



# Issue Brief

## Can Sustainable Hospitals Help Bend the Health Care Cost Curve?

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**Abstract:** As policymakers seek to rein in the nation's escalating health care costs, one area deserving attention is the health system's costly environmental footprint. This study examines data from selected hospitals that have implemented programs to reduce energy use and waste and achieve operating room supply efficiencies. After standardizing metrics across the hospitals studied and generalizing results to hospitals nationwide, the analysis finds that savings achievable through these interventions could exceed \$5.4 billion over five years and \$15 billion over 10 years. Given the return on investment, the authors recommend that all hospitals adopt such programs and, in cases where capital investments could be financially burdensome, that public funds be used to provide loans or grants, particularly to safety-net hospitals.

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### OVERVIEW

The health care sector has a large and costly environmental footprint. Hospitals, in particular, are among the country's most energy-intensive facilities, accounting for a significant percentage of U.S. greenhouse gas emissions and carbon dioxide emissions. They create 6,600 tons of waste per day and use large amounts of toxic chemicals. Reducing such pollution and greenhouse gas emissions would reduce the incidence of human disease, thereby saving money for the health care system and society as a whole.

As part of a preventive approach to controlling chronic disease, increasing numbers of hospitals have committed to minimizing the adverse environmental effects of their operations on patients, staff, and the community, serving as role models for the health sector and society at large. If such innovations were adopted nationwide, could they help bend the health care cost curve?

For this study, we collected data from hospitals implementing energy use reduction, waste reduction, and efficient purchase of operating room (OR)

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supplies. We standardized metrics and extrapolated to project national savings were all U.S. hospitals to implement such greening activities. Our conclusion is that these savings could exceed \$5.4 billion over five years, and \$15 billion over 10 years.

It has been assumed by some that interventions aimed at sustainability would cost hospitals more to undertake than any savings that would accrue to them. Based on the data analyzed in this study, we find this concern to be misplaced, even for cases in which capital costs are spent to achieve energy savings. Many interventions studied did not involve any additional identifiable costs and realized immediate savings. Given the small costs and the positive return on investment within a short time frame for the sustainability activities studied—as well as their broader environmental and public health benefits—we recommend these innovations for all hospitals. For cash-strapped safety-net hospitals, where even small capital investments are a stress, these interventions can be within reach with the use of federal and state funds to support the cost-saving changes.

## BACKGROUND

With the potential cost-saving reforms of the Patient Protection and Affordable Care Act still some years away, health care costs remain largely unrestrained. Sector efficiencies that could increase institutional savings and reduce societal costs are under active discussion, but few have been extensively implemented.

The health care sector has a large and costly environmental footprint. Hospitals are among America's most energy-intensive facilities, using 836 trillion British thermal units (Btu) of energy and spending over \$10 billion on energy annually<sup>1</sup>—often equaling 1 percent to 3 percent of a typical hospital's operating budget.<sup>2</sup> A 2007 study estimated that health care accounted for 8 percent of all U.S. greenhouse gas emissions and 7 percent of total carbon dioxide emissions.<sup>3</sup> Common energy-wasting practices in health care include fully heating or cooling spaces that are unoccupied, failing to maintain equipment, and neglecting to check for air and water leaks.

Health facilities create 6,600 tons of waste per day, much of which is transported to and buried in landfills. According to the U.S. Environmental Protection Agency, 85 percent of a typical hospital's waste is nonhazardous, yet is often mistakenly placed in “red bag” or medical waste containers. This both increases the cost of disposal and unnecessarily raises the level of treatment needed, which may in itself increase pollution through increased incineration or other polluting techniques.<sup>4</sup> One report estimates that processing red bag waste can cost nearly 20 times more than processing solid waste.<sup>5</sup> Other wasteful practices include failing to recycle or reuse items like paper, plastic, and cardboard.

Operating rooms have a particularly large environmental impact: they account for about 33 percent of all hospital supply costs and have large costs for energy use and waste management.<sup>6</sup> Among wasteful OR practices are: using disposable rather than reusable products; using blue sterile wrap one time, rather than investigating options for recycling it or replacing the wrap with reusable hard cases; and throwing away, unused, items from pre-packaged OR “packs” formulated for specific surgical procedures.

The pollution and greenhouse gas emissions that result from these and other environmentally unsound practices have major effects on the public's health, as indicated in various studies. The President's Cancer Panel stated in a 2010 report that “the true burden of environmentally induced cancer has been grossly underestimated.”<sup>7</sup> A recent study estimated that six climate change-related events cost about \$14 billion in health care expenses and lives lost.<sup>8</sup> According to the U.S. Department of Energy, reduced power plant emissions could save more than \$20 billion annually in U.S. health care costs through lowering the incidence of cancer, liver and kidney disease, and reproductive problems.<sup>9</sup> Experts commonly note that reducing waste would lower emissions of methane—a powerful greenhouse gas—from landfills, and of health-impacting emissions generated by manufacture of products and transportation of waste.

Given the costly effects of environmental damage, efficient, sustainable hospital buildings and operations have a logical place in conversations about care quality, efficiency, and costs. While these discussions remain primarily speculative as yet, health care leaders have become increasingly aware of the health care sector's impact on the environment and its costs in human health. As part of a preventive approach to controlling chronic disease, increasing numbers of hospitals have committed to minimizing adverse environmental impact of their operations on patients, staff, and the community, serving as role models for the health sector and society at large.

### HOW THIS STUDY WAS CONDUCTED

Based on existing institutional data, standardized by data currently collected and by hospital size, we calculated the fiscal effects resulting from selected environmentally friendly interventions among a group of institutions. To estimate the potential for hospital cost savings nationwide, we extrapolated our findings to all U.S. hospitals. The sustainability interventions in our study included:

- energy use reduction: a range of operational changes, from more efficient operations to use of more energy-efficient equipment;
- waste reduction: recycling, minimization of regulated medical waste through improved segregation and other interventions, and reduction in total landfilled waste through a range of interventions in daily operations;
- more efficient purchase of OR supplies through reprocessing and reuse of single-use medical devices; and
- more efficient purchase of OR supplies through reformulation of OR “packs.”

Hospitals that have reduced their environmental footprint over the past five years were identified by Practice Greenhealth, the health care institution membership subsidiary of the organization Health Care Without Harm, and by the Healthier Hospitals

Initiative.<sup>10</sup> We selected five hospitals for energy use reduction, four for waste reduction, seven for single-use device (SUD) reprocessing, and two for OR pack reformulation. We sought exemplar rather than representative hospitals to demonstrate the cost savings that are possible. We collected common data from representatives of each institution that described the facility, the costs of the interventions, and the savings realized. We collected self-reported data that the hospitals rely on to report internally to their CEOs.

A return-on-investment framework was developed incorporating the operational costs one year prior to implementation and up to five years after implementation, and savings resulting from the interventions. We made no adjustments for inflation.

To estimate the proportion of U.S. hospital activity represented by the study hospitals for the purposes of extrapolation, we standardized their size and operational data. For energy use reduction, we compared each study hospital's energy costs with total annual U.S. hospital energy costs, published by the U.S. Department of Energy, to determine each hospital's respective share.<sup>11</sup> We also determined the study hospitals' share of U.S. hospitals' total square footage, also as reported by the Department of Energy.<sup>12</sup> The cost and square footage calculations were compared to ensure the validity of our methodology. The energy savings were adjusted to account for the costs of energy improvements. For waste reduction estimates, we determined the study hospitals' share of national adjusted patient days (APD), published by the American Hospital Association.<sup>13</sup> To calculate the potential national impact of the interventions to more efficiently purchase OR supplies, we determined the study hospitals' share of all surgeries performed in the United States as reported by the U.S. Centers for Disease Control.<sup>14</sup>

### RESEARCH FINDINGS

#### Total Savings

Extrapolating from the study hospitals' experience to the country as a whole, we estimated the total

five-year national savings of the hospitals' sustainability interventions at more than \$5.4 billion. At 10 years, national savings are projected to triple, exceeding \$15 billion. The estimates for years 6 through 10 use the same annual savings, based on year 5's estimates. (See Exhibit 1 for the interventions' estimated cumulative net savings for 10 years and Exhibit 2 for the 10-year savings estimates by intervention.) Net savings over five years for energy use reduction do not accrue until year 5 because of the capital investment dollars spent by the study hospitals as part of their energy savings interventions.

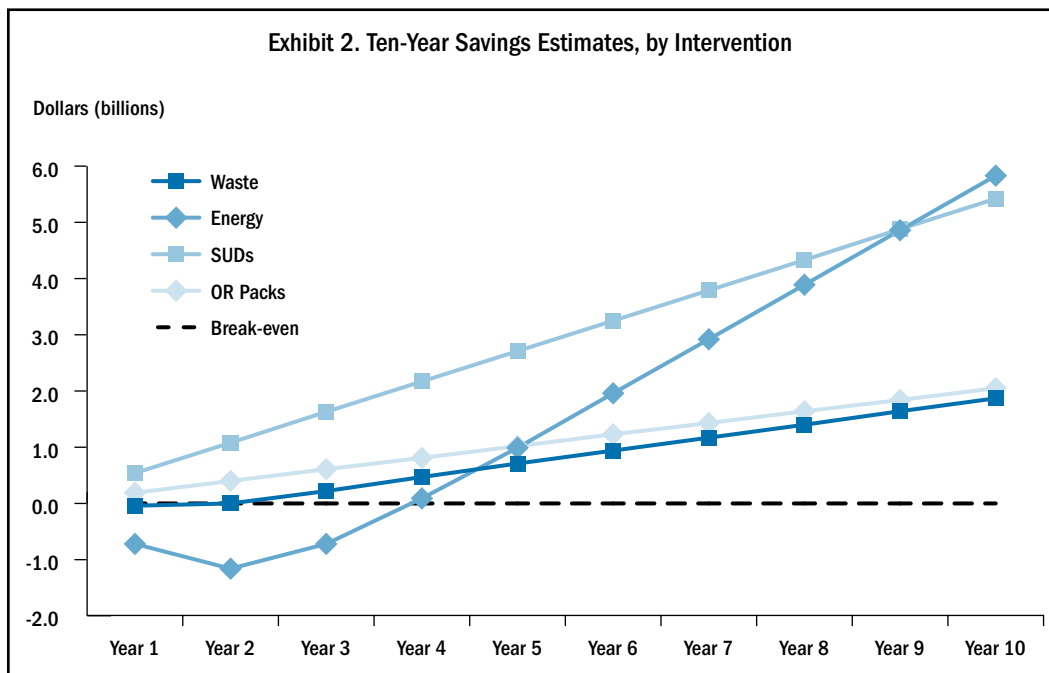
**Energy Use Reduction**

To examine energy use reduction, we collected data from five study hospitals. We report our findings in the aggregate to maintain the confidentiality of the data. Lists of and information about hospitals that are achieving significant cost savings in the energy area can be found on the Web sites of Practice Greenhealth, U.S. EPA's Energy Star for Healthcare, and other organizations. Technical information about the energy reduction interventions is available from the American Society for Healthcare Engineering, U.S. Department of Energy, U.S. Environmental Protection Agency, the American Hospital Association, Practice Greenhealth, and from consultants.

**Exhibit 1. Estimated Cumulative Net Savings from Four Interventions, Over 10 Years**

\$ billions	
Year 1	-\$0.02
Year 2	\$0.32
Year 3	\$1.73
Year 4	\$3.54
Year 5	\$5.42
Year 6	\$7.37
Year 7	\$9.32
Year 8	\$11.30
Year 9	\$13.20
Year 10	\$15.20

Hospital A, in a large Northeast city and part of a regional multihospital network, is over a century old and is a general tertiary care teaching hospital with over 900 licensed beds. Likewise, Hospital B, also in a large Northeast city and part of the same multihospital network as Hospital A, is over a century old and is a general tertiary care teaching hospital with about 600 licensed beds. Hospital C, in a small upper Midwest city, is a standalone general tertiary care hospital with more than 300 licensed beds. Hospital D, in a large Midwest city and part of a national multihospital network, is a general community teaching hospital with approximately 400 licensed beds. Hospital E, in a large West Coast city and part of a regional multihospital



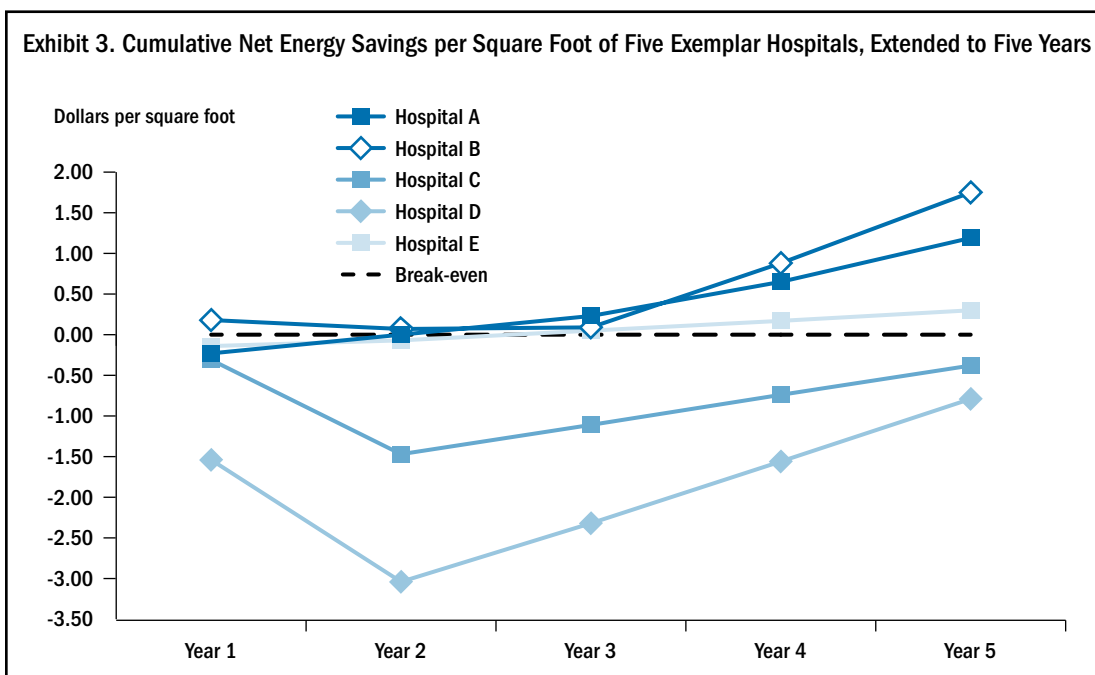
network, is a general community hospital with about 300 licensed beds.

These hospitals’ energy-related interventions included lighting upgrades, variable-frequency drives (a type of adjustable-speed drive used in a range of appliances that offer significant energy efficiency improvements over fixed-speed drives by varying motor input frequency and voltage), high-efficiency electric motors, fume hoods, motor upgrades, steam insulating jackets, occupancy sensors for public areas, zone air handler scheduling, unoccupied period controls, off-hours shutdown, annual steam trap audits, thermostatic valves on radiators/heaters, changes to steam trap design, hydronic heating controls (which use water as the heat-transfer medium in heating systems), boiler replacement with higher-efficiency boiler, central plant chiller replacement, and solar film on windows. For any given hospital, the effectiveness of the interventions depends on the state of the facility, the skill of facilities managers to continuously verify that the building’s systems are working properly, the availability of rebate and support programs from utilities and government agencies, and the mix of fuel and energy prices.

The average reduction in energy use across the study hospitals was 27.2 kBtu per square foot by year 5, or 9.8 percent relative to baseline use. Reductions

across the five hospitals ranged from 3.1 percent to 24.2 percent. The total five-year gross cost savings as a result of the energy use reduction interventions was \$2.12 per square foot. After deducting the cost of the interventions for the five-year period—\$1.40 per square foot—we estimate the five-year cumulative net savings per square foot for the five study hospitals to be 72 cents per square foot. (See Exhibit 3.) Total annual hospital energy costs in 2010 were estimated at \$10 billion.<sup>15</sup> The total square footage of U.S. hospitals is estimated at 2.24 billion square feet in 2010, increasing at 42 million square feet per year.<sup>16</sup> If the study hospitals’ interventions to reduce energy use were adopted nationwide, we estimate the five-year net cost savings would be just under \$1 billion (\$980 million). We used conservative assumptions to ensure that we would not overstate the results. For example, if reported capital improvements resulted from something other than energy savings, we nevertheless included their full costs in our estimates of the interventions’ cost.

The estimates were extended five more years, which is less than the typical life of capital system upgrades. Assuming the same level of management oversight to maintain efficient operations, the potential savings are another \$4.8 billion in constant dollars. Looking at a 10-year time frame (and beyond)



is informative since, as referred to above, net savings over five years for energy use reduction show less of a straight line relative to other interventions because of the capital investment dollars spent by two of the study hospitals.

**Waste Management**

To examine waste management interventions, we collected data from four hospitals, although one of the hospitals did not provide data on regulated medical waste. We report our findings in the aggregate to maintain the confidentiality of the data. Hospital A, in a large Midwest city, is a standalone teaching hospital with approximately 200 licensed beds. Hospital B, in a Northwest city and part of a regional multihospital network, is a large hospital with over 500 licensed beds. Hospital C, in a Northwest town and part of the same network as Hospital B, has approximately 75 licensed beds. Hospital D, in a small city in the West and part of an extensive West Coast hospital network, is a tertiary care hospital with about 250 licensed beds.

The waste management interventions at these hospitals included recycling plastics, blue wrap (a sterile wrap that protects surgical instruments and other items from contamination), Tyvek (a brand of durable sheet products), clean Styrofoam, IV bags/tubing/

plastic syringes that contained sugar or salt solutions or lactated ringers, glass, metal, paper, cardboard, paper-board, electronics, light bulbs, batteries, solvents, fluorescent tubes, electronic waste, ink cartridges, cooking oil, motor oil, x-rays, batteries, lamps, and scrap metals; growing food for the hospital cafeteria in an on-site garden; composting food waste from kitchens and cafeterias; using reusable sharps containers; educating staff about how to reduce regulated medical waste (RMW); using an on-site autoclave for RMW, followed by disposal with general trash; fluid reduction in the OR; reprocessing surgical devices; separating pharmaceutical waste; reusing office supplies, pallets, and packing crates; reducing use of plastic; and donating used items to local or national charities for domestic reuse or overseas donation.

The cost of these interventions with respect to waste sorting and staff training was judged to be minimal by three of the institutions, requiring no significant hiring or staff reassignment at one study hospital and minimal hiring at two of the study hospitals. The fourth hospital indicated that a portion of several staff persons' time was spent on waste reduction activities. The waste streams were different at each study hospital, and this in part explains their different cost and savings results.

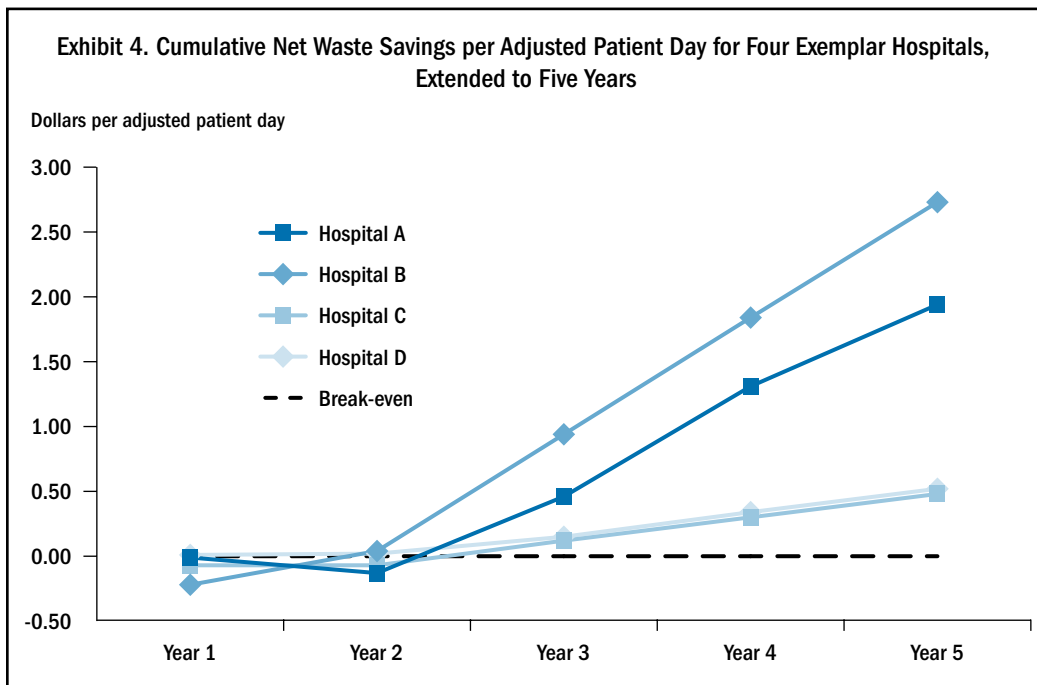


Exhibit 4 shows the five-year estimated cumulative net savings per adjusted patient day (APD) across the four study hospitals. The five-year average gross cost savings per adjusted patient day as a result of the waste reduction interventions was about 46 cents. After we accounted for the average cost of the interventions at about 7 cents per APD, the average net cost savings realized was about 40 cents per APD. From the 2009 American Hospital Association Annual Survey, the annual APD for all hospitals nationally totaled over 350 million days. On the basis of these figures, we estimated that if hospitals nationwide adopted the study hospitals’ waste management interventions, the five-year net cost savings would exceed \$700 million.

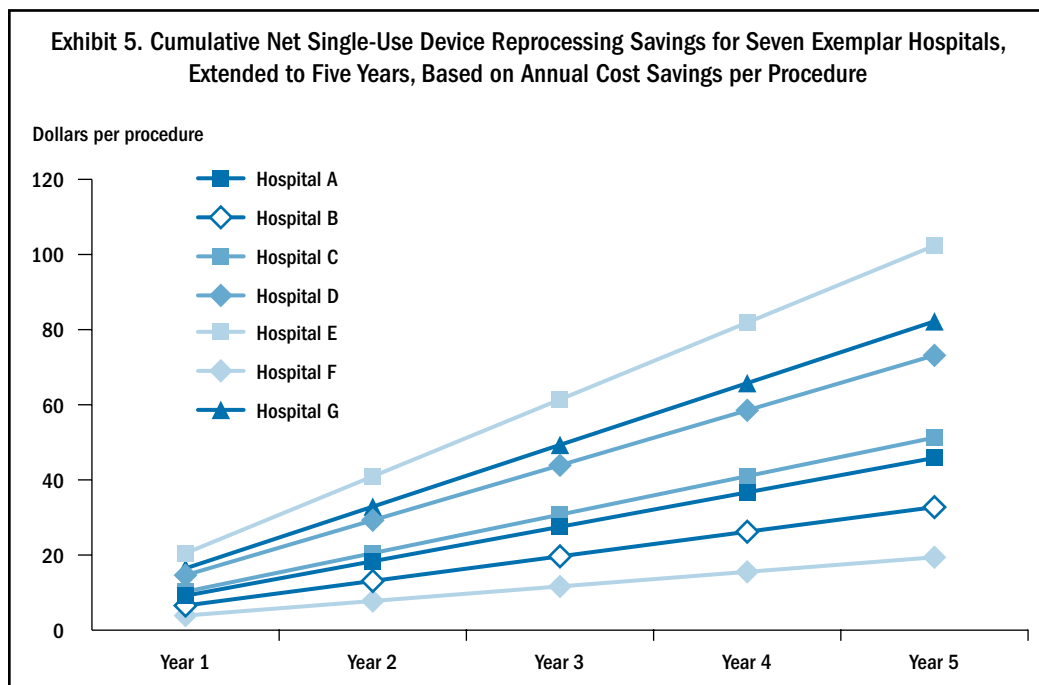
**OR Efficiencies Related to Single-Use Device Reprocessing**

To examine single-use medical devices (SUDs) used in the OR, we collected data from seven hospitals. Six of the hospitals (A–F) are part of a regional multihospital system based in the Midwest; they range from about 250 to about 700 licensed beds. Hospital G is part of another regional multihospital system located in a large Midwest city and is a tertiary teaching hospital with more than 700 beds. The hospitals contracted with a service that collected the hospitals’ SUDs from the OR,

inspected them to determine which could be reused, cleaned and sterilized them, and sold them back to the hospitals at a reduced price compared with new multiuse devices. Exhibit 5 shows the five-year estimated cumulative net SUD reprocessing savings per average annual procedure across the seven study hospitals to be about \$12 per procedure. This figure is based solely on device purchasing savings and does not include waste disposal cost savings that may have resulted.

The U.S. Government Accountability Office stated in a 2008 report that U.S. Food and Drug Administration (FDA) oversight of reprocessed SUDs has increased and that available information indicates that their use does not present an elevated health risk.<sup>17</sup> While such devices are considered single use, hospitals are reusing them based on FDA guidance. The reprocessing steps include inspection of each device after use to determine its suitability for reuse following cleaning and sterilization.

The metric used for extrapolation was the study hospitals’ share of the 45 million surgical procedures performed in the United States in 2007.<sup>18</sup> We estimated that the seven study hospitals’ cost savings over five years was about \$57 per procedure and that if hospitals nationwide adopted the study hospitals’ SUD reprocessing intervention, the cost savings would be \$540 million annually, or \$2.7 billion over five years.



## OR Efficiencies Related to Pack Reformulation

To examine another OR intervention—pack reformulation (packs are prepackaged supplies formulated for specific surgical procedures)—we collected data from two hospitals. The two hospitals studied, tertiary teaching hospitals in the Midwest, are part of the same multihospital system. Hospital A has approximately 380 licensed beds and Hospital B has more than 1,000 licensed beds. The hospitals had differences in cost savings because of the fact that one tends to perform less complicated procedures than the other and thus has fewer items in the packs.

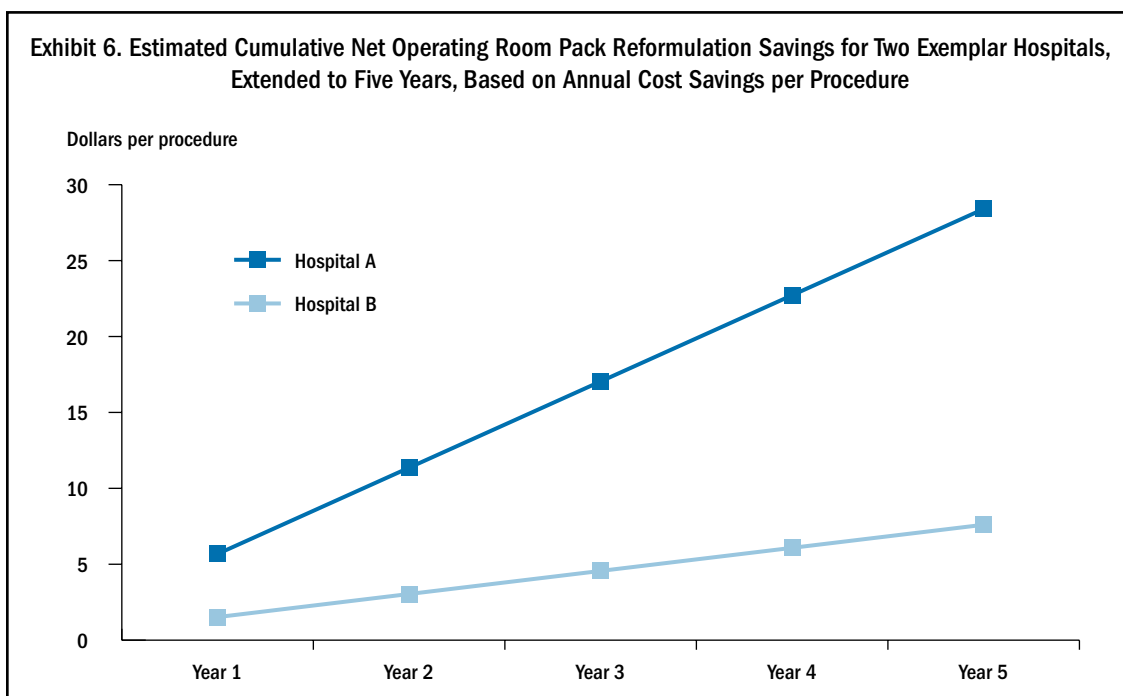
Under this intervention, hospital staff examined OR packs that had been preformulated for specific procedures, identified items in them that were often not used and thrown away after the packs were opened, and asked their suppliers to leave those items out. The hospitals reported a small implementation cost for this intervention associated with the time OR nurses spent examining the packs to identify the items to be eliminated and other related administrative activities, including meetings. The hospitals did not identify implementation costs for staff education, which was informal, or for the time spent by their “green” surgeon

who championed the reformulation effort and secured the support of the department.

The cost of the interventions was \$5,000. Exhibit 6 shows the cumulative net savings per average annual procedure for the two hospitals. The average net cost savings realized by the two hospitals as a result of the OR pack reformulation activities was \$4.33 per procedure in the year of the reformulation and \$22.66 after five years. If hospitals nationwide adopted the study hospitals’ reformulation of OR packs, the cost savings would be \$190 million in year 1 and \$1.02 billion over five years. Our calculations included the National Center for Health Statistics’ figure of 45 million surgical cases in the U.S. in 2007 and the two hospitals’ report of 20,259 surgical cases in 2010.<sup>19</sup>

## METHODOLOGY CONSIDERATIONS

Conclusions based on this study should be considered an initial estimate rather than a precise assessment of savings opportunities because of methodological limitations, including a small number of interventions selected, limited number of hospitals studied, data availability, complexities in measuring staff educational costs, and difficulty in selecting typical hospitals for extrapolation.





In selecting hospitals that showed leadership in the area of sustainability, we also sought diversity in size, type, and location to acknowledge the diversity that exists among hospitals nationwide. However, our sample is not representative, as it includes a number of academic medical centers, which likely use more energy, generate more waste, and purchase more OR supplies than average and includes hospitals that are larger than average overall. It is unclear whether the cost savings of smaller hospitals would tend to be proportionally less or greater than those for larger hospitals.

Estimations made in this study are conservative in several ways. First, the number of interventions assessed is limited. They fall into the areas of hospital waste disposal, energy use, and OR supply efficiencies, but many more opportunities exist for “greening” health care (that is, making it more environmentally friendly), from green building construction to the use of greener products and chemicals, such as green cleaners and natural pest control methods. Some of the study hospitals were early adopters of their sustainability interventions and likely had already realized some savings prior to the years for which they provided data. The results from these hospitals were blended with those of others that provided data at the point at which they began these efforts, similar to hospitals that have not begun to implement these interventions.

Additionally, in this study we looked at existing buildings and operations. We did not address the potential that new building designs, properly implemented and operated, have to achieve substantial lifetime savings with respect to energy and possibly waste handling as well.

Finally, we worked to be conservative in our calculations. In the energy area, as discussed earlier, we included the full costs of capital improvements reported to us, even if they were made for reasons other than energy use reduction. This may have overstated the costs and understated the savings for the environmentally friendly interventions studied. Several hospitals indicated that certain benefits accrued from their interventions but that they have not

been quantified. For example, one hospital noted that many of its energy efficiency projects have resulted in maintenance, parts, and labor savings, but these were not quantified as part of this study. Another hospital stated that while it tracks the savings on individual projects, the staff does not quantify many of the savings that accrue from their in-house operational efforts. Additionally, no data were collected on how the interventions studied may have affected a hospital’s overall quality or efficiency of operations, reputation, or fundraising efforts.

## **STUDY CONCLUSIONS, POLICY IMPLICATIONS, AND RECOMMENDATIONS**

Our study results indicate that concerns are misplaced about the likelihood for hospitals’ costs associated with sustainability interventions to outstrip any savings accrued. Our study of hospitals’ experience shows that intervention costs, including capital costs, are relatively small and investments yield positive returns within a short time frame. Projecting the study hospitals’ savings to hospitals nationwide, we conclude that just a few environmentally friendly interventions could produce over \$5 billion in five years and triple that figure after 10 years. We also found that an organizational culture of commitment to sustainability, set by the board and top leadership, was as important a factor in cost savings as the setting or the specific activities undertaken.<sup>21</sup> Given the small interventional costs and the positive return on investment for the interventions studied—as well as their broader environmental and public health benefits—we contend that all hospitals should implement these innovations. Hospital executive leadership should designate green teams to evaluate the implementation of these and other interventions within their organizations.

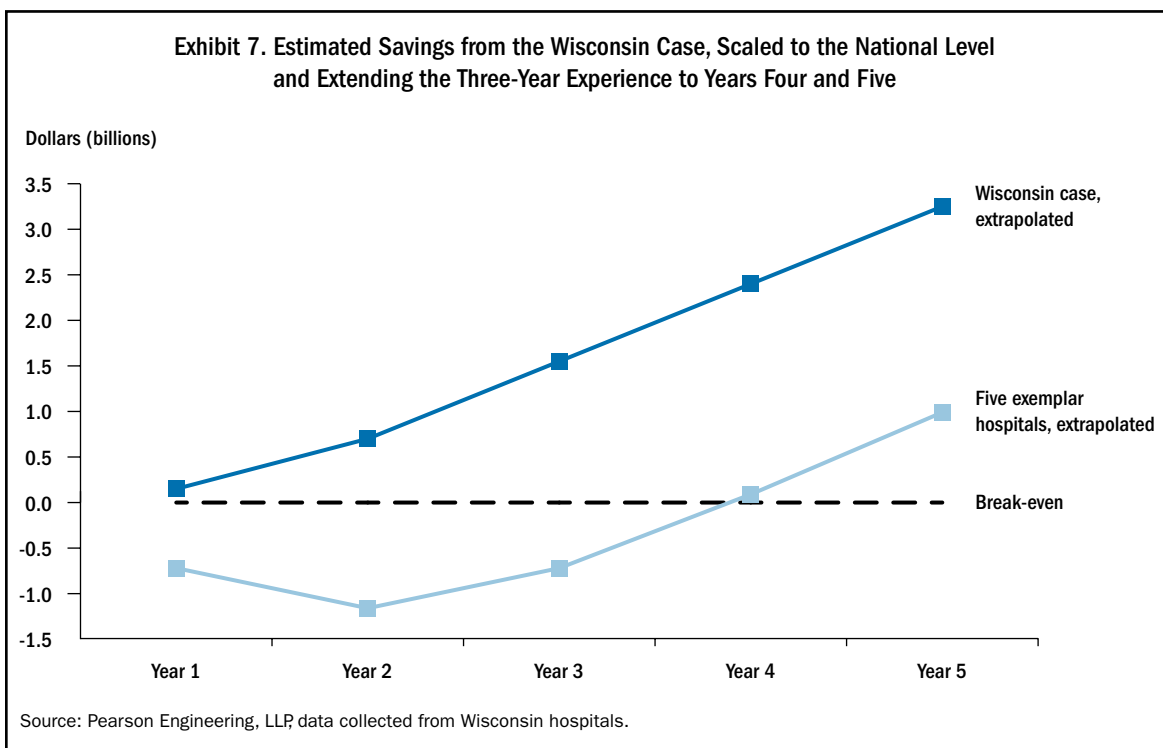
Many interventions, such as those highlighted in the Wisconsin case study (sidebar), do not involve any additional identifiable costs but realize immediate savings. Several of the sustainability activities included in this study, including use of single-use device reprocessing for the operating room and reformulation of operating room packs to remove items that are often

### Low-Cost Energy Efficiency and Conservation Interventions in Wisconsin

Recently, publicly presented data show close to 9 percent weather-adjusted energy savings in a set of 12 hospitals in Wisconsin over three years. Based on the U.S. Environmental Protection Agency’s ENERGY STAR program, the hospitals implemented a checklist of low-cost operations and maintenance activities for achieving progress towards becoming an ENERGY STAR leader.<sup>20</sup> Engineers with knowledge of this program indicate that 9 percent to 10 percent may be close to the maximum energy savings achievable in these hospitals without any capital investment.

The hospitals’ savings resulted from systematic adjustment of thermostatic and other equipment set-points, schedules, and operating conditions, such as lower steam pressure levels. Several hospitals installed variable-speed drives and controls to allow for reduced air flow in unoccupied areas, in all cases paid for out of the operating budgets. The hospital staffs compared daily energy readings with weather-adjusted predicted energy use to guide the adjustments. With strong support from senior management, the operations staff utilized the data-driven Plan-Do-Study-Act methods used by most hospital executives in clinical areas. The Wisconsin case reported savings exceeding minimal expenses for consulting support and hardware. The total savings extrapolated from the Wisconsin example over five years outpace those made by our study hospitals (Exhibit 7).

The Wisconsin case suggests that important savings are possible, with low or no capital investment, over three to five years.



not used and disposed of, require virtually no upfront costs, while cost savings begin to accrue immediately following implementation.

For cash-strapped safety-net hospitals that care for a disproportionate number of poor and uninsured patients, where even small capital investments are a stress, these interventions are within immediate reach, and federal and state funds should be designated to support these cost-saving changes. Such support could help to fund the upfront costs of energy-efficient equipment, system upgrades, and controls to reduce energy use and, in the waste management arena, be used to purchase recycling bins and compactors, and to fund space improvements to better enable the collection and transportation of recyclables, among other items. These programs will both improve the environment and help secure the continued functioning of these institutions through the ongoing cost savings produced.

While this study focuses on hospitals only, anecdotal evidence indicates that even larger cost savings may be realized through implementation of these sustainability interventions in nonacute settings, such as outpatient clinics and doctors' offices, because of the lower fixed-cost demands of these settings. Much of this anecdotal evidence is published on hospital Web sites and in newspapers and other news outlets—such as Kaiser Permanente's annual savings of tens of millions of dollars through systemwide implementation of its environmentally preferable purchasing program. We are unaware of any attempt to extrapolate such savings to outpatient settings nationwide but the large physical area, number of patients and procedures, and volume of purchases suggest the likelihood of larger savings across outpatient settings nationally.

Additionally, this study does not address how sustainability in health care could save not only the direct health care costs associated with treating environmentally induced diseases but also societal costs related to sick days, premature deaths, special educational services (needed to address the neurological effects of toxins on children), and local communities' pollution management activities, such as transporting and landfilling waste. Existing data indicate that

sustainability applied across all industries can have enormous societal benefits. For example, research by Levy et al. estimated approximately 320 premature deaths per year among the population of the region studied because of emissions from nine Illinois power plants.<sup>22</sup> Further research to delineate the societal cost savings of specific sustainability activities in health care would be enormously helpful to better understand their value and relative cost-effectiveness to society.

Based on this initial study, agencies and organizations that regulate and advise health care systems would do well to increase their educational efforts in regard to sustainability interventions for both their institutional and societal cost-saving consequences. This study additionally demonstrates the need for increased standardization of data collection and further evaluation of the costs and benefits of sustainability interventions in health care.

Although no single sustainability intervention will bend America's steadily rising health care cost curve, the national adoption of the proven environmental innovations described in this study would help. They are needed without delay.

## NOTES

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- <sup>19</sup> Ibid.
- <sup>20</sup> U.S. Environmental Protection Agency, *Energy Star Best Practices to Improve Energy Performance Acute Care & Children's Hospitals Low-Cost O&M Checklist*, April 2006 (cited Oct. 5, 2011), [http://www.energystar.gov/ia/business/healthcare/Low\\_Cost\\_O&M\\_Checklist.pdf](http://www.energystar.gov/ia/business/healthcare/Low_Cost_O&M_Checklist.pdf).
- <sup>21</sup> For a related analysis of hospital incremental cost savings—in this case, resulting from implementation of evidence-based design interventions—see B. Sadler, L. Berry, R. Guenther et al. "Fable Hospital 2.0: The Business Case for Building Better Health Care Facilities," *Hastings Center Report*, 2011 41(1):13–23.
- <sup>22</sup> J. Levy, J. Spengler, D. Hlinka et al., "Using CALPUFF to Evaluate the Impacts of Power Plant Emissions in Illinois: Model Sensitivity and Implications," *Atmospheric Environment*, 2002 36:1063–75.

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