RISK REDUCTION GUIDANCE

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ABSTRACT

Green roofs are roofs covered with vegetation and are considered a nature-based climate solution. Extensive green roofs use hardy plants and require little maintenance, while intensive green roofs resemble gardens or parks and require more maintenance. Green roofs cool their buildings and the surrounding environment through absorption of solar radiation and evapotranspiration. They benefit health by reducing the temperature of indoor environments; they can also reduce air pollution and improve mental health through nature contact. There are no studies that have directly observed impacts of green roofs on health care utilization or mortality. In simulations, widespread green roof adoption reduced indoor air temperatures 2-3°C (3-5°F), reduced population-weighted summertime temperature by 0.35°C (0.63°F), and reduced heat-related mortality by 0.21%. Green roofs are more expensive than conventional roofs to install and maintain but last about twice as long, yielding a small net cost premium that is considered marginal over the roof's lifetime. Alternatives to green roofs include high albedo (highly reflective) roofs, though these roofs also retain less solar radiation in winter, resulting in higher heating costs.

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What is the intervention?

Green roofs, also known as eco-roofs or roof-gardens, are roofs partially or fully covered by vegetation. They can be implemented in all climates and on all types of buildings, including individual housing units, and work best with native plants (Chicago green roofs). There are two main types: extensive green roofs, which tend to utilize hardy plants and require little

maintenance once implemented, and intensive green roofs, which are more complex and resemble conventional gardens or parks, thus requiring more maintenance (Using Green Roofs to Reduce Heat Islands 2014). Green roofs are considered a nature-based solution to climate change.

The benefits of green roofs are many – studies have shown that green roofs can reduce CO_2 levels and particulate matter in the air, dampen heavy precipitation through their use of soil and porous surfaces, decrease energy utilization, and provide cooling effects in their respective areas (Thokchom et al. 2022; Jamei et al. 2023). In particular, green roofs can improve thermal comfort and reduce cooling costs to building occupants. Green roofs have an albedo of 0.2-0.3, meaning they reflect approximately 20%-30% of solar radiation. An additional 60% of solar radiation is absorbed in photosynthesis, and approximately 20% of the sun's radiation is transferred to the building below (Berardi et al. 2014).
Green roofs provide cooling to their respective areas through the shading effects of their vegetation and by providing insulation with soil, waterproofing, and other components of the green roof structure. While these cooling effects are present in all climates, they are more pronounced in hotter climates. Green roofs may have other health benefits, as well, e.g., for mental health in urban areas (Rezaei et al. 2021), patient wellbeing in hospitals (O'Hara et al. 2022), and remediation of urban air pollution (Speak et al. 2012).

How effective is the intervention at protecting people's health?

Green roofs protect health by reducing the heat hazard in the indoor and outdoor environments, thereby reducing heat-related illness. One study compared the cooling effects of green roofs to those of bare roofs, and found that green roofs of 100mm and 300mm thickness were 2.5°C and 4°C cooler, respectively (Pianella et al. 2016). The cooling and insulating effects of green roofs have been shown to be even more effective in hotter climates such as Phoenix and Rio de Janeiro, suggesting that areas with higher average temperatures would benefit even more from the implementation of green roofs (Jamei et al. 2023).

There has been little research investigating the effects of green roofs as an intervention in the prevention of heat injury, specifically, and there are no studies documenting an association between green roof interventions and reductions in unplanned health care utilization or mortality.

Simulation studies provide some insight into the potential health impacts of green roof interventions. For example, a simulation of full adoption of green roofs in the city of Boston, Massachusetts and the New England area of the United States found that green

roofs reduced population-weighted summertime temperature by 0.35°C and reduced heat-related mortality by 0.21% (He et al. 2020). Other studies have used simulation to identify high priority areas where green roofs would have the greatest impact on reducing a conjoint function of heat exposure, air conditioning use, and heat vulnerability (Sharma et al. 2018).

How long does the intervention take to implement?

Installing a green roof takes slightly longer than installing a conventional roof. Estimates for installation of a residential green roof are about a week, as materials need to be installed in the correct order; installation may be quicker if all materials are available on site.

Green roof maintenance is particularly important during the first five years after installation, in order to ensure that the vegetation becomes well established. After this initial five-year maintenance period, green roofs still need to be regularly maintained but the frequency of maintenance decreases. Depending on the type of green roof installed and the types of vegetation used, a green roof can be considered well established within 2 to 5 years after planting (Operation and maintenance of green roofs - Minnesota Stormwater Manual).

How much does the intervention cost?

The estimated cost of implementing and maintaining a green roof depends on the type of green roof (extensive vs intensive), as more simple extensive roofs can cost as little as one tenth to one-third of the cost of an intensive green roof. In addition, while the initial cost of implementing a green roof is generally higher than the cost of a conventional roof, green roofs have been shown to reduce overall costs over long periods of time (Using Green Roofs to Reduce Heat Islands 2014). Moreover, green roofs last about twice as long as conventional roofs, offsetting the higher installation costs. Research has found that green roofs have a cost premium of $3.20 per square meter per year, which is considered sufficiently small to make the choice between a green roof and a low-albedo white roof a matter of preference (Sproul et al. 2014).

Are there downsides to consider?

There are two primary downsides to consider. The first, mentioned above, is the higher initial installation cost. The second is that green roofs may require supplemental water during dry periods and that green roofs may lose much a significant degree of their cooling potential during periods of severe drought, though this can be mitigated to a degree by using substrates with low thermal conductivity (Zheng et al. 2022).

What other strategies should be considered?

Use of highly reflective (high albedo) materials like white or cool roofs also improve thermal comfort of building occupants and reduce heat load in the built environment. These materials also reflect solar radiation in winter, however, potentially increasing heating costs in areas with cold winters.

What are some good sources of additional information?

Using green roofs to reduce urban heat islands from the Environmental Protection Agency
Green roofs for healthy cities

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