Health Council of the Netherlands

A healthy indoor environment in the future

Horizon-scanning report

2013/17E

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Gezondheidsraad
Health Council of the Netherlands

To the State Secretary for Infrastructure and the Environment

Subject : presentation of horizon-scanning report *A healthy indoor environment in the future*
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Dear State Secretary,

Please find enclosed the horizon-scanning report A Healthy Indoor Environment in the Future. It was drafted by the Health and Environment Surveillance Committee, which is tasked with alerting the government and Parliament to important issues in the area of health and the environment, and with identifying any associated opportunities and threats. It was reviewed by the Standing Committee on Health and the Environment.

A healthy indoor environment in Dutch buildings is a theme for which the Dutch government has been developing policies for several decades now. In this report, the above-mentioned Committee takes a forward-looking perspective with emphasis on homes. It points out various developments that will be relevant in the upcoming years to the quality of the indoor environment, such as increasing home care, office transformation and climate change.

This report is also relevant for other policy areas for which other ministers are responsible. I therefore sent this report today to the Minister of Health, Welfare and Sport and the Minister for Housing and the Central Government Sector also.

Yours sincerely,
(signed)
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Vice President

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A healthy indoor environment in the future

Horizon-scanning report

To:

the State Secretary of Infrastructure and the Environment

No. 2013/17E, The Hague, July 18, 2013

The Health Council of the Netherlands, established in 1902, is an independent scientific advisory body. Its remit is "to advise the government and Parliament on the current level of knowledge with respect to public health issues and health (services) research..." (Section 22, Health Act).

The Health Council receives most requests for advice from the Ministers of Health, Welfare & Sport, Infrastructure & the Environment, Social Affairs & Employment, Economic Affairs, and Education, Culture & Science. The Council can publish advisory reports on its own initiative. It usually does this in order to ask attention for developments or trends that are thought to be relevant to government policy.

Most Health Council reports are prepared by multidisciplinary committees of Dutch or, sometimes, foreign experts, appointed in a personal capacity. The reports are available to the public.

The Health Council of the Netherlands is a member of the European Science Advisory Network for Health (EuSANH), a network of science advisory bodies in Europe.

This report can be downloaded from www.healthcouncil.nl.

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Contents

Executive summary

The quality of the indoor environment has been a matter of concern for some considerable time, because people spend a good deal of their time indoors, and the indoor environment affects their health. The government has tackled detrimental influences by means including the introduction of legislation on the composition of building materials, and the insulation and ventilation of buildings. It has also provided information to improve the ventilation habits of users and occupants. Some problems have nevertheless proven stubborn, inadequate ventilation in homes for example. New problems also crop up regularly, such as (neuro and reprotoxic) flame retardants from electronics that end up in household dust.

The Health Council of the Netherlands considers it plausible that further health gains might be made via improvement in the quality of the indoor environment. For this reason it has bent itself to this problem, with emphasis on homes and with an eye to the future. One of the Council's committees, the Health and Environment Surveillance Committee, considered which developments might be relevant to indoor environmental quality, and therefore deserve attention in policy. During this process, the committee assessed whether the approach to the indoor environment is due for a change, given the lessons from the past and the expectations for the future.

Past and present

Various problems have plagued the indoor environment in recent decades. Much (successful) policy was instigated for these; however it did not solve everything.

Since the 1973 oil crisis, the insulation in houses has been seriously improved to save energy. Due to this, unfortunately, the ventilation has worsened. The ventilation in homes, and also in schools and crèches, is often inadequate still. Many factors play a role here: legislation, house design, technology, maintenance and the behaviour of occupants.

Building materials have been the focus of attention with some regularity. Asbestos is a well-known example. This is a legacy from the past that still leads regularly to incidents during renovations and remediations. These incidents often cause much unrest.

Products in the home can also cause indoor environmental pollution. There has for example been discussion about flame retardants and allergenic substances. The knowledge about these often lags behind developments in the market.

Future developments

Both the ventilation and substance issues will remain as relevant as ever. Besides these, new and different developments are expected.

First of all, the population is aging. Elderly people are more sensitive to the various environmental factors due to worsening physiological processes and the presence of the diseases of the elderly. It is plausible that they are also more sensitive to many indoor environmental factors. The importance of a healthy indoor environment is thus increasing. Also, older people will be cared for at home more often and for longer. The home situation of the elderly deserves a place in the social service sector's preparations based on these trends.

The use of homes may also change. Working at home and the home care just mentioned are relevant examples. The nature of these new activities changes the home environment and the contamination in it. Moreover, occupants are exposed to this environment for longer. A key attention point is the possible presence of fellow occupants, besides those working at or being cared for at home, these including sensitive groups such as children and seniors living in. Buildings can also change function, for example when offices are transformed into homes. Transformations are good opportunities to realise improvements in the indoor

environment. However, in legislation as well as in design and realisation, the indoor environment still often remains neglected.

New substances, materials and technologies will make their appearance, and the use of technology is only expected to increase. The number of ICT applications in the home, for example, will increase. These developments often proceed more quickly than knowledge about health consequences grows or legislation is modified. These changes often only follow once the new technology is already in use. The risk of surprises and new problems is thus great. It is crucial to assess the interaction with the indoor environment in advance, during the development of new technologies and systems.

Also, changes in the outdoor environment are important to the indoor environment. Urbanisation and traffic have a significant effect on air quality and environmental noise. Climate change is an important trend for the future. The heat resistance and cooling capacity of homes and urban areas will become ever more relevant. Besides heat, effects on air quality and water nuisance are to be expected. There are points of approach for these problems in air quality policy, spatial layout and home design.

Towards a more integrated approach

In the past, indoor environmental problems were often tackled reactively and one by one. This worked to an extent. However, to achieve more, more grip on the indoor environment as a whole is needed. The complex mix of developments and policy fields demands a more integrated and proactive view of the indoor environment and of home design and use. A subject like elderly care and the indoor environment for example lies on the interface between the working fields of the Ministry of Health, Welfare and Sport, the Ministry of Infrastructure and the Environment, and the Ministry of the Interior and Kingdom Relations. The pursuit of a structural indoor environmental policy with a view to the future offers better chances of health gains than does an ad hoc approach. Structural monitoring of the effects of new developments and technology on the indoor environment, and of the effect of indoor environmental policy, is of great importance in this. Because the working field is highly fragmented, it is advisable to vest a directive function explicitly in an institution.

Chapter 1

Introduction

1.1 Subject

The relationship between the quality of the indoor environment and health has been a topical theme in the Netherlands for several decades. As early as 1984, the Health Council of the Netherlands advised on the indoor climate, including the issue of decreasing ventilation in homes with continuously improved insulation.[1] Additionally, advisory reports were published on other indoor environmental issues, such as radon[2-4], smoking and passive smoking[5-7], volatile organic compounds (VOCs)[8] and allergens[9]. Findings from these advisory reports were used in the development of policies.[10-13] Recently, the council advised on the quality of the indoor environment in primary schools.[14] The indoor environment has proved to be a complex playing field of sources (materials, technology, outdoor environment), buildings (house design and technology) and behaviour (of users/occupants). The indoor environment was one of the spearheads in the National Environment and Health Programme ('Nationale Aanpak Milieu en Gezondheid').

However, many problems proved to be persistent. A clear example is suboptimal ventilation as a result of insulation measures to conserve energy. This has been a topical theme since the 1973 oil crisis[1] and continues to be relevant today, as witnessed by the Action Plan to Improve the Quality of Ventilation[15] presented in 2012. Potential public health threats were also observed when new

technologies and materials introduced new substances into homes, e.g. formaldehyde in chipboard and fire retardants in electronics.

This advisory report takes a forward-looking perspective. The Committee points out various developments that will impact indoor environmental quality and health in the upcoming years and which therefore should be addressed in our policies. Demographics and technology are among the fields where these developments take place. The Committee also ascertains whether our approach to indoor environmental issues requires change. The emphasis is on homes. The conclusions may be relevant to other residential buildings also, such as crèches, schools, and housing and care centres for the elderly, even though there are differences in such buildings and other factors impact their indoor environment as well.

1.2 Question

This report answers the following questions:

- How has the indoor environment working field* functioned up to the present?
- Which indoor environmental developments will become relevant to public health in the near future?
- How do these developments impact the working field and the indoor environment and health policy?

1.3 Committee and procedure

This report was written up by the Health and Environment Surveillance Committee. Committee role and members are outlined in Annex A. The draft report was evaluated by members of the Standing Committee on Health and the Environment, one of the permanent expert committees of the Health Council of the Netherlands.

1.4 Structure of the report

Chapter 2 briefly summarises the indoor environment working field up to the present. Chapter 3 describes anticipated developments relevant to the indoor environment field. In conclusion, Chapter 4 outlines the Committee's views on these developments.

* 'Working field' is understood to include policies, research and practices in this field.

Chapter 2

Indoor environmental developments up to the present

The indoor environment has long enjoyed the interest of both scientists and policymakers. This chapter will address developments in this field up to the present inasmuch as they have been shown to be relevant to public health*.

2.1 To what extent does the indoor environment impact health?

People in industrialised countries spend well over 85 percent of their time indoors; at work, at school, but particularly in their own home (about 65 percent of their time).[19,20] Therefore a high quality of the indoor environment is advisable in view of both occupant comfort and public health. Indoor environmental problems may also cause public concern. The Dutch Community Health Services (GGDs) analysed complaints from citizens about the environment and health over the period 2004-2010. They concluded that about two thirds of the complaints involved the indoor environment.[21-23] Citizens named the quality of the indoor environment resulting in breathing problems and discomfort as one of their concerns. Primary perceived causes included mould, dampness, pests, lack of ventilation and odours.

* For a number of international summaries, see: [16-18].

The Dutch National Institute for Public Health and the Environment (RIVM) estimates the total disease burden associated with the indoor environmental quality at 24,500 DALYs* annually (in the Netherlands in 2004). This corresponds to the disease burden as a result of noise from road, air and train traffic**.[25] Passive smoking is an important factor, as are radon (particularly from building materials) and dampness. The estimated annual disease burden in the RIVM study is about 15,000, 6,000 and 3,000 DALYs, respectively. The analysis does depend strongly on which factors are included. For instance, the European EnVIE project finds a total disease burden that is three times higher, as it also includes the influence of outdoor environmental factors (like air pollution from traffic) on the indoor environment. The EnVIE study shows that combustion products (particulate air pollution from outdoor sources in particular), biological agents (half from outside, half due to indoor dampness problems), volatile organic compounds and pathogens are relevant in the Netherlands.[26] Passive smoking and radon from building materials were not included in the EnVIE calculations. The use of disease burden in DALYs as parameter for the importance of the various indoor environmental factors has its limitations, e.g. related to weighing the severity of the various health effects, whereas it is also difficult to account for the cumulative effect of factors. Additionally, many indoor environmental factors cannot be quantified in DALYs at present. The degree to which subtopics and specific substances precisely contribute to the disease burden is therefore uncertain. Consequently, it is not easy to make any definite statements on disease burden caused by the indoor environment. Nevertheless, the subject deserves our attention from a health perspective.

2.2 Technical installations in buildings

Housing insulation was significantly improved since the 1973 oil crisis to conserve energy. Homes have become increasingly ‘closed’, reducing ventilation.[1] Combined with the use of new and a broader range of substances in homes, reduced ventilation increased health risks. The 1984 advisory report of the Health Council on indoor environment centred on the production of carbon dioxide and particularly human body odours as ‘unavoidable sources’ in setting a ventilation standard (at least 25 m^3/hour per person). This made discomfort an important endpoint, but other health aspects were also included. The other

* DALY stands for Disability-Adjusted Life Years, a measure for the burden of disease: lost life years and life years lived with disease, weighed by its severity.

** Particulate air pollution is the environmental factor with the highest health burden by far; five times as many DALYs. Noise takes second place.[24]

contamination sources were considered ‘avoidable sources’. They would have to be limited by preventive policies (including product standards) to such an extent that even with a ventilation rate of 5 m^3/hour per person per room, indoor environmental quality would still be safeguarded. The 1984 Health Council advisory also recommended educating occupants on the importance of ventilation.

Suboptimal or poorly maintained ventilation and air condition have long been a focus of attention. For instance, the 'Sick Building Syndrome' was a topical theme in the 80s and 90s. Office employees reported headache, respiratory irritation and other health complaints. Causes were sought in poor ventilation, mould, volatile organic compounds and social and psychological aspects such as stress.[27-29]

Ventilation standards for new housing estates have now been included in the Building Decree. However, ventilation continues to be insufficient in many Dutch homes, schools and crèches.[14,30] As in the past, energy conservation and improvement of the indoor environmental quality often oppose each other. For instance, the RIVM notes that when spending housing and school developmental incentives on energy conservation, there is a risk that negative effects on the indoor environment are inadequately factored in.[30]

More recent are the debates on mechanical and balanced ventilation. The new housing estate Vathorst in Amersfoort is a well-known example, where many complaints were reported in houses with balanced ventilation. In many cases, ventilation did not function correctly, was not used correctly and caused noise nuisance.[30-32]

In addition to the degree of ventilation, various other climate control aspects in buildings – such as temperature (thermal comfort), noise, light, dampness and air flow – impact occupant comfort and stress.[33-35] It is plausible that prolonged physical stress has health effects, such as cardiovascular disease. For instance, noise nuisance affects sleep quality and causes high blood pressure and cardiovascular disease.[36] Another example is the quality of lighting. Adequate and good light is important to the circadian rhythm and sleep quality, concentration and mood.[37,38] All these aspects contribute to occupants' well-being.

Heating and cooking equipment may cause exposure to combustion products. In the past, carbon monoxide poisoning resulting from ‘poorly functioning chimneys when stoves were lit in the still cold houses on a windless, cold autumn day’ was a well-known problem.[1] Carbon monoxide is currently produced in most cases by unvented gas water heaters and central heating boilers and continues to cause casualties up to this day. Every year, carbon monoxide

poisoning causes 11 deaths and 150 hospitalisations on average.[39] Unvented equipment has been phased out for some time now and these installations have reduced in number.[40] However, many such installations are still present in homes and it is hard to get a handle on handymen installing gas water heaters themselves. Continued attention for this is advisable. Gas cookers produce nitrogen dioxide; concentrations in Dutch homes are high because gas is used frequently for cooking. Nitrogen dioxide may have untoward respiratory effects.[1,41] Combustion of solid fuels, such as wood in a fireplace or wood stove may increase particulate matter and carbon monoxide levels. Since the advent of central heating, fire places have become less common in the Netherlands*. However, new, sometimes unvented, multiburners are introduced that use gas, fluids (e.g. ethanol) or gels (e.g. ethanol in cellulose) as fuel.

2.3 Building materials and construction

Building materials and substances they release (such as volatile organic compounds) also impact indoor environmental quality. Asbestos was used frequently in the previous century because of its insulating and fire-resistant properties. Its use has declined greatly since 1980 due to increased concerns about its health effects, such as lung membrane and abdominal membrane cancer (mesothelioma) and lung cancer. Professional use and handling of asbestos has been prohibited in the Netherlands since 1993. Material used in the past is still present in many locations. This constitutes a risk in renovation or demolition of old buildings.[43] Therefore strict safety regulations are in place for renovation of buildings where asbestos is suspected to be present. Incidents have occurred regularly over the past years, where small quantities of asbestos were released during renovations or fires.

Exposure to radioactive decay products of radon and thoron – radioactive gases released from some stony building materials, including concrete – was and continues to be a current topic.[1-4] Its primary health effect is an increased risk of lung cancer, especially in combination with smoking. In many countries, soil is the primary source of radon. However, building materials are a larger source in the Netherlands, as the soil is relatively radon-depleted here.[44]

The emission of volatile organic compounds (VOCs) for building materials constituted an important new topic in the 80s, in part because of the advent of chipboard and synthetics in construction. It was shown that formaldehyde

* Smoke from burning solid fuels in homes continues to be a significant health factor in various (other) parts of Europe.[42]

evaporated from chipboard and insulation materials. Solvents and preservatives evaporated from other building, hobby and home construction materials – including wall and floor covering, glues, paints, wood preservatives, detergents and furniture.[1,8] The primary effects of these substances include odour nuisance and respiratory and eye irritation. Formaldehyde is still found in higher concentrations than the allowed 10 µg/m^3 in 50-60% of the kitchens and other rooms with sheet materials.[30,45,46] Some volatile organic compounds are known to have carcinogenic or sensitising effects and cause reproduction toxicity. The Health Council's perspective in its 2000 VOC advisory report was to prevent exposure to these three substance types in the indoor environment.[8]

Dampness and mould, produced by thermal bridges and materials sensitive to mould, constituted another major problem. High humidity may cause increased mould and house dust mite, causing and aggravating allergies and chronic respiratory diseases such as asthma.[1,9] Low humidity, however, may cause eye and skin irritation in e.g. contact lens users and people with allergies and skin conditions.[30] These problems have declined in the Netherlands,[24,30] partly by improvements in construction and construction regulations. In older homes, however, this continues to be an issue.

2.4 Substances from products in homes

Fire retardants are used in electronics, furniture and textiles. These substances prevent fire accidents and are obviously useful. However, they also become part of the house dust. The resulting health risks have been much debated. Various fire retardants have been shown to accumulate and cause neurotoxicity and reproduction toxicity when they enter the body. A number of (brominated) fire retardants are prohibited in the European Union. The alternative substances which were subsequently used appeared as 'emerging contaminants' in house dust[16,47-50] and also became the subject of debate. However, the amount of toxicological information is limited, making it difficult to assess the risks of exposure to fire retardants in the indoor environment.

A similar issue is that of the plasticisers, such as phthalates, in plastics; used in e.g. furniture, clothing and toys. A number of plasticisers are known to disrupt the hormone system (endocrine disruption). Here again, our knowledge is often limited and does not keep pace with the introduction of new variations. Both phthalates and phthalate replacers are emerging contaminants.[16,30,47-50]

A number of other new substances and applications are now being discussed due to potential allergic sensitisation. Examples include aromatic substances in

air fresheners[51], synthetic musks[47,49,50] and phenols in detergents[16,47]. This also includes the recent discussion in connection with PUR foam.

A problem in assessing health risks of substances present in the home is the fact that exposure may occur via multiple routes: various sources in the indoor environment, but also food or cosmetics*. Someone who has been sensitised, e.g. by cosmetics, to a substance may develop complaints in the indoor environment at low exposure levels. A current issue is how to incorporate this cumulation of exposures and risks in policy.

Lastly, tobacco products continue to be the primary source of indoor environmental pollution and associated disease burden. For smokers this is a lifestyle choice, for occupants subject to passive smoking an indoor environmental problem. Smoking is obviously not only a 'product issue', but also involves behaviour. Exposure to tobacco smoke may result in discomfort, respiratory irritation, aggravated asthma, respiratory disorders, heart disorders and lung cancer.[1,5-7] The percentage of smokers has come down since the 80s from about 40% to 28% and has been relatively stable over the past few years.[53] Smoking has been pushed back in public areas but at home, in a private setting, it continues to be a significant and difficult health issue.[7] The most notable situations are those where risks are not taken voluntarily and where vulnerable groups, such as pregnant women and children, are exposed.

2.5 Discussion

Indoor environment policies were actively developed over the past decades and progress has been made in certain areas. For instance, consistent policies and good monitoring were effective against dampness. Additionally, based on advisories and reports of the WHO, the Dutch National Institute for Public Health and the Environment (RIVM) and the Health Council of the Netherlands, ventilation and building material requirements in the Building Decree have been tightened. Progress benefiting the indoor environment has been made in the outdoor environment also, particularly in terms of air quality. See Table 1 for a summary.

* As a result of the European label obligations, lists are available for allergies in food and cosmetics (EU Directives 2003/89/EC and 2003/15/EC respectively). See also: [52].

Table 1 Potential trends in the home for which policy was developed. The trends are shown at scale levels from large (outdoor environment) to small (occupant).

Major trends	Implications
Outdoor environment	
Air quality	• Impact on indoor air quality (including particulate matter)
Noise	• Prolonged physical stress; effects include cardiovascular disease
Building and building materials	
Radon from certain stony building materials	• Radon decay products cause lung cancer (amplified by combination with smoking)
Asbestos	• Lung membrane and abdominal membrane cancer (mesothelioma) and lung cancer • Currently a particular point of attention in renovations
Volatile organic compounds from chipboard and synthetics	• Nuisance and harmful effect on and through airways
Dampness	• Exposure to mould and other allergens; detrimental effects including those on the airways
Technical installations	
Increasing insulation	• Reduced ventilation and associated increased exposure to contaminations • Technology, maintenance and occupant behaviour impact ventilation effectiveness
Climate control (temperature, light, noise, air flow, etc.)	• Impact on occupant comfort and stress; effects include cardiovascular disease
Combustion equipment (cooking, heating, etc.): release of carbon monoxide, nitrogen dioxide	• Respiratory irritation • Carbon monoxide poisoning
Products in the home	
Fire retardants and plasticisers	• Possibly various toxicological effects including endocrine disruption • Limited knowledge impedes health risk assessment • Risk analysis does not keep pace with developments and application of alternative substances
Occupants	
Smoking and passive smoking	• Lung disease • Cardiovascular disease

It is difficult to assess the exposure to indoor environmental factors and their health effects. Additionally, implementation of know-how may be problematic, e.g. in ventilation. That is why this topic merits continued attention. A difficult issue is that the indoor environmental quality as a whole and the comfort of occupants depend on many factors (degree of ventilation, occupant behaviour, temperature, air flow, acoustics, air pollution sources) and their interactions.[33-35] Exposure can also come from multiple sources. This emphasises the importance of prospective and integrated research and good monitoring. In the field, however, problems were frequently approached in isolation; consequently, measures may have insufficient or even opposing effects. Additionally, the approach to indoor environmental issues was often reactive. New materials,

substances and applications were introduced and used in homes rapidly. When at a later stage this was shown to cause problems in the indoor environment, ad-hoc solutions were sought. Risks of such an ad-hoc approach include a lack of structural progress in improving the indoor environmental quality as a whole, and new problems caused by the alternatives and solutions themselves (so-called 'risk migration'[54]).

Chapter 3

Future indoor environmental developments

Various trends are to be anticipated in the indoor environment of the future that will impact the health of users and occupants. Insulation will continue to increase as a result of the permanent need to improve energy performance in buildings. New materials, substances and technologies will also continue to be introduced. Both the issues related to ventilation and to polluting compounds will therefore continue to be relevant.

This chapter particularly addresses trends that have received little attention in the field up to the present, but will impact the indoor environment in the future. This includes changes in the physical indoor environment and in the use of this environment. Lifestyles change and homes are (increasingly) a place to care, work and relax in addition to 'a roof over your head'.[55]

3.1 Changing population structure

The care function of homes will increase as a result of the ageing Dutch population. Projections suggest that the ageing population will increase over the upcoming decades as a result of the postwar baby boom.[56-58] Statistics Netherlands (CBS), the Dutch central statistical office, refers to 'double ageing': the '80+' proportion is increasing significantly within the '65+' group.[59] On average, the elderly are more vulnerable to various environmental factors as a result of a general decline in biochemical and physiological processes and by the presence of disease (of old age) and chronic disorders (see [60]). It is also likely

that they are more susceptible to many indoor environmental factors. Additionally, the elderly spend more time at home, increasing exposure to indoor environmental factors. This makes a good indoor environmental quality the more important.

The population is also becoming culturally more diverse. The immigrant population will increase in the future, particularly in the large cities.[58] Cultures differ in their expectations and use of space.[55] Larger families and possibly other forms and habits of use may be relevant to the indoor environmental quality. However, specific knowledge about immigration/multiculturality and the indoor environment is lacking. What we do know is that the level of health, housing situation and access to healthcare are lower on average in the non-native than the native population.[61] The Committee expects that raising public awareness, e.g. using mass media or user instructions for homes, will be less effective within this group as a result of cultural and language barriers.

3.2 Changing use of the home

Living at home longer and home nursing

There is a shift in healthcare away from hospital and rest home nursing in favour of increased home nursing. In this situation, there is a desire to have the elderly live and cared for at home longer (home nursing and informal care); the same trend is visible for sick people in general. Since the previous cabinet, government policy aims at keeping people with a limited care need at home for longer and focus on small-scale care in the neighbourhood*.[63,64] The time patients are nursed in the hospital continues to be shortened also, shifting a larger portion of postoperative care to the home. This increases the number of vulnerable occupants in homes. Additionally, medical materials and equipment, and substances they emit, may play a larger role in the indoor environment, causing additional exposure to more substances. It would be wise to monitor technological developments, such as those in connection with antibacterial materials (including nanosilver), nebulisers, medical equipment and medicines.

Nursing homes and simple nursing may be transferred to houses that were not specifically designed for this. This will likely involve situations where care is given to e.g. the elderly, chronically ill and people with limitations. There is an interest among care providers, cities and housing corporations in small-scale housing/care combinations, such as group housing.[65] Not all buildings are

* However, this may cause a lack of occupancy in nursing homes.[62]

sufficiently suitable for this in view of the sometimes limited ventilation and temperature control options. When more generations live together, and where informal care is used, situations may arise more frequently where rooms not designed for permanent use, such as renovated attics, are occupied permanently*. The indoor environmental quality in these rooms may be suboptimal. It would be wise to ascertain whether building regulations and health care inspections adequately anticipate these trends.

Naturally the risks of home nursing and living at home longer should be measured against the benefits this brings to the elderly and sick. For example, staying in familiar surroundings, and contact with neighbours and (grand)children have psychosocial benefits. There are of course also other relevant risks, such as accident risks (including falling for the elderly).

Increased work from home

Increasingly, homes are also used as workplace. 'The New World of Work' currently enjoys much interest; it is part of a broader trend of teleworking. Indeed it is an attractive option from a cost containment, traffic jam reduction and sustainability perspective. The proportion of employers offering telework facilities was up to 53% in 2009 from 28% in 2003.[66] In 2009, 19% of employees regularly worked 'outside of company premises with access to company systems' (versus 16% in 2007). Working from home is suitable for computer work, but also e.g. telephone work, packaging, sorting, folding and labelling, product testing and small-scale production work. Much has already been written about the labour law and psychosocial aspects, both the negative and positive sides of working from home (e.g.: [67-69]). The topic also raises indoor environmental questions. Homes are usually not designed for use as business accommodation and facilities for e.g. ventilation and cooling are not necessarily optimal**. Harmful substances may be released during work, such as solvents, glue, paint, ozone or particulate matter and dust. An important issue here is that not only the employee is exposed to this, but also any other occupants, possibly including vulnerable groups such as children and the elderly. It would be wise to explicitly address the indoor environment and ventilation in education given by the employer (as part of their duty of care). It may also be relevant for product

* Such situations occur now also, particularly in attics used permanently as bedrooms. These rooms are often 'undesignated areas' for which there are only few requirements. The occupant generally does not know that these rooms do not satisfy the health protection regulations (e.g. ventilation, noise) for occupancy.

** Naturally this at times applies also to offices and commercial buildings.

and building design and in regulations, e.g. the Health and Safety at Work Act. Work and life are often considered separate in this context, but they are becoming more and more interrelated. An integral discussion is therefore needed.

3.3 Modification of buildings

Modification of existing buildings to new functions or new requirements is a highly current topic. Important examples include transformation of empty offices into housing, the above-mentioned small-scale care in renovated homes (including care for the elderly and youth, day care) and modification or renovation of old homes (also in terms of energy performance). Modification of existing homes is of course no new development. However, its relevance will continue in view of legacies from the past, such as asbestos and persistent fire retardants, and reduced ventilation as a result of improved insulation. More generally, sustainability and 'green buildings' are a current topic in the construction world and the EU. There is much attention for energy and material consumption and effects on the outdoor environment. It is important to include the indoor environment in sustainability and energy conservation programmes. Modification, transformation and renovation do provide opportunities for improvement of the indoor environmental quality. Indeed, this is the time when more drastic modifications, improvements or replacements of technical installations and building materials can be done. However, the Committee notes that indoor environmental aspects do not receive due attention in legislation or in the design and realisation of modifications, transformations and renovations.*

Office transformation is a recent trend. Lack of office occupancy has increased by an average 5% over the years 1990-2001 up to 14% in 2010.[72] This trend is expected to continue, although to what extent remains uncertain. But the underlying factors continue to follow the same trend: it is expected that both employment and office use per employee will decrease.[72] The government considers this a major problem and various initiatives have been started to transform empty offices into homes in particular.[73] Remarkably, under the 2012 Building Decree new homes only need to satisfy the 'legally obtained quality' criterion of the office building, not the requirements for newly built homes.[74,75] However, they must meet requirements for existing buildings (particularly in terms of safety) and noise nuisance, for which the Noise Nuisance Act stipulates specific standards.

* See e.g.[70] for office transformation and[25,71] for home renovation.

3.4 Technological changes in the home

All home functions – also living and recreational functions in addition to the care and work functions described above – require specific technology. Many households are buying new technology, ranging from televisions and e-readers to computers, printers, household equipment, fitness equipment, security systems and atmospheric and room design (new lighting, air fresheners). Innovations are also to be expected in the field of building materials, e.g. nanocoatings and modern paints. It is to be expected that the use of technology will increase. The developments in the field of new technology and new materials and substances used for them are high-paced – usually faster than the development of knowledge on exposure to and health effects of the used substances and materials*.[76] These issues may put additional pressure on the indoor environment in the future. Additionally, these developments cause increased exposure to electromagnetic fields (EMF) indoors, especially radiofrequent fields. EMF is a cause for concern among the population. Therefore the topic could be included in general monitoring.

In addition to the increased use of technology, it is to be expected that technology will become more and more interwoven in the house, e.g. in the form of domotics (home automation). Here equipment is combined with sensors, motors and ICT infrastructure to carry out various functions in the home, measure things or provide services.** Many simple applications have now become commonplace, e.g. a time-switch thermostat connected to heating, room lighting connected to a motion sensor or alarm systems sending an SMS to the home owner or emergency centre. More advanced sensors and links of many, if not all, devices and systems in the home are conceivable in the future. Examples ranging from need-based ventilation control and personalised lighting, temperature and music in rooms based on the persons present at that time, to robotic control. Domotics enable remote care, (user) safety, energy efficiency, comfort and relaxation. It is currently in an initial phase and the Committee anticipates that large-scale application will still take some time. However, it expects the highest risks to indoor environmental quality especially in the initial phase, particularly when the indoor environment is not or insufficiently included

* To a greater or lesser degree, this applies to many technological and social trends, including many of the developments described in this chapter.

** The common definitions of domotics are broad. Domotics includes all equipment and infrastructure in and around homes that use electronic information to measure, program and control functions to benefit occupants and service providers.[77]

in system design. There are recent examples of ventilation systems on the market which regulate ventilation level using a carbon dioxide (CO_2) or humidity sensor, in order to conserve energy. However, CO_2 level has limited value as an indoor air quality indicator.[14] There may be accumulation of concentrations of harmful substances, such as radon and VOCs when the occupant is away from home for some time. Additionally, ventilation may fall short for low CO_2 sources, such as small children. The additional requirement for sensors, electronics and cables may also increase exposure to substances used in their production, such as fire retardants, plasticisers and new materials. However, smart technology may also provide opportunities for improvement of the indoor environmental quality. For instance, occupants may be given an indication of the indoor environmental quality on the basis of e.g. temperature, air quality and house dust measurements, or ventilation or other purification equipment may be activated. It may also help improve occupant comfort. However, a broad, integral approach is vital in the development of such systems.

It is difficult to assess the pace at which these developments are adopted. At any rate, 'home technology' in relation to the indoor environment should be included in the design, renovation or new planned use of buildings for occupation.

3.5 Changes in the outdoor environment

Changes in the outdoor environment also impact the indoor environment. For example, urbanisation and traffic have a significant effect on air quality and ambient noise. Both also influence indoor environmental quality. Policies have been developed for these factors for many years, but they will continue to be relevant in the future.

Climate change is a relatively new trend which will significantly impact indoor environmental quality in the future.[78-81] Organisations such as housing corporations seem hardly aware of this.[82] The number of warm days is expected to increase and the number of cold days will decrease.[79-81,83] Also the frequency, duration and intensity of heat waves and cold spells will very likely change. Both heat and cold impact our health. Over the past decades, heat waves in the Netherlands have caused a mean 40 additional deaths daily; a 13% excess mortality.[84] The same percentage applies to cold spells. The elderly and people with respiratory and cardiovascular disease are vulnerable in particular. Climate change increases the risk of overheating in the home.[78] Increasing insulation is also implicated here. It can keep part of the heat out – but not heat from solar radiation through the windows – but it also retains more of the heat. In addition

to direct effects on health, heat can increase the emissions of e.g. volatile organic compounds from (building) materials.[78] Cooling and protection against heat from outside are therefore becoming increasingly important. This can be done at a building level, e.g. using air conditioning, reflective windows, white walls or green roofs.[85,86] However, the layout of the street, neighbourhood and city are also important. Urbanised areas retain heat, making them warmer than rural areas.[87-89] This may be limited e.g. with open water, planting and lighter coloured pavements.[85,86]

Increased heat may also increase air pollution, particularly by particulate matter and ozone (summer smog) and pollen (extended pollen season for some plant species). This impacts the indoor air quality. Additionally, ozone may react with certain volatile organic compounds in the indoor environment to cause secondary pollution.[78,90] More intense rain showers are also expected in summer.[83] This may cause flooding, which at least for some time could cause damp homes. This may have health consequences, e.g. as a result of mould and house dust mite, but the extent is unknown. With respect to flooding, the Committee notes an increasing trend to lower the placement level (floor level in relation to the street). This improves accessibility and reduces building costs as fewer building materials are required. However, depending on the local situation, the risk of flooding may be increased.[91]

3.6 Summary

In conclusion, Table 2 summarises the developments presented in this chapter.

Table 2 Future trends impacting the indoor environment, but not yet considered related (or only to a limited degree). The trends are shown at scale levels from large (the outdoor environment) to small (the occupant).

Major trends	Implications
Outdoor environment	
Climate change	• Heat is more common, therefore becomes more prominent in the design of houses and neighbourhoods • Also effects on e.g. air quality, flooding
Urbanisation	• Noise and air quality continue to be important
Building and building materials	
Building transformations and renovations (office transformation, small-scale care, home renovation)	• Risk that indoor environment is not adequately considered as a result of a one-sided focus, e.g. on solving lack of occupancy or conserving energy • Transformation is a good moment to improve indoor environmental quality
Technical installations	
Domotics	• Risk of oversimplifying indoor environmental quality in the development or use of technology • Potential exposure to (new) substances from technology • Also opportunity to improve indoor environmental quality and occupant comfort
Products in the home	
More technology in the home	• Potential exposure to substances from technology • Health risk knowledge and policies do not keep pace with rapid technological developments. The same is true in other trends.
Occupants	
Ageing population	• Vulnerable group expands • Prolonged exposure
Immigration	• Implications as yet unclear
Home nursing and home care	• Vulnerable group expands • Prolonged exposure • More medical materials and technology in the home • Need to address ventilation and temperature control explicitly • The elderly and sick possibly more comfortable in their own home (good for psychosocial health)
Working from home	• Indoor environment in the home more important in view of prolonged exposure • Exposure to work-related substances in the home. Additionally, psychosocial and labour law aspects (positive and negative) need to be addressed. • Exposure of family members (including the elderly, children) to work-related substances

Chapter 4

Committee view

4.1 Relevant developments for the indoor environment of the future

The Committee noted a number of developments that will impact the future indoor environmental quality of homes, and in that connection the health of occupants and users, but which until recently have not (or to a limited degree only) been considered as related issues. These are changes in the population structure, the use of rooms and buildings, and the outdoor environment. It is difficult to estimate their health effects. The Committee takes the view that it is important to consider these developments in future policies. The emphasis in this advisory report is on homes, but the trends and conclusions may also apply to other buildings with occupants, such as crèches, schools and housing and care centres for the elderly.

Changes in the population structure

Of the anticipated changes in the population structure, the ageing population is expected to significantly impact the relationship between indoor environment and health. As a result of deteriorating physiological processes and the presence of geriatric diseases, the elderly are more susceptible to environmental pollution and on average spend more time in the home. Additionally, the trend towards increased home nursing and home care may cause the group of vulnerable occupants in homes to expand. The importance of a healthy indoor environment

will increase as a result of both these trends. The Committee is of the opinion that it is important to explicitly address the housing situation of the elderly in preparing the health care sector for these trends. Important issues in this connection include ventilation, temperature, accident prevention, accessibility and exposure to substances from medical materials.

The importance to the indoor environment and health for a growing cultural diversity in the population is less clear, but nevertheless deserves our attention.

Changes in the use of rooms and buildings

The use of rooms and buildings will also change. As in the past, new technologies and materials will be introduced for the living and recreational functions of homes. As a result, occupants may have increased exposure to more and new substances. Additionally and increasingly, the home will take on a care function and a work function, which may impact the indoor environment. The question is whether the used buildings and rooms are sufficiently suitable for these functions. Issues include the sometimes limited options for ventilation and temperature control and the other substances and equipment taken into the home. Legislation, e.g. building and labour law rules, and their enforcement should specifically take this into account. An important difference with the situation of working outside the home is that others, such as children and the elderly, may be present in the home. Additionally and increasingly, rooms will be used that were not intended and designed for prolonged occupancy, such as attics, garages and cellars.

Modification of existing buildings to new functions or new requirements is also a highly current topic, e.g. transformation of offices into homes, small-scale care in renovated homes (including care for the elderly and children) and modification and renovation of old homes (including energy performance improvements). The market for renovation and transformation is growing, both in absolute figures as in relation to the construction of new buildings*. Renovations and transformations provide opportunities to improve the indoor environmental quality of the buildings. These opportunities are most probably not yet fully used. Building rules currently do not safeguard a good indoor environmental quality following renovations and transformations. The

* A figure of 16.7 billion Euros is projected for the renovation market in 2014 (EIB/Euroconstruct; see [92]). In the future, however, there will be high demand for newly constructed buildings in the large cities. The Amsterdam Region, for example, expects it will have to realise 300,000 new homes up to 2040.[93]

Committee recommends that the indoor environmental quality be explicitly addressed in such changes.

Changes in the outdoor environment

In addition to the known factors such as urbanisation and traffic, climate change is a significant outdoor environmental factor of which we now know that it will significantly impact circumstances indoors in the future. Heat has a strong negative impact on indoor environmental quality, and the number of tropical days and heat waves is expected to increase. It is therefore becoming increasingly important to address cooling capacity and heat insulation in the design of buildings. There are various options, e.g. green roofs and air conditioning. Also the lay-out of neighbourhoods and cities provides opportunities to limit heat and its consequences, e.g. by allowing for more planting and water. Climate change also impacts air quality (summer smog, pollen) and flooding. There are opportunities to act on this in terms of air quality, environmental planning and house design.

4.2 Outlook on the working field

The Committee notes that the approach to problems in the indoor environment over the past decades was mostly reactive and that responses were ‘per problem’ (in isolation). Incidents regularly led to social unrest and prompted ad-hoc responses. The Committee anticipates the working field will continue to be characterised by persistent issues and new problems. In order to improve outcomes, a stronger grip is needed on indoor environmental quality as a whole. Trends in the use, design and renovation of homes serve various social needs, and many developments have high economic sensitivity. Consequently, there is a risk that indoor environment and public health will be inadequately considered. Indoor environmental quality and occupant comfort require an integral perspective; they are more than the sum of a number of physical factors. A reactive approach to problems is insufficient. A proactive approach is preferred, even though rapid developments in the field of technology and materials may cause surprises. There is a strong focus on ventilation in current indoor environmental policies. Ventilation will continue to be an important topic in the future. However, the ‘indoor environment’ working field is now highly fragmented and the Committee recommends to assign a directing function to a government authority. The increasingly interrelated nature of work, care and personal life alone make this advisable.

4.3 In conclusion

The complex mix of developments, interests and policy fields* requires an integral and proactive view on the indoor environment – both physical and social factors – and the design, use and changed use of buildings, in policy, in research and in practice. Such a perspective is consistent with the line of thinking in e.g. the National Prevention Programme ('home and life in a healthy neighbourhood and surroundings', 'healthy working')[94] and the work of the WHO and EU ('Health in all Policies' approach).

The Committee recommends a structural and integrated indoor environmental policy with a forward-looking perspective. It takes the view that such an approach will have more health gains in the long term than an ad-hoc approach. Opportunities to develop policies include: the desired quality level and the safeguarding of building quality, innovation, awareness/education of citizens and industry, and standards for e.g. exposure or product emissions. Additionally, it is important to always explicitly address the aspect of indoor environmental quality in technological developments, new housing developments, renovation and changed functions of buildings.

Structural monitoring of the effects of new developments and technology on the indoor environment and of the effects of indoor environmental policies is essential. In this connection it will be wise to explicitly make government authorities responsible for direction, observation and monitoring. The Committee recommends the ministries in question (Health, Welfare and Sport; Infrastructure and the Environment; Interior and Kingdom Relations) to make specific arrangements for this in collaboration with all stakeholders. Perhaps this can be done in tandem with current initiatives, such as the National Prevention Programme and the Action Plan to Improve the Quality of Ventilation.

* For example: the construction of homes comes under the Ministry of the Interior and Kingdom Relations, standardisation of substances under Infrastructure and the Environment, care for the elderly under Health, Welfare and Sport and work (from home) under Social Affairs and Employment.

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A The Committee

Annex

Annex **A**

The Committee

The Health and Environment Surveillance Committee has the task of bringing subjects concerning health and the environment to the attention of the government and Parliament, and of highlighting threats and opportunities. This may be in relation to new issues but may equally concern topics that require attention once again.

Members of the Committee charged with the preparation of the present horizon-scanning report:

- Prof. W.F. Passchier, *chairman* (until 8 April 2013)
  Emeritus Professor of Risk Analysis, Maastricht University
- Dr. F. Woudenberg, *chairman* (from 8 April 2013)
- Psychologist, Head of the Environmental Health Department, Municipal Health Service (GGD) Amsterdam
- Prof. M. van den Berg
  Professor of Toxicology, Institute for Risk Assessment Sciences, Utrecht University
- Prof. J.W. Erisman
  Professor of Integrated Nitrogen Issues, VU University, Amsterdam; Director of the Louis Bolk Institute, Driebergen
- Dr. P.J. van den Hazel
  Physician, Specialist in Environmental Medicine, Public Health Service Central Gelderland, Arnhem

- Prof. E. Lebret
  Professor of Environmental Health Impact Assessment, Institute for Risk Assessment Sciences, Utrecht University; National Institute for Public Health and the Environment, Bilthoven
- Prof. R. Leemans
  Professor of Environmental Systems Analysis, Wageningen University and Research Centre
- Dr. J.P. van der Sluijs
  Associate Professor Emerging Risks, Copernicus Institute of Sustainable Development, Utrecht University
- Dr. J.F.M. van der Waals
  Ministry of Infrastructure and the Environment, The Hague, *observer*
- Dr. P.W. van Vliet, *scientific secretary*
  Health Council of the Netherlands, The Hague
- Dr. J.A. Wardekker, *scientific secretary*
  Health Council of the Netherlands, The Hague

When drawing up this horizon-scanning report, the Committee consulted prof. P.M. Bluyssen, professor on indoor environmental quality at Delft University of Technology, and F. Duijm, physician and specialist in environmental medicine at the Municipal Health Service (GGD) Groningen.

The Health Council and interests

Members of Health Council Committees are appointed in a personal capacity because of their special expertise in the matters to be addressed. Nonetheless, it is precisely because of this expertise that they may also have interests. This in itself does not necessarily present an obstacle for membership of a Health Council Committee. Transparency regarding possible conflicts of interest is nonetheless important, both for the chairperson and members of a Committee and for the President of the Health Council. On being invited to join a Committee, members are asked to submit a form detailing the functions they hold and any other material and immaterial interests which could be relevant for the Committee's work. It is the responsibility of the President of the Health Council to assess whether the interests indicated constitute grounds for non-appointment. An advisorship will then sometimes make it possible to exploit the expertise of the specialist involved. During the inaugural meeting the declarations issued are discussed, so that all members of the Committee are aware of each other's possible interests.

Health Council of the Netherlands

Advisory Reports

The Health Council's task is to advise ministers and parliament on issues in the field of public health. Most of the advisory reports that the Council produces every year are prepared at the request of one of the ministers.

In addition, the Health Council issues unsolicited advice that has an 'alerting' function. In some cases, such an alerting report leads to a minister requesting further advice on the subject.

Areas of activity

Optimum healthcare
What is the optimum result of cure and care in view of the risks and opportunities?

Prevention
Which forms of prevention can help realise significant health benefits?

Healthy nutrition
Which foods promote good health and which carry certain health risks?

Environmental health
Which environmental influences could have a positive or negative effect on health?

Healthy working conditions
How can employees be protected against working conditions that could harm their health?

Innovation and the knowledge infrastructure
Before we can harvest knowledge in the field of healthcare, we first need to ensure that the right seeds are sown.

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