



Greenery in and around nursing homes, hospitals and other clinics is good for the climate inside and outside the facility and has a positive effect on patients' recovery and state of mind as well as on the general well-being of patients, staff and visitors. This document provides information on the benefits of greenery in relation to recovery and well-being in healthcare settings, including references to scientific literature. It concludes with some tips on how to ensure the successful and full inclusion of greenery.

What does greenery do?

- ▶ Visible greenery, both indoors and outdoors, reduces stress of patients and staff.
- ▶ Plants in offices purify the air: they reduce concentrations of CO₂ and volatile organic compounds, keeping the air fresh and healthy.
- ▶ Outdoor vegetation curbs heat in and around buildings in the summer, reducing heat stress and cooling requirements.



Proven successes

- ▶ In a US study in-bed recovery time was almost 10% shorter for patients who had a view of trees than it was for patients who had a view of a brick wall.¹
- ▶ In the same study patients with a view of trees used up to 30% less heavy painkillers.¹
- ▶ In a laboratory experiment people were able to tolerate more pain when there were houseplants in the room.²
- ▶ Green roofs and façades increase insulation capacity: lower heating costs in winter and cooler temperatures in summer.
- ▶ Greenery is more attractive and creates more variety, moving the focus away from pain and stress.
- ▶ Indoor plants release water vapour and humidify the air, reducing headaches.
- ▶ If the environment is greener, and therefore more attractive, people will be more likely to go outside and to be more active. This also applies to elderly and ambulatory patients.



Applications

- ▶ Courtyards and other gardens as areas to relax or take some time out
- ▶ Courtyards and other gardens as treatment areas
- ▶ Green roofs and façades
- ▶ Green walls and indoor plants in central areas, canteens, waiting rooms and specific treatment areas
- ▶ Attractive landscaping of the hospital premises, including green borders, hedges and trees
- ▶ Continuing the landscape's natural flow of greenery around the hospital
- ▶ 'I just feel less unwell,' said one of the cancer patients receiving treatment in the 'chemo garden' at Tergooi hospital in the Netherlands.



1. R.S. Ulrich (1984), View through a window may influence recovery from surgery. *Science* 224:420-421.
 2. V.I. Lohr, C.H. Pearson-Mims (2000), Physical discomfort may be reduced in the presence of interior plants. *Hort- Technology* 10(1):53-58.

Greenery and healthcare

More information on the effects of greenery



Temperature

Many hospitals are located in urban areas, where average temperatures are higher than in the surrounding areas (the heat island effect). This effect occurs in metropolitan cities as well as in provincial towns and village centres, and increases as built-up areas become denser. The maximum differences measured vary from one to several degrees, with peak values reaching around 8°C and incidental values even exceeding 10°C. Heat stress caused by excessively high temperatures adversely affects health (particularly among the elderly, chronically ill and pregnant women) and can increase mortality rates. It also negatively affects the ability of staff to work and concentrate. Research has shown that 35% of urban areas in the Netherlands already experience heat stress at least seven days a year. Increasing urban density and further global warming will increase the frequency of periods of heat stress. However, greenery can help to lower urban temperatures.

How greenery works

- ▶ Greenery provides cooling by blocking solar radiation (i.e. providing shade) and through water evaporation; a 10% increase in vegetation can reduce the heat island effect in urban areas by an average of 0.6°C.¹
- ▶ Green roofs, possibly combined with green façades, improve insulation of buildings. They reduce warming in hospital buildings, limiting the effects of heat stress on patients and staff as well as lowering heating and cooling costs.²
- ▶ Larger elements of greenery have a cooling effect on the environment, provided that the cool air from these elements can flow into the environment.³ Thus green spaces around hospitals help to reduce heat stress in the surrounding area.
- ▶ Green areas also help to capture CO₂.⁴
- ▶ Shade from trees in car parks reduces fuel evaporation from tanks and reduces heat in car interiors.⁵



Recommendations

- ▶ Green roofs on top of healthcare institutions reduce heating and cooling costs and extend the roof lifespan.
- ▶ Increasing vegetated surfaces and planting trees in green strips around healthcare institutions help to reduce the heat island effect.
- ▶ Larger green zones around healthcare institutions can help to create a more pleasant climate in the wider surroundings, provided that the structure and location of these zones allow for effective air circulation.

1. G.J. Steeneveld, S. Koopmans, B.G. Heusinkveld, L.W.A. van Hove & A.A.M. Holtslag (2011), Quantifying urban heat island effects and human comfort for cities of variable size and urban morphology in the Netherlands. *Journal of Geophysical Research*. D, Atmospheres 116 (D20129).
2. M.E.C.M. Hop & J.A. Hiemstra (2013), Ecosysteemdiensten van groene daken en gevels. Een literatuurstudie naar diensten op het niveau van wijk en stad. Wageningen UR – PPO.
3. B.G. Heusinkveld, G.J. Steeneveld, L.W.A. van Hove, C.M.J. Jacobs & A.A.M. Holtslag (2014), Spatial variability of the Rotterdam urban heat island as influenced by urban land use. *Journal of Geophysical Research*: Atmospheres 119:677-692.
4. Z.G. Davies, J.L. Edmondson, A. Heinemeyer, J.R. Leake & K.J. Gaston (2011), Mapping an urban ecosystem service: Quantifying above-ground carbon storage at a city-wide scale. *Journal of Applied Ecology*.
5. K.I. Scott, J.R. Simpson & E.G. McPherson (1999), Effects of tree cover on parking lot microclimate and vehicle emissions. *Journal of Arboriculture* 25(3):129-142.

Greenery and healthcare

More information on the effects of greenery



Air quality

Major air pollutants, including nitrogen oxides (NOx), particulates (PM10/PM2.5) and volatile organic compounds such as benzene, mainly come from industry and traffic. Long-term exposure causes lung problems and cardiovascular disease. Although air quality in most locations in the Netherlands complies with the applicable standards, this does not mean the risk is fully eliminated. There is no safe lower limit and concentrations can rise significantly, especially in areas close to busy roads and intersections. Indoor air quality is often poor; large numbers of people in a relatively small space frequently cause CO₂ levels to rise significantly. Moreover, volatile organic compounds from construction materials, including formaldehyde and benzene, may be present.



Recommendations

- ▶ Use indoor plants to improve air quality inside buildings: they remove pollutants from the air (especially CO₂ and volatile organic compounds) and improve humidification.
- ▶ Plant shade trees in car parks to reduce evaporation of fuel from fuel tanks, reduce heat stress for visitors and lower fuel consumption by reducing the use of air-conditioning in cars.
- ▶ Since air exchange with the surrounding environment is essential for air quality, vegetation around healthcare institutions must allow for effective air circulation.

How greenery works

- ▶ Indoor vegetation can be used to improve air quality in healthcare institutions. Given enough light and water, plants absorb CO₂ from the air, helping to reduce ambient CO₂ levels.¹
- ▶ Indoor vegetation releases water vapour, helping to humidify dry air inside buildings.
- ▶ Plants also filter volatile organic compounds from the atmosphere. It has been established, for example, that the well-known houseplant *Spathiphyllum* can absorb and convert 20 mg of formaldehyde per 500 grams of foliage per hour. Formaldehyde is a common disinfectant, but in excessive doses it can be toxic and carcinogenic to humans.²
- ▶ Patients who receive chemotherapy treatment in a green chemo garden rate the location as more comfortable than patients who receive chemotherapy in hospital, citing aspects such as temperature and air quality.³



1. B. van Duijn, J. Klein Hesselink, M. Kester, J. Jansen & H. Spitters (2011), Rapport 'Plant in de klas'. Productschap Tuinbouw/Fyttagoras/TNO.
2. B.C. Wolvert, W.L. Douglas & K. Bounds (1989), A study of interior landscape plants for indoor air pollution abatement (Report). NASA. NASA-TM-108061.
3. Tanja-Dijkstra, K., van den Berg, A., Maas, J., Bloemhof-Haasjes, J., & van den Berg, P. (2017). Chemotherapie in de tuin. Nederlands Tijdschrift voor Oncologie, 14, 175-181.



Stress and state of mind

Visiting or staying in hospital is a stressful experience for most patients, and high stress levels can stand in the way of speedy recovery. Greenery in and around an institution can help to reduce stress in patients, thereby facilitating and accelerating their recovery. Also, it should be noted that working in such environments is stressful for nursing staff. For more information on the benefits of greenery in the working environment, please see the fact sheet on Greenery and Work.

How greenery works

- ▶ Plants in waiting rooms reduce stress.¹
- ▶ Plants in hospital rooms reduce anxiety and pain.²
- ▶ Visiting an indoor garden lifts the spirits of children in hospital treatment.³
- ▶ Patients who receive chemotherapy treatment in a chemo garden report slightly more positive and restorative feelings than patients receiving chemotherapy indoors.⁴
- ▶ Recent studies using modern medical scanning technology, including functional MRI (fMRI) and functional near-infrared spectroscopy (fNIRS), show a favourable effect on brain activity: people are more relaxed and more positive when they are looking at natural surroundings than when they are shown a built-up area. EEG scans taken in everyday surroundings also indicate that people are more relaxed in natural surroundings than in urban surroundings.⁶
- ▶ Studies based on self-reported states of mind in specific locations reach a similar conclusion: people feel happier in more natural surroundings. This effect is visible in agricultural areas, but is strongest on the beach.⁷
- ▶ Closer to home street trees also make a difference. The more trees there are within 100 metres from the home, the lower the use of antidepressants; this relation is most notable among less well-off people.⁸
- ▶ Even a view of greenery from the home is associated with an improved sense of mental well-being. This was especially the case in times of strict lockdown during the coronavirus pandemic.⁹
- ▶ Although it is clear there is a positive association between most types of greenery and mental health (Braubach et al., 2021), there are early indications that especially trees have a positive effect.¹⁰

Recommendations

- ▶ Make sure the view from hospital rooms (preferably from the bed) and other locations frequented by patients (e.g. waiting rooms, common rooms) includes plants and/or other greenery.
- ▶ Create attractive green outdoor areas (gardens) for ambulatory patients (and care providers) to relax and take some time out; make sure these areas are accessible to wheelchair users and other people with limited mobility.
- ▶ Ensure easy access to the indoor and outdoor green areas, including areas that are not necessarily part of the institution itself, such as public green spaces.
- ▶ Also use other means to promote the use of these green spaces (information, signs, guided activities, etc.).
- ▶ Create larger green areas in the immediate environment where staff and patients can go for walks, boosting productivity of staff and the recovery patients.

1. C.J. Beukeboom, D. Langeveld & K. Tanja-Dijkstra (2012), Stress-reducing effects of real and artificial nature in a hospital waiting room. *The Journal of Alternative and Complementary Medicine* 18(4):329-333.
2. S.H. Park & R.H. Mattson (2009), Ornamental indoor plants in hospital rooms enhanced health outcomes of patients recovering from surgery. *The Journal of Alternative and Complementary Medicine* 15(9):975-980.
3. S.A. Sherman, J.W. Varni, R.S. Ulrich & V.L. Malcarne (2005), Post-occupancy evaluation of healing gardens in a pediatric cancer center. *Landscape and Urban Planning*, 73, 167- 183.
4. K. Tanja-Dijkstra, A. van den Berg, J. Maas, J. Bloemhof-Haasjes & P. van den Berg (2017), Chemotherapie in de tuin. *Nederlands Tijdschrift voor Oncologie*, 14, 175-181.4.
5. Bolouki, A. (2022). Neurobiological effects of urban built and natural environment on mental health: systematic review. *Reviews on Environmental Health*.
6. Braubach, M., Kendrovski, V., Jarosinska, D., Mudu, P., Andreucci, M. B., Beute, F., ... & Russo, A. (2021). Green and blue spaces and mental health:: new evidence and perspectives for action. *World Health Organization*.
7. De Vries, S., Nieuwenhuizen, W., Farjon, H., Van Hinsberg, A., & Dirckx, J. (2021). In which natural environments are people happiest? Large-scale experience sampling in the Netherlands. *Landscape and urban planning*, 205, 103972.
8. Marselle, M. R., Bowler, D. E., Watzema, J., Eichenberg, D., Kirsten, T., & Bonn, A. (2020). Urban street tree biodiversity and antidepressant prescriptions. *Scientific reports*, 10(1), 1-11.
9. Nguyen, P. Y., Astell-Burt, T., Rahimi-Ardabili, H., & Feng, X. (2021). Green Space Quality and Health: A Systematic Review. *International journal of environmental research and public health*, 18(21), 11028.
10. Ribeiro, A. I., Triguero-Mas, M., Santos, C. J., Gómez-Nieto, A., Cole, H., Anguelovski, I., ... & Baró, F. (2021). Exposure to nature and mental health outcomes during COVID-19 lockdown. A comparison between Portugal and Spain. *Environment international*, 154, 106664.

Greenery and healthcare

More information on the effects of greenery



Recovery

Greenery in and around hospitals provides relaxation and distraction for convalescing patients.



Recommendations

- ▶ Green indoor and outdoor areas can also be used to provide (parts of) therapies in a less stressful environment (e.g. chemo gardens or green physiotherapy exercise rooms).



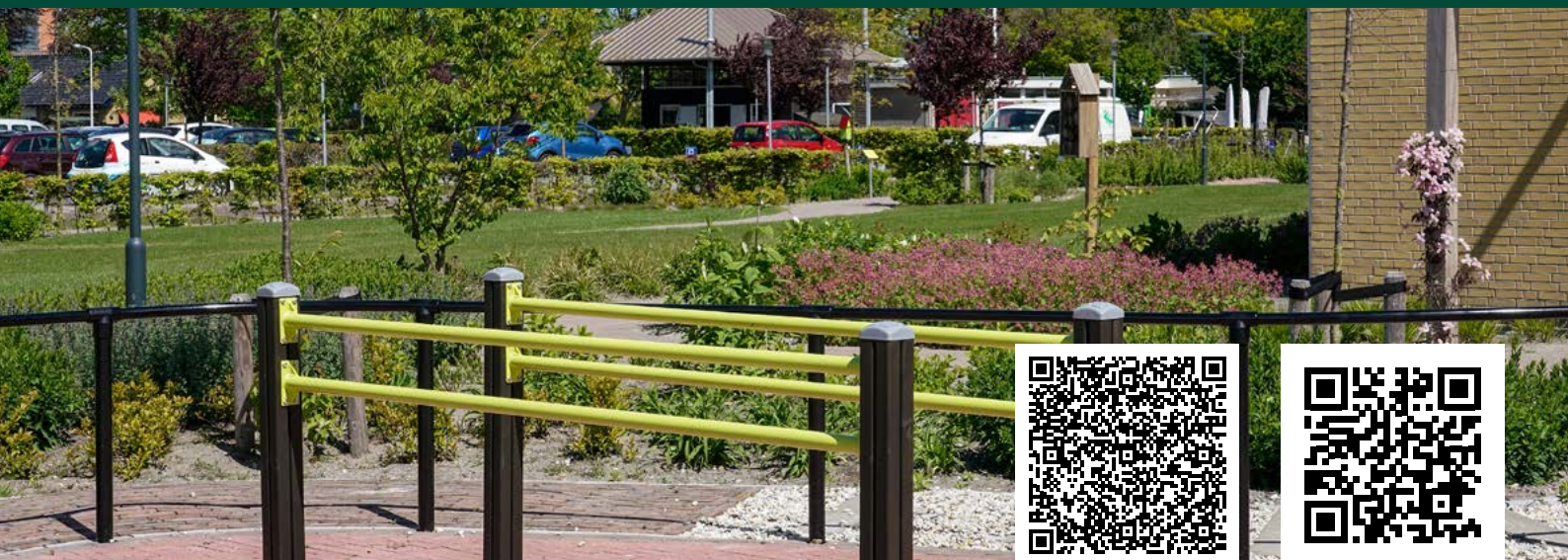
How greenery works

- ▶ Having a view of greenery from the hospital room helps to reduce the length of hospital stays (by nearly a day).¹
- ▶ Having a view of trees helps to reduce the length of hospital stays, provided that the room does not get (too) dark.²
- ▶ In an American hospital patients recovering from gallbladder surgery who had a view of trees from their room used less heavy painkillers than patients with a view of a brick wall.¹
- ▶ A view that includes greenery shortens hospital stays.
- ▶ In hospitals with greenery incorporated in their design a boost in social support for the patients staying there is observed.

1. R.S. Ulrich (1984), View through a window may influence recovery from surgery. *Science* 224:420-42
2. Mascherek, A., Weber, S., Riebandt, K., Cassanello, C., Leicht, G., Brick, T., Gallinat, J. & Kühn, S. (2022). On the relation between a green and bright window view and length of hospital stay in affective disorders. *European Psychiatry*.

Greenery and healthcare

More information on the effects of greenery



The Green Agenda
2020-2023

Looking for a digital
overview of hundreds
of studies about the
benefits of trees?

Check:
degroenestad.nl/facts

Further information

This fact sheet is one of a series of five fact sheets on the added value of greenery in our living environment. The other fact sheets take a closer look at greenery in residential, work, education and general contexts.

The fact sheets were updated in 2022, funded by the Horticulture & Propagation Materials Top Sector as part of the tailored knowledge programme The Green Agenda. Partners of this programme are Stichting de Groene Stad and Wageningen University & Research.

More information can be found on the websites of De Groene Stad, Groen Kennisnet and Wageningen UR:

- ▶ <https://www.wur.nl/nl/onderzoek-resultaten/onderzoeksprojecten-Inv/expertisegebieden/kennisonline/de-groene-agenda-2020-2023-valorisatie-van-groene-kennis-voor-een-klimaatadaptieve-en-leefbare-stad.htm>

- ▶ www.degroenestad.nl
- ▶ groene-agenda.nl
- ▶ groenkennisnet.nl

There are many examples of applications and studies that illustrate and prove the added value of vegetation. Other useful sources of information include:

- ▶ <https://ruimtelijkeadaptatie.nl/hulpmiddelen/factheets-groen/>

Here you will also find a table listing 120 tree species and their specific benefits as vegetation.

A useful tool for the design of a green healthy city is available at

- ▶ <https://tools.wenr.wur.nl/groenegezondestad/>

Specific questions on reference projects, research results, etc., can be sent directly to info@degroenestad.nl.

