Required data	Public health data regarding either total emergency room admissions or hospital admissions for specific disease categories. Population data.
Data input type	Quantitative
Data collection frequency	Before and after NBS implementation
Level of expertise required	Low to moderate
Synergies with other indicators	Synergies with the indicator group *Temperature* indicators
Connection with SDGs	SDG 3 Good health and well-being, and SDG 13 Climate action
Opportunities for participatory data collection	No opportunities identified
Additional information	
References	Agarwal, A.K., Dwivedi, S. & Ghanshyam, A. (2018). Summer heat: Making a consistent health impact. Indian Journal of Occupational and Environmental Medicine, 22(1), 57-58. Davis, R.E., & Novicoff, W.M. (2018). The impact of heat waves on emergency department admissions in Charlottesville, Virginia, U.S.A. International Journal of Environmental Research and Public Health, 15(7) 1436. Gronlund, C.J., Zanobetti, A., Schwartz, J.D., Wellenius, G.A., & O'Neill, M.S. (2014). Heat, heat waves, and hospital admissions among the elderly in the United States, 1992-2006. Environmental Health Perspectives, 122(11), 1187-1192.

22.7 Heat-related mortality

Project Name: CONNECTING Nature (Grant Agreement no. 730222)

Author/s and affiliations: Adina Dumitru[1], Catalina Young[2], Irina Macsinga[2]

[1] *Universitry of A Coruña, Spain*

[2] *West University of Timisoara, Romania*

Heat-related mortality	**Health and Wellbeing**
Description and justification	A built-up environment has significant influence on urban air temperature, which has been found to be considerably warmer than its surrounding rural or peri-urban areas. This phenomenon is called the urban heat island (UHI) effect,

where urban structures absorb solar heat (radiation) during the daytime and release it back to the environment at nighttime (Oke, 1981 as cited in Lehmann, 2014, p. 5). Introducing greenery in cities is seen as the most cost effective strategy for mitigating the urban heat island effect, because greenery helps to cool the environment through the process of evapotranspiration where large amounts of solar radiation can be converted into latent heat (Lehmann, 2014).

Bowler, Buyung-Ali, Knight and Pullin (2010) reviewed the cooling effect of urban greening and found moderate to strong evidence for reduced temperature. The meta-analysis demonstrated that, on average, a park is 0.94 °C cooler as compared to surrounding built environments. Increased heat is a strong predictor of a range of diseases (including several which have to date not been addressed in studies on natural environments and health, such as infant mortality and renal disorders) and mortality (Basagaña, Sartini, Barrera-Gómez, Dadvand, Cunillera, Ostro, Sunyer, & Mercedes Medina-Ramón, 2011; Benmarhnia, Deguen, Kaufman, & Smargiassi, 2015). It also has an impact on mental health (Berry, Bowen, & Kjellstrom, 2010).

The relation between heat and lung cancer mortality is not sufficiently investigated (van den Bosch and Ode Sang, 2017). An increase in mortality with heat has been reported for some specific causes, namely cardiovascular disease, respiratory disease, mental, and nervous systems disorders, diabetes, and kidney and urinary system diseases (Basagaña et al., 2011).

In the heat-related mortality literature, it is typical to distinguish two types of heat exposures: first, increases in ambient temperatures which can be defined as periods of high temperatures over single days, associated with mortality, and second, consecutive days of high heat also known as heat wave days, where population mortality is greater than on non-heat wave days (Benmarhnia et al., 2015). Basagaña et al. (2011) used a long mortality series (24 years) in a large geographic area of Spain to assess the effect of extremely hot days on mortality using a fine classification of the cause of death, including external causes and causes of infant mortality. The study included all persons who died in Catalonia during the warm season (defined as May 15–October 15, which included the half-months with an average maximum temperature greater than 20°C) of the 24-year period from 1983 to 2006.

	Exposures to temperature and to humidity (records) were assigned to each deceased person based on the values registered in the nearest weather station within the climatic zone of the town of death. Epstein and Moran (2006) advanced arguments for use of DI - the Discomfort Index – for the measurement of heat stress.
Definition	**Heat-related Deaths Indicator** shows the annual rate for deaths classified by medical professionals as "heat-related" in a given country, based on death certificate records. Every death is recorded on a death certificate, where a medical professional identifies the main cause of death (also known as the underlying cause), along with other conditions that contributed to the death. These causes are classified using a set of standard codes. Dividing the annual number of deaths by the country's population in that year, then multiplying by one million, will result in the death rates (per million people) that this indicator shows (Climate Change Indicators: Heat-Related Deaths, n.d.). **Mortality** measures deaths caused by a specific disease, deaths resulting from treatment for a specific disease, or deaths in which a specific disease is a contributing factor, but not the primary cause. Mortality is the number of deaths due to a disease during a specific time divided by the number of persons in that population at the beginning of the time period. Hence, mortality is a rate in the sense that it represents how quickly deaths occur relative to population size and the passage of time. It can be interpreted as reflecting the risk of death from a particular cause faced by persons within the population being studied (National Institutes of Health. Autoimmune diseases coordinating committee—Autoimmune diseases research plan, n.d.).
Strengths and weaknesses	+ robust evidence as to UHI being a strong predictor of death rates, especially for certain health conditions, like cardiovascular disease, respiratory disease, renal disorders, etc. - limited empirical evidence on heat's role in lung cancer complications, etc.
Measurement procedure and tool	☒ *Quantitative*: epidemiological data (Health Data Administration/Cities) Recommended variables: o Discomfort Index, DI (i.e., Temperature–humidity index, THI) - combination of temperature and humidity that is a measure of the degree of discomfort experienced by an individual in warm weather (Temperature–

	humidity index - Meteorological Measurement, n.d.) o Heat-related Deaths Indicator
Scale of measurement	-
Data source	
Required data	✓ Essential: NBS characteristics for each city/site
Data input type	Quantitative
Data collection frequency	Before and after NBS implementation (longitudinal)
Level of expertise required	☒ Methodology and data analysis requires high expertise in psycho-social research ☒ Quantitative data collection requires no expertise
Synergies with other indicators	HW3 General Wellbeing and Happiness HW4 Life expectancy and healthy life years expectancy HW6 Prevalence, incidence, morbidity, and mortality of cardiovascular disease (CVD) HW7 Prevalence, incidence, morbidity, and mortality of respiratory disease (RD) HW10 Prevalence, incidence, morbidity of chronic stress HW11 Mental Health Wellbeing: Depression and Anxiety HW12 Restoration-Recreation: Enhanced physical activity and meaningful leisure HW13 Levels of aggressiveness and violence
Connection with SDGs	Goal 3. Ensure healthy lives and promote well-being for all at all ages Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
Opportunities for participatory data collection	-
Additional information	
References	Basagaña, X., Sartini, C., Barrera-Gómez, J., Dadvand, P., Cunillera, J., Ostro, B., Sunyer, J., & Medina-Ramòn, M. (2011). Heat waves and cause-specific mortality at all ages. *Epidemiology,* 22, 765–772. doi: 10.1097/EDE.0b013e31823031c5 Benmarhnia, T., Deguen, S., Kaufman, J.S., & Smargiassi, A. (2018). Vulnerability to Heat-related Mortality: A Systematic Review , Meta-analysis , and Meta-regression Analysis. Epidemiology (Cambridge, Mass.), 26. doi: 10.1097/EDE.0000000000000375 Berry, H., Bowen, K., & Kjellstrom, T. (2010). Climate change and mental health: A causal pathways framework. *International Journal of Public Health*, 55, 123-32. doi: 10.1007/s00038-009-0112-0 Bowler, D., Buyung-Ali, L., Knight, T.M., & Pullin, A. (2010). Urban greening to cool towns and cities: A systematic review of the

empirical evidence. *Landscape and Urban Planning*, 97, 147-155. doi: 10.1016/j.landurbplan.2010.05.006

Climate Change Indicators: Heat-Related Deaths (n.d.). Retrieved from https://www.epa.gov/climate-indicators/climate-change-indicators-heat-related-deaths

Epstein, Y. & Moran, D. (2006). Thermal Comfort and the Heat Stress Indices. *Industrial Health*, 44, 388-98. doi: 10.2486/indhealth.44.388

Lehmann, S. (2014). Low carbon districts: Mitigating the urban heat island with green roof infrastructure. *City, Culture and Society*, 5, 1-8. doi: 10.1016/j.ccs.2014.02.002.

National Institutes of Health. Autoimmune diseases coordinating committee—Autoimmune diseases research plan. (n.d.). Retrieved from https://www.niaid.nih.gov/about/autoimmune-diseases-committee

Temperature–humidity index - Meteorological Measurement (n.d.). Retrieved from https://www.britannica.com/science/temperature-humidity-index

van den Bosch, M. & Ode Sang, Å. (2017). Urban natural environments as nature-based solutions for improved public health – A systematic review of reviews. *Environmental Research*, 158, 373-384. doi: 10.1016/j.envres.2017.05.040