



**ARE WE THE INDOOR GENERATION?**

**HOW DID WE GO FROM BEING AN OUTDOOR TO AN INDOOR SPECIES  
IN JUST A FEW SHORT YEARS?**

**WHAT ARE THE PHYSIOLOGICAL AND PSYCHOLOGICAL EFFECTS OF SPENDING  
ALMOST ALL OUR TIME INSIDE BUILDINGS AND VEHICLES?**

**WHAT CAN WE DO TO MAXIMISE THE BENEFITS AND MINIMISE  
THE DANGERS OF MODERN, INDOOR LIVING?**

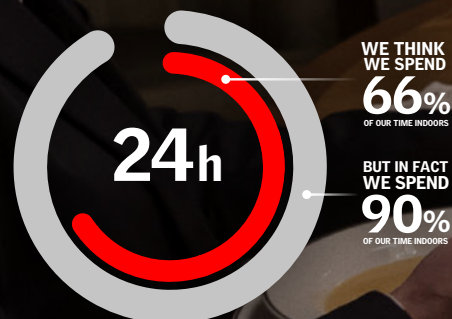
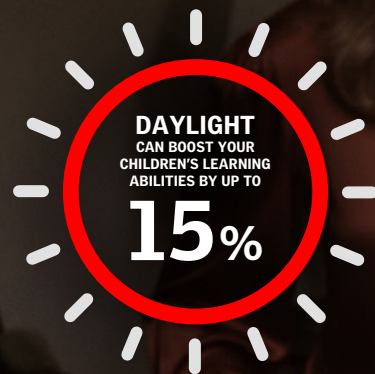
These are just a few of the questions addressed in this publication, which combines new survey data with existing scientific research to describe our bodies' changing relationship with the natural world, as we move away from the outdoor environment and 24-hour solar cycles that governed the human species for hundreds of thousands of years.



The Indoor Generation

## THE EFFECTS OF MODERN INDOOR LIVING ON HEALTH, WELLBEING AND PRODUCTIVITY





**KIDS'**  
BEDROOMS ARE OFTEN  
THE MOST POLLUTED  
ROOM IN THE HOUSE

## RUSSELL FOSTER

"From the year 1800 to 2000, we've moved from 90% of people working outside to less than 20%. In a very short space of time, we've gone from being an outdoor species to spending most of our time in dim, dark caves."

Russell Foster, head of the Nuffield Laboratory of Ophthalmology and the Sleep and Circadian Neuroscience Institute, University of Oxford.



# WE ARE THE INDOOR GENERATION

Health is a hot topic nowadays. Year after year we increase our expenditure on fitness clubs and yoga, on exercise trackers and equipment, yet we spend more time indoors than ever before. We are becoming a truly indoor generation.

Never before has our life been such an elaborate mix of commuting, indoor work and indoor activities, detaching us from the natural world that has been the driving force behind our evolution as a species.

## THE EFFECTS OF MODERN, INDOOR LIVING

Over recent decades, scientific research has provided increasingly consistent evidence of the negative effects that today's sedentary indoor lifestyle can have – and is having – on people's health.

Limited fresh air and light during the day can negatively impact mood, sleep and performance, while our respiratory systems suffer in unhealthy indoor environments.

## PERCEPTION VS REALITY

This report sheds light on the phenomenon of indoor living, and examines the gap in perception between the way we think we live and the way we actually do. It takes a look at why this is important. And it makes practical suggestions as to how we might make improvements that will benefit ourselves, our families, and society as a whole.

## THIS REPORT

The conclusions of this report are derived from a new survey, conducted in cooperation with the analysis institute YouGov, alongside existing data from different published scientific studies and papers.

For the YouGov survey, approximately 16,000 online interviews were performed in March 2018 with members of the general public in 14 countries across Europe and North America. Data is weighted on the dimensions of gender, age and region to ensure representative results.

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# YOU'RE PROBABLY INDOORS MUCH MORE THAN YOU THINK

Home, school, work, back again... We're spending more time indoors than ever before. But just how much? And are we even aware of it?

Our survey asked people how much time they spend indoors and 82% of respondents said they spend less than 21 hours indoors each day, with 62% thinking they actually spend less than 18 hours inside. On average, respondents think they spend 66% of their time indoors.

However, we know that on average, people actually spend 90% of their time (or nearly 22 hours per day) indoors<sup>1,2</sup>. These findings unveil a significant disconnect between our perception and the reality.

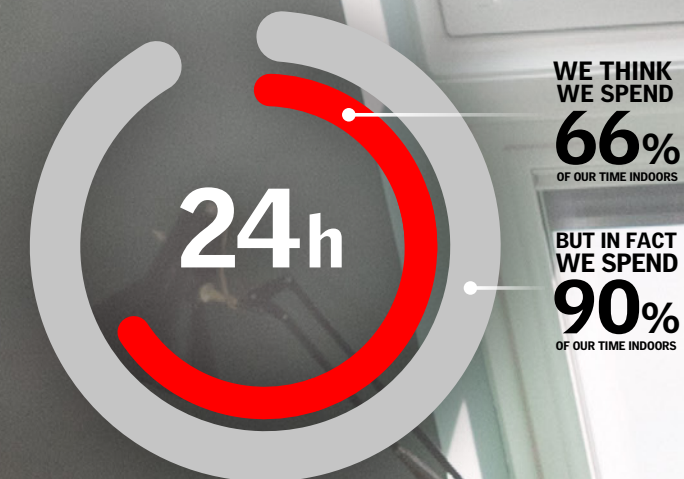
## WHY SHOULD WE BE CONCERNED?

For two main reasons, which we will explore in more detail on the following pages.

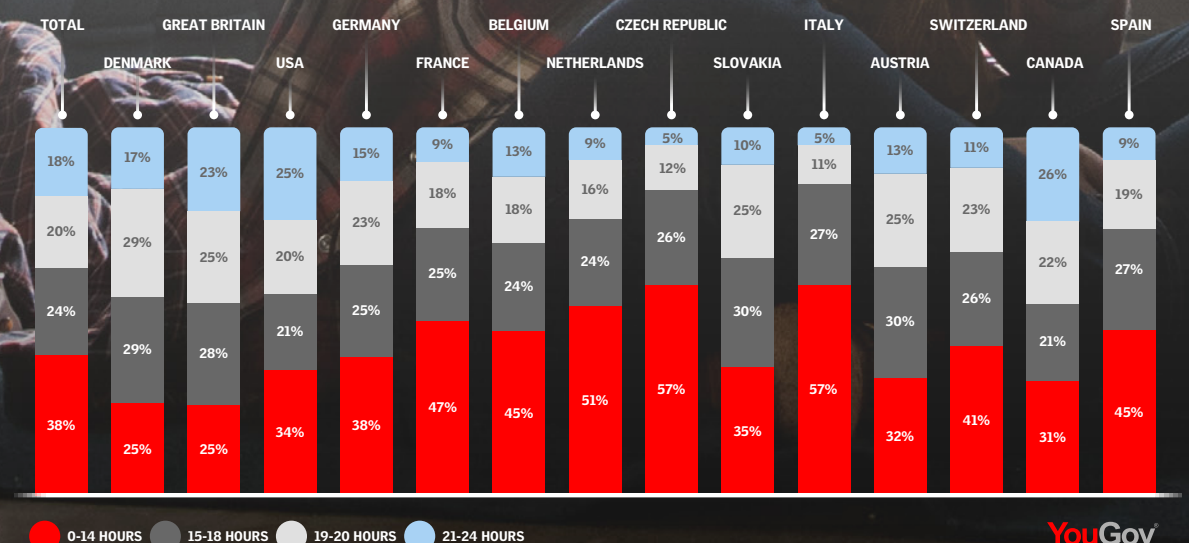
Firstly, the air inside buildings tends to be more polluted than the air outdoors, even in large cities. This pollution brings with it a host of potential associated ailments including irritation of eyes, nose and throat, along with coughs and other respiratory illnesses.

Secondly, being indoors cuts us off from the natural 24-hour cycle in which we evolved as a species. Chronobiologist Till Roenneberg reports that an average employee on an average working day spends just 15 minutes outdoors during the daytime<sup>3</sup>. This figure is based on responses from several thousand people via online questionnaires. Electric light, digital devices and a 24-hour society have increasingly isolated us from the rhythms of nature. This can disrupt our natural circadian rhythm (the 24-hour body-clock that anticipates and adapts our physiology to the different phases of the day), with a severe impact on sleep quality and general health.

We need to be more aware, as individuals and as a society, of the disconnect between the way we think we live and the way we actually do. This will lead to a better understanding of the way modern life affects our health and physiology so we can live - and feel - better.



## HOW MUCH TIME DO YOU THINK YOU SPEND INDOORS DURING AN AVERAGE 24 HOUR DAY?



<sup>1</sup> World Health Organisation. Combined or multiple exposure to health stressors in indoor built environments. <http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2014/combined-or-multiple-exposure-to-health-stressors-in-indoor-built-environments>

<sup>2</sup> United States Environmental Protection Agency. Report on the Environment (ROE). <https://cfpub.epa.gov/roe/chapter/air/indoorair.cfm>

<sup>3</sup> Till Roenneberg. Life between Clocks: Daily Temporal Patterns of Human Chronotypes. [https://www.researchgate.net/publication/10917322\\_Life\\_between\\_Clocks\\_Daily\\_Temporal\\_Patterns\\_of\\_Human\\_Chronotypes](https://www.researchgate.net/publication/10917322_Life_between_Clocks_Daily_Temporal_Patterns_of_Human_Chronotypes)

All numbers are rounded due to readability. Decimal numbers can be provided per request. Total sum is weighted against country population size.



# YOUR HOME IS PROBABLY POLLUTED

The air we breathe is just as important as the food we eat or the water we drink. An average adult breathes in around 15,000 litres of air every single day.

As our cities grow, outdoor urban pollution is high on the agenda, and is top of mind for many people. However, you may be surprised to find out that in fact, the air inside our homes can be up to five times more polluted than the air outdoors<sup>1</sup>.

According to the YouGov survey, 78% of people are unaware that indoor air is more polluted than outdoor air, let alone that it can be up to five times more polluted.

## HOW DOES THE AIR INDOORS GET SO BAD?

The air inside your house starts off pretty much the same as the air outside, carrying whatever pollution is already present from the outdoor environment. Then you need to add in pollutants that emanate from toxic materials inside, such as building materials, cleaning products, furniture, plastics, toys, etc. Then add human activities such as cooking, burning candles, drying clothes indoors, etc. And not forgetting what we do all day long: breathing – a typical family of four emits around 1,800 litres of CO<sub>2</sub> and 10 litres of water<sup>2</sup> into the atmosphere every single day, just by breathing.

## WHAT ARE THE EFFECTS?

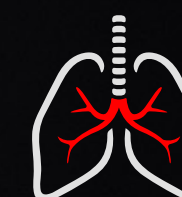
Poor indoor air quality can lead to short-term symptoms such as: irritation of the eyes, nose, and throat; headaches; dizziness; and fatigue. Long-term effects can be more severe, including respiratory diseases, asthma, chronic obstructive pulmonary disease (COPD) and heart disease<sup>3</sup>. In fact, people are 40% more likely to have asthma when living in damp or mouldy homes, and today 2.2 million Europeans have asthma as a result of their living conditions<sup>4</sup>.

The economic costs related to treatment and medical care are significant too, reaching €82 billion per year across Europe, including direct costs related to treatment and medical care, as well as indirect costs such as loss of work productivity<sup>5</sup>.

**8 out of 10 ARE UNAWARE**  
**THAT INDOOR AIR CAN BE UP TO 5 TIMES MORE POLLUTED THAN OUTDOOR AIR**



**KIDS'**  
BEDROOMS ARE OFTEN THE MOST POLLUTED ROOM IN THE HOUSE



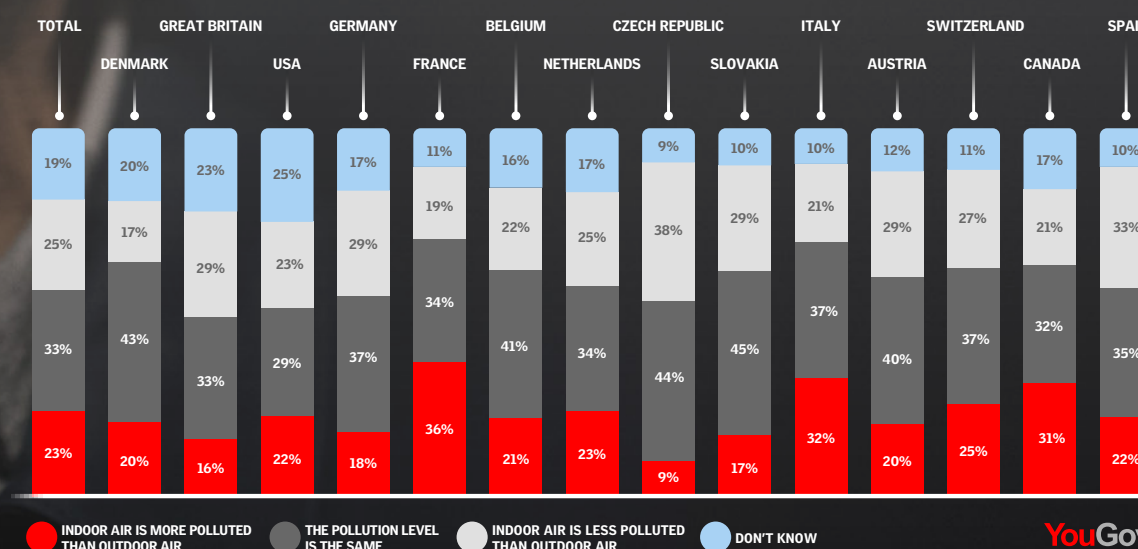
LIVING IN DAMP AND MOULDY HOMES INCREASES THE RISK OF ASTHMA BY **40%**

Fraunhofer IBP



**82 BILLION**  
COST TO EUROPEAN SOCIETY OF ASTHMA AND COPD (DIRECT AND INDIRECT)

## DO YOU THINK INDOOR AIR IS MORE OR LESS POLLUTED THAN OUTDOOR AIR?



<sup>1</sup> United States Environmental Protection Agency: Report on the Environment. <https://cfpub.epa.gov/roe/chapter/air/indoorair.cfm>

<sup>2</sup> British Standard, BS 5250: Code of Practice Control of Condensation of Buildings, 2002.

<sup>3</sup> United States Environmental Protection Agency. Introduction to Indoor Air Quality. <https://www.epa.gov/indoor-air-quality-iaq/introduction-indoor-air-quality>

<sup>4</sup> Fraunhofer IBP. Mould and dampness in European homes and their impact on health (2016).

<sup>5</sup> European Respiratory Society: The European Lung White book – Respiratory Health and Disease in Europe., pp. 16-27.

All numbers are rounded due to readability. Decimal numbers can be provided per request. Total sum is weighted against country population size.



# OUR 24-HOUR CIRCADIAN BODY CLOCK

HELPS TO REGULATE SLEEP, FEEDING, BLOOD PRESSURE AND BODY TEMPERATURE



## DAYLIGHT IS GOOD FOR YOUR MOOD...

Daylight is important for health, physiologically as well as psychologically. Recent studies have shown the significant effects that daylight can have on mood – and the survey suggests that most people are also aware of this fact.

68% of respondents in the YouGov survey believe that daylight has a significant effect on mood. This stands to reason – we all know how a bright sunny day can lift the spirits, and light has even been shown to be an effective anti-depressant. A 2016 study in Canada<sup>1</sup> showed light-box therapy to be several times more effective than the anti-depressant drug fluoxetine in treating non-seasonal depression.

### ...AND STOPS YOU FEELING SAD

It is estimated that approximately 15% of the world's population suffers from different levels of SAD (Seasonal Affective Disorder, or winter depression), with a higher tendency with an increase in latitude, and this may be a direct result of limited exposure to light<sup>2</sup>.

Typical SAD symptoms are fatigue, lack of motivation, feelings of hopelessness and depression, as well as sleep problems. The most effective treatment for SAD is light therapy.

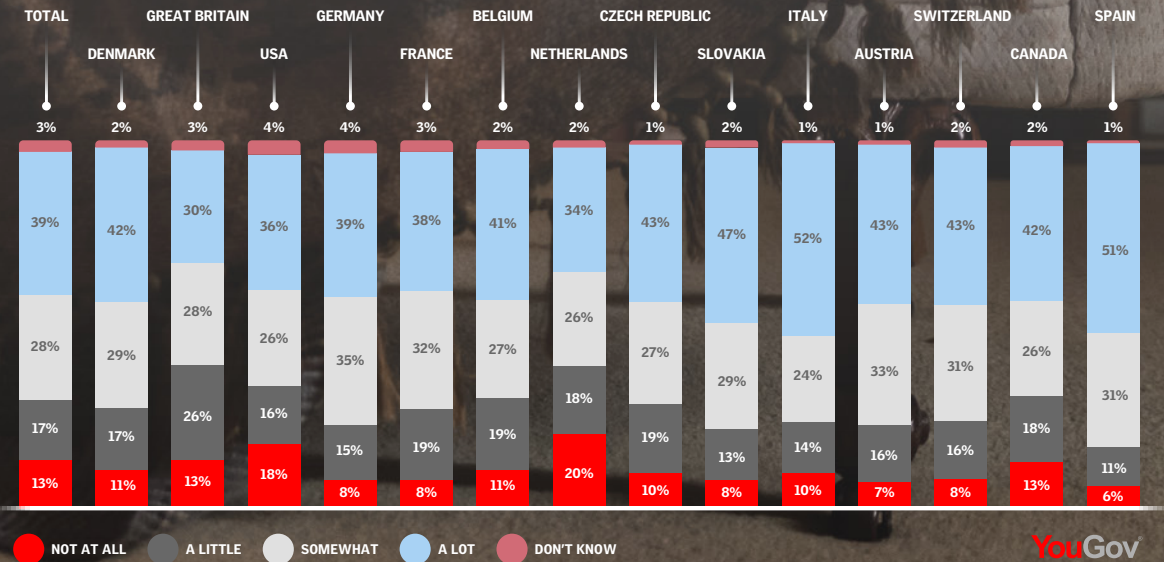
### CIRCADIAN VS VISUAL: HOW MUCH LIGHT IS ENOUGH LIGHT?

One problem is that the amount of light we need for our visual system is much less than the amount we need for our circadian system.

Typical indoor lighting levels of 300-500 lux are comfortable for us to perform the majority of visual tasks, but insufficient in most cases to ensure a robust regulation of our circadian body-clock.



## HOW MUCH DOES DAYLIGHT INFLUENCE YOUR MOOD?



<sup>1</sup> Efficacy of Bright Light Treatment, Fluoxetine, and the Combination in Patients With Nonseasonal Major Depressive Disorder: A Randomized Clinical Trial. Lam RW, et al.

<sup>2</sup> Prevalence of seasonal affective disorder at four latitudes, Kasper et al. 1989.

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# GETTING BETTER SLEEP: NATURE'S BEST MEDICINE

Sleep is absolutely vital to the correct functioning of mind and body, and sleep disorders are associated with a host of health problems. Fatigue, irritability and reduced concentration are obvious ones, but weight gain, heart disease and diabetes are also associated with sleep disorders and can be potentially life-threatening.

## DAYLIGHT (DURING THE DAY) HELPS YOU SLEEP (AT NIGHT)

When asked about the importance of daylight for achieving good quality sleep, 53% of respondents to the YouGov survey said they thought that daylight has a significant effect on sleep. This is indeed the case, with broad scientific acceptance of the importance of light-dark cycles in promoting good quality sleep.

Daylight is the principal cue used by the human circadian clock to regulate the sleep-wake cycle – so we need plenty of daylight during the day, and darkness during the night, to ensure a good night's sleep.

Typical light levels indoors tend to be around 300 lux; sitting by a window you're exposed to around 3,000 lux; while outside you will receive around 10,000-100,000 lux. Outdoor levels of light will easily saturate the retinal ganglion cells in the eye that help regulate the circadian clock in just 30 minutes.

The right dose of daylight in a robust light-dark cycle is crucial for achieving a healthy biological rhythm and balance. Sleep disruption makes us less productive, increases our error rate and leads to poor concentration and memory.

On the other hand, daylight is a physiological and psychological stimulant. It increases alertness, improves mood and wellbeing, while increasing productivity and learning ability, with substantial benefits for society as a whole.

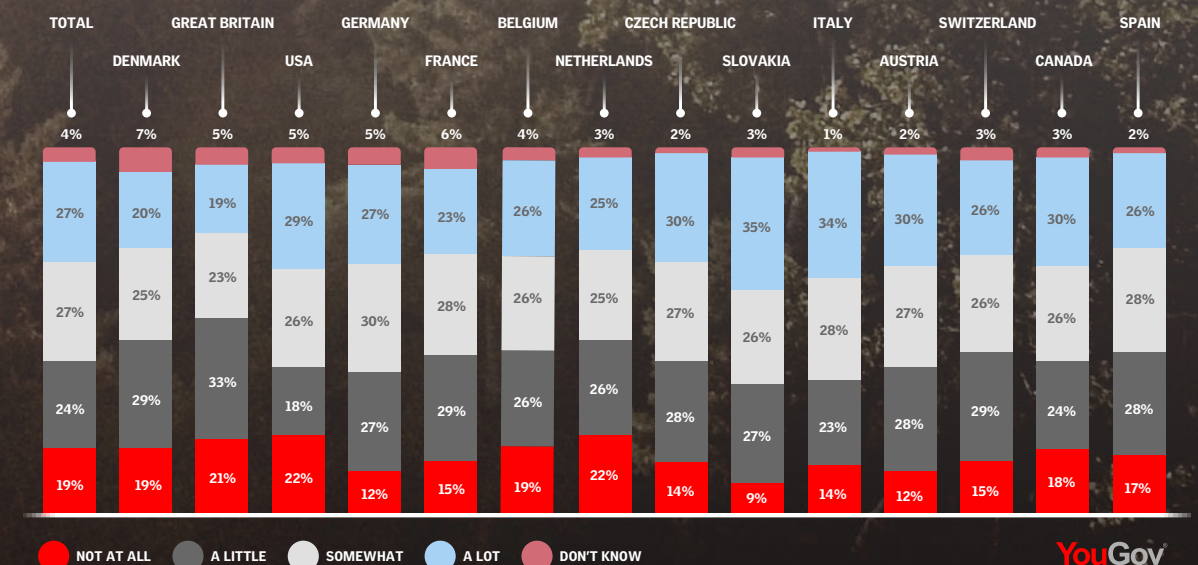
## UNPLUGGED FROM NATURE

The introduction of electrical lighting in the 19th century, and the resulting restructuring of work times and longer "economic" days have progressively detached us from the solar 24-hour cycles of light and dark. The consequence is disruption of our internal body clock, which tells the body when it is time to go to sleep and when it is time to wake up.



TYPICAL LIGHT LEVELS

## HOW MUCH DOES DAYLIGHT INFLUENCE YOUR SLEEP?



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# Enhancing Productivity

Today's world is a competitive one, whether it's nations competing on the global stage, businesses competing in international markets, or individuals trying to get ahead at work or at school.

When asked about the effect of daylight on productivity, 63% of the YouGov respondents said they think that daylight has a significant effect on our productivity – so awareness is high on this topic.

Most people have probably experienced first-hand the increased levels of alertness that come with working in a bright, daylight room as opposed to a dim, poorly lit space. This has also been shown to be the case in scientific studies.

## Bright Offices – Productive Workplaces

The link between daylight and work productivity has been examined in several studies, with results demonstrating that daylight and a view to the outside increase performance at work.

In their 2003 study<sup>1</sup>, for example, the Heschong-Mahone Group examined workers in a call centre, as well as other office workers, and gauged their performance in work tasks as well as specific cognitive tests. Better access to views, along with improved daylight conditions, were found to significantly improve performance in both tests, with workers in the call centre found to process calls 6% to 12% faster when they had the best possible view versus those with no view. Office workers, meanwhile, were found to perform 10% to 25% better on tests of mental function and memory recall when they had the best possible view versus those with no view.

## Better Results for Students

And it's not just office workers who benefit from daylight. The pan-European SINPHONIE study<sup>2</sup> looked at 114 schools in 23 countries and found that increased daylight levels in classrooms improved pupils' test results in maths and logic by up to 15%. Meanwhile in the US, the Heschong-Mahone Group (1999, 2001 & 2003) examined test score results from 21,000 students in 2,000 classrooms and found that students with the most daylighting in their classrooms progressed 20% faster on maths tests and 26% faster on reading tests.

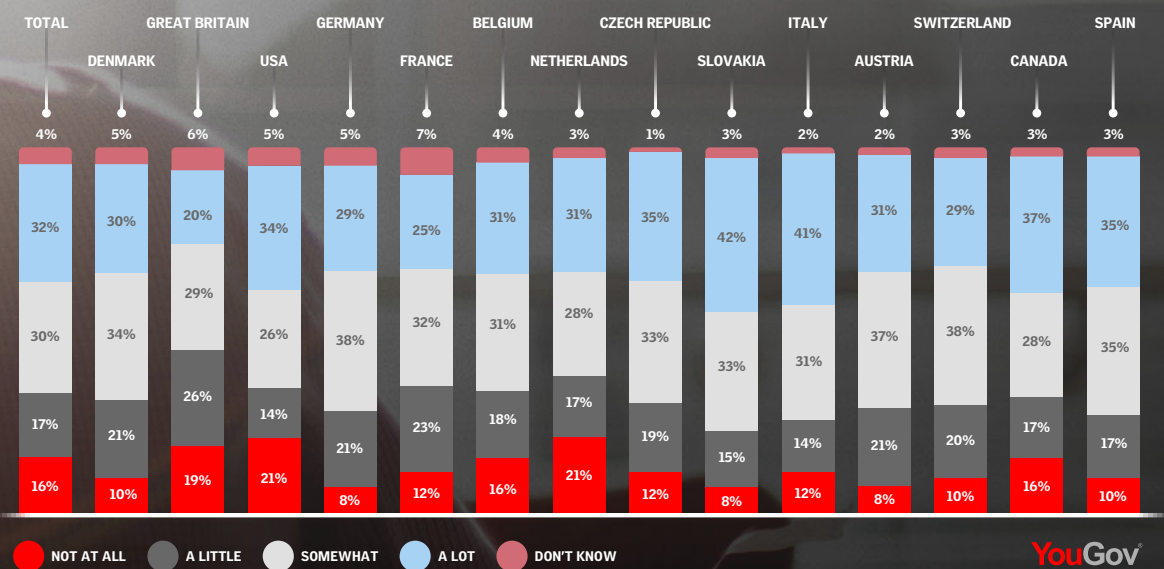


### STEVEN LOCKLEY

"Light is an acute stimulant which directly alerts the brain. If you're exposed to brighter and bluer light in the daytime, then you get a better stimulant effect. You'll be more alert and have better cognitive function, potentially be more productive at work and so on. If we're thinking of offices, schools, hospitals, etc., it's the alerting effects of light in the daytime which we want to take advantage of."

Steven Lockley, Associate Professor of Medicine, Harvard Medical School. Neuroscientist, Division of Sleep and Circadian Disorders, Departments of Medicine and Neurology, Brigham and Women's Hospital.

## How much does daylight influence your productivity?



All numbers are rounded due to readability. Decimal numbers can be provided per request. Total sum is weighted against country population size.

<sup>1</sup> Heschong Mahone Group (2003) Windows and Offices: A Study of Office Worker Performance and the Indoor Environment. [http://newbuildings.org/sites/default/files/A-9\\_Windows\\_Offices\\_2.6.10.pdf](http://newbuildings.org/sites/default/files/A-9_Windows_Offices_2.6.10.pdf)

<sup>2</sup> Schools Indoor Pollution & Health Observatory Network in Europe, 2014. [https://ec.europa.eu/health/sites/health/files/healthy\\_environments/docs/2015\\_sinphonie\\_frep\\_en.pdf](https://ec.europa.eu/health/sites/health/files/healthy_environments/docs/2015_sinphonie_frep_en.pdf)





# THE INDOOR GENERATION

We are the indoor generation, for better or worse. The industrialisation and technological developments that have brought us in from the fields to our modern, indoor existence have provided huge advantages in areas such as standard of living, healthcare and education, to name but a few.

But as a result of our modern way of life, we face some new challenges. Humans have evolved over hundreds of thousands of years, essentially as an outdoor species. Over the last 200 years all that has changed with people in industrialised nations now spending 90% of their time indoors.

## BUILDING AWARENESS

The gap between perception and reality uncovered in this report shows that we need to increase awareness around the effects of indoor living on our bodies and minds. If we are to mitigate or reverse increasing incidences of health problems such as sleep disruption, seasonal depression, asthma and chronic obstructive pulmonary disease, heart disease and diabetes, then we should act to adapt both our behaviours and our indoor environments. And these are not only issues of individual health – they also represent a steep cost to society in terms of medical treatment and lost productivity.

So let's be aware of our new surroundings, and take the steps necessary to make indoor living as healthy, happy and productive as possible. Some of these steps can be very, very simple. Others will require more commitment and investment. But all are worthy of consideration.

## TAKING ACTION: AT HOME, AT WORK...

Some of the simplest remedies are no more than minor behavioural changes. Take opportunities to be outdoors when they arise, like walking or cycling to and from work, taking outdoor breaks if possible, and spending more holiday time outside.

When indoors, let as much daylight in as possible and take steps to freshen the air that we breathe. Opening windows to air out the house a couple of times a day will dramatically reduce levels of CO<sub>2</sub> and other pollutants.

Then it's a question of what we have and what we do in the house: avoid products containing toxic materials; don't burn candles indoors; dry clothes outside wherever possible; keep bathroom doors closed and ventilate from the outside when bathing.

## ...AND IN ARCHITECTURE

We will continue to spend the vast majority of our lives inside buildings. Shouldn't we then be rethinking how we design and build the homes, schools and offices where we spend so much of our time?

Buildings should be designed to provide good levels of daylight and fresh air, and to be in tune with our 24-hour circadian rhythm. Circadian House design makes it easier to live in balance with nature, adapting to changing daily and seasonal conditions, while protected from harmful substances.

This would have huge benefits for the health and wellbeing of individuals and society as a whole, while also boosting productivity and reducing societal costs. In his paper from 2000<sup>1</sup>, William J. Fisk states: "For the United States, the estimated potential annual savings and productivity gains [from better indoor environments] are \$6 to \$14 billion from reduced respiratory disease, \$1 to \$4 billion from reduced allergies and asthma, \$10 to \$30 billion from reduced sick building syndrome symptoms, and \$20 to \$160 billion from direct improvements in worker performance that are unrelated to health."

And done right, buildings designed in this way can also offer extremely high energy performance, which will be key to meeting the environmental challenges of our future.

Get inspiration and learn more about how indoor living affects us at: [www.velux.nn/indoorgeneration](http://www.velux.nn/indoorgeneration)

<sup>1</sup> **Health and productivity gains from better indoor environments and their relationship with building energy efficiency, William J. Fisk 2000.**  
<https://www.annualreviews.org/doi/pdf/10.1146/annurev.energy.25.1.537>