Masters Project Report

Duke Health Sustainability Project

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April 22, 2022

Masters Project submitted in partial fulfillment of the requirements for the
Master of Environmental Management Degree in the Nicholas School of the Environment,
Duke University, May 2022.

Table of Contents

Introduction

The healthcare sector is responsible for around 10% of GHG emissions and 9% of non-GHG air pollutants in the U.S. (Sherman et al., 2020). This system is placing significant demands on Earth's finite resources and in the process is driving environmental degradation, in direct conflict with the U.S. healthcare system's commitment to "do no harm." Worst of all, the healthcare sector is an important contributor to the climate crisis.

The climate crisis is "the biggest global health threat of the 21st century" (Wang & Horton, 2015). Anthropogenic activities such as burning fossil fuels, deforestation, urbanization, and shifts in vegetation patterns alter the composition of land surfaces and the atmosphere, resulting in environmental degradation and changes in the climate that can harmfully affect human health and well-being. Greenhouse gas (GHG) emissions, particularly carbon dioxide, methane, and nitrous oxide, trap the heat reflected from the earth's surface, resulting in warming temperatures and changes in precipitation patterns. Various pollutants, including particulate matter, carbon monoxide, and ground-level ozone are harmful to human health and are especially known to have negative impacts on human respiratory systems. Humans are also using energy, whether it be for electricity, transportation, or manufacturing, at an unprecedented rate, which increases the demand for fossil fuels. Human activities are resulting in the overconsumption and contamination of water. We produce more waste than there is space for, which often results in air pollutants and further contamination of water (Sherman et al., 2020). These are just a few examples of how humans are impacting the environment and driving poor health outcomes.

Climate change also threatens to exacerbate racial and socioeconomic disparities. The climate crisis' effects on air quality, infectious diseases, food security, and other significant environmental health outcomes means that tackling the health effects of climate change could become the "greatest global health opportunity of the 21st century" (Wang & Horton, 2015).

The Duke University Health System (DUHS) has the potential to become a leader in both hospital sustainability and climate health research, but plans need to be made and implemented quickly to avoid and/or diminish the impacts that the climate crisis will have on human health and the environment. It is possible, as many peer institutions have already made significant advances in their sustainability efforts and their efforts can be used as models for Duke Health's Sustainability efforts. Many of these sustainability initiatives have even led to significant cost savings at peer institutions. Examples of these cost savings include Johns Hopkins saving about $65,000 annually through LED light installation in operating rooms and energy-efficient HVAC settings when rooms are unoccupied; UCLA saving $833,000 annually from water reduction projects; the Cleveland Clinic saving $2,000,000 annually from set-back hourly air changes from more than 25 during occupied periods down to six when operating rooms are unoccupied.

By adopting more sustainable practices, DUHS can emerge as a leader in the field and experience similar cost-savings as their peer institutions. This could also increase student and employee satisfaction and provide additional research and leadership opportunities for the Duke community (Society for Human Resource Management, 2011). Finally, advances in its sustainability practices could improve the health and well-being of its patient population by reducing its contributions to the global climate crisis, thereby helping Duke University Hospital to "advance health together" (Duke Health, n.d.).

Objectives

The overarching goal of this Masters Project was to provide Duke University Hospital System with a pathway to embrace sustainability and determine ways that the hospital system can save energy, conserve water, and reduce waste. Throughout the course of this project, we also determined the sources of emissions and waste from within Duke Hospital and communicated with healthcare workers and other employees to hear how they perceive sustainability and their thoughts on its importance in the workplace.

Component 1: Creating a Greenhouse Gas Baseline for Duke University Hospital for Fiscal Year 2019

History of Duke University Hospital's Greenhouse Gas Accounting Efforts

The first component of our Masters Project was creating a greenhouse gas baseline for Duke University Hospital. It is important to note that Duke University Hospital is part of the broader Duke University Health System (DUHS). Further, it is notable that Duke University and DUHS are separate entities with different governance structures and budgets. Duke University and Duke Hospital therefore make independent decisions about their operations. Duke University has conducted greenhouse gas inventories for its operations, but prior to this Masters Project, Duke University Hospital had not completed a greenhouse gas inventory to establish a greenhouse gas emissions baseline.

A greenhouse gas emissions baseline is a crucial part of reducing emissions and advancing sustainability. With a greenhouse gas emissions baseline, Duke University Hospital can take data-informed steps to reduce its carbon footprint. Therefore, as part of our Masters Project, our team completed a greenhouse gas inventory for Duke University Hospital. Our team used fiscal year 2019 as the baseline year, which specifically includes the dates of July 1, 2018, to June 30, 2019. Our team chose not to use fiscal year 2020 as the baseline year for this analysis because the COVID-19 pandemic affected data that year in an exceptional way that would not be indicative of trends over longer time periods. Our team did not choose fiscal year 2021 or 2022 because fiscal year 2021 data was not available at the time our project began and fiscal year 2022 is still occurring as of the writing of this report.

Overview of Data Sources and Methodology

For our data sources, our Masters Project team gathered data with the help of Sustainable Duke, Duke University Health System (DUHS), Duke Hospital's Procurement Department, and other departments within DUHS. Our team obtained the majority of our data from Sustainable Duke. Although Sustainable Duke does not create greenhouse gas accounting analyses for Duke University Hospital, they were nonetheless able to provide

a large majority of the data that our team needed. We are grateful for their assistance as well as the assistance of other departments at DUHS and Duke University.

Our methodology for our greenhouse gas emissions inventory is consistent with the Greenhouse Gas Protocol's methodology. The Greenhouse Gas Protocol is an internationally recognized standard for calculating greenhouse gas emissions. The Greenhouse Gas Protocol categorizes emissions into scope 1, scope 2, and scope 3 emissions. Scope 1 emissions are direct emissions. Scope 2 emissions are indirect emissions from sources such as purchased electricity, steam, heating, and cooling. Scope 3 emissions are all other indirect emissions within an entity's value chain.

Once our team had the data, we could begin calculating greenhouse gas emissions, using emissions factors in Appendix 1. These emissions factors are consistent with the emissions factors that Duke University uses. Once we had the necessary data and the appropriate emissions factors, we inputted the data into Excel, completed calculations using the emissions factors, and were able to determine numbers for CO_2 equivalent emissions in tons.

Overview of Duke University Hospital's Emissions

Consistent with the Greenhouse Gas Protocol's emissions categorizations, our team categorized Duke University Hospital's emissions into three scopes. As mentioned above, scope 1 emissions are direct emissions, scope 2 emissions are indirect emissions from purchased electricity, and scope 3 emissions are all other emissions in the value chain.

<u>Scope 1 Emissions</u>

Scope 1 emissions occur from activities that Duke University Hospital directly owns or controls. Specifically, these scope 1 emissions for fiscal year 2019 included:

- On campus stationary fuel sources, specifically from natural gas emissions
    - Duke University Hospital does not use any coal or fuel oil for on campus stationary fuel sources, so natural gas emissions are the only on campus stationary fuel sources used in this analysis.

- Duke University Hospital owned vehicle emissions, from both from gasoline and diesel emissions
- Refrigerants
    - In fiscal year 2019, Duke University Hospital used HFC-404a and HCFC-22 refrigerants. These are two common refrigerants.

Scope 1 Emissions: Duke University Hospital (fiscal year 2019)		
Scope 1 Emissions Category	**Metric tons of CO_2e (equivalent)**	**Percentage of Scope 1 Emissions**
Natural gas	25,362	94.32%
Duke Hospital owned fleet emissions (gasoline)	538	2.00%
Duke Hospital owned fleet emissions (diesel)	1	0.00%
Refrigerants (HFC-404a and HCFC-22)	989 (781 for HFC-404a, and 208 for HCFC-22)	3.67%
Total Scope 1 Emissions	**26,890**	**100%**

Scope 2 Emissions

Scope 2 emissions are emissions from electricity used at Duke University Hospital, specifically from sources that are not owned or operated by the hospital. Scope 2 emissions are emissions from purchased electricity and are measured in actual kilowatt hours of electricity used. For Duke University Hospital, the hospital purchased electricity from Duke Energy. In fiscal year 2019, Duke University Hospital used 135,739,679 kwh of electricity, which is the equivalent of 42,079 metric tons of CO_2.

Scope 2 Emissions: Duke University Hospital (fiscal year 2019)		
Scope 2 Emissions Category	**Metric tons of CO_2e (equivalent)**	**Percentage of Scope 2 Emissions**
Purchased electricity from Duke Energy	42,079	100%
Total Scope 2 Emissions	**42,079**	**100%**

Scope 3 Emissions

Scope 3 emissions constitute all other emissions that do not fall within scope 1 or scope 2 emissions. Consistent with the Greenhouse Gas Protocol's methodology which we used, there are fifteen subcategories of scope 3 emissions. These fifteen subcategories of scope 3 emissions include purchased goods and services, capital goods, fuel and energy related activities, upstream transportation and distribution, waste generated in operations, business travel, employee commuting, leased assets, downstream transportation and distribution, processing of sold products, use of sold products, end-of-life treatment of sold products, leased assets, franchises, and investments (EPA, n.d.).

For fiscal year 2019, our Masters Project team was not able to include several subcategories of the scope 3 emissions categories that the Greenhouse Gas Protocol suggests organizations track. For this greenhouse gas analysis, our team tracked the following scope 3 emissions categories: staff and faculty commuting, air travel, natural gas fugitive emissions, transmission losses from electricity, incinerated waste, and landfilled waste. Therefore, our Masters Project team encourages any future greenhouse gas inventories of Duke University Hospital's emissions to include additional scope 3 emissions data from the following subcategories that we were not able to track. Those categories include purchased goods and services, capital goods, fuel and energy related activities, transportation and distribution, any leased assets, processing of sold products, use of sold products, end-of-life treatment of sold products, and any investments. In the future, including more scope 3 emissions subcategories like the ones listed above would give Duke University Hospital a more complete picture of both its scope 3 emissions and the hospital's overall, total emissions.

Additionally for the purposes of our analysis, actual scope 3 emissions numbers for Duke University Hospital for fiscal year 2019 are likely higher than the number listed here, due to the contribution of other scope 3 emissions subcategories that our team was not able to track. Although the scope 3 emissions numbers for Duke University Hospital are likely higher than what our team is reporting here, our team is confident that this

scope 3 emissions number is still a useful baseline for Duke University Hospital to use as a starting point to reduce scope 3 emissions.

Duke University Hospital's scope 3 emissions in fiscal year 2019 included the following data categories, listed below.

- Emissions from staff and faculty commuting
- Transmission losses from electricity
- Air travel
- Landfilled waste
- Incinerated waste (negligible)
- Natural gas fugitive emissions (negligible)

Scope 3 Emissions: Duke University Hospital (fiscal year 2019)		
Scope 3 Emissions Category	**Metric tons of CO_2e (equivalent)**	**Percentage of Scope 3 Emissions**
Emissions (gasoline) from staff & faculty commuting	26,897	75.75%
Emissions (diesel) from staff & faculty commuting	957	2.70%
Transmission losses from electricity	3,787	10.67%
Air travel	2,199	6.19%
Landfilled waste	1,437	4.05%
Incinerated waste	-922	-0.26%
Natural gas fugitive emissions	322	0.91%
Total Scope 3 Emissions	**35,507**	**100%**

Total greenhouse gas results – scope 1, scope 2, and scope 3 emissions

Concerning total emissions, the figure below shows Duke University Hospital's scope 1, 2, and 3 emissions for the fiscal year 2019. Scope 1 emissions constituted 26% of the hospital's emissions, scope 2 emissions constituted 40% of the hospital's emissions, and scope 3 emissions constituted 34% of the hospital's emissions.

Total Emissions: Duke University Hospital (fiscal year 2019)		
Emissions Category	**Metric tons of CO_2e (equivalent)**	**Percentage of Total Emissions**
Scope 1	26,890	26%
Scope 2	42,079	40%
Scope 3	35,507	34%
Total Emissions	**104,477**	**100%**

Comparison of Duke University Hospital's GHG Emissions to Duke University's GHG Emissions

For comparison purposes, our team compared Duke University Hospital's greenhouse gas emissions with Duke University's greenhouse gas emissions. Duke University has a campus wide goal of achieving climate neutrality by 2024 (Sustainable Duke, 2019). Duke University's climate neutrality goal encompasses the university-side of Duke University, including the School of Medicine and the Duke School of Nursing, but the carbon neutrality goal does not include Duke University Hospital, as mentioned before. Yearly, Duke University takes inventory of its greenhouse gas emissions. In fiscal year 2019, Duke University's emissions sources contributed approximately 270,00 metric tons of CO_2 equivalent (Sustainable Duke, 2022). This number compares to Duke University Hospital's emission number of approximately 104,000 metric tons of CO_2 equivalent for fiscal year 2019. Our team chose the fiscal year 2019 for the greenhouse gas baseline year for Duke University Hospital, specifically including the dates of July 1, 2018, to June 30, 2019. Duke University uses the same fiscal year dates of July 1 to June 30 for its calculation of greenhouse gas emissions.

Concerning percentages of emissions, for Duke University Hospital for fiscal year 2019, scope 1 emissions were 26% of total emissions, scope 2 emissions were 40% of total emissions, and scope 3 emissions were 34% of total emissions. For Duke University for fiscal year 2019, the breakdown of scopes of emissions were similar, with scope 1 emissions constituting 26% of Duke University's total emissions, scope 2 emissions constituting 38% of total emissions, and scope 3 emissions constituting 36% of total emissions.

Duke University's 2019 Climate Action Plan, which is the university's most recent published climate action plan**,** states that emissions reductions at Duke University at that time "had been achieved primarily through the following strategies: investments in energy efficiency and utility improvements, discontinuing the use of coal in campus steam plants, and Duke Energy reducing the carbon content of its electricity" (Sustainable Duke, 2019). These strategies are mentioned here to highlight ways that the university has been successful at reducing greenhouse gas emissions. These emissions reductions at Duke University are especially impressive, given that Duke University's gross square footage had increased in that timeframe (Sustainable Duke, 2019). Another comparison would be the emissions per square foot between Duke University Hospital and Duke University. This comparison is an opportunity for further analysis by future individuals who continue this work. These facts are mentioned to give Duke University Hospital insights into possible ways to reduce emissions.

Comparison of Duke University Hospital's GHG Emissions to Other University Hospital's GHG Emissions

Our team also contacted other university hospitals and health systems to compare greenhouse gas emissions between Duke University Hospital and other hospitals and health systems. It is important to remember that geographic locations use different emissions factors based on their local grids and the types of energy that exist within that geographic location. Therefore, emissions between hospitals can vary considerably based on geographic location and corresponding emissions factors. Additionally, total greenhouse gas emissions can vary considerably based on the square footage of a hospital, number of employees, and other factors. Our Masters Project team communicated with sustainability officers at Emory University, the University of

Michigan, and Stanford University. These universities were chosen because they are part of the "Ivy Plus" consortium of universities, of which Duke is a part of. Our team reached out to additional universities within the Ivy Plus consortium but did not receive responses.

Our team learned that Emory University, the University of Michigan, and Stanford University use the Greenhouse Gas Protocol's greenhouse gas accounting methodologies, which is also the methodology that Duke University uses. This methodology is also the one that our Masters Project team used. From discussions with these sustainability officers, our team learned that Emory University does track hospital and health system emissions data, but Emory University combines that data with their overall greenhouse gas inventory. Therefore, Emory University does not have a healthcare-only greenhouse gas inventory. Further, our team was able to obtain greenhouse gas emissions from the University of Michigan and from Stanford University. A main takeaway from our Master Project team's consultation with other hospitals and health systems is that baselining greenhouse gas emissions for the healthcare sector is important, as a greenhouse gas emissions baseline then allows hospitals and healthcare systems to work to reduce their emissions.

Recommendations for Moving Forward

A greenhouse gas emissions baseline is the first step to reducing greenhouse gas emissions. With this emissions baseline, Duke University Hospital can take steps to reduce its emissions. Listed below are specific recommendations that Duke University Hospital could implement to reduce its greenhouse gas emissions, categorized by scope 1, scope 2, and scope 3 emissions reductions recommendations.

Scope 1 Emissions Reductions Recommendations

Scope 1 emissions are emissions that Duke Hospital directly owns or controls. For Duke University Hospital in fiscal year 2019, these sources included natural gas on campus usage, Duke Hospital owned fleet emissions, and HFC-404a and HCFC-22 refrigerants. With scope 1 emissions, natural gas from on campus

sources constituted 94% of scope 1 emissions, followed by refrigerant use constituting 4% of scope 1 emissions, and Duke owned fleet emissions constituting 2% of scope 1 emissions.

To reduce scope 1 emissions, our Masters Project team first recommends that Duke University Hospital investigate its natural gas usage, since this is the largest percentage of scope 1 emissions, per our analysis. Second, our team also recommends that Duke University Hospital track anesthetic gas usage because some of these gasses, such as desflurane, have a very high global warming potential (GWP). Importantly, the half-life of a greenhouse gas is not as important as its warming potential and for a gas like desflurane, its global warming potential is very high. Duke University Hospital should start tracking the impact that gasses like desflurane are having on their emissions. Our team then encourages the hospital to take steps to reduce the use of these anesthetic gasses. Notably, there is more on desflurane later in our paper as well**.** Additionally, there are anesthesiology efforts already underway to track the desflurane anesthetic gas at Duke University Hospital, which is a promising and important effort. And our third scope 1 emissions reduction recommendation is that Duke University Hospital should encourage the use of electric vehicles in its fleet, if possible, to reduce emissions from the hospital's fleet.

Scope 2 Emissions Reductions Recommendations

Scope 2 emissions are emissions from purchased electricity. To reduce scope 2 emissions, it is recommended that Duke University Hospital reduce its energy usage. The scope 2 emissions reductions recommendations are for Duke Hospital to invest in energy efficiency measures and to encourage policies that ensure that Duke Energy's energy mix is less emissions intensive. Ideally, the purchased electricity from Duke Energy would use less emissions-heavy sources of electricity in favor of electricity like solar energy. Overall, Duke University Hospital should aim to reduce emissions from electricity by energy efficiency measures or through purchasing electricity from cleaner sources in order to reduce its scope 2 emissions.

Scope 3 Emissions Reductions Recommendations

Scope 3 emissions include all other emissions in the value chain that are not included in scope 1 or scope 2 emissions. For this greenhouse gas analysis, our team tracked the following scope 3 emissions categories: staff and faculty commuting, air travel, natural gas fugitive emissions, transmission losses from electricity, incinerated waste, and landfilled waste. However, there are more subcategories of scope 3 emissions that our team did not track. Therefore, the first scope 3 emissions reduction recommendation is for Duke University Hospital to track emissions from more scope 3 emissions subcategories. Including more scope 3 emissions subcategories will give Duke University Hospital a more complete picture of both its scope 3 emissions and its overall, total emissions. The scope 3 emissions subcategories that Duke University Hospital could track, but that our team did not track in this analysis, include: purchased goods and services, capital goods, fuel and energy related activities, transportation and distribution, any leased assets, processing of sold products, use of sold products, end-of-life treatment of sold products, and any investments.

For the second scope 3 emissions reduction recommendation, Duke University Hospital should encourage less emissions heavy ways of transportation for employees. Concerning scope 3 emissions from our analysis, about 79% of scope 3 emissions occur from staff and faculty commuting. Therefore, Duke University Hospital should encourage less emissions heavy methods of employee commuting. As a caveat, our data is from fiscal year 2019. Since that time, it is likely that Duke University Hospital's commuting profile and the prevalence of electric vehicles has changed, which would result in less emissions intensive ways of commuting. However, it would still be beneficial for Duke University Hospital to encourage less emissions intensive methods of employee commuting.

Third, for scope 3 emissions, about 11% of the scope 3 emissions from this analysis are from transmission losses. Some of these emission losses are inevitable, but Duke University Hospital could consider working with Duke Energy to reduce these losses. As a fourth recommendation, the percentage of scope 3 emissions from air travel was around 6% from scope 3 emissions. This figure will likely be less given that our

team tracked this information in fiscal year 2019, before changes in telecommuting and online conferences starting in 2020. Duke University Hospital should nonetheless consider ways to reduce emissions from air travel. As a fifth recommendation, the last largest component of scope 3 emissions was landfilled waste. Duke University Hospital should encourage stronger recycling policies and composting policies so that the hospital sends less waste to the landfill. Sending less waste to landfills would reduce Duke University Hospital's greenhouse gas emissions from landfilled waste. Overall, Duke University Hospital now has an emissions baseline and can work towards reducing its carbon footprint in data-driven, meaningful ways.

Component 2: Pilot Projects

Introduction

Once a baseline of emissions and waste is established, the next steps are to begin implementing pilot projects to initiate real change within the hospital. Pilot projects are defined as "initial small-scale implementations that are intended to prove the viability of a project idea" (____). The fact that they are "pilots" takes off some of the pressure of committing to large scale changes but even more importantly, they are a great way to begin seeing positive impacts as a result of these changes which will encourage continued investment in the process.

Our approach was to work with interested internal stakeholders to develop roadmaps that outline the path individuals within the hospital should take to carry out specific sustainability initiatives. Throughout the process, we evaluated (1) what types of sustainability initiatives other hospitals have implemented, (2) what criteria to consider when determining which projects would be most appropriate for DUHS to implement, and (3) an outline of the implementation process which included identifying those stakeholders that will be important to include in the decision making and implementation process. Our level of involvement in the projects consisted of both direct involvement, where we assisted in carrying out steps of implementation, and indirect involvement, where we used research to determine the resources and actions required to carry out the project.

Based on the above process, we identified the following Pilot Projects for DUHS's Sustainability Plan:

1. Greening the Operating Room
2. Reducing the use of Anesthetic Gasses with high Global Warming Potentials (GWP)
3. Education and Training

Implementation Roadmap - An Overview

Creating meaningful change with an existing system requires stakeholder buy-in, realistic timelines with trackable deadlines, an interdisciplinary approach that evaluates each aspect of the process, and the collection of needed resources. The following section outlines the key components of a Pilot Project Implementation Roadmap.

1. *Stakeholders*

Key stakeholders for implementing these projects include:

- Hospital Leadership
- Administrative Departments (Facilities, Procurement etc.)
- Healthcare providers
- Staff

The support of hospital leadership is critical to supplementing support through a top-down approach to sustainability and to illustrate the healthcare system's commitment to reducing emissions and waste as part of its vision to deliver tomorrow's healthcare today. In order to establish a baseline for emissions and waste and move the needle on adopting sustainable purchasing habits and building operation, engagement and support from various administrative departments are also key.

Healthcare providers play a critical role in encouraging the adoption of these initiatives and taking the lead in ensuring continual compliance with sustainability guidelines. Hospital staff can support and take ownership of these efforts as well.

2. *Timeline*

Sustainability is not a one-time process but instead takes time, commitment, and a constant willingness to evolve to optimize operations to reduce emissions and waste. Therefore, initiatives should include short and long-term goals and incorporate routine maintenance checks to evaluate opportunities for further improvement.

3. *Process*

The process for each project will be outlined in the respective roadmaps, highlighting the interdisciplinary nature required for success.

4. *Resources Required*

Short-term initiatives will primarily require data from various departments and willingness to engage in training sessions. However, long-term strategies could include a "Green Revolving Fund", as seen in the Cleveland Clinic's sustainability plan, which provides funding for additional sustainability projects using money saved from earlier projects (i.e., energy star retrofits) (Better Buildings Solution Center, n.d.).

Methods

1. Peer Institution Research

Numerous healthcare systems across the United States are already addressing the environmental impacts of their operations. Our team had the opportunity to speak with sustainability professionals at the following institutions:

- UCLA Health
- Memorial Sloan Kettering
- Cleveland Clinic
- Hackensack Meridian Health
- OhioHealth
- The Ohio State University Wexner Medical Center
- Children's Hospital of Philadelphia

These institutions provided a wealth of knowledge and best practices regarding their sustainability initiatives. Each institution emphasized the importance of targeting the following areas:

- Energy Usage

- Waste Disposal & Diversion
- Employee Engagement & Re-training
- Procurement Shifts

Energy Usage

The energy intensity of a hospital building is 738.5 kWh/m2. In comparison, the average office building has an energy intensity of 246 kWh/m2 (Bawaneh et al., 2019). To decrease the energy intensity of the space and reduce utility costs, institutions have implemented the following efforts:

Cleveland Clinic: Adjusted the operating schedules of their HVAC system in non-emergency operating rooms through air setbacks to lessen the energy load. This shift saved roughly $200 million a year (A. Pettitas, personal communication, February 21, 2021).

Memorial Sloan Kettering: Set a goal of all new buildings obtaining at least a Silver LEED Certification, with 8 buildings currently holding this certification. LEED buildings are projected to, on average, use 25% less energy and result in a 19% reduction in operational costs (S. Dunne, personal communication, March 4, 2021).

Waste Disposal & Diversion

Hospitals generate on average over 29 pounds of waste per patient per day (Practice Greenhealth, n.d.). This staggering amount of waste results in tremendous costs to the healthcare system and the environment. Therefore, peer institutions have implemented the following:

UCLA Health: UCLA set several aggressive waste diversion targets:

- By September 2023 UCLA Health aims to phase out the sale and free distribution of single-use plastic beverages and water bottles on all food facilities and vending machines.
- Issued over 9 million washable/reusable isolation gowns since May 2012 (J. Evans, personal communication, January 2021).

Children's Hospital of Philadelphia: Developed a mandatory electronics recycling program and implemented a diaper donation program to a local food bank from the neonatal intensive care unit (NICU) (T. Weaver, personal communication, March 2, 2021).

Employee Engagement & Re-training

Ohio Health: Stresses the role of climate change as a social determinant of health in community partnerships and the hiring process. Promotes the role of mission-driven work by creating opportunities for employees to engage in diversity, equity, and inclusion initiatives by tackling the main community-identified issue, air pollution. Applied for several DEI and community benefit reporting awards and grants (A. Wiesler, personal communication, November 16, 2021).

Children's Hospital of Philadelphia: Led waste-retraining sessions for nurses throughout the hospital to encourage the proper sorting of waste (particularly focused on reducing the mixing of hazardous and non-hazardous waste) (T. Weaver, personal communication, March 2, 2021).

Procurement Shifts

Cleveland Clinic: Shifted suppliers to support vendors with stronger sustainability goals and encourage vendors to utilize trusted frameworks and existing certifiers and eco-labels (such as my green lab, B-Corp Certification, and FSC) to increase vendor transparency (A. Pettitas, personal communication, February 21, 2021).

UCLA Health: Recognizing that using one bottle of desflurane has the same environmental impact as burning 440 kg of coal2, which is 26 times the global warming potential of sevoflurane and 13 times the potential of isoflurane, UCLA committed to reducing the amount of desflurane purchased and using it as the primary gas for >1% of procedures (J. Evans, personal communication, January 2021).

Duke Health's peer institutions have paved the way for reducing operational costs while improving the health and well-being of employees, patients, and community members. Critical components for a successful

sustainability program include having “physician champions” who advocate for sustainable practices within their respective departments and showing the financial and social benefits of every project. Sustainability initiatives should be evaluated along the criteria of the time and financial investment required and the return on investment as well as the environmental impact.

2. Pilot Project Selection Criteria

Once we built out a list of the changes peer institutions implemented in the early stages of their sustainability journeys, We then used a decision matrix to weight the different projects according to a set of criteria we designed specifically for DUHS that generally considered financial and technical feasibility, the scale of environmental impact the change would have (which was important considering we wanted the success to help fuel continued improvements), and existing buy in amongst the DUHS community. We also considered more broadly the goals and mission of DUHS, which is ultimately to provide world-class care.

- Financial feasibility represents the cost of the project. Our ranking of 1-5 scores the projects based on how feasible implementation is purely from a cost standpoint when compared with the other initiatives considered.
- Technical feasibility represents our considerations of the technical and operational changes required to implement the project. Higher scores represent projects with existing operational capacity or low technical and operational requirements while lower scores represent those projects that will require larger upfront investments in technical changes and operational support.
- The cost savings score indicates the scale of savings generated annually following full implementation of the project, depicting the expected monetary benefits of the project.
- Environmental Impact scores consider the relative environmental impact of the project. This environmental impact can be in the form of waste reduction or energy use reduction.

- The Visibility score indicates the internal visibility the considered project could have. This element was important to include as projects with higher visibility are likely to lead to continued implementation of sustainability initiatives through shifts in institutional culture and motivation from seeing action and change.
- Employee Interest is the final criteria and potentially most important consideration as the biggest barrier to changes made to an existing system can often be process re-training. With existing employee interest, this hurdle can be more easily overcome because it represents the fact that employees are aware of a problem, are aware of where the problem exists within their operations and have a desire to change it. Higher scores represent expressed interest on behalf of hospital staff in implementing the project.

Project	Financial Feasibility	Technical Feasibility	Cost Savings	Environmental Impact	Visibility	Employee Interest	Total
Waste Audits and Waste Stream Training	5	5	4	4	5	5	28
LED Lighting Upgrades	2	2	5	5	3	2	19
Composting of Food Waste	3	2	2	4	3	3	17
Green Cleaning Products	5	4	1	2	4	2	18
Reduce Desflurane	4	3	3	4	4	5	23
LEED Retrofitting	3	2	3	4	5	4	21
Local and Sustainable Food Purchasing	2	2	1	3	4	2	14
Reusable Medical Devices	2	3	3	4	3	2	17
Reusable Isolation Gowns	3	3	3	4	3	2	18
Air setbacks in non-24/7 ORs	5	2	5	5	1	1	19
NICU Diaper Donations	5	3	1	1	5	4	19
Eliminate Plastic Bags at Hospital Entrance	4	4	2	1	5	2	18

As the following roadmaps will show, all our projects have a strong financial and environmental case, however, we discovered in this process that the most important criterion is institutional support. Because hospitals are so process dependent and centered around efficiency of care, as opposed to energy or waste efficiency, and procedural changes can threaten this efficiency, the biggest barrier to change is cultural and behavioral. Therefore, the success of a project really hinges on existing support amongst those individuals that are affected. This was the driving consideration for our pilot project selection and all the following projects have physicians and residents actively advocating for these changes.

Pilot Project 1: Greening the OR

I. The Case for Greening the OR

The operating room (OR) is one of the most productive parts of a hospital to reduce its environmental impact and save money. Operating rooms are very resource-intensive and are three to six times more energy-intense per square foot than a hospital, as they require lighting, air conditioning, and patient monitoring equipment at most hours of the day (*Energy Efficiency in the OR*, n.d.). They have also been reported to contribute up to 30 percent of a hospital's waste, and up to 90 percent of OR waste is improperly sorted and sent for unnecessary biohazard waste processing (Wu & Cerceo, 2021). For example, many medical supplies that could be reused through sterilization or reprocessing are sent to hazardous waste. Not only does this increase the amount of waste going to landfills, but hazardous waste is much more expensive for the hospital to deal with than recycling or regular waste. Additionally, ORs are responsible for 40 to 60 percent of a hospital's total supply costs (Practice Greenhealth, n.d.).

Due to the high costs and environmental implications associated with the OR, we have decided that greening the OR would be the best pilot project for us to plan and implement at Duke Hospital. There are many best practices that can be implemented as part of a "greening the OR" initiative. These include reducing the amount of energy used through structural and technical changes such as utilizing occupancy sensors for

lighting, using LED surgical lighting, using anesthetic gas capturing systems, and programing HVAC systems to reduce air changes when ORs are unoccupied (Practice Greenhealth, n.d.). However, the largest focus and opportunity for sustainability related improvement is waste segregation and diversion from regulated medical waste. Waste reduction and prevention in the OR includes actions such as conducting a waste audit, recycling medical plastics, using a fluid management system, and collecting FDA-approved medical devices for reprocessing. Further waste reduction methods that promote waste reduction before it is even produced includes environmentally preferable purchasing, reformulating OR kits to reduce excess supplies and overage, purchasing reprocessed medical devices, purchasing reusable gowns, table covers, and other necessary OR items, and using environmentally preferable cleaners and disinfectants. The reasons waste reduction in the operating room is such a powerful initiative are due to both cost savings and environmental impact. However, and importantly, employee satisfaction is another key driver in the case for greening the operating room. This section will conclude with a discussion around the feasibility of this initiative and finally a discussion of the barriers to implementation.

Cost Savings

Since ORs are extremely resource intense, it can be very expensive to keep stocking the disposal items and dealing with the incorrectly sorted hazardous waste. Practice Greenhealth has estimated that hospitals implementing "greening the OR" best practices can see annual savings of up to $20,060 per operating room. These cost savings will come through decreased electricity and water bills, reduced payment for hazardous waste processes, and reduced need for purchasing new medical products. Some of the most significant cost savers include medical device reprocessing (which can save up to $6,206 per year), utilizing fluid management systems (which can save up to $3,389 per year), and anesthetic gas reduction (which can save up to $2,593 per year) (Practice Greenhealth, n.d.).

Environmental Impact

Many positive environmental implications can arise from greening the OR practices. Decreasing energy use (e.g., by using LED lighting, occupancy sensors, or HVAC setbacks) helps decrease the demand for energy production, which is often done through the burning of fossil fuels and results in large quantities of greenhouse gas emissions. Reducing unnecessary packaging and instruments (e.g., by reusing medical products or reformulating OR kits) can help eliminate excess in the waste stream and reduce waste being sent to landfills. For example, the widespread use of single-use polypropylene packaging for sterilization of surgical instruments results in about 115 million kilograms of plastic wage every year in the U.S. (Fredericy et al., 2021). Reducing the need for this packaging could greatly decrease the amount of waste caused by this packaging every year. Environmentally preferable purchasing (e.g., using non-toxic cleaning agents) can help reduce the harm caused by these chemicals both to the environment and to humans.

Employee Satisfaction

The master's project team was approached by Dr. Michael Lipkin and Dr. Ankeet Shah, urologists from Duke Hospital's Urology Department, as well as Vishal Venkatraman, a Duke medical student, all of whom were concerned about the massive amount of waste coming out of every OR after a surgery. This interaction instigated the creation of a pilot project for greening the OR with the urology department as a case study. It also shows that hospital employees want to see these changes. According to a study from *The Joint Commission Journal on Quality and Patient Safety,* "Surveys of physicians and other staff show that ecological sustainability is important and a driver of engagement" (Wu & Cerceo, 2021).

Feasibility

Greening the OR is an ideal pilot project in terms of feasibility because it has a wide range of requirements financially, operationally, and technically. Since there are so many best practices that hospitals can put in place to green their ORs, they can start smaller with projects that may be cheaper and less technically complicated (i.e., educating employees about proper waste sorting techniques and OR kit reformulation), or

much more expensive or technically involved (i.e. installing LED surgical lighting or installing fluid management systems). A waste training, for example, would be very cheap and very operationally and technically feasible. It would not require any new employees or goods to be purchased. Additionally, many of the practices with high upfront costs end up saving large amounts of money in the long run. For example, switching to LED lighting may be expensive, but the reduction in energy bills will pay back those initial costs in a short time. Some of the best practices may be operationally difficult due to existing contracts. This mainly includes actions that involve changing the specific products that are being procured and where they are coming from, such as switching to reusable medical supplies, gowns, etc.

Barriers

According to Practice Greenhealth, one of the greatest challenges for greening the OR "can be convincing the surgical teams, who rely on empirical data and consistencies in structure and process, to consider changes in their respective practices". They also identify data, communication, and collaboration across disciplines as the key factors that can contribute to success (Practice Greenhealth, n.d.).

Determining ways that Duke Hospital can reduce waste, energy use, water use, and harmful chemical use in their operating rooms is an ideal pilot project since it will help reduce costs, reduce their environmental footprint, and increase employee satisfaction. It is also a financially, operationally, and technically feasible project– especially due to its flexibility and the fact that there are many pathways the hospital can take within this effort. Employee interest is also an important driver behind the decision to choose this as one of our few pilot projects. The fact that multiple employees within the hospital were concerned about the environmental footprint of their workplace shows that there will likely be many healthcare workers willing to put in the necessary effort to green their ORs.

II. Case Study - Greening the Urology OR

In November of 2021, Dr. Michael Lipkin and Dr. Ankeet Shah, urologists from Duke Hospital's Urology Department, and Vishal Venkatraman, a Duke medical student, approached our team and expressed concerns about the massive amount of waste coming out of every OR after a surgery. Considering we had already identified Waste Auditing and Waste Retraining as an ideal initial pilot project, our team felt it was extremely important to capitalize on this opportunity to leverage existing employee interest to mobilize sustainability efforts and inform our roadmap for the implementation of waste diversion across the hospital system.

Dr. Lipkin, Dr. Shah, and Vishal had questions about the different types of wastes generated in a typical urology operation, the amount of each type of waste, and the available strategies around proper handling of that waste to reduce impact. Our team also wanted to understand more about the waste generated for the purposes of providing appropriate recommendations for waste diversion and to support the internal desire to facilitate operational changes that reduce the hospital's environmental impact. Through many discussions around all our individual and shared priorities, Dr. Lipkin, Dr. Shah, Vishal and our team developed a plan for a collaborative project that would sow the seeds for our first pilot project recommendation, Greening the OR.

While the opportunities to reduce the environmental impact of operating rooms also include structural changes to the built environment that lead to energy savings, a very large portion of Greening the OR is addressed through waste reduction and prevention. Dr. Lipkin, Dr. Shah, and Vishal's priorities were also around waste reduction, and we therefore established a project where we would evaluate the waste generated in an operating room in the urology department and develop a management system to reduce that waste. This project also serves as a case study that informs the implementation road map laid out in the following section. This section contains the details and results of the case study.

Project Objectives

The objective of this project is to quantify the amounts of each waste stream the operating room in the urology department is generating and develop strategies to reduce the environmental impact of operations occurring in this space through the implementation of waste and energy mitigation efforts.

Deliverables

1. A waste audit of the operating room.
    a. Non-Hazardous Waste
    b. Hazardous Waste
    c. Sharps
2. Waste re-training to ensure that waste is disposed of in the appropriate bins and collected by the appropriate parties (i.e., recycling service, janitorial staff)
3. Proper signage above each disposal bin to ensure compliance.
4. Identification of environmentally preferred purchasing options.
5. A report of best practices (ranging from managing waste streams to decarbonizing the physical space).

Audience

The audience for the project deliverables will primarily be the Urology department at Duke University Hospital in addition to medical students (David Sykes and Vishal Venkatraman) conducting research in this space.

Approach

Methodology:

The key target areas to address to assess and reduce the environmental impact of OR procedures are organizational development, waste reduction and prevention, environmentally preferred purchasing, and the built environment. For the purposes of this partnership and effort, we will be focusing on waste reduction and prevention and environmentally preferred purchasing.

To identify opportunities for improvement in these areas, we first need to conduct an analysis of current practices. We will conduct a waste audit in operating rooms to understand what kind of waste is produced in a typical operation and we will conduct remote research to map the current waste streams leaving the operating room. We will specifically be looking to see if the different types of waste listed below are currently separated and to what extent. Based on this information, we will develop and implement a process for segregating waste into respective waste streams.

To address purchasing, we will again conduct an informal audit of the materials typically used in the operating room. We will then investigate the source and nature of purchased materials, and what alternatives exist. Finally, we will produce a report containing this inventory along with identified alternatives, the feasibility of replacement, and the justification for replacement to support petitioning for environmentally preferable purchasing.

Work Plan:

1. Conduct waste audit in OR (Mid-February 2022)
    a. Will conduct more than one audit as control
2. Investigate current recycling methods (February 2022)
    a. By contacting waste management at the hospital
    b. If plastics are not currently recycled, Item 4. will not be pursued

3. Investigate current waste streams (Early February 2022)
    a. By observing current practices in the OR
    b. Can collect some of this information at the same time as waste audits
    c. Waste streams we will look for:
        i. Pre-incision, non-pharmaceutical waste
        ii. Non-infectious solid waste
        iii. FDA-approved medical devices
        iv. Pharmaceutical waste
4. Implement a process to recycle medical plastics from the OR (assuming investigation leads to conclusion that plastic recycling is possible) (Mid-March 2022)
    a. Create a separate bin to collect the following plastic materials:
        i. Clean, rigid plastics of any shape (e.g., trays, containers, and packaging)
        ii. Clean, empty bottles (e.g., saline and alcohol)
        iii. Clean blue wrap (polypropylene sterile wrap)
        iv. Clean, soft plastics (e.g., overwraps)
        v. Clean Tyvek
        vi. Any others identified
    b. Ensure collected materials are taken to a proper recycling station (Early March 2022)
5. Implement a process to separate wastes into respective waste streams (Mid-March 2022)
    a. Provide necessary stations to:
        i. Divert pre-incision, non-pharmaceutical waste from regulated medical waste stream into a clear bag for non-infectious waste disposal
        ii. Segregate non-infections solid waste from the regulated medical waste stream during and after the procedure

iii. Collect FDA-approved medical devices for reprocessing with an FDA- approved third party re-processor

iv. Segregate pharmaceutical waste into specially labeled containers for appropriate disposal

III. Implementation Roadmap

The case study conducted using operating rooms within the urology department can serve as justification for the potential benefits generated from improving waste management and purchasing practices and informs the following roadmap towards Greening the ORs across the entire hospital system.

While narrowing efforts to first addressing the impact of operating rooms is an excellent first step and efficient way to maximize the scale of impact and minimize the burden of differentiated operational changes, efforts can be further broken down and prioritized to limit waste and ensure the success and longevity of the program. Beginning with waste segregation is a powerful way to reduce the infectious waste stream and generate significant savings. We recommend that efforts to green ORs across the hospital system also begin with waste management and success in these areas can motivate additional projects to further reduce impact.

Stakeholders

Every new project or initiative undertaken on this sustainability journey will require collaboration with and support from individuals across the hospital system. Therefore, it is very important to identify key stakeholders and establish relationships before beginning implementation. For waste management in the Operating Room, the key stakeholders are as follows:

- Operating Room Leadership
- Department heads
- Environmental Services
- Infection Prevention
- Purchasing Department

Process

Step 1: Establish leadership support

As we saw through our case study, success of the project was contingent on support from OR leadership and staff. To expand waste stream management to operating rooms across the hospital, it is important to first reach out to OR staff to see if anyone is interested in championing this effort with other staff. Establish this leadership support within each OR department so that support is concentrated and widespread. Behavior change is often the most difficult barrier to overcome and having a member of OR staff within each department championing the initiative will help to address this.

Use the following checklist to track identification of leadership support within each department:

Checklist:

- Cancer: _____
- Cardiology: _____
- Ear Nose and Throat: _____
- Eye Care: _____
- Endocrinology: _____
- Gastroenterology: _____
- Geriatrics: _____
- Nephrology: _____
- Neurology: _____
- Neurosurgery: _____
- Obstetrics and Gynecology: _____
- Pulmonology: _____
- Rheumatology: _____
- Spine Care: _____

- Urology: _____

Step 2: Establish a baseline

Once support is established, the next step is to evaluate current practices. In the case of waste stream management, this evaluation can be in the form of a waste audit. Environmental Services or Infection Prevention departments could be valuable resources in carrying out this step. Conduct an inventory of the different waste streams generated during operations, differentiating the operations by department so that data can be more accurately generalized, and the existing processes in place for handling that waste.

Use the following checklist to document the approximate volume of each type of waste:

Checklist:

- Pre-incision, non-pharmaceutical waste
- Non-infectious solid waste
    - ★ Keep a special eye out for gowns, textiles, basins, and surgical instrumentation cases as this data could be useful for advocating for the switch to reusables!
- FDA-approved medical devices
- Pharmaceutical waste
- Medical plastics

Step 3: Provide for the process

Once each department understands the different waste streams generated in a typical operation, the next step is to provide the signage and receptacles that can allow for segregation. This step requires the purchasing of the different collection containers, the creation of signage, and the implementation of signage and containers in the OR's.

The different receptacles for the above waste streams could be as follows:

- Clear bag for:
    - Pre-incision, non-infectious waste
    - Post-incision, non-infectious, non-sharps waste that cannot be reprocessed or reused
- Typical red bag used to collect regulated medical waste
- Reusable Sharps container for needles and syringes
- Blue bag for recyclable medical plastics

Step 4: Educate!

Beyond signage, there needs to be a concerted effort to help all OR staff understand the new segregation goals, what behavior changes are required, and to answer questions and address concerns. Powerful ways to ensure success during this stage are through, once again, empowering OR leadership and physician leadership. It is important that leadership is on board so that they can help to reinforce these new procedures for the rest of the staff.

Step 5: Track Progress

Tracking progress is the final key step and is extremely important for maintaining motivation among staff and leadership. Seeing the waste reductions and cost savings resulting from these changes will empower the entire organization as the metrics reveal just how much power we have to create positive impacts. Celebrate success and let that success build momentum to tackle harder sustainability practices!

As mentioned above, proper waste management and responsible purchasing are just two ways of reducing the environmental impact of operating rooms. Once these two initiatives are established, additional best practices should eventually be embraced to further reduce impact and drive down cost. The following list outlines some of those initiatives:

1. Partner with a third-party re-processor to divert and purchase reprocessed medical devices
2. Reformulate operating room kits according to the type of surgery to reduce routine disposal of items that are never used in those procedures.
3. Implement operating room setback mechanisms to decrease air changes during unoccupied hours to save energy and cost.
4. Structural changes to the built environment

Pilot Project 2: Reduce Environmental Impact of Anesthetic Gasses

I. The Case for Reducing Desflurane

Anesthetic gasses are GHGs that make up about five percent of a hospital's GHG emission footprint and about fifty-one percent of an operating room's (OR) emissions. As the healthcare sector works to address its impact on climate change, one significant change many hospitals are making is reducing their use of desflurane, a halogenated anesthetic gas. Desflurane is one of the most commonly used anesthetic agents but is also one of the most expensive in addition to being more damaging to the environment than its potential alternatives. Global warming potentials (GWP) are used to compare the strength of different greenhouse gasses' ability to trap heat in the atmosphere relative to carbon dioxide (CO_2), and they are calculated as the warming potential over 100 years for a kilogram of a substance in the gaseous phase relative to a kilogram of CO_2. The GWP100 (100-year global warming potential) of desflurane is about 2,540 years. This is much higher than the estimated 510 years for isoflurane, 130 years for sevoflurane, and 298 years for nitrous oxide (Practice Greenhealth, 2019). When patients inhale the gasses, their bodies only metabolize roughly 5% of the gas, and the rest is exhaled and sent into the atmosphere. Desflurane lasts in the atmosphere for about 14 years. In contrast, sevoflurane breaks down in just one year, and isoflurane breaks down in about 3.5 years (Gadani & Vyas, 2011). It is clear that desflurane use is much more environmentally degrading than its alternatives. It is also important to note that most of these gasses, especially sevoflurane, are clinically similar to desflurane. This

means that there are very few instances when you would medically need to use one over the other (Garg et al., 2020). Overall, there are three main reasons Duke Hospital should decrease its use of desflurane: reduce costs, decrease its environmental footprint, and increase employee satisfaction.

Cost

Despite being one of the most used anesthetic agents, desflurane is also more expensive per ounce than its counterparts (Schwotzer & Sheehan, 2020). Also, because desflurane is a less potent drug, more of it is required to keep a patient unconscious so you need to purchase a higher quantity to start with (Fang, 2021). Reducing desflurane use can save thousands to hundreds of thousands of dollars every year. For example, Virginia Mason Medical Center completely eliminated desflurane use by September 2019 and has saved about $30,000 each year since initiating the switch. Providence Oregon has been able to save over $500,000 per year by cutting its desflurane use (Schwotzer & Sheehan, 2020).

Environmental

As mentioned above, the environmental footprint of desflurane is extremely high. Decreasing its use gives a hospital the chance to significantly reduce their scope 1 emissions, thereby greatly reducing their contribution to climate change. A conglomerate of hospitals in Vancouver reported that education on the impacts of desflurane compared to other anesthetics in the anesthesiology department led to a significant shift away from desflurane, resulting in a 66% reduction in harmful GHGs over a five-year period (Wu & Cerceo, 2021).

Employee Satisfaction

Desflurane's significant environmental impact is well known among younger anesthesiologists and medical students, and they are often the ones who spark the initial efforts to reduce desflurane use in hospitals around the country. In fact, we were approached by a Duke anesthesiology resident, Fintan Hughes, who expressed his and his colleague's desire to reduce desflurane use at Duke Hospital, as well as Dr. Michael Lipkin, a urologist at the hospital who wants to see desflurane use reduced. We also spoke with Henry Lather,

an anesthesiology resident at Duke Raleigh, who has already created initiatives to reduce desflurane use at the hospital. He was supported by his mentors, Dr. Brad Taicher, DO, MBA (Associate Professor, Assistant Director of Anesthesia Perioperative Services, Director of Anesthesia Patient Safety and Quality) and Dr. Guy Dear, MB ChB (Associate Professor, Maestro Care Champion) By making these conscious, sustainable changes, Duke Hospital can show employees that their opinions matter and that they are willing to take the effort to reduce their carbon footprint. This is especially important for the retention of high-quality healthcare workers, as a passion for the environment and for helping humans often go hand in hand.

Feasibility

Financially, reducing desflurane would only have positive impacts. Since it is the most expensive anesthetic agent, using less of it or replacing it with alternative gasses will cut costs for the hospital. Technically, since desflurane can clinically be interchanged with sevoflurane and isoflurane, the switch will not complicate matters in a medical sense. This project may be a bit more challenging operationally, as the higher-ups in the hospital would need to be convinced that this is enough of an issue to take action. This operational challenge is described in more detail below in the *Barriers* section.

Barriers

While it is clear that reducing desflurane use in a hospital can help reduce the facility's costs and environmental footprint, there are still a few key barriers that have prevented everyone from making the switch. The main one is purely a cultural and behavioral barrier. Since many physicians, especially the veteran ones, have been using desflurane for years, they are most comfortable with using it. The negative implications of a patient waking up mid-surgery have led anesthesiologists to want to use what they know how to use best. However, it may not always be clear to them how easy it can be to use the alternatives like isoflurane and sevoflurane. There is also a lack of education about how potent a GHG desflurane is. Desflurane does wear off slightly quicker than some of its alternatives and can result in a smoother wakeup for its patients, but it is important to note that the difference in wake-up time is only a few minutes and does not generally result in the

patient going home sooner. However, if physicians do not know about desflurane's environmental impact, they will likely not be convinced to initiate the switch away from it, especially since it has its strengths as an anesthetic gas. Physician buy-in is an extremely crucial part of any major hospital change, so these are all barriers that will be addressed within our recommendations. Another main barrier, according to Henry Lather, is how to manage the logistics of storing and dispensing the desflurane vaporizers. Pharmacists have indicated that they do not believe there is enough space to store the vaporizers when not in use. Finally, before making the switch to a different anesthetic gas, desflurane reserves need to be used up. Even in large hospitals where many surgeries take place each day, it could take years to go through the reserves to make space for the new anesthetic gas. The decision to switch away from desflurane needs to be made from the top-down, and for this to occur, you need physician and anesthetic nurse buy-in.

Despite the potential barriers to adoption, reducing desflurane would be an extremely effective pilot project for Duke Hospital. It will reduce costs, improve the hospital's environmental footprint, and improve employee satisfaction. Also, it is a small and relatively simple change that will result in big impacts. Finally, there has been expressed internal desire from members of the anesthesiology department, which is key in helping this initiative move forward.

Peer Institutions

Other hospitals throughout the country have been successful at reducing or completely eliminating their use of desflurane and have significantly reduced their environmental impact and costs as a result.

- *UCLA Health:* Recognizing that using one bottle of desflurane has the same environmental impact as burning 440 kg of coal, which is 26 times the global warming potential of sevoflurane and 13 times the potential of isoflurane, UCLA committed to reducing the amount of desflurane purchased and using it as the primary gas for >1% of procedures (J. Evans, personal communication, January 2021). This initiative has helped them save over $190,000 since its inception (UCLA Health, n.d.).

- *Virginia Medical Center:* Completely eliminated desflurane use by September 2019 and saves $30,000 per year (Schwotzer & Sheehan, 2020).
- *Providence Oregon:* Saves $500,000/year after reducing desflurane use and prioritizing the use of sevoflurane (Schwotzer & Sheehan, 2020).

II. Implementation Roadmap

This pilot project has been selected as one of our recommendations for initial steps the hospital should take on its sustainability journey because in addition to reducing costs, reducing impact, and improving workspace morale, there are already physicians and residents aware of and actively seeking solutions to the problems created by desflurane use. Henry Lather, a Duke Raleigh Anesthesiology Resident, first learned that volatile anesthetics were GHGs from prior Quality Improvement projects. He then took it upon himself to learn more about the impacts of anesthetic gasses on climate change, as well as determine how this impact could be reduced in the workplace. He implemented a few of his own initiatives to reduce desflurane use at the hospital, all with varying success. There are ways that the hospital could take part in these projects to improve their success. These initiatives include:

1. Fresh gas flow (FGF)

This method is an essentially free way of reducing desflurane use, but it does require a bit more attention than the normal administration of anesthesia. For this method to work, employees would need to be aware of how much gas they are using for a certain amount of time. This could come in the form of a pop-up alert in Epic (Duke Hospital's electronic medical record system) to inform people when their GHG is greater than a certain amount (e.g., 1L/min). However, there is currently no functionality within Epic to record the FGF from the anesthesia machines. The main way to pull data from Epic, Slicer Dicer, is not set up to analyze the presence of desflurane, despite it being within its capabilities. Henry submitted a work order to request an Epic pop-up if it

detects inappropriate use of desflurane during a case, but requests like these can take a while. Duke Hospital administration can help to move this forward by putting pressure on Epic to make these changes happen.

2. FGF Education

Another method for encouraging the reduction of desflurane use is to educate staff. Henry has begun this process by creating tip sheets explaining the benefits of low-flow anesthesia. Included were also instructions on how to properly use low-flow anesthesia, and they were distributed via email and through the clinical resources link in Epic. He also hung cards in the ORs. This intervention has had mild success, but big change is unlikely to be durable since most of the cards have fallen off the machines or have been removed. Hospital administration can help improve the success of this intervention by reinforcing these note cards that have fallen or by creating their own mandatory training sessions regarding the use of low-flow anesthesia.

3. Remove Desflurane Completely

Ideally, the hospital could follow in Yale's footsteps and completely remove desflurane from the formulary. However, one of the biggest barriers to getting rid of desflurane is tradition. Since many physicians, especially the older ones, have been using desflurane for years, they are most comfortable with using it. Some attendings at Duke have also advocated for the use of desflurane in certain circumstances, such as with obese or older patients. There would likely be too much pushback to completely remove it.

While these potential desflurane reduction methods hold merit, there are still downsides to the options. Based on Henry's experience and recommendations, as well as our own research, there are a few initiatives we believe Duke Hospital should take to reduce its environmental impact from anesthetic gas usage. Despite the growing interest in reducing desflurane at the hospital, there is still a strong culture around its use. Therefore, our main recommendations for ways to reduce desflurane involve changing the culture around its use rather than completely banning it.

Our Recommendations

1. Education and Awareness of Desflurane Impacts and Ease of Using Alternatives

Our first recommendation is to promote education about the environmental implications of using desflurane as well as how easy it should be to make the switch to sevoflurane or isoflurane. This education can take the form of note cards placed throughout their workplace (ones that are reinforced so they do not get removed), focus groups, or mandatory training sessions. The hope is that educating physicians on the harmful impact of desflurane and the ease of switching to viable alternatives will make physicians more likely to request the alternatives.

2. More Stringent Desflurane Protocols

While education is always an important tool, a potentially more effective recommendation is to change the accessibility of desflurane. We recommend removing desflurane from the ORs altogether, forcing physicians to order the gas through the pharmacy. In contrast, the alternatives can be taken directly off the pharmacy counter without going through the ordering process. When the pharmacy is busy, this could make obtaining desflurane difficult enough to incentivize using a different gas. The simple change and inconvenience can help break the habit around its use and force physicians to consider their need to use desflurane over other gasses. There are many examples of restricted drugs in the hospital, including others in the acute pain service that are run by anesthesia attendings such as ketamine and lidocaine. Exparel is an example of a restricted drug in the perioperative setting. When an anesthesia provider places the order, they need to list an anesthesiology attending's name who has the approval to use the drug in the comments, and it must be approved by that attending before the pharmacy can expense it. This is one method that could be replicated for desflurane. It could also be as simple as not having desflurane in the room to start with. Stanford University Hospital has removed desflurane from the ORs, forcing physicians to ask the techs to deliberately add it if they want to use it. According to Dr. Ellen Wang, this has been enough to discourage its use (H. Lather, Personal

communication, April 11, 2022). At Rochester General Hospital, physicians simply need to ask the anesthesiology tech to bring it to the room instead of having it on the machine by default. According to Dr. Steve Breneman, this has saved $600,000 in one year (H. Lather, Personal communication, April 11, 2022).

Another slightly more controversial but effective way to reduce desflurane use could involve restricting desflurane use to only patients that fit certain criteria such as a BMI>45 or are above a specific age. This has the potential to become complicated since vaporizers would need to be changed every time a different anesthetic gas is used. However, this would not be a problem if only a few surgeries are done with desflurane each day, and there could be specific operating rooms dedicated to desflurane use. This strategy may also be unpopular with the pharmacy, as they would be responsible for ensuring the correct vaporizers are in the right operating rooms. However, this tension can be reduced by support from residents and physicians who can take it upon themselves to do this check. As mentioned in the barriers section, there is also the issue of where to store the vaporizers when not in use. Determining where space could potentially be made to store these vaporizers is a key next step in this strategy. UCLA has removed desflurane vaporizers and only made them available for use under medical necessity or teaching purposes. This has helped them save over $190,000, which shows that this strategy has the potential to have major environmental and economic impacts. Since this restriction is more complicated and controversial, we suggest starting off with an order-only mandate and eventually incorporating new restrictions to ease physicians into the change.

Pilot Project 3: Education and Training

I. The Case for Education and Training

Background

During the selection of our pilot projects, we determined that institutional support was the most important criteria for a project's success. Our efforts have largely been possible due to the passion of a few healthcare providers, administrators, and employees who have collaborated with our team to create meaningful

change. Therefore, we find it imperative that future generations of healthcare providers are equipped with the knowledge and tools they need to recognize the impacts of climate change on the health of their future patient populations. These efforts will ensure the longevity and success of our project.

Peer Institutions

Numerous medical and nursing schools across the country are already incorporating this work, with 119 medical schools offering environmental health coursework pre-clerkship and 74 post-clerkship in 2019 (AAMC). The University of Colorado offers a fourth-year elective course entitled "Climate Medicine" that provides students with an understanding of the impact of climate change on health through poor air quality, vector-borne diseases, food insecurity etc. and offers clinical, political, and advocacy solutions (University of Colorado Department of Emergency Medicine). The Icahn School of Medicine at Mount Sinai is also making strides in including this critical driver of health into their curriculum by developing a "climate change curriculum infusion project (CCCIP)" approach which integrates climate change into existing lectures rather than creating a separate course (Kligler et al., 2021).

The Duke University School of Nursing (DUSON) is actively pursuing these efforts, with DUSON becoming a partner of the Nurses Climate Challenge School of Nursing Commitment, a national campaign spearheaded by the nursing community to educate over 50,000 health professionals on the links between climate change and human health. The Duke School of Medicine (DSOM) has yet to make similar commitments, as most of their climate response has been sourced from student driven initiatives (DUSON Joins National Nurses Climate Challenge, n.d.). Medical student Trisha Dalapti is currently leading the charge on how to incorporate the link between climate and health into DUSOM's curricula and provided insight into key areas of incorporation.

Implementation Roadmap

The identified areas of incorporation include:

- Climate and health curriculum as part of the first-year course "Cultural Determinants and Health Disparities"
- Incorporation of climate impacts during rotation didactic lectures (T. Dalapti, personal interview, March 16, 2022)

Our team will be meeting with Dean Ramos of the School of Nursing and Dean Klotman of the School of Medicine to present this vision and initiate collaboration with the schools' course directors. All recommendations provided will be based on the report *"Climate & Health Curriculum Reforms in Medical Schools"* by Medical Students for a Sustainable Future (Medical Students for a Sustainable Future et al., 2020).

Barriers

The barriers to implementation include:

- A lack of faculty expertise
- A lack of student interest
- A lack of time to include additional materials in pre-existing curriculum
- A lack of "solutions" to the problems presented during lectures

Our team hopes to overcome some of these barriers by providing solutions that the instructors can teach as meaningful alternatives and by fostering a relationship between environmental health faculty at the Nicholas School of the Environment and DUSOM (T. Dalapti, personal interview, March 16, 2022).

Benefits

The benefits of this pilot project are plentiful, ranging from increased employee satisfaction and retention to improved health outcomes for patients (Business Money, 2021). Healthcare providers need a full range of information to properly diagnose their patients and provide adequate treatment plans, and as climate change continues to have an increasing impact on human health, this knowledge will be imperative to fulfilling those obligations.

Component 3: Recommendations for Continued Success

If these projects are going to continue to be a success and if the hospital wants to be in a position to build off that success, there are a few structural things that need to be done to provide a landscape for change. This plan includes 4 key recommendations followed by discussions of additional sustainability implementations for the future.

1. ***Support Structure***

The first is building a support structure - identifying and involving those champions and building a team from there to mobilize initiatives. Because implementing new programs requires buy-in and support from all levels of leadership and across all departments, it is vital to seek input from individuals ranging from senior leadership to front-line workers. Additionally, building a team can leverage the expertise of those individuals who are already championing sustainability initiatives at the hospital, empowering those change-makers, and strengthening the success of implementations.

DUHS is in a powerful position to be embarking on an organized sustainability journey right now as there is already a lot of existing interest amongst a wide variety of individuals in making changes that will reduce the environmental impact of the hospital system. In Vizient's "Sustainability Toolkit: Setting up a green team" (Vizient, n.d.), they recommend including representation from a wide range of areas within the department. Through the development of our project, we have identified a few of these individuals and have listed them below:

1. Clinical areas:
    a. Ankeet Shah, MD (Urology)
    b. Michael Lipkin, MD (Urology)
    c. Jennifer Mah Lawson, MD (Pediatrics)
    d. Henry Lather, MD (Anesthesia)

    e. Fintan Hughes, MD (Anesthesia)
    f. Austin Livingston, MD (Urology)
2. Nursing:
    a. Christine Parilli, RN (Anesthesia)
    b. Liane Wong, Transplant Coordinator, CNA
3. Medical Students
    a. Isabelle Byers, MD Candidate (Duke University School of Medicine)
    b. Alex Gunn, MD Candidate (Duke University School of Medicine)
    c. Vishal Venkatraman, MD Candidate (Duke University School of Medicine)
    d. David Sykes MD Candidate (Duke University School of Medicine)
4. Purchasing & Supply:
    a. William P. Trofi, AVP Supply Chain, Strategic Sourcing, DUHS
    b. Jim Churchman, Vice President, Procurement and Supply Chain, DUHS
5. Environmental Services
6. Facilities Management
7. Food Services
8. Infection Control
9. Laboratory
10. Pharmacy
11. Safety
12. Education
    a. Trisha Dalapti, M.D. Ph.D. Candidate (Duke University School of Medicine)

With this preliminary list, and the addition of other identified leaders in the remaining departments, DUHS can begin by formally inviting members to join the team. It is important to establish a core team with

invested members who are committed to attending meetings and actively develop, implement, and maintain programs. Considering the fact that there will likely be individuals who are interesting in seeing change and embracing sustainability initiatives but may not be willing to commit to the responsibilities of being an official Green Team member, an important priority for the team should be to create a consistent communication channel (whether through a newsletter that individuals can subscribe to or a web-based platform that is regularly updated) to keep those secondary support structures engaged.

While the specific actions taken by the Green Team will organically evolve from the opportunities exposed through collaborative meetings, success is best assured with the guidance of clear goals and objectives.

2. Define What Sustainability Means for DUHS

As the first step in strategic planning, a strong vision helps to delineate plans that serve as a guiding principle and a blueprint for measuring success. Because 'sustainability' encompasses an almost endless and ever evolving set of practices, principles, and guidelines, it is important that sustainability is clearly defined based on what that means for DUHS. This definition should begin in the form of a vision, where the sustainability leadership team develops a concept that guides the sustainability journey. A vision statement should consider the specific environmental focus (e.g. waste reduction, energy reduction, emissions reduction, or even research and education), DUHS's unique resources and assets and how they can propel environmental stewardship (e.g. the fact that some of the most elite researchers and students in the country are members of the Duke community), and how DUHS's existing vision ties into sustainability goals (e.g. DUHS cannot 'Build healthy communities' or 'Connect with the world to improve health globally' (Duke Health, n.d.) without addressing the way that the health system itself impacts local and global health through environmental degradation).

Once a team and a vision are established, it is vital to follow with the establishment of clear, specific, and time-bound goals. Goals specify the actions that must be taken in order to achieve the vision. The

goals should define who is involved, the scope of the action, the timeline for implementation, and the team members that are to act as key leaders. Goals are likely to evolve throughout the journey, but they are necessary for the journey to begin.

3. Stronger Together

Just as there are consortiums made up of sustainability officers from different universities and peer institutions that facilitate best-practice sharing and the exchange of campus sustainability solutions, such as the Ivy Plus Consortium of which Duke University is a member (Yale Sustainability, n.d.), DUHS should form groups with peer university hospital systems to similarly collaborate and share. Regional green teams can be a great way to exchange information and ideas, and even collaborate on projects. Additionally, DUHS is situated right in the "City of Medicine" (City of Durham, n.d.) and neighbors to WakeMed Health & Hospitals in Raleigh and UNC Health in Chapel Hill. The abundance of research and education in this Research Triangle Park offers an incredible opportunity to partner with local allies to create positive environmental change at scale.

These partnerships can also lead to purchasing coalitions that allow institutions to consolidate buying power to influence sustainability in supply. Through the development of this project, we have seen just how large of an impact the supply chain has on the hospital system's ability to embrace sustainability. Many of the issues with waste production cannot be addressed through internal action alone. Integration of sustainable procurement practices can help reduce negative impacts from the purchasing and supply of pharmaceutical and medical devices and those sustainable procurement initiatives can be further strengthened through purchasing coalitions that allow for best practice sharing and aggregate influence of supply-side priorities. However, for sustainability in procurement to be realized, this must be enforced through a top-down approach, otherwise supply chain engagement is unlikely to move beyond "standard compliance issues" (Sustainable Healthcare

Coalition, n.d.). This call for leadership leads into our final key recommendation for ensuring long-term success.

4. Sustainability Leadership

Finally, DUHS eventually needs a full-time sustainability leader. While the research we have conducted has allowed for significant engagement, learning, and even some implementation of sustainability-related initiatives at DUHS, and even revealed opportunities for further research projects that can facilitate DUHS sustainability goals, strong sustainability leadership is needed to carry out implementation that will have a long-lasting impact. According to Practice Greenhealth 2021 Sustainability Benchmarking Data, 89% of the hospitals surveyed reported having hired someone to lead sustainability efforts at the facility level with 69% being full-time positions (Practice Greenhealth, n.d.). Although the success of initiatives hinges on engagement across the system, implementation relies on senior-level executives to champion sustainability (Boone, 2012). Not only will leadership help through support and facilitation of sustainability-related changes, but the establishment of this role will signal DUHS's investment in global health, improving both the reputation and culture of the entire health system.

Additional Considerations for Future Sustainability Work

I. <u>Leader in Research on Climate and Health</u>

The field of climate and health is ripe with opportunities for additional research and publication, with major health publications such as the Lancet prioritizing these efforts through campaigns such as their "Countdown on Climate Change and Health". The Nicholas School of the Environment and DUSOM and DUSON could partner on these efforts to generate additional research opportunities for students and faculty alike (About the Lancet Countdown on Health and Climate Change, n.d.).

II. Invest in Environmentally Preferred Purchasing

Utilize the strength of DUHS's purchasing power to become a driver of change within the healthcare supply chain following Environmentally Preferred Purchasing standards set forth by Healthcare Without Harm, Clean Production Act, Practice Greenhealth. Following the leadership of institutions such as Kaiser Permanente, DUHS should ensure that the products purchased are free of chemicals of concerns, are recyclable, contain at least 10% post-consumer recycled content, are certified by the Forest Stewardship Council, and do not create a hazardous waste product. These efforts should be prioritized through DUHS's existing partnership with Vizient, Inc (Supply Chain, n.d.). An example of an implementation roadmap can be found below:

Environmentally Preferable Purchasing Roadmap

Conduct device audit in OR

Investigate purchasing practices by researching the following

- Current supplier
- Current volume of supplies
- Composition of supplies (where applicable)
- Cost of current supplies

Investigate alternatives to identified supplies/devices

- Provider of alternatives
- Cost of alternatives
- Potential alternatives include:
    1. Reformulated OR kits to reduce unnecessary items
    2. Reprocessed medical devices
    3. Reusable instead of disposable
    4. PVC-free
    5. Mercury-free

6. Environmentally preferred cleaners

Provide report of findings to support proposal for alternative purchasing practices

- Report to include:
    1. Inventory of current purchases
    2. Potential alternatives
    3. Justifications

III. Retrofitting Buildings

Buildings account for 76% of electricity use and 40% of U.S. primary energy use in the United States (Shaikh & Umrani, 2017). Retrofitting buildings has tremendous impacts on reducing energy consumption, resulting in numerous environmental and cost-saving benefits. Buildings that have received Leadership in Energy and Environmental Design (LEED) Certifications are reported to see the following benefits:

Economic Benefits:

- $1.2 billion in energy savings
- $149.5 million in water savings
- $715.3 million in maintenance savings
- $54.2 million in waste savings

Health Benefits:

- Increased employee productivity. Higher recruitment and retention rates.
- Improved indoor air quality.
- Reduced pollution and improved outdoor air quality in industrialized areas.
- Fewer chemical exposures from paints, furniture, and finishings.
- Environmental Benefits:
    1. 34% less carbon-dioxide emissions
    2. 25% less energy consumed overall

3. 11% less water consumed
4. 80 million tons of waste diverted from landfills (U.S. Green Building Council, 2021).

Duke University's main campus has developed and pursued its own framework which enhances the work of LEED Certifications through Duke Facility Management's High-Performance Building Framework. This standard is designed to, "establish green building standards that align with Duke's aggressive sustainability goals and embrace the unique challenges and synergies associated with sustainable building design in Durham, North Carolina." It "build(s) on and rework(s) the core tenants of the LEED rating system to create a design guideline that will guarantee high-performance, sustainable building designs while placing an increased focus on Duke University's priorities: energy and water conservation." (High Performance Building Framework, June 2019).

Adopting this standard or continuing to LEED certify new and existing buildings would unite Duke Health with the larger efforts of Duke University to prioritize building decarbonization and the conservation of finite resources while reducing the building's operational costs. Guidelines around the implementation of these efforts can be found in the High-Performance Building Framework 2019 report and on the U.S. Green Building Council website (High Performance Building Framework, June 2019).

IV. Based on GHG accounting: more sustainable electricity sources

Duke University Hospital should encourage Duke Energy to have a less emissions intensive energy mix so that the hospital can purchase less emissions intensive electricity. Duke University Hospital should also encourage employees to commute sustainably. These measures are a few of many possible emissions reduction measures outlined in our report that can help Duke University Hospital reduce its emissions.

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Appendices

Appendix 1: Emission Factors

An emission factor (EF) is the amount of emissions generated from an activity per unit of that activity (e.g., emissions/MMBtu of natural gas, emissions/gallon of gasoline or emissions/passenger mile flown). The table below summarizes each emission factor that our Masters Project team used for our fiscal year 2019 Duke University Hospital greenhouse gas (GHG) inventory analysis and its originating source.

Activity	Emission Factor ($MTCO_2e$)	Unit	Source
Natural Gas	.0529	$MTCO_2e$/MMBtu	Clean Air Cool Planet (CACP)
Gasoline	.008935	$MTCO_2e$/gallon	Clean Air Cool Planet (CACP)
Diesel	.0101	$MTCO_2e$/gallon	Clean Air Cool Planet (CACP)
Synthetic Fertilizer	.0040	$MTCO_2e$/lb	Clean Air Cool Planet (CACP)
Organic Fertilizer	.0038	$MTCO_2e$/lb	Clean Air Cool Planet (CACP)
Refrigerant: HFC-134a	.5902	$MTCO_2e$/lb	Clean Air Cool Planet (CACP)
Refrigerant: HFC-404a	1.48	$MTCO_2e$/lb	Clean Air Cool Planet (CACP)
Refrigerant: HCFC-22	.7718	$MTCO_2e$/lb	Clean Air Cool Planet (CACP)
Electricity	.3100	$MTCO_2e$/MWh	Duke Energy
Air Travel	.000482	$MTCO_2e$/passenger mile flown	Clean Air Cool Planet (CACP)
Natural Gas Fugitive Emissions	.0529	$MTCO_2e$/MMBtu	Duke Facilities Management Department (FMD)
Transmission Losses	.3100	$MTCO_2e$/MWh	Duke Facilities Management Department (FMD)
Incinerated Waste	-0.1100	$MTCO_2e$/short ton	Clean Air Cool Planet (CACP)
Landfilled Waste	.25667	$MTCO_2e$/short ton	Clean Air Cool Planet (CACP)

Appendix 2: Full Greenhouse Gas Inventory Results for Duke University Hospital for Fiscal Year 2019

The following tables give specific detail on the results of the fiscal year 2019 greenhouse gas inventory for Duke University Hospital.

Total Emissions: Duke University Hospital (fiscal year 2019)		
Emissions Category	**Metric tons of CO_2e (equivalent)**	**Percentage of Total Emissions**
Scope 1	26,890	26%
Scope 2	42,079	40%
Scope 3	35,507	34%
Total Emissions	**104,477**	**100%**

Scope 1 Emissions: Duke University Hospital (fiscal year 2019)		
Scope 1 Emissions Category	**Metric tons of CO_2e (equivalent)**	**Percentage of Scope 1 Emissions**
Natural gas	25,362	94.32%
Duke Hospital owned fleet emissions (gasoline)	538	2.00%
Duke Hospital owned fleet emissions (diesel)	1	0.00%
Refrigerants (HFC-404a, and HCFC-22)	989 (specifically, 781 for HFC-404a, and 208 for HCFC-22)	3.67%
Total Scope 1 Emissions	**26,890**	**100%**

Scope 2 Emissions: Duke University Hospital (fiscal year 2019)		
Scope 2 Emissions Category	**Metric tons of CO_2e (equivalent)**	**Percentage of Scope 2 Emissions**
Purchased electricity from Duke Energy	42,079	100%
Total Scope 2 Emissions	**42,079**	**100%**

Scope 3 Emissions: Duke University Hospital (fiscal year 2019)		
Scope 3 Emissions Category	**Metric tons of CO_2e (equivalent)**	**Percentage of Scope 3 Emissions**
Emissions (gasoline) from staff & faculty commuting	26,897	75.75%
Emissions (diesel) from staff & faculty commuting	957	2.70%
Transmission losses from electricity	3,787	10.67%
Air travel	2,199	6.19%
Landfilled waste	1,437	4.05%
Incinerated waste	-922	-0.26%
Natural gas fugitive emissions	322	0.91%
Total Scope 3 Emissions	**35,507**	**100%**

Appendix 3: Greenhouse Gas Accounting Excel File

Please see the attached Excel file for our greenhouse gas emissions Excel file, titled:

DukeUniversityHospital_GHG Analysis_04-22-22.xlsx