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INTRODUCTION

An emerging body of literature on the study of the carbon footprint generated within the operating room (OR) is growing, specifically whether the surgical approach (open, laparoscopic, or robotic assisted surgery (RAS)) makes a difference. Most evaluations of the carbon footprint generated within the OR do not extend their assessments to post-operative recovery.

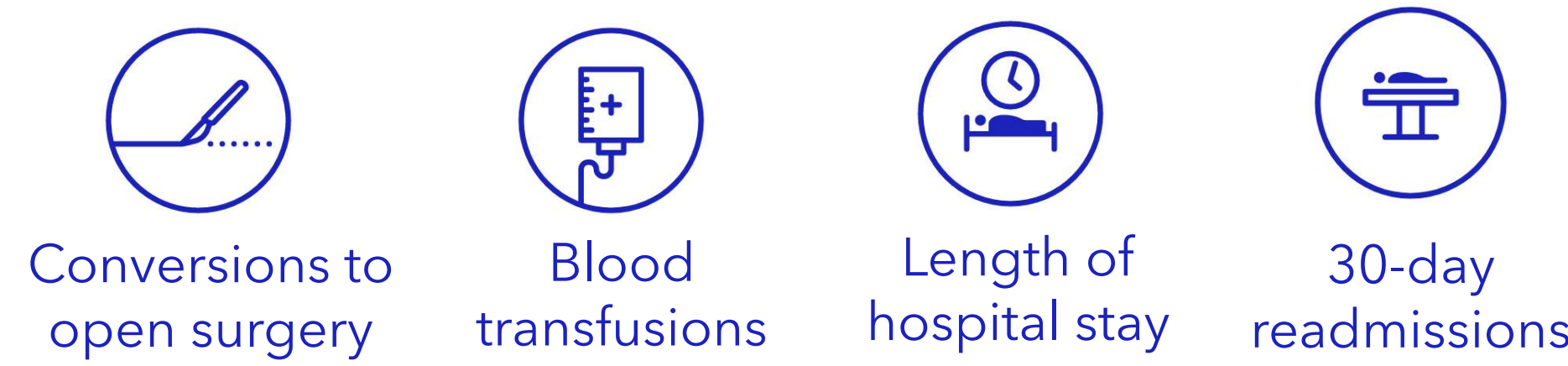
AIM

We develop a model to estimate carbon avoidance, related to perioperative outcomes beyond the operating across three surgical modalities.

METHODS

➤ A carbon avoidance model was built using the inputs:

1. Pooled clinical data from a published meta-analysis by Ricciardi R et al. ¹



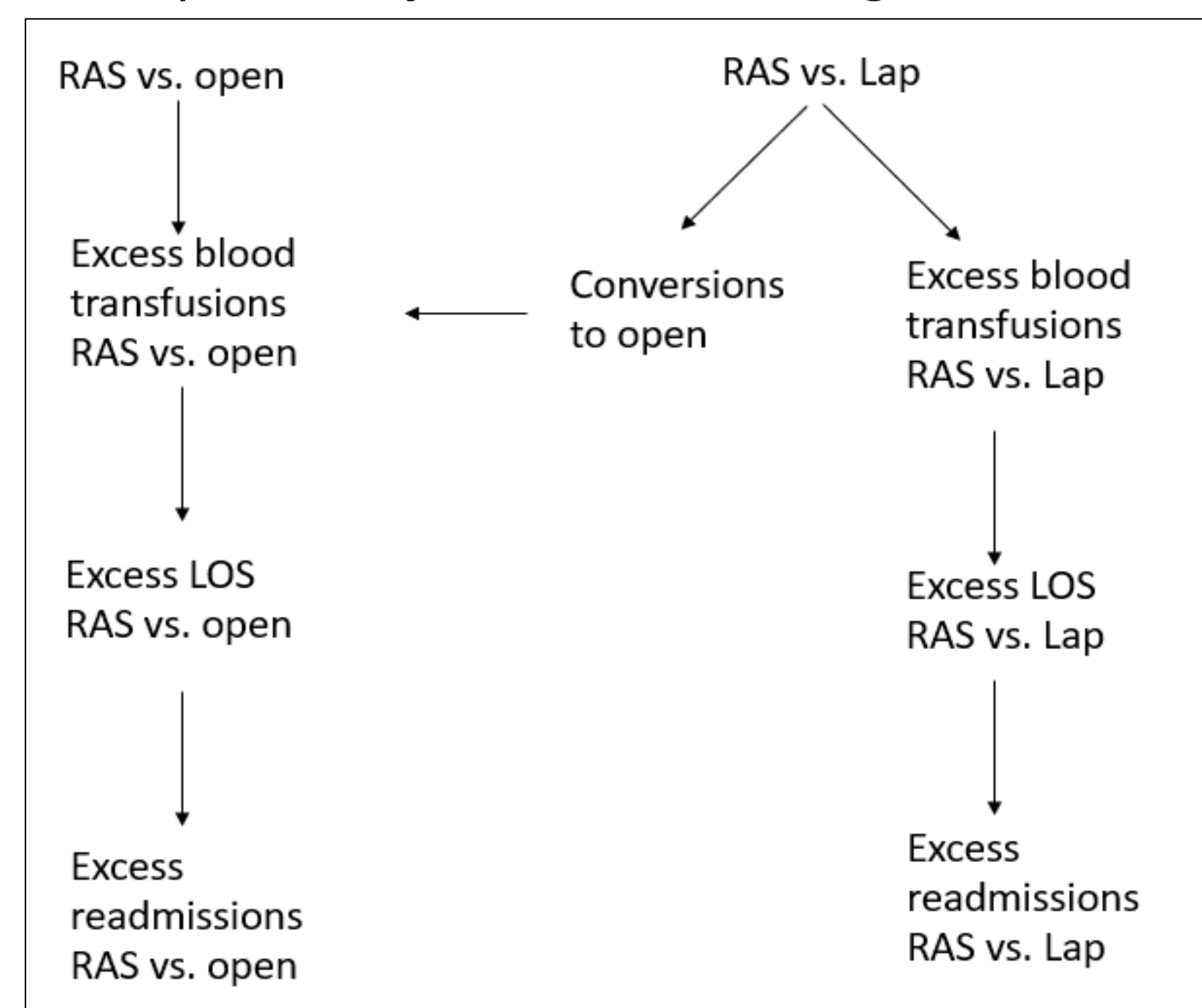
2. Energy use and material waste estimates from peer-reviewed literature ^{2,3,4}



3. Total number of robotic-assisted procedures using da Vinci surgical systems performed in year 2025

3,153,000

Figure 1: Patient pathway for measuring carbon avoidance



RESULTS

Table 1: Robotic Assisted Surgery Carbon Avoidance Model

Number of dV RAS procedures in 2025		3,153,000
Number of dV RAS procedures since 1998		20,000,000
Model Inputs		
	dV RAS vs Open	dV RAS vs Lap
Weighted mean difference of length of hospital stay (days)	1.85	0.51
Weighted rate difference of hospital readmissions (%)	2.1%	0.7%
Weighted rate difference of blood transfusions (%)	7.6%	0.8%
Weighted rate difference of conversions to open surgery (%)	NA	5.9%
Material waste per procedure (kg)	10.0	11.6
Emission per waste (kg CO2/kg waste)	0.92	0.92
Total avoided emissions due to avoided excess waste in 2025 (kg CO2)	28,940,756.40	33,571,277.42
Emissions per day in hospital during recovery (non-surgical) (kg CO2)	45.00	45.00
Excess conversion (N)	NA	186,027
Excess hospital days due to conversions (days)	NA	344,150
Excess days in hospital (days)	5,833,050	1,513,156
Length of hospital stay per readmission (days)	1.00	1.00
Excess hospital readmissions (N)	66,213	20,769
Excess hospital days due to readmissions from conversions (days)	NA	3,907
Total avoided emissions due to avoided excess hospital stay in 2025 (kg CO2)	265,466,835	84,689,170
Excess blood transfusions (N)	239,628.0	23,735.78
Excess blood transfusions due to conversions (N)	NA	14,138.05
Emissions per blood transfusion (kg CO2)	6.50	6.50
Total avoided emissions due to avoided excess blood transfusions in 2025 (kg CO2)	1,557,582.0	246,179.93
Total avoided carbon emission (kg) in 2025	295,965,173.40	118,506,627.47
Total avoided carbon emission (MT CO2e) in 2025	295,965.17	118,506.63
Custom avoided emissions factor (kg CO2e /procedure) in 2025	93.87	37.59
Total Estimated Avoided Carbon since 1998 (kg CO2)	1,877,356,000	751,707,120
Total Estimated Avoided Carbon since 1998 (MT CO2e)	1,880,462.62	751,003.82

Figure 2: Distribution of avoided carbon emission for waste, blood transfusions and hospital stay

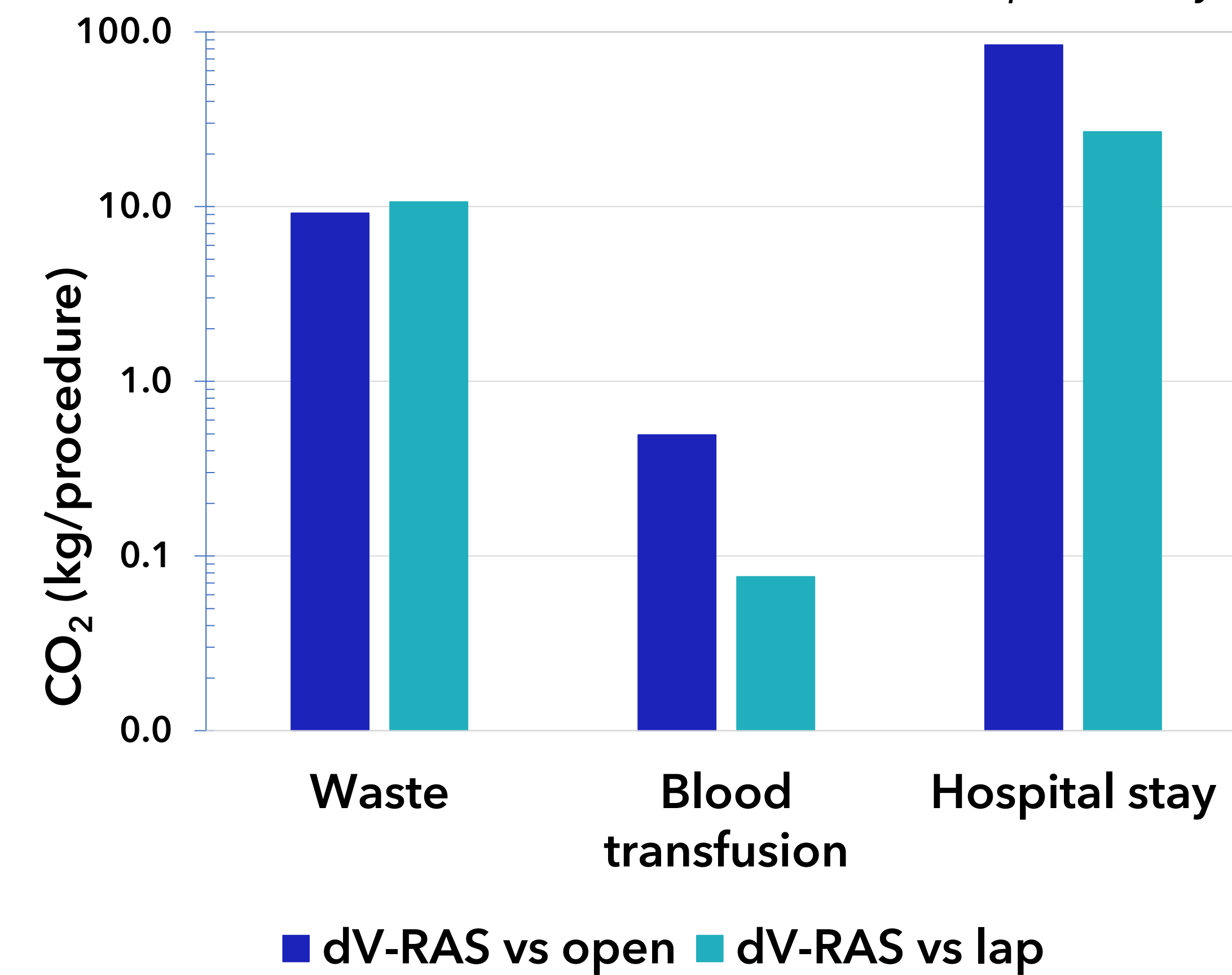
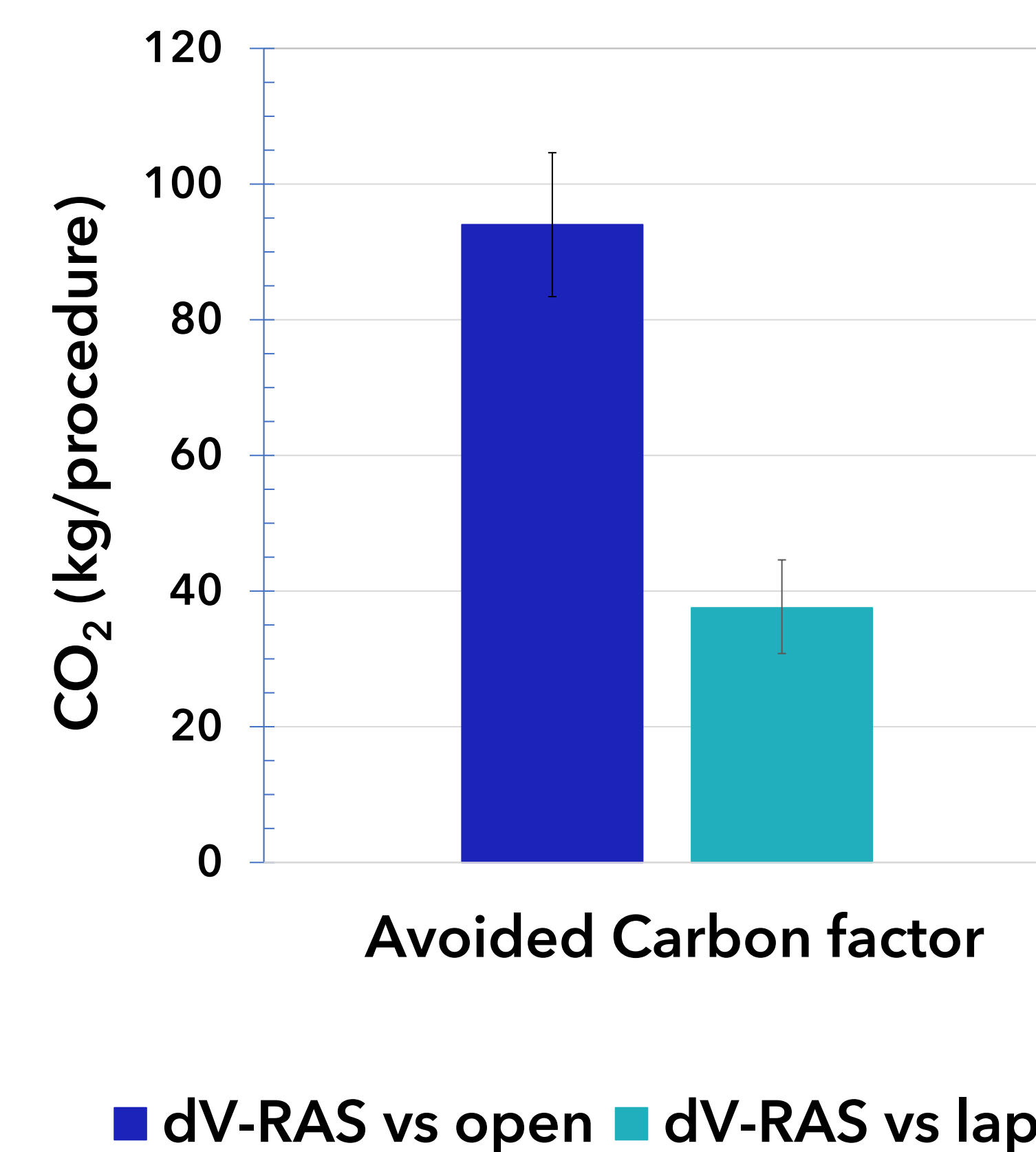


Figure 3: Variation of Total CO2 emissions attributed to length of stay



DV-RAS IMPACT OF TOTAL AVOIDED CARBON EMISSIONS

Figure 4: Equivalent Global Greenhouse Gas emissions (GHG) from gas powered cars in 2025 (# cars)⁵

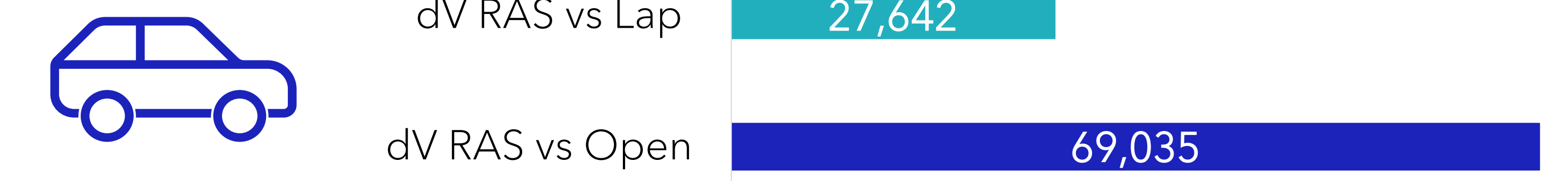


Figure 5: Equivalent CO2 emissions from homes' energy use in 2025 (# homes)⁵

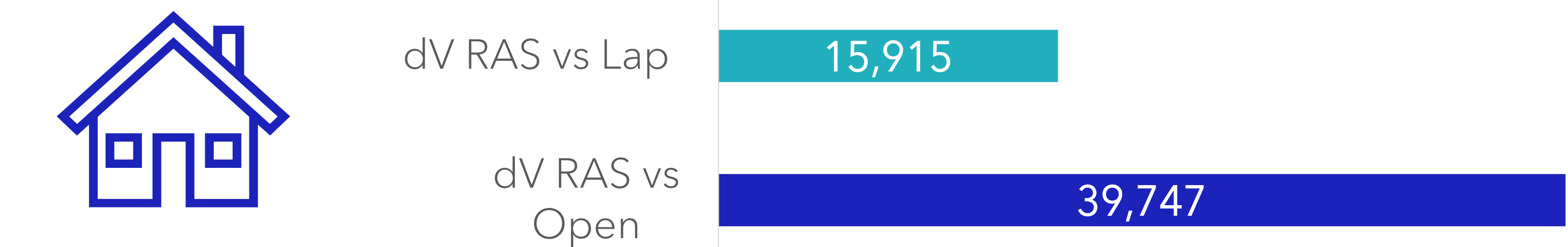
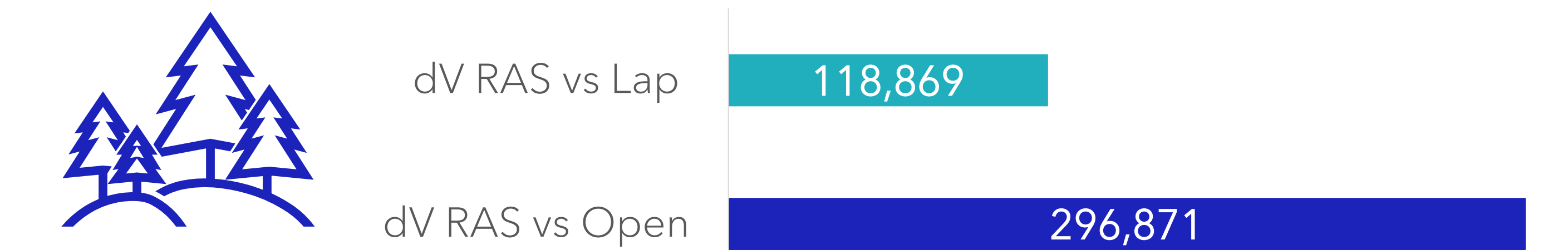


Figure 6: Equivalent Carbon sequestered by acres of US forest in 1 year in 2025 (# acres)⁵



CONCLUSIONS

- Carbon avoidance beyond the operative room itself can be quantified and is dependent on surgical approach.
- Robotic-assisted surgery using the da Vinci system results in higher carbon avoidance in comparison to open and laparoscopic surgery.
- Further study in this field is warranted.

REFERENCES

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