

Introduction

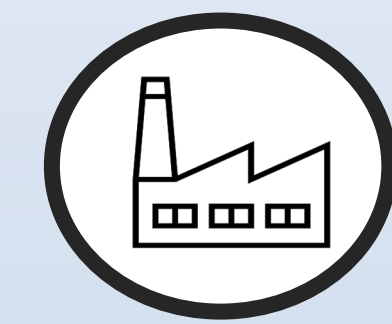
- The United States is the **second-largest emitter** of greenhouse gases in the world, with the healthcare industry contributing **8%** of national emissions [1]
- The operating room is estimated to consume **three to six times more energy** than the associated hospital as a whole [2]
- Harmful effects of volatile anesthetics have been clearly identified, and successful interventions have minimized the volume and utilization of gases with higher carbon footprints [3]
- Medical devices and consumables are the largest contributors to the carbon footprint of healthcare** [4]. The production, utilization, and disposal of single-use plastics, especially at high frequency in the perioperative setting, contribute substantially to the large carbon emissions of the healthcare industry
- The Laryngeal Mask Airway (LMA) offers the clinical advantages of shorter time to airway securement, atraumatic insertion, faster emergence from anesthesia, and lower rates of post-operative sore throat [5]
- The Endotracheal Tube (ETT) allows for definitive airway securement and has more robust data to support its efficacy, given the longer duration of existence
- For low-risk procedures in patients without significant comorbidities, **it is up to the provider to select which airway device is used**

Study Aims

- Quantify the carbon footprint of the LMA and ETT
- Extrapolate the data to their application in orthopedic, gynecologic, urologic, and vascular surgery cases over a five-year period at Tufts Medical Center to promote environmentally conscious clinical decision-making in the perioperative setting

Methods

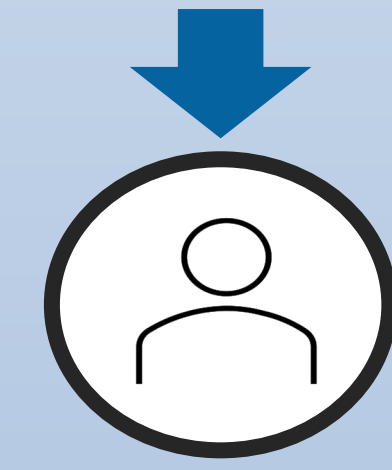
- The **ISO 14044:2006 International Life Cycle Assessment Guidelines** were used to calculate the carbon footprint of the 7.0 mm Sheridan® High Volume Tapered Cuffed ETT, size 4 Ambu® Aura-I Disposable LMA, and BD® 10 mL Syringe



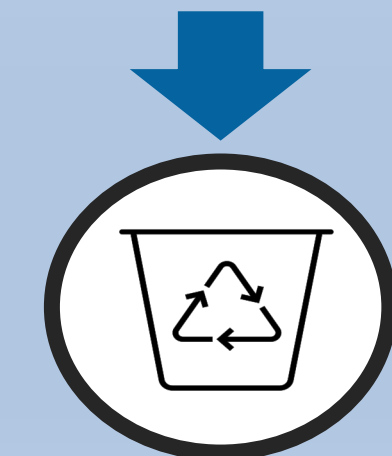
Raw Material & Manufacturing



Transportation



Use



Disposal

- The five year utilization of LMAs and ETTs at Tufts Medical Center was collected from anesthesia cases between 2020 to 2025. The gynecologic, orthopedic, urology, and vascular surgery departments were selected given the relatively similar rate of LMA and ETT utilization.

Raw Materials and Manufacturing: The composition of each product was identified using manufacturing information. The mass of each individual component was directly measured. The Industrial Design and Engineering Materials Database (Idemat) was used to identify the associated carbon dioxide emission (CO₂e) for the creation, acquisition, and use of each component in the manufacturing process.

Transportation: The exact distance between each manufacturing plant and Tufts Medical Center was calculated. The amount of diesel fuel was estimated based on average miles per gallon for the most commonly used make and model of truck utilized for medical equipment supply shipments.

Use and Disposal: LMAs, ETTs, and 10 mL syringes are single-use and disposed in general waste, without need for sterilization or incineration. The United States Environmental Protection Agency Center for Corporate Climate Leadership Emission Factor Inventories was used to estimate the carbon emissions for the degradation of each product.

Results

- The CO₂e for the LMA was greater than the ETT, even with the inclusion of the 10 mL syringe. The carbon footprint for each product is summarized in the table below
- Polyvinylchloride contributed the largest kilograms of carbon dioxide for both the ETT and LMA
- The transportation portion of the LCA was the highest contributor to the overall CO₂e for both products

Single Use Airway Equipment Carbon Emission (kg CO₂)

	ETT	LMA	10 mL Syringe
Material Production	0.129	0.176	0.019
Transportation	58.410	103.70	19.283
Disposal	0.0014	0.0015	0.00019
Total	58.540	103.871	19.302

- The five year utilization of LMAs and ETTs at Tufts Medical Center is summarized below. The orthopedic department demonstrated the most similar rate of ETT and LMA utilization

LMA and ETT CO₂e Over a 5 Year Period at Tufts Medical Center

	ETT		LMA	
	Number of Uses	CO ₂ e (metric tons)	Number of Uses	CO ₂ e (metric tons)
Gynecology	709	55.19	356	36.98
Orthopedics	925	72.00	736	76.45
Urology	410	31.92	653	67.83
Vascular Surgery	242	18.84	141	14.65

References

- Eckelman MJ, Sherman J. Environmental Impacts of the U.S. Health Care System and Effects on Public Health. PLoS One. 2016 Jun 9;11(6).
- MacNeill, Andrea J et al. The Impact of Surgery on Global Climate: A Carbon Footprinting Study of Operating Theatres in Three Health Systems. The Lancet Planetary Health, Volume 1, Issue 9, 381-388.
- Park EJ, Bae J, Kim J, Yoon JU, Do W, Yoon JP, Shon HS, Kang Y, Kim HY, Cho AR. Reducing the carbon footprint of operating rooms through education on the effects of inhalation anesthetics on global warming: A retrospective study. Medicine (Baltimore). 2024 Mar 1;103(9):e37256.
- Robinson PN, Surendran K, Lim SJ, Robinson M. The carbon footprint of surgical operations: a systematic review update. Ann R Coll Surg Engl. 2023 Nov;105(8):692-708.
- Babette F. van Esch, Inge Stegeman, Adriana. L. Smit. Comparison of laryngeal mask airway vs tracheal intubation: a systematic review on airway complications. Journal of Clinical Anesthesia. Volume 36. 2017. Pages 142-150.

Contact Information

Caroline O’Brien
Tufts University School of Medicine Class of 2026
Email: Caroline.O_Brien@tufts.edu

Conclusion

- The ETT is a safe and effective method of airway securement that has a lower carbon footprint compared to the LMA. The **CO₂e for the LMA is 1.8 fold greater**, despite a 1222-mile increase in transportation from manufacturing plant to hospital for the ETT
- If every orthopedic case over the five-year period had chosen to use an LMA instead of an ETT, the total CO₂e would be 172.3 metric tons CO₂. If every case had selected an ETT, the total CO₂e would be 97.3 metric tons CO₂. This is a difference of 75.3 metric tons of CO₂. **This difference is equivalent to driving from New York City to Los Angeles 8.5 times** with a standard passenger car
- Limitations of this study include narrow generalizability given the single model and brand of airway studied, lack of healthcare specific Idemat data, transportation route estimation, and reporting inaccuracies regarding airway selection over the five-year period
- Adopting small clinical practices will enable providers to support both individual and institutional sustainability goals without compromising patient care.** Further research in biodegradable materials for use in healthcare, packaging techniques with minimal plastic, and reusable intubation equipment should all be considered to improve the environmental impact of anesthesia