TITLE

Evaluating the Existing Market for Healthcare Sustainability Metrics and Proposal for a New Normalized Index

ABSTRACT

The healthcare industry is increasingly prioritizing sustainability, yet existing metrics for environmental performance often lack standardization and fail to account for hospital size, leading to skewed benchmarking. The proposed Healthcare Sustainability Normalized Index (HSNI) addresses these shortcomings by integrating key sustainability metrics and normalizing them based on critical performance indicators, such as Adjusted Patient Days, Case Mix Index, and surgical complexity. This approach enables a level playing field for hospitals of varying scales, offering a more precise and actionable framework for sustainability benchmarking. Unlike current metrics that disproportionately penalize larger institutions, the HSNI accounts for variations in patient volume, procedural complexity, and resource utilization, providing a nuanced assessment of environmental impact. By weighting emissions, waste, energy, and water usage equally, the HSNI delivers a composite score that accurately reflects each hospital's sustainability performance. This novel index positions itself as a transformative tool for healthcare providers aiming to enhance environmental stewardship while maintaining operational efficiency.

KEYWORDS

Environment and Public Health, Public Health Infrastructure, Public Health Systems Research

CONTRIBUTION TO THE LITERATURE

The proposed Healthcare Sustainability Normalized Index (HSNI) advances the literature on healthcare environmental metrics by addressing the critical gap of standardization and comparability across hospitals of varying sizes. While existing metrics often fail to adjust for hospital scale and operational complexity, the HSNI integrates normalization factors such as adjusted patient days, Case Mix Index, and procedure-specific environmental impacts. This approach facilitates a more equitable assessment of sustainability performance and benchmarking, offering a comprehensive tool that accommodates the diverse operational realities of healthcare facilities. By standardizing comparisons, the HSNI enables more effective identification of best practices and drives targeted improvements in environmental sustainability within the healthcare sector.

INTRODUCTION

In recent years, the healthcare sector has not only become increasingly aware of its environmental impact: studies show that the healthcare sector accounts for about 8.5% of all greenhouse gas emissions in the U.S. and approximately 4.5% of worldwide emissions [1]. These emissions primarily result from the continuous operation of energy-intensive facilities, as well as the extensive use of pharmaceuticals, medical devices, food, and other goods and services involved in providing care, which often leads to considerable waste. This awareness and the subsequent push towards reduction have spurred the development and implementation of various sustainability initiatives aimed at improving the environmental performance of healthcare facilities. However, there is the lack of an internationally (or even nationally) accepted system to track these sustainability changes.

This lack of a standardized, normalized index frequently hampers meaningful comparison and benchmarking across hospitals. For instance, hospitals of different sizes face challenges in utilizing metrics like total CO_2 emissions effectively, as larger hospitals inherently produce more emissions [2]. As a result, there is a critical need for a new index that facilitates fair comparison and effective benchmarking, independent of hospital size. This report explores the existing healthcare sustainability measures and proposes a new integrated normalized index designed to address these challenges and better align measurement practices to track progress across the sector.

Current Landscape of Healthcare Sustainability Metrics

Several organizations and initiatives have developed sustainability metrics to address the environmental impact of healthcare operations. Practice Greenhealth has one of the most comprehensive reporting systems with 26 metrics across 10 topic areas such as energy consumption and efficiency, water usage, waste management, greenhouse gas emissions, sustainable procurement, climate change mitigation, social and environmental responsibility, and food and nutrition. Key measures include total kBtus saved, percentage of energy from renewable sources, total gallons saved, pounds of waste diverted, and metric tons of CO2 equivalent avoided [3].

Similarly, the Institute for Healthcare Improvement emphasizes high-priority measures like reducing waste and emissions intensity, focusing on building energy, transportation, anesthetic gas, pharmaceuticals and chemicals, and medical devices and supplies [4]. The Environmental Protection Agency (EPA) also provides extensive data on energy and emissions, including kilowatt-hours avoided, tons of CO2 equivalent, and various greenhouse gases [5].

In addition to these efforts, the Joint Commission Sustainability Certification introduces a structured framework for healthcare organizations to advance their environmental sustainability initiatives [6]. While this certification helps in setting priorities, creating baselines, and measuring greenhouse gas (GHG) reductions, its current framework may be limited. The certification primarily focuses on specific areas and might not fully capture the comprehensive nature of sustainability in healthcare.

A holistic approach to sustainability metrics, which normalizes various factors, could provide a more thorough evaluation of environmental impact across different healthcare organizations. Such an approach would allow for better benchmarking and comparison, integrating diverse aspects of sustainability—such as energy use, emissions, and waste management—into a unified framework. This would enhance flexibility and adaptability, ensuring that organizations of varying sizes and resources can effectively participate in and benefit from sustainability efforts.

Academic institutions like MIT and Harvard tend to use pre-made comprehensive frameworks for tracking Scope 1, 2, and 3 emissions, covering direct emissions from owned operations, indirect emissions from purchased energy, and all other indirect emissions occurring in the value chain [7]. Hospitals nationally use this framework, including Beth Israel Deaconess Medical Center, which tracks emissions through meticulous data collection, advanced monitoring, and targeted interventions [8]. For Scope 1 and 2 emissions, the center uses energy-efficient technologies, optimizes HVAC systems, and invests in renewable energy. For Scope 3 emissions, the center assesses supply chain impacts, partners with sustainable suppliers, and implements a comprehensive waste reduction program, aiming for zero waste by 2030.

While these existing measures provide valuable insights, they often suffer from a lack of standardization and comparability. Different hospitals use different metrics and methodologies, making it challenging to benchmark performance and identify best practices across the sector. Moreover, these metrics often do not account for various factors like the varying sizes of hospitals and the type of specific procedures and surgical cases they practice, which all affect the hospital's environmental impact. Furthermore, no healthcare metric has hospital specific metrics, such as the differing environmental impact and waste generated from different surgical procedures, something that this proposed normalized index seeks to change.

MATERIALS AND METHODS

Proposed Normalized Index for Healthcare Sustainability

To address these challenges, a new integrated normalized index for healthcare sustainability is proposed. The Healthcare Sustainability Normalized Index (HSNI) will enable meaningful comparison and benchmarking across hospitals, driving more effective sustainability practices regardless of the hospital's size. This index will be based on key sustainability metrics already measured in healthcare systems (such as CO_2 emissions, tons of waste generated, etc.) and will be normalized by hospital key performance indicators and other relevant factors.

Each of the following metrics can be accessed from Epic and other commonly used electronic health record software nationally and will be used to normalize within HSNI.

- Adjusted patient days, sometimes referred to as adjusted discharges, measure a hospital's total patient volume. This metric is derived by combining inpatient days with a conversion factor for outpatient services. The conversion factor is determined by multiplying inpatient days by the ratio of total gross outpatient revenue to gross inpatient revenue [9]. The commonly used formula for adjusted patient days is:

  Adjusted patient days = Inpatient days + [Gross outpatient revenue/Gross inpatient revenue] x Inpatient days.

This factor is key for sustainability measurements, since it essentially measures the amount of resources used by measuring the average number of days a patient stays, whether inpatient or outpatient. This is measured on a per day basis, on average, as with most values in this paper.

- The commonly used Case Mix Index (CMI), which measures the average complexity of diagnoses and treatments at a hospital. It is calculated by summing the relative weights of diagnosis-related groups (DRGs) for all Medicare discharges and dividing by the number of discharges. A higher CMI indicates more complex and resource-intensive care. The index helps in assessing hospital performance and determining appropriate reimbursement rates. CMI data is updated annually to reflect changes in hospital cases and payment systems. It is a federally defined metric used by hospitals nationally [10].
- Number of Labs Ordered Per Day (On Average), including blood tests, urine tests, pathology reports, microbiology reports, etc. Labs are resource intensive and it will be a valuable metric [11].
- Number of Imaging Reports Per Day (On Average), including radiology and diagnostic imaging reports, such as X-rays, MRIs, CT scans, ultrasounds, etc. Again, these are resource intensive [12].
- Number of Surgeries Per Day (On Average). Surgeries are environmentally costly ("Operating rooms are responsible for approximately 30% of total hospital solid waste"), and some more so than others, as categorized below [13]. "ORs can use up to six times more energy than the rest of the hospital and put out more than half of the waste across the hospital," notes a statistic from the American College of Surgeons [14]. It will be up to hospital discretion to decide the category that a surgery goes into, with the guidelines below. Essentially, there will be three metrics- Number of Category 1 Surgeries Per Day (On Average), Number of Category 2 Surgeries Per Day (On Average), Number of Category 3 Surgeries Per Day (On Average)

Category 1: Minor Outpatient Procedures

- Definition: Simple outpatient procedures with minimal impact on resources and waste generation.

- Examples: Dermatological procedures, minor endoscopies, basic dental surgeries.
- Environmental Impact:
    - Waste Production: Low volume of biohazardous waste (e.g., small bandages, minimal disposable equipment).
    - Energy Use: Minimal energy consumption in procedure rooms.
    - Anesthesia Gases: Minimal anesthesia gas usage.

Category 2: Moderate Complexity Procedures

- Definition: Intermediate surgeries with moderate resource consumption and waste production.
- Examples: Appendectomies, knee arthroscopies, cataract surgeries.
- Environmental Impact:
    - Waste Production: Moderate volume of biohazardous waste (e.g., surgical drapes, disposable instruments).
    - Energy Use: Moderate energy consumption due to equipment use (e.g., surgical lights, monitors).
    - Anesthesia Gases: Standard anesthesia gas usage.

Category 3: Complex Procedures

- Definition: Major surgeries with significant resource utilization and waste generation.
- Examples: Open-heart surgeries, organ transplants, complex orthopedic reconstructions.
- Environmental Impact:
    - Waste Production: High volume of biohazardous waste (e.g., extensive surgical kits, disposable equipment).
    - Energy Use: High energy consumption from complex equipment (e.g., heart-lung machines, robotic surgical systems).
    - Anesthesia Gases: Elevated anesthesia gas consumption due to longer procedures and patient needs.

The 7 Metrics in Summary:

1. Adjusted Patient Days

2. Case Mix Index (CMI)
3. Number of Labs Ordered Per Day (On Average)
4. Number of Imaging Reports Per Day (On Average)
5. Number of Category 1 Surgeries Per Day (On Average)
6. Number of Category 2 Surgeries Per Day (On Average)
7. Number of Category 3 Surgeries Per Day (On Average)

The Metrics and Normalization Factors:

These metrics will be measured across hospitals, and each metric will be normalized with each normalization factor above. These below metrics are fairly standard and are measured across different hospitals and workplace settings [15].

1. Total Greenhouse Gas Emissions in Metric Tons of Carbon Dioxide Equivalents (CO2) Per Day on Average
2. Total Waste Generated in Tons Per Day on Average
3. Energy Usage in kiloWatts Per Day on Average
4. Water Usage in Gallons Per Day on Average

Note: To simplify the process, all gaseous emissions from Scope 1, 2, and 3 are not normalized/categorized as separate metrics.

Mathematical Framework of the HSNI

The HSNI will be calculated as a composite score combining the normalized metrics. Each metric will be weighted based on its importance to organizational priority. The mathematical framework for the HSNI is as follows:

$$\text{HSNI} = \sum_{i=1}^{n} w_i \cdot \left(\frac{M_i}{N_i}\right)$$

where:

- w_i is the weight assigned to the i-th metric,
- M_i is the measured value of the i-th metric,
- N_i is the normalization factor for the i-th metric.

Figure 1, The HSNI formula and the meaning of each component.

RESULTS

Example Calculation

To illustrate the application of the HSNI, let's consider an example of two hospitals, Hospital A and Hospital B, with different sizes (one is a large urban hospital, one is a small clinical in a town), but seemingly different environmental impacts at first glance. After calculation, one will see that the HSNI performs well at normalizing across hospital size: the bigger hospital, although it has larger amounts of weight and emissions, has a smaller index value [16].

Metric	Hospital A	Hospital B
Total Emissions (Tons Per Day)	10.5	22.0
Total Waste Generated (Tons Per Day)	5.0	10.5
Energy Usage (kW Per Day)	120,000	250,000
Water Usage (Gallons Per Day)	100,000	210,000

Table 1, Example Metrics From Hospitals of Different Sizes

Apply Each Normalization Factor to Every Metric:

Notice, here, hospital A and B are ***hypothetical*** hospitals, one small, one large. All the metric data and normalization data are hypothetical, and used for illustration purposes for the calculation.

Construct a table as below, with every single metric, and then divide it by the column, which represents the normalization factor. The calculation is shown in the first table, and then the final values, along with a "Total" value, which represents the total "normalized" value for each metric.

HOSPITAL A	**Normalization Factors**						
Metric	Adjusted Patient Days	CMI	Lab Reports	Imaging Reports	Category 1 Surgeries	Category 2 Surgeries	Category 3 Surgeries
Emissions	10.5/15	10.5/0.9	10.5/60	10.5/30	10.5/1.2	10.5/0.4	10.5/0.05
Waste	5 /15	5/0.9	5/60	5 /30	5/1.2	5/0.4	5/0.05
Energy	120000/15	120000/0.9	120000/60	120000/30	120000/1.2	120000/0.4	120000/0.05
Water	100000/15	100000/0.9	100000/60	100000/30	100000/1.2	100000/0.4	100000/0.05

Table 2, Calculations for Hypothetical Hospital A.

HOSPITAL A	**Normalization Factors**							
Metric	Adjusted Patient Days	CMI	Lab Reports	Imaging Reports	Category 1 Surgeries	Category 2 Surgeries	Category 3 Surgeries	TOTAL
Emissions	0.7	11.666666667	0.175	0.35	8.75	26.25	210	257.8916667
Waste	0.3333333333	5.555555556	0.08333333333	0.1666666667	4.166666667	12.5	100	122.8055556
Energy	8,000	133333.3333	2000	4000	100000	300000	2400000	2,947,333
Water	6,667	111111.1111	1666.666667	3333.333333	83333.33333	250000	2000000	2,456,111

Table 3, Results After Calculations for Hypothetical Hospital A.

HOSPITAL B	**Normalization Factors**						
Metric	Adjusted Patient Days	CMI	Lab Reports	Imaging Reports	Category 1 Surgeries	Category 2 Surgeries	Category 3 Surgeries
Emissions	22/150	22/1.8	22/130	22/70	22/3	22/1.8	22/0.2
Waste	10.5/150	10.5/1.8	10.5/130	10.5/70	10.5/3	10.5/1.8	10.5/0.2
Energy	250000/150	250000/1.8	250000/130	250000/70	250000/3	250000/1.8	250000/0.2
Water	210000/150	210000/1.8	210000/130	210000/70	210000/3	210000/1.8	210000/0.2

Table 4, Calculations for Hypothetical Hospital B.

HOSPITAL B	**Normalization Factors**							
Metric	Adjusted Patient Days	CMI	Lab Reports	Imaging Reports	Category 1 Surgeries	Category 2 Surgeries	Category 3 Surgeries	TOTAL
Emissions	0.1466666667	12.22222222	0.1692307692	0.3142857143	7.333333333	12.22222222	110	142.4079609
Waste	0	5.833333333	0.08076923077	0.15	3.5	5.833333333	52.5	68
Energy	1,667	138888.8889	1923.076923	3571.428571	83333.33333	138888.8889	1250000	1,618,272
Water	1,400	116666.6667	1615.384615	3000	70000	116666.6667	1050000	1,359,349

Table 5, Results After Calculations for Hypothetical Hospital B.

Now, multiply each metric with the appropriate weight. The weights must add up to 1. It is up to hospital discretion as to which of the four metrics will be given more or less importance. Below are some suggestions, depending on which metrics the hospital values more:

One way to determine the metrics valued more by hospitals is conducting a materiality assessment in the hospital to help determine the importance of each sustainability metric to stakeholders as well as the relative environmental/business impact. This process will enable one to identify and understand the relative importance of specific ESG and sustainability topics to the organization [17].

One can therefore use the materiality results to determine which set of weights to use. A few sets of weights are written here below:

1. Environmental Impact Focus

This prioritization assumes emissions and energy are most critical due to their significant environmental impacts.

- Emissions: 0.4
- Energy: 0.3
- Water: 0.2

- Waste: 0.1

2. Resource Use Efficiency Focus

This prioritization gives higher importance to energy and water use efficiency.

- Energy: 0.35
- Water: 0.35
- Emissions: 0.2
- Waste: 0.1

3. Comprehensive Sustainability Focus

This approach equally balances all metrics to cover various aspects of sustainability.

- Emissions: 0.25
- Energy: 0.25
- Water: 0.25
- Waste: 0.25

4. Operational Efficiency Focus

This prioritization emphasizes energy and waste due to their direct impact on operational costs and efficiency.

- Energy: 0.4
- Waste: 0.3
- Emissions: 0.2
- Water: 0.1

5. Water Conservation Focus

This scenario emphasizes water conservation, reflecting its importance in areas facing water scarcity.

- Water: 0.4

- Energy: 0.3
- Emissions: 0.2
- Waste: 0.1

Here, we will utilize approach 3, comprehensive sustainability, assigning equal importance to all metrics.

Hospital A Calculation: (257.891*0.25) + (122.805*0.25) + (2947333*0.25) + (2456111*0.25)

= 1350956.174

Hospital B Calculation: (142.408*0.25) + (68*0.25) + (1618272*0.25) + (1359349*0.25)

= 744457.852

DISCUSSIONS

These two HSNI values can be directly compared, or they can be converted to values between 0 and 1 for easier comparison- there is no advantage or disadvantage in either method, it is simply for ease of comparison and because indices are usually between 0 to 1 that the latter method is proposed (in detail after next few paragraphs).

Understanding what higher or lower HSNI values mean involves interpreting how the score relates to sustainability efforts:

1. **Higher HSNI:**
   - A higher HSNI indicates better sustainability performance relative to the metrics included in the index. It suggests that the hospital has lower environmental impacts (such as energy use, water consumption, waste generation, CO_2 emissions) per unit of operational measure (like per bed or per patient day) compared to other hospitals.
   - Hospitals with higher HSNI scores are generally more efficient in resource use, have lower environmental footprints, and may have implemented effective sustainability practices and initiatives.
2. **Lower HSNI:**

- Conversely, a lower HSNI indicates that the hospital has higher environmental impacts per unit of operation. This could be due to higher energy consumption, water usage, waste generation, or CO_2 emissions relative to similar hospitals.
- Hospitals with lower HSNI scores may need to focus on improving sustainability practices, reducing resource consumption, implementing more efficient technologies, or enhancing waste management strategies.

In summary, a higher HSNI signifies better sustainability performance and efficiency, while a lower HSNI suggests areas where improvements in sustainability practices and resource management are needed to align with environmental goals and standards. It serves as a comparative tool to help hospitals gauge their sustainability efforts and strive for continuous improvement.

Suggestions to Clean Up and Further Normalize HSNI:

If you have one HSNI value for each hospital and you want to normalize each HSNI value individually to a scale of 0 to 1, you can directly apply the min-max normalization formula. Here's how you can normalize each HSNI value:

Identify the minimum and maximum values from all your HSNI values across hospitals you are comparing (in this case, hospitals A and B) . Let's denote these as HSNI_min and HSNI_max.

For each hospital's HSNI value,

HSNI_hospital_normalized = (HSNI_hospital_current - HSNI_min)/ (HSNI_max - HSNI_min)
This formula scales each HSNI value linearly between 0 and 1 based on its relative position between the minimum and maximum values. Do note, if you are only comparing two hospitals, you will get a HSNI of zero and one, corresponding to the lower and the higher HSNI.

CONCLUSIONS

In conclusion, the healthcare sector's growing awareness of its environmental impact has prompted the development of various sustainability metrics aimed at improving operational efficiency and reducing environmental footprints. However, the lack of a standardized, normalized index has hindered meaningful comparisons and benchmarking across hospitals, particularly those of varying sizes. Existing metrics often fail to account for these differences, leading to skewed assessments and ineffective benchmarking practices.

This paper has proposed the Healthcare Sustainability Normalized Index (HSNI) as a comprehensive solution to these challenges. By integrating key sustainability metrics and normalizing them based on relevant factors such as hospital size, patient care activity, and specific procedures, the HSNI facilitates fair comparisons and benchmarking across hospitals. This approach ensures that hospitals of different scales can accurately assess and improve their sustainability performance without bias towards larger facilities.

The HSNI incorporates metrics crucial to healthcare sustainability, including energy efficiency, water conservation, waste management, greenhouse gas emissions, sustainable procurement, climate change mitigation, social responsibility, and dietary sustainability. Each metric is carefully chosen and normalized to provide an accurate reflection of a hospital's environmental impact relative to its operational context.

Moreover, the HSNI's mathematical framework allows for flexibility in weighting metrics based on their importance to overall sustainability goals, ensuring alignment with industry standards and stakeholder expectations. This index not only serves as a comparative tool but also encourages continuous improvement in sustainability practices across the healthcare sector.

By adopting the HSNI, hospitals can better understand their environmental impacts, identify areas for improvement, and implement targeted strategies to enhance sustainability performance. Ultimately, the HSNI supports the sector's commitment to environmental stewardship while promoting a healthier and more sustainable future for healthcare operations worldwide.

REFERENCES

Here’s the complete list of references in Vancouver-NIH style:

1. Pennar K. Health care’s hidden climate footprint. Stat News. 2022 Oct 27. Available from: https://www.statnews.com/2022/10/27/health-care-hospitals-climate-pollution/

2. Practice Greenhealth. 25 hospitals setting the standard for sustainability in health care. Practice Greenhealth. 2022. Available from: https://practicegreenhealth.org/about/news/25-hospitals-setting-standard-sustainability-health-care#:~:text=Cleveland%20Clinic%20sources%2030%%20of%20their%20food,people%20as%20well%20as%20a%20healthier%20planet.

3. Practice Greenhealth. 2023 sustainability data. Practice Greenhealth. 2023. Available from: https://practicegreenhealth.org/tools-and-resources/2023-sustainability-data

4. Agency for Healthcare Research and Quality. Decarbonization in health systems: A practical guide. Agency for Healthcare Research and Quality. 2023. Available from: https://www.ahrq.gov/sites/default/files/wysiwyg/healthsystemsresearch/decarbonization/decarbonization.pdf

5. U.S. Environmental Protection Agency. Greenhouse gas equivalencies calculator. U.S. Environmental Protection Agency. 2023. Available from: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

6. The Joint Commission. Sustainable healthcare certification. The Joint Commission. 2023. Available from: https://www.jointcommission.org/what-we-offer/certification/certifications-by-setting/hospital-certifications/sustainable-healthcare-certification/

7. Greenhouse Gas Protocol Initiative. Corporate value chain (scope 3) accounting and reporting standard. World Resources Institute; 2013. Available from: https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf

8. Beth Israel Deaconess Medical Center. Environmental initiatives. Beth Israel Deaconess Medical Center. 2023. Available from: https://www.bidmc.org/about-bidmc/helping-our-community/environmental-initiatives

9. U.S. Department of Housing and Urban Development. Housing and sustainable communities: A guide for practitioners. U.S. Department of Housing and Urban Development; 2023. Available from: https://www.hud.gov/sites/documents/46151X1HSGH.PDF

10. Centers for Medicare & Medicaid Services. Acute inpatient PPS files for download. Centers for Medicare & Medicaid Services. 2023. Available from: https://www.cms.gov/medicare/medicare-fee-for-service-payment/acuteinpatientpps/acute-inpatient-files-for-download-items/cms022630

11. Geyer R, Lindner J, Stryi-Hipp G, et al. Circular economy – a new paradigm for the European Union? Waste Manag. 2019;87:30-37. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6849007/

12. GE Healthcare. Committing to sustainability in MRI. GE Healthcare. 2023. Available from: https://www.gehealthcare.com/insights/article/committing-to-sustainability-in-mri

13. American Society of Anesthesiologists. Greening the operating room: Waste disposal. American Society of Anesthesiologists. 2023. Available from: https://www.asahq.org/about-asa/governance-and-committees/asa-committees/environmental-sustainability/greening-the-operating-room/waste-disposal#:~:text=Operating%20rooms%20are%20responsible%20for,of%20total%20hospital%20solid%20waste.&text=Ongoing%20staff%20education%20is%20essential%20to%20improve%20proper%20waste%20disposal%20segregation.&text=Proper%20waste%20stream%20management%20reduces%20environmental%20and%20financial%20costs.&text=In%20nature%2C%20waste%20from%20one%20system%20is%20feedstock%20for%20another

14. American College of Surgeons. Going green in operating rooms reduces cost and improves environmental impact. American College of Surgeons. 2022. Available from: https://www.facs.org/media-center/press-releases/2022/going-green-in-operating-rooms-reduces-

cost-and-improves-environmental-impact/#:~:text=The%20healthcare%20industry%20accounts%20for,the%20waste%20across%20the%20hospital.

15. Conservice. Five environmental sustainability metrics worth tracking. Conservice. 2023. Available from: https://esg.conservice.com/five-environmental-sustainability-metrics-worth-tracking/#:~:text=Environmental%20metrics%20typically%20include%20reduction,saved%2C%20and%20increased%20waste%20diversion.

16. Cyberhoot. Data normalization. Cyberhoot. 2023. Available from: https://cyberhoot.com/cybrary/data-normalization/

17. Conservice. Strategic value of ESG materiality assessments. Conservice. 2023. Available from: https://esg.conservice.com/esg-solutions/strategic-value-of-esg-materiality-assessments/#:~:text=A%20materiality%20assessment%20is%20designed,organization%20and%20importance%20to%20stakeholders.

FIGURES AND TABLES

$$\mathrm{HSNI} = \sum_{i=1}^{n} w_i \cdot \left(\frac{M_i}{N_i}\right)$$

where:

- w_i is the weight assigned to the i-th metric,
- M_i is the measured value of the i-th metric,
- N_i is the normalization factor for the i-th metric.

Figure 1, The HSNI formula and the meaning of each component.

Metric	Hospital A	Hospital B
Total Emissions (Tons Per Day)	10.5	22.0
Total Waste Generated (Tons Per Day)	5.0	10.5
Energy Usage (kW Per Day)	120,000	250,000
Water Usage (Gallons Per Day)	100,000	210,000

Table 1, Example Metrics From Hospitals of Different Sizes

HOSPITAL A	**Normalization Factors**						
Metric	Adjusted Patient Days	CMI	Lab Reports	Imaging Reports	Category 1 Surgeries	Category 2 Surgeries	Category 3 Surgeries
Emissions	10.5/15	10.5/0.9	10.5/60	10.5/30	10.5/1.2	10.5/0.4	10.5/0.05
Waste	5 /15	5/0.9	5/60	5 /30	5/1.2	5/0.4	5/0.05
Energy	120000/15	120000/0.9	120000/60	120000/30	120000/1.2	120000/0.4	120000/0.05
Water	100000/15	100000/0.9	100000/60	100000/30	100000/1.2	100000/0.4	100000/0.05

Table 2, Calculations for Hypothetical Hospital A.

HOSPITAL A	**Normalization Factors**							
Metric	Adjusted Patient Days	CMI	Lab Reports	Imaging Reports	Category 1 Surgeries	Category 2 Surgeries	Category 3 Surgeries	TOTAL
Emissions	0.7	11.666666667	0.175	0.35	8.75	26.25	210	257.8916667

Waste	0.3333333333	5.555555556	0.08333333333	0.1666666667	4.166666667	12.5	100	122.8055556
Energy	8,000	133333.3333	2000	4000	100000	300000	2400000	2,947,333
Water	6,667	111111.1111	1666.666667	3333.333333	83333.33333	250000	2000000	2,456,111

Table 3, Results After Calculations for Hypothetical Hospital A.

HOSPITAL B	**Normalization Factors**						
Metric	Adjusted Patient Days	CMI	Lab Reports	Imaging Reports	Category 1 Surgeries	Category 2 Surgeries	Category 3 Surgeries
Emissions	22/150	22/1.8	22/130	22/70	22/3	22/1.8	22/0.2
Waste	10.5/150	10.5/1.8	10.5/130	10.5/70	10.5/3	10.5/1.8	10.5/0.2
Energy	250000/150	250000/1.8	250000/130	250000/70	250000/3	250000/1.8	250000/0.2
Water	210000/150	210000/1.8	210000/130	210000/70	210000/3	210000/1.8	210000/0.2

Table 4, Calculations for Hypothetical Hospital B.

HOSPITAL B	**Normalization Factors**							
Metric	Adjusted Patient Days	CMI	Lab Reports	Imaging Reports	Category 1 Surgeries	Category 2 Surgeries	Category 3 Surgeries	TOTAL
Emissions	0.1466666667	12.22222222	0.1692307692	0.3142857143	7.333333333	12.22222222	110	142.4079609
Waste	0	5.83333333	0.08076923077	0.15	3.5	5.833333333	52.5	68

		3						
Energy	1,667	138888.8889	1923.076923	3571.428571	83333.33333	138888.8889	1250000	1,618,272
Water	1,400	116666.6667	1615.384615	3000	70000	116666.6667	1050000	1,359,349

Table 5, Results After Calculations for Hypothetical Hospital B.