravate the symptoms of people with allergies. Plastic membranes and glass fibre surfaces can have colonies of fungi and bacteria that are 1,000–50,000 times greater than on the surface of natural materials.

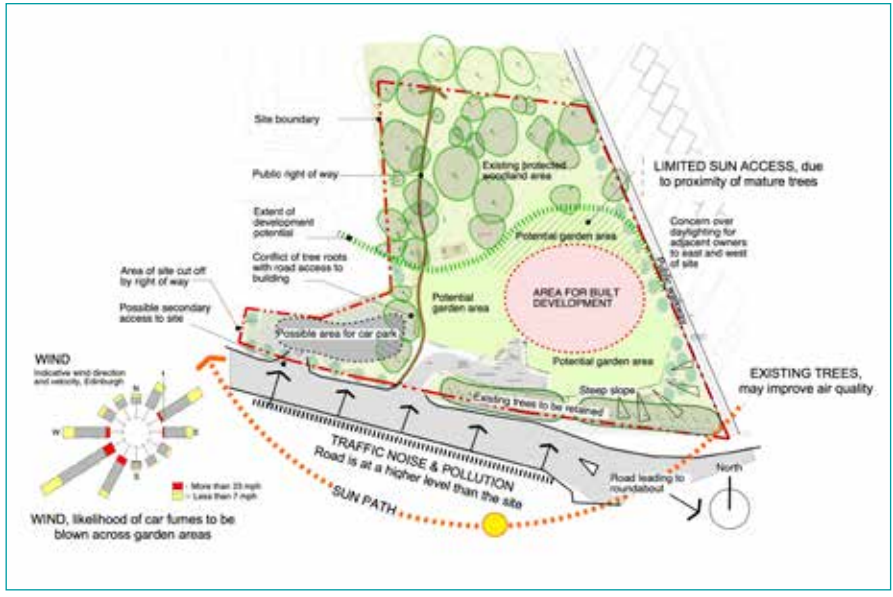
Recommendations:

- Choose materials that will not harbour moisture and therefore micro-organisms.
- Consider carefully methods of building construction and ventilation techniques that will produce an internal environment for optimum health and relative humidity of between 40% and 60%.

Chapter 3

Design considerations and strategy

Discussions at briefing stage for new-build or refurbishing projects are essential to minimise pollutants in our buildings and to ensure that residents, staff and visitors will be comfortable.



Source: Annie Pollock

Factors which should be considered include site selection, minimising air pollution, building layout, thermal comfort, building materials, furnishings and ventilation.

1. Site selection

Because polluted outdoor air can enter buildings and degrade the quality of the indoor air that we breathe, there is much to be gained by building schools, hospitals etc. away from heavily polluted roads. A location's postcode can be used as a reasonable surrogate for exposure to certain outdoor pollutants.[50]

(Note: This report was updated in 2018, sadly noting that the air quality crisis is growing, not reducing).

At the outset of any building design or renovation, the design team should assess the local outside air quality and consider the building design in relation to this.

Interestingly, a very recent report (September 2020)[51] notes that: *'Asphalt-based materials are abundant and a major non-traditional source of reactive organic compounds in urban areas, but their emissions are essentially absent from inventories.'*

Asphalt has only recently been noted as a possible outdoor pollutant that can add to indoor pollutants, if windows and doors in proximity to an asphalted area are open. This research paper is based on US studies but is relevant world-wide. It notes the following:

Liquid asphalt is a petroleum-based product widely used in cities...urban areas comprised of 45%+ paved surfaces and 20% roofs.

The total emission factor for primary road asphalt rose with temperature.

The vast majority of asphalt is used outdoors, where solar radiation represents a major environmental factor.

Clearly in hotter climates this poses greater issues – and should be taken into account in the siting and design of a building.

Recommendations:

- Consider climate, landform and geographical factors that may affect the local environment, for example, mountains, hills, flat ground, coastal or inland, forested or open; city or country location; local industry and planting (trees and shrubs). All of these can affect air temperature and quality.
- Site a building away from traffic-based pollution, e.g. noise, exhaust emissions and particles from tyre wear and brake linings. Even with electric cars, pollution will only be halved. When designing the building layout, avoid car parking or loading near residents' windows, doors or outdoor spaces for their use.
- Ideally choose a site near public transport routes, minimising the need for staff and visitors to use cars.
- The possible building layout and design should take into account sun angles and wind direction.
- Consider access to outdoor space or at least a balcony or terrace. For further information on this we refer you to an earlier publication, *The Room Outside*.[52]
- Ensure that outdoor spaces and living or bedroom windows do not open over large asphalted surfaces, especially in hot climatic areas.

Case study 1 – 'A home for life', Fortune Place, Edinburgh, Scotland

Architects: ***Smith Scott Mullan Associates 378 Leith Walk, Edinburgh EH7 4PE***
Client: ***Castle Rock Edinvar, 1 Hay Avenue, Edinburgh EH16 RW***

Credit: Smith Scott Mullan Associates

Our site is adjacent to Gilmerton Park (The Dell) which provides lots of open space and fresh air for recreation. Within our site, we created secure communal landscaped gardens to encourage movement, which contain seating, raised planters and access to an outside toilet to increase confidence in using the space. A Garden Room with kitchen and toilets was provided in the shared garden. This has large glazed screens so the room can be opened to the garden. The extensive use of glass gave people a visible connection to each other, to see if they want to be involved, or watch from a distance.

Credit: Castle Rock Edinvar, Amelia Jacobsen

LESSONS LEARNED

The Garden Room has enabled a programme of social and wellbeing events, bringing people together, and also encouraging them to use the outdoor spaces. Sliding doors provide lots of vital fresh air. Easy access to toilets in the Garden Room encourages residents to use the outdoor space without worrying they will not be able to make it to toilet facilities in time.

We prioritised private outdoor space for each home. A useable balcony or private garden space, large enough for a small table and chairs and other small garden items, is part of as many homes as possible. By providing private outdoor space and large windows, we brought the outside in, as well as access to fresh air. The detailed design of the balconies ensures protection from the weather and provides residents with views of the park and the shared gardens.

LESSONS LEARNED

The private outdoor space was a real design success. People say it is a 'must have' and that they 'love it'. Almost everyone uses their private space at least once a week, 34% using it daily.

Credit: Smith Scott Mullan Associates, Castle Rock Edinvar, Amelia Jacobsen

2. Minimising a building's contribution to air pollution

New buildings should avoid contributing to climate change, by using renewable energy where possible and avoiding materials which, in themselves, are unrecyclable or add to air pollution. For example, concrete production is responsible for 8% of global greenhouse gas emissions, and as populations continue to grow, demand for concrete continues to rise.[53]

Renewables: with air quality worsening, and the need to reduce our dependence on fossil fuels, it's worth considering using renewables to provide power, where possible. Renewables can provide electricity for heating, cooling and ventilation, thereby reducing external air pollution by replacing gas, oil and coal fired systems.

The most popular renewable energy sources currently are:[54]

- solar energy
- wind energy
- hydro energy
- tidal energy
- geothermal energy
- biomass energy.

In the UK renewable energy is generally 40%;[55] and in Scotland, provisional figures indicate that in 2020, the equivalent of 97.4% of Scotland's gross electricity consumption was from renewable sources, falling just short of the target to achieve 100% renewable electricity by 2020.[56]

In Australia, it was reported that in 2019, 21% of the country's total electricity generation was from renewable energy sources, including wind (7%), solar (7%) and hydro (5%). The share of renewables in total electricity generation in 2019 was the highest since levels were recorded in the early 1970s.[57]

By September 2020:

About one in four Australian homes have rooftop solar panels, a larger share than in any other major economy, and the rate of installations far outpaces the global average. The country is well ahead of Germany, Japan and California, which are widely considered leaders in clean energy.[58]

More power is needed to stay cool than to stay warm – and hot, sunny countries have great opportunities to generate this extra electricity from solar energy. Consideration of this should be part of briefing discussions for all new and renovation projects, wherever they may be located.

Building materials

Designers should ask for Material Safety Data Sheets (MSDS)[59] – and generally select materials that can be reused or recycled easily at the end of their lives using existing recycling systems.[60]

To protect our environment, generally, the following should be avoided or used with caution:

- Any material or technique that is 'high embodied':
  - Initial embodied energy: the energy required to initially produce the building. It includes the energy used for the abstraction, the processing and manufacturing of the materials of the building as well as their transportation and assembly on site.
  - Recurring embodied energy: the energy needed to refurbish and maintain the building over its lifetime.
  - Demolition energy: the energy necessary to demolish and dispose of the building at the end of its life.[61]
- Anything that doesn't biodegrade – such as plastics.

- Anything that 'off-gases' in the built environment – i.e. produces VOCs.
- Anything taken from a threatened habitat.

Further information on this can be found in the following references:

- *Sustainable Construction (Second Edition)* by Sandy Halliday (2019, Routledge).
- The Living Building Challenge Red List by the International Living Future Institute.[62,63]

Recommendations:

- Encourage the design team to work with environmental health in mind – and make guidance available on the use of healthy materials to the contractor/design team/managers, to ensure pollutants are not inadvertently introduced.
- Design the ventilation system with care – using natural ventilation where possible.
- Consider the use of renewable sources of energy appropriate to the location.
- Ensure that general building maintenance is undertaken at regular intervals so that everything functions optimally.
- Understand that site selection is fundamental to achieving a sustainable design.

Solar panels on a rooftop

3. Building layout

The internal layout of a building, room dimensions and window design and sizes are fundamental to good internal air quality. Building orientation and the way rooms are arranged within a building can affect internal temperatures due to heat gain from direct sunlight or overshadowing from trees and large shrubs.

These are vital to consider at the outset of a new building and equally with an existing refurbishment project, when there may be a change to rearrange the internal layout to create a better environment.

Recommendations:

- Consider and discuss at design stage, the ways of achieving optimum air quality and environmental conditions for residents, internally and externally.
- Choose the right orientation for living spaces, with access to outdoor space or a window as required.
- Locate windows and doors so that air movement within a room is a positive asset and provides good air quality.
- Where possible, provide windows to the outside in bathrooms and toilets, so that odours can be purged with fresh air.
- Ensure a good build quality for components such as windows, doors, and mechanical ventilation where needed – these are so important for the success of accommodation for older and vulnerable people and all have a role to play in thermal comfort.
- Provide external shading devices, whether in a hot or cool climate, to prevent direct sunlight causing heat gain and glare at certain times of the year.
- By design, avoid draughts, especially where people like to sit.
- Plant trees/shrubs for shade or remove them if the shade they cast is going to be problematic.

4. Ensuring thermal comfort

We are all different, but our thermal comfort is generally related to our age, our clothes and how much physical activity we do. High and low temperatures, high levels of moisture in the air, and air that is too dry are all detrimental to our thermal comfort and health.

Being too hot, too cold or feeling draughts is likely to make us want to open or shut windows – which in turn will obviously affect the internal air quality. Older people and those with dementia are particularly vulnerable to dehydration caused by high indoor temperatures and hypothermia from low indoor air temperature in their own homes, and particularly so as they generally spend more time indoors as well.

Older people in particular may be affected by any of the following:

Hypothermia: generally caused by a combination of things such as a lower metabolic rate, immobility, poor nutrition and reduced muscle mass, which can inhibit our ability to shiver. It can cause apathy, impaired judgement, slurred speech and in severe cases, cardiac arrhythmias and respiratory failure.

Overheating: our climate is changing. Extreme heat and heat waves are increasingly common during the summer months

Our changing climate

The highest temperatures ever recorded in France during June 2019 reached 45.6°C.

The Bureau of Meteorology estimates Australia has warmed on average by 1.44°C (±0.24°C) between 1910 and 2019.[64]

Canada broke its country temperature record for three straight days in July 2021–49.6°C (121.3°F) in the village of Lytton, British Columbia. 'A wildfire has now burned 90% of the village and damaged critical infrastructure,' local officials say, 'Before… temperatures in the country had never passed 45°C.'[65]

Normal blood temperature is around 37.5°C. Older people are prone to dehydration for many reasons – forgetfulness, lack of easy access to fluids, problems with swallowing, concerns over continence or lack of mobility. Getting too hot will make dehydration even more likely, which can result in constipation, lethargy, feeling dizzy or fainting on standing up (which can lead to falls), renal failure, electrolyte imbalances, cardiac arrhythmias and ultimately a higher risk of death.

Draughts: older people are particularly aware of air movement at lower temperatures, which can cause them to feel cold, then to shut doors and windows so worsening indoor air quality.

Humidity: in addition to the problems caused by high relative humidity, a humid atmosphere can exacerbate dehydration by interfering with the body's natural cooling mechanisms.

Recommendations:

- Understand that visitors and staff, who don't live in the care facility, may be unaware of the less than perfect environmental conditions that the residents are living with.
- Ensure that those commissioning a project, their design consultants and care staff understand what may affect the wellbeing of older people and those with dementia, as their needs may be very different to those caring for them.
- Advise relatives of those living alone that they may be unable to make the necessary changes without help and guidance – and advising them where to get this help.
- Ensure that, according to climatic conditions, heating, cooling, and dehumidification systems are carefully designed, with ease of use, sustainability and carbon neutral considerations at the forefront.

5. Building materials and furnishings

Construction materials, interior furnishings, finishes and paints should, as far as possible, have no emissions or very low emission rates ('off-gassing'), so that avoidable indoor pollutants (VOCs) are minimised.

In selecting doors and windows, it's important to remember that older people and those with dementia need to be able to use them with ease, so that they can open windows and use doors at will.

All materials should be easy to clean and maintain. Hard floor coverings (with a soft backing for good acoustics) or carpets with waterproof backing that are easily cleaned and may also be hypoallergenic, are preferable. Whilst carpets with a high wool content are hard wearing, they are increasingly prone to attack by 'carpet moths' or 'carpet beetles', which require treatment with chemical applications that could be harmful for residents for a period afterwards.

Recommendations:

- Allow time for thorough discussion of constructional and furnishing materials.
- Ensure that the design team are well versed in these considerations.
- Treat concrete and screeded floors with benign materials to reduce absorption of spillages/contamination.
- Ensure that the ventilation system as well as cooling, heating and humidity controls are easy to use and easy to maintain.
- Keep the residents uppermost when making choices, so that they have some control over their environment too.
- Select windows and doors that are easy to understand and operate, with older people and people with dementia in mind.

For acoustic considerations, refer to *Acoustics in Aged Care* by Richard Pollock.

6. Ventilation – commissioning, maintaining, cleaning and controls

In addition to the points discussed in chapter 2 on Moisture Management, ventilation design is key to the comfort and health of all.

If the ventilation design strategy is not well thought-out when designing facilities for older people and those with dementia, there will be an impact on the following:[66]

The building fabric

- excessive condensation and dampness, which can result in mould growth
- because of this, more frequent redecoration as well as the need to renew soft furnishings more often, all of which adds to the running costs of a building.

The residents

- poor indoor air quality
- health problems – caused by asthma or sick building syndrome (used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified)[67]
- unpleasant smells
- for residents, staff and visitors, an overall unpleasant environment to be in, possibly resulting in a high staff turnover.

The building owner

- costly remedial work, redecoration and staffing costs
- potential health claims
- poor image when attracting new residents
- these can result in a loss of revenue, which could cause the facility to be unpopular and eventually become financially unviable.

Recommendations:

- Ensure by design, sufficient good quality fresh air in all rooms. By 'good quality', we mean the best possible, given that indoor air quality is obviously affected by outdoor air quality. (There may be ways of mitigating the quality of the outdoor air and this is discussed in chapter 6).
- Explore the need for additional filtration systems to deal with infection.
- Minimise the impact of cold winter draughts and summer overheating.
- Control moisture and condensation to prevent its side effects.
- Dilute/remove odours and pollutants by extractor fans in rooms such as kitchens and bathrooms.

Then, when the building is complete, the following strategies need to be followed:

Commissioning, maintaining and cleaning the building

Programme in a period of time after the building 'fit-out' is completed before moving residents in. This is to allow any pollutants from glues, paints, furniture etc. to 'off-gas' and be purged.

Cleaning

Once the building is occupied, thorough and regular maintenance is vital for creating and maintaining a good internal environment that keeps its residents and staff in optimal health. This should be underpinned by a regular schedule of thorough cleaning. A clean building is vital for our health and wellbeing, and especially for older people and those living with dementia, who may spend more time indoors.

Recommendations:

Commissioning the building

- Increase ventilation rates and allow time for all materials to 'off-gas' (i.e. purge the VOCs) after fitting out a new building.
- Monitor CO, CO_2 and VOC levels and act on any findings.
- Ensure window, external door mechanisms and ventilation controls are working appropriately and easy to use, to enable fresh air and easy access to the outdoor areas.
- Ensure that ventilation systems, air conditioners or heat exchange units are all functional.
- In outdoor areas, ensure that planting will not overshadow rooms and that appropriate species are planted, some of which may help to reduce outdoor pollution, such as traffic exhaust fumes.

Maintaining and cleaning the building

- Keep ducts and filters clean, replacing filters as and when required. With lack of regular maintenance (in particular), the ventilation system can contribute pollutants to the indoor environment and become ineffective and noisy.
- Use only non-toxic cleaning materials and ensure good ventilation whilst cleaning and immediately afterwards too.
- Avoid air fresheners and scented candles, tackling the cause of odours in other ways, such as opening windows and using extraction fans.
- Keep washing well away from living areas, use a special ventilated room or outdoor hanging space.
- Avoid sources of contaminants in anything used within the building.
- Cut back plants which cast shade over living areas and ensure that paths are kept free of rotting vegetation.

Older people living in their own homes and the need for controls

It is generally recognised that there are many benefits for older people and those with early-stage dementia to remain, as long as possible in their own homes. However, we need to consider the issues that might affect them and how they might need assistance.

The following gives examples for consideration, when selecting windows:

- Some people may turn off heating or cooling appliances and be reluctant to open windows. Being economical with fuel bills can be very ingrained in older people's memories.
- Others may feel most comfortable by opening windows, which was common practice before the 1960s when fresh air was recognised as an aid to good health – yet be unaware of the weather conditions outside.
- Older people may have dulled temperature perception or impaired homeostasis and not recognise when their environment is too warm or cold.
- Someone living alone in their own home may have difficulty in removing or adding appropriate clothing or adjusting the indoor temperature by altering thermostat settings.
- Their homes may be less than functional due to lack of maintenance.
- If the outdoor environment is noisy, the resident may shut their window to sleep at night, so this needs to be considered at an early stage in the design process to include windows that allow ventilation even if closed.

They may have any or all of the following impairments:

- a poor sense of smell, which may diminish with age and can be further impaired by Parkinson's and Alzheimer's disease
- impaired hearing
- impaired sight, dry eye syndrome or eyes that water easily
- a weakened respiratory system, common with older age and further impaired by asthma or COPD
- impaired mobility.

If the air quality is poor due to windows being shut, they may feel drowsy, and not realise that the cooker or fire is left on or that they are too cold or too hot. With impaired sense of smell they may not smell burning, or with the sensory impairment that can be a symptom of Alzheimer's may think something is burning when it is not.[68]

This is where specialised controls can help, which include the following:

- warning alarms and controls – for example smoke and CO detectors to detect burning or gas leaks
- safety devices on cookers to turn off gas/electric rings that have been accidentally left on (note: People with pacemakers cannot safely use 'induction' hobs)
- thermostatically controlled heating/cooling when required, to resist rapid changes in temperature
- ensuring that windows are safe, cause minimal draughts and are easy to open or shut. This is particularly important if there has been any redecoration undertaken and new flooring or furniture installed. In the UK, building regulations include a requirement for 'trickle ventilators' in new windows.
- windows that are fitted with controls to open and shut them according to weather conditions or build-up of CO_2 or other contaminants – and this is particularly useful in care home buildings.

Recommendations:

- Consider installing controls for the person living at home.
- Consider automatic window controls for all care facilities, in addition to easy to open windows.
- Provide somewhere to hang washing, to avoid damp or humid air in living areas and bathrooms.
- Provide easy access to a safe outdoor space, where there might be a washing line or 'hills hoist', barrier-free and with handrails if required.
- Encourage cleaners to use non-toxic cleaning materials.
- Arrange regular maintenance and repairs to ensure that all appliances, doors, windows and extractor fans work properly.
- For those living in their own home, arrange for regular visitors, family or carers, to check that all is in order.

More general information on controls is provided in the following chapter.

Chapter 4
Constructional considerations

Maurice Zeffert Home, Perth. Credit: Damian Utton, Pozzoni Architects

Best practice principles

With new-build or refurbishing projects, design should adopt 'best practice' principles to create a well-insulated and air-tight building.[69] We need to keep in mind what is a comfortable temperature for most people.

A practice note written by Sue Roaf in 2017, for the Royal Incorporation of Architects in Scotland (RIAS), explains:

> *Roughly between 18°C to 28°C, people are comfortable just putting on extra clothes to keep warm enough and above 28°C to around mid-skin temperature at c. 33°C, adapted people simply need more breeze to keep cool in light clothing. Above such temperatures one can't take any more clothes off if it does get hotter and evaporation of sweat off the skin becomes the main way the body cools itself so strong breezes are the best coolers here and particularly those harvesting pre-cooled air from night-time cooling and/or other coolth reservoirs within a building.*[70]

'Emerging Mantras for Comfort Design', discussed in the same document, include:

> ***From active to passive:*** *Only heat/cool buildings when absolutely necessary – naturally ventilate them for as much of the day/year as possible.*
>
> ***Heat/cool the people not the building:*** *Crucially, small local 'Personal Environmental Technologies' (PET) used to heat/cool people during extreme events also negate the need to over-size mechanical systems to meet peak loads as they can be used locally as a low energy supplement to heat or cool in extreme micro-climates or for uncomfortable individuals when needed.*

Personal Environmental Technologies used will depend on the climate and needs, but might include, for example, small heaters, fans or air-conditioners to provide local comfort for individuals within low (or high in hot climates) background temperatures.

> ***Design climate refuges into buildings:*** *Every home/building should have a safe cool or cosy corner so that people (particularly the old and the young) can stay warm/cool there during extreme weather. You just need one room to be safe during such periods.*
>
> *To provide refuges is a very sensible design solution, as with climate change, sudden changes in temperature can occur very quickly and a refuge that is well insulated can provide immediate relief.*

Moisture transfusive strategy

The use of moisture transfusive materials is more common in Northern Europe, often mistakenly called 'breathing' external fabrics. They are, more accurately, 'sweating constructions' and the concept is most simply understood by comparison with the human body. Without porous skins we would die.

We are most comfortable in clothing that allows moisture to pass through it, and the sportswear industry has developed fabrics to deal with this. Similarly, from an ecological perspective, when properly designed, these forces allow moisture to naturally and passively diffuse from the inside to the outside of a building in response to a vapour pressure gradient. This relies on the surfaces being left uncoated or coated in vapour-permeable finishes. It can offset the need for mechanical systems.[71]

> *'Hygroscopic building materials are nine times more effective than mechanical ventilation in controlling indoor relative humidity'*[72]

This form of construction needs to be looked at far more closely to minimise the need for expensive ventilation systems – and can provide a healthier indoor environment by controlling indoor humidity.

Recommendations:

- Design buildings with 'high thermal mass', i.e. with the ability to resist the rapid changes in temperature that give rise to fluctuations in relative humidity.
- Avoid 'cold bridges' – these are areas in a building where a gap occurs in the insulation (e.g. the roof/wall junction and the wall/floor junction). Such areas will be colder than the main areas, leading to a greater risk of condensation forming, creating damp, cold areas and mould growth.
- Be open minded about strategies, such as using moisture transfusive fabrics, for maintaining a balanced relative humidity, in addition to well-designed ventilation. Providing every home/building with a safe cool or cosy corner so that, the old, the vulnerable and the young, in particular, can stay warm/cool there during extreme weather. This too should be well ventilated to prevent the build-up of pollutants and excess moisture.
- Avoid internal bathrooms without windows if possible. If not possible, then ensure that extractor fans extract directly from the bathrooms, diverting odours away from living/sleeping areas and are as quiet as possible.
- Minimise ventilation noise – people with dementia can find noises confusing and distracting. Regular maintenance is vital.

1. Ventilation strategy[73]

For care homes and residential accommodation for older people and those with dementia, the ventilation strategy needs to provide good indoor air quality for residents, staff and visitors. It should be designed to suit the different requirements of each environment, providing fresh air, removing pollutants (odours, CO_2 emissions etc.) and preventing condensation risk and mould growth.

Care home owners constantly strive to provide premises that are clean, hygienic and free from offensive odours to ensure dignity and care for their residents. Therefore, ventilation systems designed specifically for care homes need to offer tailored solutions to meet the needs of individual rooms or spaces.

An example of a care home in the UK

Each ensuite has a humidity-sensitive extract discreetly fitted into the ceiling plasterwork.

The humidity-sensitive extracts respond automatically to changes in relative humidity in the ensuite, boosting extraction as required to ensure that a fresh, dry, draught- and odour-free environment is maintained.

The 'intelligent' mechanical ventilation system consists of extracts linked by ducting to continuously running low energy central extract fans located in the roof space and from the fan to discreet ventilation terminals on the roof. This system thus ensures each bedroom/ensuite is ventilated to regulatory requirements but without any occupant input or the need to turn fans on or off.

Through the remote location of the fans it also eliminates the usual noise of extract fans running in the ensuite. Extraction is gentle and generally continuous, operating automatically between a relative humidity of 40%–70%.

The window inlets ensure fresh external air is drawn in to replace the extracted air, again without draughts. The roof-space fans are the only element to require any electrical power, the 'intelligent' extracts opening and closing automatically in response to changes in relative humidity.

Case study courtesy of Passivent

Key issues for care home ventilation

Because this type of accommodation is occupied 24 hours a day, seven days a week, a continuous demand-controlled ventilation system is most suited.

Care home ventilation systems need to be energy efficient, coupled with low initial cost and lower lifetime running costs.

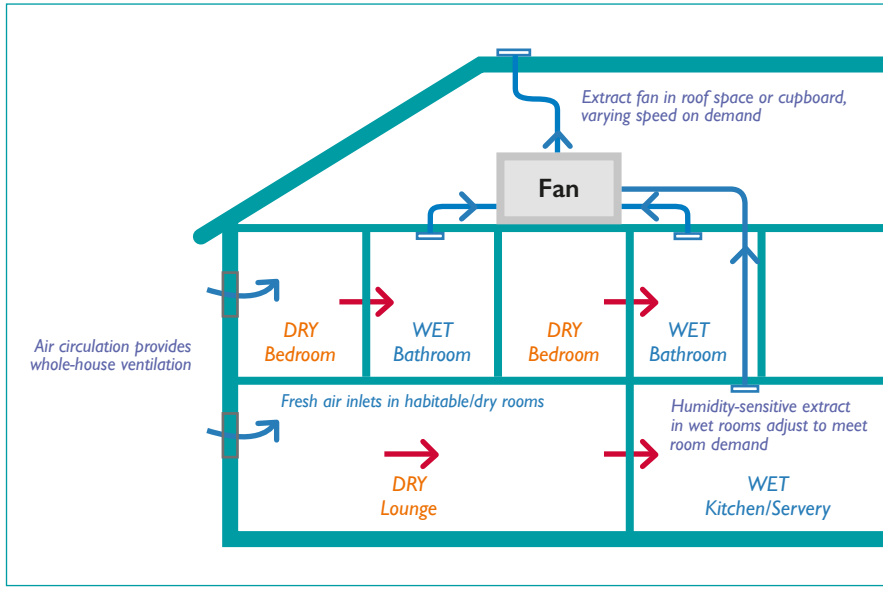
- Rooms within a care environment will have different principal management problems. Kitchens and bathrooms can have high humidity which if not managed can give rise to mould and condensation. In toilets the principal issue may be unpleasant odours. Bedrooms can have a combination of high humidity and odours.
- Ventilation systems need to be designed to suit the relevant issues in each room.
- Rooms are occupied for different lengths and times across the 24 hours. Automatic demand control ventilation is suited to this type of occupancy as it removes the need for occupant interaction, automatically switching on when and where required detecting rises in humidity/pollutants and responding accordingly.

- Ventilation solutions in care homes should require as little occupant input as possible. Intermittent extraction that relies on an occupier is not ideal, as research has shown there is often a risk of insufficient ventilation or over ventilation, increasing energy costs. Often the ventilation is not sufficient to reduce humidity and maintain levels below the 70%* target for prolonged periods. Intelligent ventilation systems remove the need for occupier interaction.
- Ventilation systems are required to be quiet to reduce disturbance. At night with low demand, the fan speed reduces, meaning less noise and therefore less disturbance.

Or better, 60%, relating to the diagram in chapter 2, page 19.

Important factors for a care home ventilation solution include:

- good indoor air quality providing fresh air all year round
- maintaining relative humidity below 60% to control condensation
- effectively removing pollutants
- ensuring that pollutants and viruses cannot be spread around the building, i.e. air is not recycled between rooms.



Credit: Passivent

The typical installation of an 'intelligent' ventilation system within a care home will use t-pieces to join multiple rooms together.

The system illustrated in this diagram is designed to transfer air through the dry rooms to the wet rooms via undercuts in doors, typically 10mm as shown by the red arrows.

Fresh air will come from window (trickle vents) or wall vents into the dry rooms and air will be drawn from these dry rooms to replace extracted air in wet rooms otherwise the system will stall.

Typically, this will be from bedrooms to en-suites and a living/dining room to the servery, which is open to the dining room in any case.[74]

Controls

There is an inherent conflict with an automated system of ventilation. Everyone likes some degree of personal control over their indoor environment, e.g. being able to open a window, control the heating or cooling or turn a fan on or off. We all need the opportunity to manage our environment if we can and indeed this is good for our mental wellbeing.

However, for people with dementia this can lead to systems not working properly, so in the care home environment an automated HVAC system can be the best solution, as long as there is still some personal control over opening or closing windows.

Installing high level, controlled vents is one solution to solve this issue, and examples provided by Passivent are shown below.

A suitable tile vent

A suitable ridge vent

Recommendations:

Consider simple low-tech solutions rather than something complicated which may need specialist management. Controls need to be:

- able to provide an automatic rapid response when a change is needed, but additionally with simple methods such as opening windows to allow residents some choice.
- managed by simple overrides and can be switched off when not needed
- easy to see, understand and use, located in the most appropriate place, depending on who will use them, e.g. staff and/or residents.
- robust and flexible enough to provide fresh air under the wide range of conditions that might arise.

There are good sources of information on how to design and control buildings and their heating and ventilation systems using solutions that are cost effective and environmentally responsible.[75]

There is also a thorough and useful bibliography in *Sustainable Construction* (see 'Environmental Design' chapter) by Sandy Halliday.[76]

2. Windows, doors and controls

We have talked about the need for these to be easy to understand, open and shut and clean. It is also important to understand their many functions, how they add to good ventilation in a room and how technology can help.

Windows and doors can provide the following:

- A means of escape in an emergency.
- A sound barrier and protection from glare.
- Daylight and views, which help us orientate ourselves within the building and can encourage us to go outside into garden areas.
- Ventilation, which gives us fresh air.

These last two functions are what particularly concern us in respect of getting fresh air.

Recommendations:

- Provide windows with low sills so that people sitting in chairs can appreciate the views and be encouraged to go outside and breathe fresh air.
- Insect screens are useful in hot weather to allow wide open windows, whilst preventing access to insects.
- Maximise the flow of fresh air – warm air rises, so airflow works if there are low and high level openings to create circulation.
- Ensure that curtains, blinds and screens do not prevent daylight and fresh air from entering indoor spaces.
- Consider the use of appropriate control systems to ensure the best natural ventilation for older people and those with dementia, and thereby, hopefully avoiding conflicts over whether windows should be open or not.
- Provide balconies and sheltered outdoor spaces – but with awareness of orientation.

Credit: Lisa Broom

Controls – how can technology help?

Windows need to prevent penetration of rain, noise and condensation, to be safe and have visible operating mechanisms suitable for use by older people and those with dementia.

Inevitably, opening or closing windows can lead to conflicts, so the design team should consider carefully the window design, orientation and controls, together with the need for shading devices, blinds or curtains and insect screens, which allow fresh air in without invasion of pests.

Automated window controls can ensure that internal temperatures, CO_2 levels and water ingress are controlled automatically. The simplest form of automated window or louvre control is an open/close electrical switch, operating in response to a sensor in the electrical circuit. Temperature sensors can open a window when a pre-set temperature or pollution level is reached and close the window again, once these levels fall.

- CO_2 sensors can open and close windows to introduce fresh air and/or purge stale air to improve the quality of the indoor environment.
- Rain sensors can automatically close a window to keep rainwater out.

As mentioned before, it is important to take into account an occupant's need to have some control over their environment by ensuring that windows are easy to open and shut with clear mechanisms that are comfortable to us.

However, windows with controls that open or shut windows according to temperature, rain, build-up of CO_2 etc. should be located out of easy visual range of residents so that the automation does not cause confusion and possibly undermine their remaining abilities and independence.

Both high-level windows and high-level roof vents as noted in the section on ventilation above, can provide the answer, as residents will be largely unaware of them.

Case study 2 – Tudsbery Court, phase 2, Craigmillar, Edinburgh, Scotland

Architects: ***Smith Scott Mullan Associates 378 Leith Walk, Edinburgh EH7 4PE***
Client: ***Places for People, Development Agent for Castle Rock Edinvar Housing Association; completed in 2020***

Our site is adjacent to the Thistle Foundation Conservation Area and was the implementation of our earlier Thistle Masterplan from 2007.

Tudsbery Court is a phased development of 222 new homes in a multi-tenure residential development in Craigmillar. It has a wide mix of unit types and sizes including one-, two- and three-bedroom flats and two- and three-bedroom houses.

There are also 32 apartments for older people. These are entered via shared access decks which are designed to enable an increase in social interaction between neighbours.

The detailed design of the individual homes includes large double doors to living spaces, with a 'Juliet' balcony or direct access to a balcony or garden area.

Credit: Smith Scott Mullan Associates, McAteer Photograph

Master bedrooms are provided generally with 'Juliet' balcony full height windows, allowing generous light to the rooms and views out over the gardens or streets. In addition, there are smaller ventilation windows generally used for night-time ventilation.

All the apartments for older people overlook the 'sunken garden' specifically allocated to this part of the development, where the older residents can meet and participate in activities.

The design of the garden areas and provision of seating encourages the residents to use the outdoor spaces, meet, interact and feel part of a community.

LESSONS LEARNED

The importance of generous space standards, larger windows maximising fresh air, daylighting and views out formed an important part of the brief for Tudsbery Court. This has resulted in high levels of customer satisfaction.

Credit: Smith Scott Mullan Associates, McAteer Photograph

Credit: Smith Scott Mullan Associates

The landscaping is at an early stage but will provide attractive outdoor seating areas viewed from the housing.

Case study 3 – Tudsbery Court, phases 3 and 4, Craigmillar, Edinburgh, Scotland

Architects: ***Smith Scott Mullan Associates 378 Leith Walk, Edinburgh EH7 4PE***
Client: ***Places for People, Development Agent for Castle Rock Edinvar Housing Association; completed in 2020***

The small private gardens with low fences have been popular as, whilst segregated from the shared garden areas, they feel part of the whole and encourage increased communication with neighbours. Housebuilders tend to want 1.8m high fences to all private gardens, but these discourage communication and also shade the outdoor spaces.

LESSONS LEARNED

Larger windows are popular as rooms are brighter and enable good views out and natural surveillance of the garden areas as well as good ventilation. The shared gardens have been well used and looked after by the residents, encouraging outdoor recreation.

Credit: Smith Scott Mullan Associates, McAteer Photograph

Case study 4 – Heath View, Congleton, England

Architects: ***Pozzoni Architecture, Woodville House, 2 Woodville Road, Altrincham, WA14 2FH***
Client: ***Plus Dane Housing; completed in 2010***

This development provides extra-care 45 flats and the whole site is accessible by wheelchair.

As shown in this photo, the design is an excellent example of the provision for residents of large windows, balconies and garden areas.

The windows and balconies provide fresh air and encourage use of the outdoor facilities because the environment is so attractive and welcoming.

Credit: www.jameswhitephotography.co.uk

Case Study 5 – Villa Lyhde, Viherlaaksonranta 8, 02710, Espoo, Finland[77]

Villa Lyhde is a home providing care for people with dementia, comprising two households of 12 dementia residents each plus day-care.

It has views over a lake and beautiful grounds for use by the residents.

The overhanging roof provides shelter from sun, rain and snow in the winter, allowing residents to access the outside and breathe fresh air.

Shading devices

- Outdoor canopies to limit heat build-up through glazing and provide shade for those wanting to sit outside. These can be fixed or retractable and can allow people to sit outside in the fresh air even when raining.

The following features can help:

- Indoor blinds or curtains prevent glare and discomfort (but take care that they do not cause a reduction in daylight levels).
- Insect screens allow fresh air through open windows and doors without invasion of pests. It's important that the mesh is fine so that views out are not obscured and some may also provide glare reduction. A particular benefit, apart from allowing in fresh air, is that this can cut down on insect repellent sprays etc. which can contribute to poor internal air quality.

Credit: Damian Utton, Pozzoni Architecture

Case Study 6 – Gradmann Haus, Fohrenbuehlstrasse 10, 70569, Stuttgart-Kaltental, Germany

This provides for 24 residents with severe dementia in two households, 12 day-care (moderate and severe dementia) and also 18 assisted living residents on the site. The secure garden can be accessed from the street or the east lounge and allows for a looped path, seating areas and gardening activities. The open side of the garden faces a heavily wooded area. There is also a small internal courtyard.

Credit: Damian Utton, Pozzoni Architecture

These photos show the external roof overhang and external blinds which are vital for controlling heat gain in the summer as well as glare the year round. It also has a green roof as part of the design for thermal insulation and rainwater management with rooflights for daylight and ventilation into central areas. Find out more at: www.demenz-support.de

Case study 7– HammondCare Darlinghurst inner city aged care, Australia

Architects: ***Integrated Design Group***

HammondCare Darlinghurst is a purpose-built, residential aged care home for older people experiencing homelessness, or at risk of homelessness, with high care needs.

Located in inner Sydney, Australia, the home helps fill a gap in existing services by providing permanent accommodation and high-level health care to those experiencing homelessness in an area where services are needed most – the inner city.

The five-storey building accommodates 42 private bedrooms with ensuite shower rooms. The building is divided into four apartments of 11 or 9 bedrooms each and each apartment has a dedicated domestic-style kitchen where all meals are prepared for the household, as well as a dining room, lounge areas and outdoor spaces.

The building and its interiors are designed to make residents feel comfortable and at home, especially those who require specialised dementia and psycho-geriatric care. The overriding purpose is to help restore dignity and maximise independence for its residents.

The inner-city location presented challenges to maximise airflow and access to the outdoors for residents. This challenge was addressed with the following measures:

- access to private balcony spaces in most bedrooms
- prioritisation of openable windows/french doors in bedrooms and living spaces
- use of glazed louvres to maximise air flow and give control to the residents
- use of folding-sliding doors to the courtyard and internal balconies – blurring the boundary between inside and outside
- use of a courtyard space increasing the external envelope and maximising cross-ventilation.

Each living area has direct balcony access

Attractive views encourage time spent outdoors (left). Central courtyard area provides green space and maximises air flow (right).

Chapter 5
Planting considerations

1. Landscaped outdoor spaces

Access to an attractive outdoor space should always be provided for residential accommodation. It can provide a welcome respite to less than perfect indoor air quality if windows have been shut for too long, as well as a sense of peace and wellbeing.

Planting can also help to mitigate poor outdoor air quality, in both private open spaces and in parks and streets.

Careful thought has to be given to how to achieve good results for older people and those with dementia. For example, plants that are highly perfumed may be a delight to some people with dementia – yet overpowering for others. Reference should be made to *The Room Outside: Designing outdoor living for older people and people with dementia*, published by HammondCare in 2018.[78]

Credit: Annie Pollock

2. Planting to mitigate air pollution

Trees and street planting

There have been many studies looking at whether trees and shrubs can help reduce poor outdoor air quality. A recent study[79] by the UK's DEFRA concluded that:

> *Overall, vegetation and trees in particular are regarded as beneficial for air quality, but they are not a solution to the air quality problems at a city scale*

Another study[80] concluded that:

> *...greater concentration of trees contributes to better local air quality.*

But that:

> *...species with severe allergenicity can increase local asthma hospitalisation rates.*

The dimensions of a street can affect the ability of trees to ameliorate air pollution – one study[81] concluded that, in urban streets (usually canyon-shaped with high buildings on both sides of the road), trees generally have a negative impact on air quality, whilst low level dense vegetation, e.g. hedges, generally has a positive impact as it traps emissions from car exhausts. On open roads, thick dense vegetation has a positive impact on air pollution, evergreen species of trees being the most useful.

A study in January 2019[82] noted that hedges (or a combination of hedges and trees) are the most effective in combating near-road pollution and that this can cut black carbon by up to 63%. Black carbon (or soot) is part of fine particulate air pollution (PM2.5) and contributes to climate change. The health effects of PM2.5 are discussed in chapter 1 of this book.

The diagram below shows graphically the effect of trees and hedges on air quality and is based on the original in this study, but using different photographs.[83]

Another benefit of trees and green spaces in urban environments is that they can reduce urban air temperatures.[84]

Not all trees are useful in reducing pollution and within different countries, the preferred species of tree will vary according to climate, location and exposure. However, irrespective of the country and climate, the plant traits which can be linked with better particulate capture include:

- being in leaf all year
- a large canopy leaf area
- a high canopy density that is still porous enough to allow air movement through it
- wrinkled leaf surface, the presence of micro-roughness, veins or hairs.[85]

More research is needed, but there is no doubt that, carefully located, the right species of trees and hedges can help reduce outdoor air pollution as well as providing an attractive environment.

Where possible, evergreen trees and hedges are preferable, so that their mitigating effects can continue during winter months when deciduous trees lose their leaves. Species that work well in this respect will vary according to country and climate.

A recent report by the Royal Horticultural Society in 2020 noted that *Cotoneaster franchetii*, a 'bushy, hairy-leafed cotoneaster', is a 'super plant' because of its special ability to fight pollution by trapping harmful airborne particles. This plant will grow in many countries and is over 20% more effective at soaking up pollution compared to other shrubs.[86]

Recommendations:

- Understand the characteristics of different trees and as a result, choose species with care, appropriate for the climate and location.
- Understand that some trees are better at cooling than others.
- Be aware that some trees are better at removing pollutants than others,[87] but that some species can produce allergens and therefore can pose risks to people.[88]

Green walls

Growing plants vertically on building walls, generally referred to as 'living walls', could remove nearly 10 times as much NO_2 and nearly 12 times as much PM10 from street-canyon air as horizontally grown rooftop vegetation.[89]

However, the right kind of greenery needs to be used. The *New Scientist* magazine described the use of moss-covered walls to clean city air, and cited studies in Germany, the Netherlands and Australia.[90] Although not shown to be particularly effective along busy bus routes, they may be more useful in 'urban canyons' where trees alone can be counterproductive in reducing air flow. In July 2019, one of London's most polluted primary schools installed a 126-metre-long green wall of some 12,000 plants to block and absorb harmful pollutants from reaching schoolchildren in the playground. Monitoring showed a drop of NOx by about 90%.[91]

Credit: Kongphop Petwichai

Case study 8 – Murrayside Care Home, Edinburgh

Architects: ***BPA Architecture;*** **Client:** ***Care UK; completed in 2018***

Credit: Care UK

Murrayside Care Home which opened in 2018, has 'green walls' installed around its garden areas.

Whilst this was primarily to screen concrete retaining walls, the green walls will also improve outdoor and indoor air quality for the residents – and will encourage them to venture outside too.

In this case, the evergreen plant used was Ivy (*Hedera helix*).

LESSONS LEARNED

There are very many advantages to green walls apart from the visual ones, including improvements to air quality and feelings of wellbeing for the residents.

Case study 9 – Bosco Verticale, Milan, Italy

Architects: ***Stefano Boeri Architects,*** www.stefanoboeriarchitetti.net***; completed in 2014***

Bosco Verticale, one of the biggest European redevelopment projects, consists of two residential towers containing 400 condominium units. The largest is 26 floors and 110 metres high and the smaller is 18 floors and 76 metres high.

This project was designed as part of the rehabilitation of the historic district of Milan between Via De Castillia and Confalonieri in Porta Nuova.

Credit: Dimitar Harizanov and Stefano Boeri Architects

A BBC programme in October 2019[92] looked at whether 'vertical forests' could improve our cities and health and cited Bosco Verticale as an outstanding example.

The benefits of the Bosco Verticale project are:

- The trees and plants absorb carbon dioxide and produce oxygen.
- They remove gas from the air that adds to global warming.
- The overall scheme used 900 trees, 5,000 shrubs and 11,000 other plants.
- Maintenance considerations have been designed in from the outset.
- The planting adds insulation from heat and cold to the building fabric.

The great advantages are cleaner air for residents, insulation to the building fabric, and of course the sense of wellbeing and pleasure for all living there.

This philosophy could be used for smaller projects such as housing for older people and those with dementia, and in addition to the benefits noted above will provide wildlife interest as well.

LESSONS LEARNED

Resident Simona Pizza noted:

> *Having these plants right on the terrace, real trees, has certainly had a positive impact on my life. It brings [the] temperature down in the summer and it feels like these plants have generated a microclimate, it's very pleasant.*
>
> *It's fresher and more ventilated, especially at certain times of the day.*[93] *Without trees and plants, the windows and dark exterior would trap a lot more heat.*

The design has also had an effect on individual energy use:

> *In the winter, we use less heating thanks to this greenhouse effect and in the summer, we use less air conditioning because the air is cooler.*

Credit: Laura Cionci and Stefano Boeri Architects

Green roofs

A study in Chicago showed that a total of 1,675 kg of air pollutants was removed by 19.8 ha of green roofs in one year with ozone (O_3) accounting for 52% of the total, NO_2 (27%), PM10 (14%), and SO_2 (7%).

The 20,300 square foot City Hall rooftop garden has over 20,000 herbaceous plants installed as plugs of more than 150 varieties including 100 woody shrubs, 40 vines and 2 trees – a Cockspur Hawthorn (*Crataegus crus-galli*) and Prairie Crab Apple (*Malus ioensis*).[94]

Find out more at https://www.greenroofs.com/projects/chicago-city-hall/

Another study, a collaboration between Imperial College London and a startup 'Arborea', has developed a system under which tiny plants can be grown across large platforms and installed like solar panels on top of various buildings and landscapes. According to researchers, this system uses photosynthesis to purify the same amount of air as 100 trees – all while taking up the same amount of space as a single tree.[95]

Chicago City Hall. Credit: Roofmeadow Services Inc., www.roofmeadow.com

Recommendations:

- Consider establishing green walls along boundaries of care facilities in areas where outdoor air quality is poor – this will help to reduce pollution of CO_2 and NOx emissions.
- Understand that green walls on buildings can add another layer of insulation, reducing heat gain and heat loss.
- Green roofs are also worth considering too, according to current studies, but the additional weight of these must be taken into account at design stage.

Undoubtedly, selected with care and understanding, planting can significantly help to reduce outdoor air pollution as well as making a much more attractive environment for us to live in.

3. Indoor planting

When it comes to the impact of indoor plants on air quality, the jury is still out. Studies vary enormously on whether indoor plants can help or not. One study[96] notes:

> *Plants can improve indoor air quality (IAQ) by simultaneously taking up CO_2 and releasing O_2 through light-dependent photosynthesis, and increase air humidity by water vapor transpired from leaves through microscopic leaf pores, namely stomata.*
>
> *In addition, indoor air pollutants can passively collect on the external surfaces of the complete root–soil system of the plant and, thus, be effectively removed.*

But the *National Geographic Magazine* notes in November 2019:[97]

> *Bringing plants indoors can provide a number of benefits, but cleaner air isn't one of them, say experts.*
>
> *Plants, though they do remove VOCs, remove them at such a slow rate that they can't compete with the air exchange mechanisms already happening in buildings.*

Recommendations:

- Keep up with current research, but at present, don't rely on plants to improve poor indoor air quality.
- Recognise the pleasure that indoor plants can give all of us, in particular older people and those with dementia – and that caring for them is therapeutic for many people.
- Take care that no part of the plant is toxic or harmful to people with dementia.
- Ensure that plants are well maintained in bright locations.
- Avoid plastic plants, as they can contribute to poor general air quality due their manufacturing processes, and indoors, they harbour dust. When discarded, they add to plastic pollution.

Credit: sasilsolutions

Appendix 1

Lessons learned from the COVID-19 pandemic and forest fires

1. COVID-19

Credit: sturti

At the time of writing this book, the pandemic is present in many countries worldwide. There have been several studies of the role of air quality in the spread of the virus, which may well change and develop as knowledge and understanding of this and other similar diseases is gained.

The pandemic disproportionately affects people of colour and those of older age. In many countries, people in care homes (many of whom have dementia) have been particularly badly affected, resulting in a significant number of deaths. At the date of writing this, approximately half of the total number of deaths from the virus had occurred in care homes.[98]

In Australia in 2020, nursing home residents represented 7.5% of all COVID-19 cases and 75.3% of all COVID-related deaths.[99]

Research has also shown that people with a genetic variant that increases the risk of Alzheimer's dementia also have a greater chance of developing severe COVID-19.[100]

Ventilation and internal air quality

During the current pandemic, it has been suggested that in some cases, in addition to other routes, COVID-19 may have spread around care homes through the ventilation system and in this situation, advice from the UK's Health and Safety Executive notes that if a centralised ventilation system removing and circulating air to different rooms is in use, then re-circulation should be turned off and a fresh air supply used instead.[101]

A report by the Federation of European Heating, Ventilating and Air Conditioning Associations reinforced this, noting that:

> *Well-maintained HVAC systems, including air-conditioning units, securely filter large droplets containing SARS-CoV-2. COVID-19 aerosols (small droplets and droplet nuclei) can spread through HVAC systems within a building or vehicle and stand-alone air-conditioning units if the air is recirculated.*[102]

Interestingly, the budget airline, Ryanair, when returning to flying after the first lockdown due to COVID-19 in 2020, stated that one of their priorities was to install highly efficient particulate air (HEPA) filters on all its aircrafts, noting that:

> *…HEPA filters are designed to remove more than 99% of airborne microbes from the cabin, including SARS-CoV-2 droplets, and to continuously clean the air onboard. As a result, the air in the cabin is comparable with the sterile environment of a hospital operating theatre.*[103]

External air quality

During the first lockdown in the UK, studies showed some improvement in outside air quality, due to the reduction of commuting and people using their cars.[104]

But other interesting effects have emerged too.[105] Once lockdown was eased, the reluctance to use public transport resulted in an increase in the use of private cars and an associated increase of air pollution.[106]

Air pollution may affect the spread of coronavirus. As well as predisposing the people who have lived with polluted air for decades, scientists have also suggested that air pollution particles may be acting as vehicles for viral transmission.[107] This means that tackling air pollution may be a critical factor in tackling the virus.

An article in *The Guardian* newspaper (13th July 2020)[108] stated:

> *There is 'compelling' evidence that air pollution significantly increases coronavirus infections, hospital admissions and deaths, according to the most detailed and comprehensive analysis to date. and refers to research by Harvard.*[109]

A particularly interesting aspect of this article is that:

> *The study of the outbreak of COVID-19 in the Netherlands is unique because the worst air pollution there is not in cities but in some rural areas, due to intensive livestock farming, which produces large amounts of ammonia. These particles often form a significant proportion of fine particulate matter in air pollution. This study was carried out by Professor of Environmental Economics, University of Birmingham.*[110]

Professor Matthew Cole, who was part of the team that conducted the research, said, 'We used data at much finer resolution, with the average size of the 355 Dutch municipalities being 95 km^2 compared to the 3,130 km^2 for a US county.'[111]

The most prominent previous study was conducted by Harvard University researchers and found an 8% increase in coronavirus deaths for a single-unit rise in fine particle pollution.

Internal air quality

> *Deterioration of indoor air quality (IAQ) might result from the current home isolation requirement that is in place to reduce the spread of coronavirus disease (COVID-19). Ventilation itself can also be viewed as source of contamination and exposure.*[112]

In respect of public buildings, leading scientists from across the world have signed a petition that calls on the World Health Organization (WHO) to take 'swift and decisive action' on indoor air quality in public buildings to help to curb the spread of coronavirus:

> *An indoor humidity level of between the 40%–60% relative humidity (RH) is the optimum threshold for inhibiting the spread of respiratory viruses such as influenza. The petition is designed to not only increase global awareness among the public on the crucial role indoor environmental quality plays in physical health, but also to call on the WHO to drive meaningful policy change, which they say will be a 'critical necessity' during and after the coronavirus crisis. The scientists point to research that shows that breathing dry air impairs our respiratory immune system's ability to efficiently capture, remove and fight airborne viruses and germs, rendering us more vulnerable to respiratory infections such as COVID-19.*[113,114]

In the case of vulnerable people (and this includes older people and those with dementia) resilient passive solutions are clearly preferable to mechanical solutions that may introduce noise, pollution and maintenance requirements and present a risk if they fail, which could happen due to lack of maintenance and/or power cuts.

Lastly, it is suggested that vitamin D deficiency may be implicated in COVID-19. Given that many older people and those with dementia generally spend a lot of time indoors and ever more so during this pandemic, vitamin D deficiency may be a contributory factor to the high death rate amongst older people and those in care homes.

> *There is ample evidence that various non-communicable diseases (hypertension, diabetes, CVD, metabolic syndrome) are associated with low vitamin D plasma levels. These comorbidities, together with the often concomitant vitamin D deficiency, increase the risk of severe COVID-19 events.*
>
> *In the meantime, eight studies have started to test the effect of supplementing vitamin D in different dosages (up to 200,000 IU) on the course of the COVID-19 disease. The aim is to clarify whether supplementation with vitamin D in different dosages has an influence on the course of the disease or, in particular, on the immune response, or whether it can prevent the development of ARDS [acute respiratory distress syndrome] or thromboses.*[115]

Observations

- People who carry two copies of the e4 variant of the *APOE* gene, which is known to increase the risk of developing Alzheimer's disease, doubles the risk of COVID-19 or becoming unwell. Whilst this is an interesting study, it has not yet been peer reviewed.
- Airborne infection from COVID-19 is more likely indoors than in the outdoor environment.
- Ventilation systems must bring in full fresh air and not circulate existing air.
- Siting buildings for particularly vulnerable groups of people (e.g. care homes) should take into account long-established concerns about traffic noise and pollution alongside the findings that are beginning to be emerge on air quality and COVID-19.
- It appears that intensive livestock and mink farming may exacerbate the airborne spread of COVID-19 and so ideally because of this and the health risks from the ammonia produced, it's advisable to avoid using sites for residential development that are close to livestock farms.

Two reports produced during the COVID-19 outbreak are worth reading in detail.

The first is:

Design and Cost Considerations in Extra Care Housing (2020), written by Pozzoni Architecture and co-produced with Housing LIN.[116]

Excerpts from the section on 'Considerations for Infection Control' are below:

> *COVID-19 has impacted on every aspect of our lives and has caused registered providers and their consultant teams to reassess their building management protocols and the design and cost implications to mitigate the spread of COVID-19, NoroVirus, flu and other transmittable infections and viruses.*
>
> *Many issues concerning managing the spread of infection can be addressed by careful building management and with the COVID-19 pandemic, most registered providers are providing care and support by adapting their practices rather than needing to change their buildings.*
>
> *However, there are elements to the design of extra care housing to be considered which may reduce transmission risk of infection and reduce pressure on building management.*

It notes these design elements as:

- social distancing:
  - circulation spaces of wider corridors and passing places in corridors
  - larger common areas
  - a one-way system for stairs and/or circulation areas
- apartments grouped in clusters or wings, which could be isolated in the event of illness
- avoiding pinch points in circulation, e.g. providing alternative access routes to gardens and common areas
- balconies for everyone to have access to outdoor space
- larger garden areas with wide paths, one-way routes, distance seating etc.
- better use of natural ventilation
- gallery access or single banked corridors to reduce the number of people using a corridor
- adaptable and flexible use of spaces
- separate staff/visitor and resident entrances and exits to reduce the risk of infections being introduced into the scheme
- staff changing and visitor screening near entrances PPE storage, hand wash/ hand sanitising stations
- technology to restrict the number of people in a lift
- technology to enable social contact between residents/staff/relatives.

Many of these design decisions such as wider corridors and larger common areas will have cost implications. Others may not be practical for people with mobility impairments or dementia. Assessment of the practicality, cost and programme implications of such design decisions is an essential part of the briefing process for both new-build and adaptations to existing extra care schemes.

Credit: Damian Utton, Pozzoni Architecture

The second is:

The 2021 COVID-19 Guidance (Version 4.1) by Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA).[117]

This contains advice on the operation and use of building service systems during an epidemic of COVID-19 to reduce its transmission. It is written in a user-friendly way with some good illustrations and provides good information relating to the risks of COVID-19 and ventilation.

Amongst its many recommendations, it notes that openable windows should be actively used, more than normal – even if this does cause some thermal discomfort. Windows should be opened for about 15 minutes when entering a room and especially when the room has been occupied by other people beforehand.

Even in buildings with mechanical ventilation, opening windows can further boost ventilation.

Conversely, opening windows should be avoided in toilets to maintain negative pressure and the right direction of mechanical ventilation air flows.

Case study 10 – HammondCare cottage model, Australia

HammondCare is an independent Christian charity specialising in dementia and aged care services. Their model of care for people living with dementia is based around small, home-like 'cottages,' each housing a small number of residents.

The design of each HammondCare cottage is guided by a research-driven design framework which aims to promote autonomy and self-esteem for residents.

Design features:

- domestic and familiar
- small in size and scale
- unobtrusive safety features
- reduce unwanted stimuli
- scope for ordinary activities
- different spaces, different uses
- support walking and wayfinding
- easy access to safe outside spaces
- multiple consistent cues for orientation
- scope for personalisation
- community connection.

Several of these design features have also proved beneficial during the COVID-19 pandemic, particularly the size of the cottages and the focus on access to the outdoors.

A home, not a facility

Cottages that are small in size and scale (typically 8–15 residents) operate more like a domestic home than a care facility. This scale of residence is easier to quarantine during a viral outbreak, and can operate self-sufficiently with kitchen and laundry facilities, reducing the need for contact with outside providers. The model of staffing ensures a consistent team in each cottage, which not only helps staff and residents to get to know each other better, but during the COVID-19 pandemic has also assisted in reducing movement across the site and enables care teams to be more easily isolated when required.

The small scale of HammondCare's cottages and apartment layouts allows naturally good cross ventilation within the buildings.

In addition, all HammondCare cottages feature window operation which is independent from mechanical air systems, allowing residents themselves to control their own environment, and optimising air flow from outdoors without sacrificing comfort during the hot Australian summer.

Something for everyone

Every cottage has easy access to its own dedicated outdoor spaces, providing residents with essential fresh air, sunshine, awareness of weather, time passing (hours and seasons) and opportunities to do meaningful things. The small scale of the cottages means that spaces can be personalised to meet residents' needs and thus be more appealing to spend time in. In Woy Woy (New South Wales) residents have their own lawn bowls green; at Caulfield Village (Victoria) the maintenance shed is open for interested residents to participate in gardening and maintenance activities, while the BBQ facility enables daytime work to turn into evening relaxation. Other cottages provide children's playgrounds to entertain visiting grandchildren and all have backyard clothes lines to create a home-like feel.

Bowling green at Woy Woy

Easy access to an appealing space

To encourage people to go outside, outdoor spaces are situated close to living areas – typically opening directly from the main living space. The doors are visible and unlocked 24/7 and the outdoor space is designed to be safe and secure. This means residents are more able to go outside independently when they want.

The outdoor areas provide shelter and clear wide pathways to facilitate wayfinding. A sheltered area outside each exit allows people to venture outside even in hot or rainy weather. Older people's eyes take longer to adjust to light levels, so having a covered entrance means that there will be a more gradual change in light level between inside and outside.

Out of sight, out of mind…

HammondCare's design principles recognise that if we want people to use outdoor spaces, they need to be able to see them. In addition, a view of nature is good for general wellbeing. For this reason, all of HammondCare's purpose-built residential homes have outdoor spaces next to the living areas and have windows and glazed doors to help people see out.

Backyard with traditional clothes line at Harding Cottage, Hammondville

2. Forest and bushfires

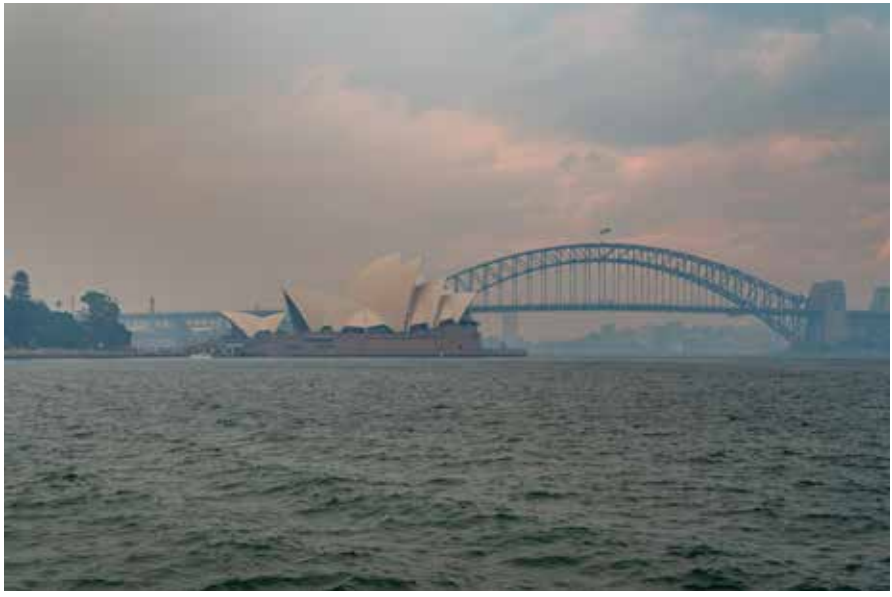
Recently there have been devastating bush and forest fires in Australia, Brazil, California and Canada. Some are due to logging activities (Brazil) and others to climate change, causing intense summer temperatures, resulting in unseasonably hot and dry conditions.

> *Although wildfires are part of the Australian eco-system and are an important process for regenerating land, these fires are the worst since records began with climate change being partly to blame.*
>
> *An estimated 90% of the total particle mass emitted from wildfires is fine particles, this, therefore, makes particulate matter (PM2.5) the number one public health threat from long-term exposure to wildfire smoke.*[118]

This photo was taken around 9 am north of San Francisco and shows the effect of the forest fires in that region during 2020.

A US document 'Wildfire Smoke: a guide for public health officials' has been revised in August 2019,[119] and offers sound advice on the best actions to be taken during these extreme weather events.

Smoke from wildfires as seen from a balcony in California. Credit: Shiraz Kaderali, California



Credit: DoraDalton

The most common advice is to 'stay indoors' with doors and windows tightly closed. Unfortunately, there is a conflict with advice on COVID-19 for vulnerable residents, which is to avoid ventilation systems which recirculate indoor air. With a wildfire emergency, to prevent smoke inhalation, ventilation will have to be recirculated because the highly polluted, smoky outdoor air would likely pose a bigger danger to life than the pandemic.

Recommendations:

- Clean, replace, upgrade as necessary the filters in mechanical ventilation systems whenever the risk of wildfires rises. In general, the higher the filter rating, the higher the filter's removal efficiency for at least one particle size range.
- Reduce other indoor sources of air pollution.
- Ensure no smoking during an emergency such as this, even if there is an indoor smoking room.
- For a 'fresh air ventilation system', the fresh air setting should be turned off during smoke events, closing/sealing off outdoor air intakes, but remembering to reset the system once the smoke outside clears.
- An appropriate indoor air purifier may help.
- Using an appropriate N95 or P100 respirators may be beneficial for older residents and those with dementia, if they cannot move to locations with better air quality or take other steps to clean their indoor air. These may also provide some protection against the transfer of infections.

Appendix 2
Current legislation on air quality

Current legislation currently existing in the 'Developed World' (2019–21)

There is no doubt that stronger regulations are needed world-wide, but governments are slow and possibly unwilling to legislate. It is to be hoped that current regulations on air quality will be added to and made more comprehensive with time. CO monitors will generally only be required where there is a carbon fuelled appliance.

This is a brief but not comprehensive overview at the time of writing:

United Kingdom

In the UK, Building Regulations set the standard that apply to all buildings to make sure that they are safe for the people who use them, They vary between the UK nations (England, Wales, Scotland and Northern Ireland) and are mandatory.

The law on smoke and carbon monoxide regulation varies between England and the devolved nations. Generally, it has been mandatory to have alarms in rented accommodation. In Scotland in 2022 (delayed due to the pandemic) it will be mandatory to install fire and smoke alarms in all homes. It is to be hoped that grants will be available to enable this.[120]

British Standard BS EN 50292:20133 – states that carbon monoxide alarms should be fitted in the same rooms as fuel-burning appliances (either wall or ceiling mounted) – such as an open fire, gas cooker or boiler, However, British Standards and other guides on ventilation such as those produced by CIBSE (the (Chartered Institution of Building Services Engineers) are only mandatory if referred to in legally binding documents.

Europe

EU Construction Products Regulation – for VOC emissions, no construction product should cause any harm to the occupants of a building. However, the EU did not specifically detail this requirement, so national regulations may interpret it in different ways.

The EU also rules that the 26 chemicals most likely to cause skin reactions must be declared. But this is further complicated, because many chemicals readily react with ozone in the air to create new secondary compounds, which also affect our indoor environments.[121]

Australia

CO meters are not mandatory and currently there are no specific controls on indoor air quality – apart from workplace situations under the National Occupational Health and Safety Commission.[122]

United States of America

As of March 2018, a majority of states have enacted statutes regarding CO detectors and another 11 have put into effect regulations on CO detectors.[123]

Otherwise there appears to be little other than guidance on indoor air quality.[124]

Most developed countries have specified standards for various building classes for the number of air changes required in different rooms within a building.

So, we can see that a great deal of legislative work is required globally to ensure that our air quality is improved and safe for all residents and in particular, for those who are more vulnerable.

Conclusion

Good air quality is vital to the health and wellbeing of people of all ages – and we should strive to create environments that provide clean air. This requires avoidance of exposure to pollution in all its forms.

Air quality is bound up with climate change and the need to preserve and hopefully enhance biodiversity – all of these are issues of global concern and affect the health of all living beings. Older people and people with dementia are particularly at risk.

Some countries provide an Air Quality Index (AQI) which can alert people on poor air quality. The following are some references that could be followed up, when looking at particular sites for development or during adverse conditions such as forest fires.

The UK: DEFRA, providing advice on air quality https://uk-air.defra.gov.uk/forecasting/

The US: The AirNow website, a multi- agency web site run by EPA that reports air quality using the AQI https://www.airnow.gov

Australia: A Real-time Air Quality Index Visual Map https://aqicn.org/map/australia/

- We need to apply the knowledge we have on air quality in terms of siting care homes and the use of techniques to minimise exposure to pollution.
- We need to make every effort to minimise poor air quality, especially for those who may be unaware of their environment or unable to make decisions, such as children, older people and those with dementia.
- We need to be aware of the wider issues of global warming and the effect it is having world-wide and take action wherever possible.

This book should provide a useful starting point by making people aware of the causes and impact of air pollution on us all and particularly on the more vulnerable people in our society. It will hopefully open up the debate and result in improvements to the benefit of everyone.

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"External and internal air quality play a major role in how our physical environment supports or undermines our health and wellbeing."

Tom Grey, Senior Research Fellow, TrinityHaus Research Centre, Trinity College Dublin

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Air pollution is a global problem that has far-reaching effects for millions of people every year. *A Breath of Fresh Air* is an important guide to the issue and the impact of older people and people living with dementia who are more vulnerable to poor air quality.

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