# *Quantitative Modeling of Intubation at Scale*
# *An Open-Source Intubation Calculator*


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# *Disclosures*

## Runnels

Associate Professor at the University of Utah

Inventor of Runnels Steerable Introducer

CEO of TTCmed.com

Co-Director of ASA/FAER Swimming with Sharks

## Norris

None

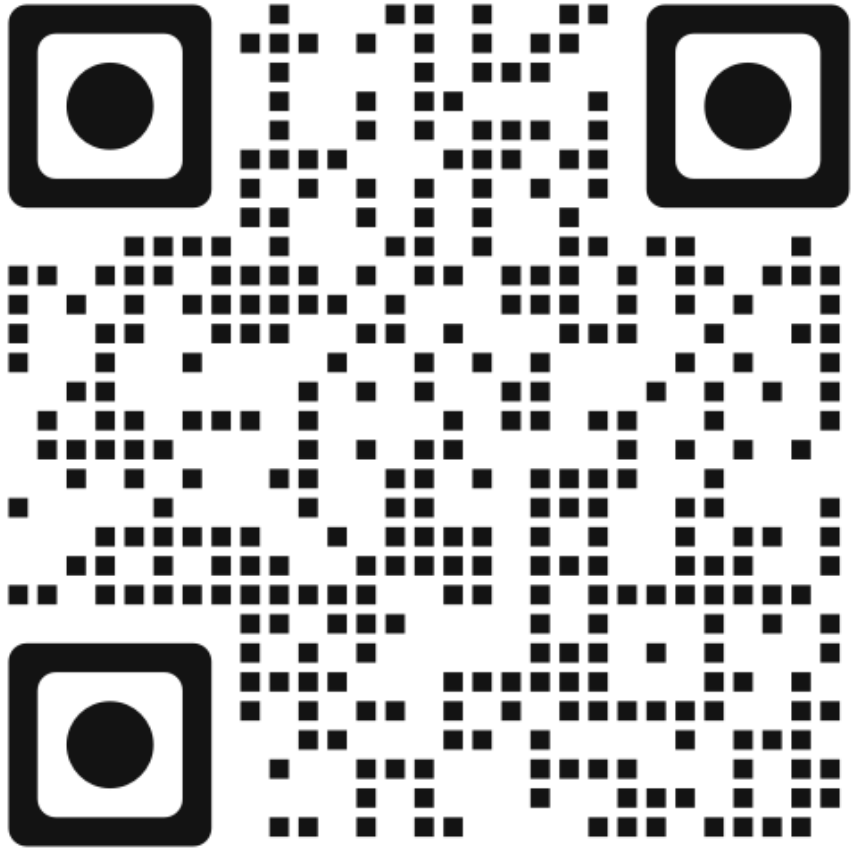
# Understanding Objectives

- Modeling DL era to VL era transition
  - Clinical outcomes
  - Economic outcomes
  - Cause and scaled impact of first pass failure

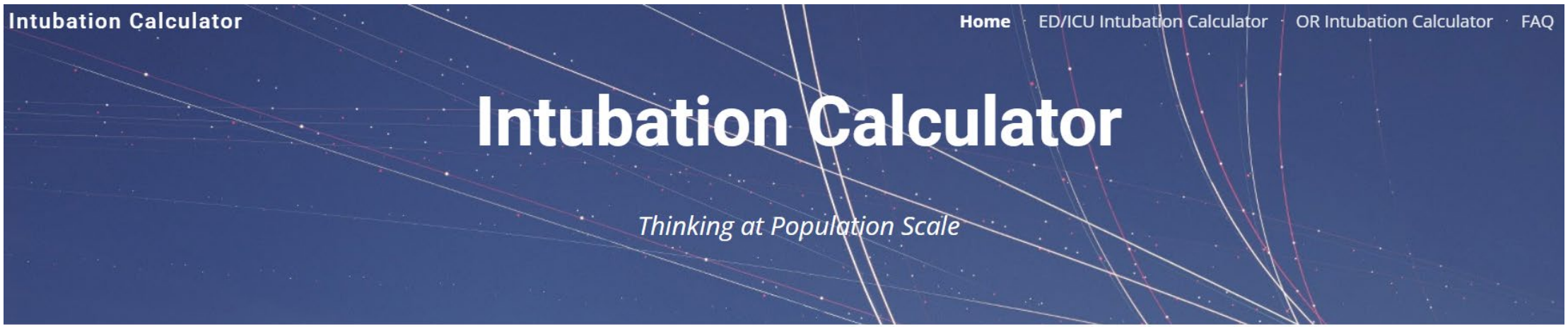
# Why Build a Mathematical Model of Intubation Practices??

- Data Integration
- Scenario Building
- Prediction and insight
- Scaling Outcomes
- Decision Support

# Link to Calculator



https://sites.google.com/view/intubation-calculator/edicu-intubation-calculator




**To begin, select your intubation location below.**

ED/ICU | Operating Room

WAMM 2025 Abstract

# Questions for the Calculator

# *What is the main cause of first pass failure as VL use increases?*

DL Clinical Problem!

***“Can Not See”***

***Visualization Failure***

# VL Clinical Problem!

***"I Can See The Cords, But I Can't Deliver the Tube!"***

***Tracheal Access Failure***

A prospective cohort evaluation of the McGrath™ MAC videolaryngoscope in a series of 979 cases

Hannah M. Phelan [a], Sarah L. Stobbs [a], Massimiliano Sorbello [b], Patrick A. Ward [c], Alistair F. McNarry [c, d, *]

[a] South East Scotland School of Anaesthesia, Royal Infirmary of Edinburgh, Edinburgh, EH16 4SA, UK
[b] Anesthesia and Intensive Care, AOU Policlinico San Marco Catania, Italy
[c] NHS Lothian, St John's Hospital, Howden, Livingston, EH54 6PP, UK
[d] NHS Lothian, Western General Hospital, Crewe Road South, Edinburgh, EH4 2XU, UK




# Intubation Calculator

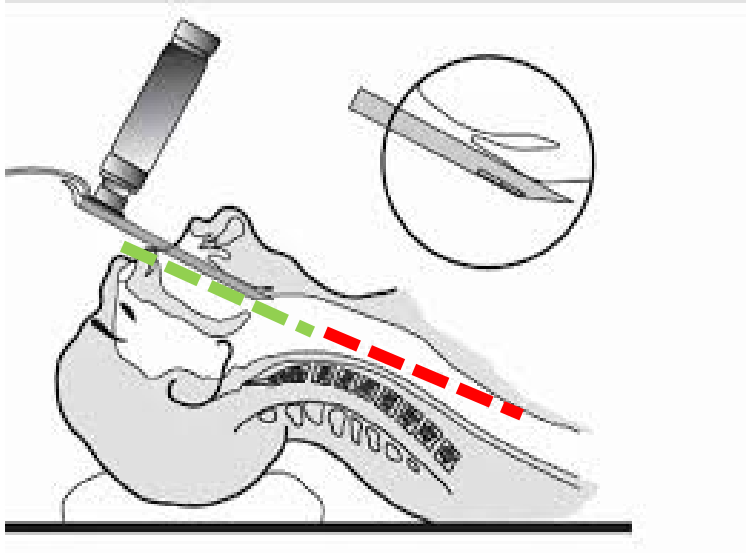
*Thinking at Population Scale*

**To begin, select your intubation location below.**

ED/ICU | Operating Room

WAMM 2025 Abstract

# VL vs DL *Kriege 2023 (OR)*



*First pass rate*

- VL 94%
- DL 82%

## Failure Mode

| | DL | VL |
|---|---|---|
| Visualization | 84% | 14% |
| Tracheal access | 16% | 86% |

# First Pass Failure and Attempt Failure Mode

# OR intubations (Kriege 2023)

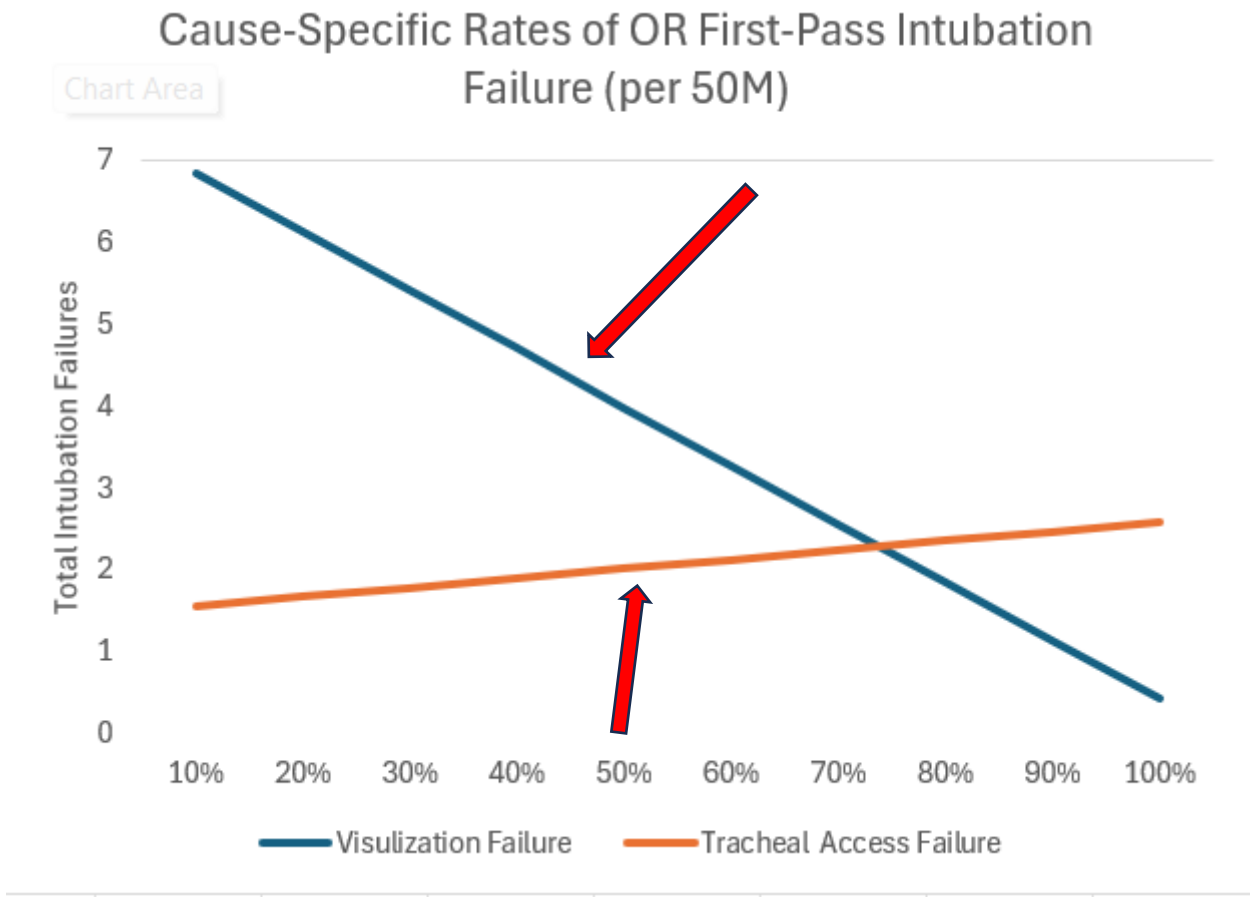
**Operating Room**
Intubation Failures Caclucator

**INSTRUCTIONS**

tal number of first pass intubation failures for a given VL and DL usage. To use er of intubations to be analyzed. Conceptually, this may be the total number of ntubations globally, nationally, institutionally etc.

**Enter the total number of intubations --->** **25,000,000**

| VL Use | DL Use | VL First Pass Failure Rate (Kreige et al.) | DL First Pass Failure Rate (Kreige et al.) | VL First Pass Failures | DL First Pass Failures | Total First Pass Failures | Visualization Failures | Tracheal Access Failures |
|---|---|---|---|---|---|---|---|---|
| 10% | 90% | 6% | 18% | 150,000 | 4,050,000 | 4,200,000 | 3,423,000 | 777,000 |
| 20% | 80% | 6% | 18% | 300,000 | 3,600,000 | 3,900,000 | 3,066,000 | 834,000 |
| 30% | 70% | 6% | 18% | 450,000 | 3,150,000 | 3,600,000 | 2,709,000 | 891,000 |
| 40% | 60% | 6% | 18% | 600,000 | 2,700,000 | 3,300,000 | 2,352,000 | 948,000 |
| 50% | 50% | 6% | 18% | 750,000 | 2,250,000 | 3,000,000 | 1,995,000 | 1,005,000 |
| 60% | 40% | 6% | 18% | 900,000 | 1,800,000 | 2,700,000 | 1,638,000 | 1,062,000 |
| 70% | 30% | 6% | 18% | 1,050,000 | 1,350,000 | 2,400,000 | 1,281,000 | 1,119,000 |
| 80% | 20% | 6% | 18% | 1,200,000 | 900,000 | 2,100,000 | 924,000 | 1,176,000 |
| 90% | 10% | 6% | 18% | 1,350,000 | 450,000 | 1,800,000 | 567,000 | 1,233,000 |
| 100% | 0% | 6% | 18% | 1,500,000 | 0 | 1,500,000 | 210,000 | 1,290,000 |




**VL Use Percent**

# Insight

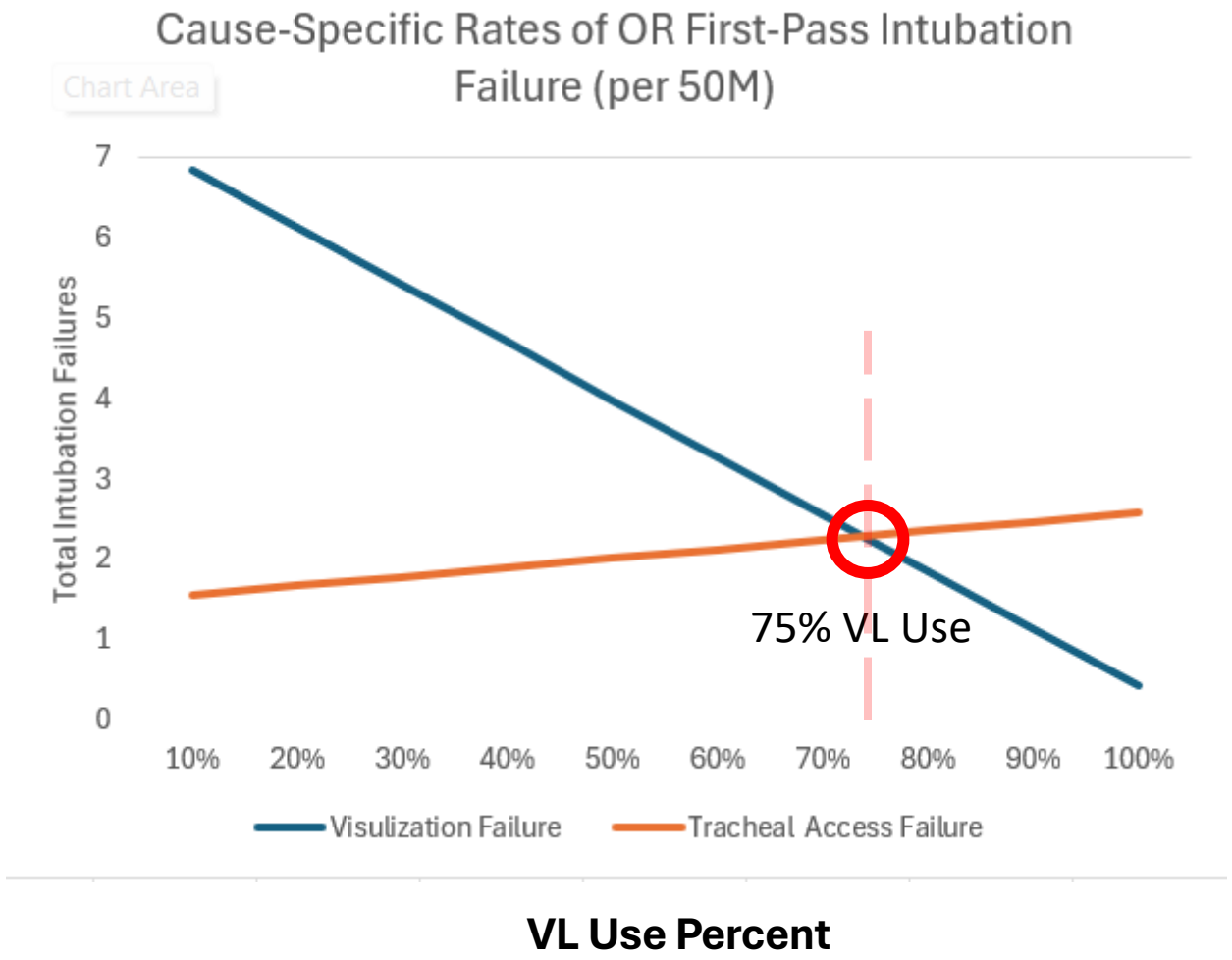
## As VL use increases:

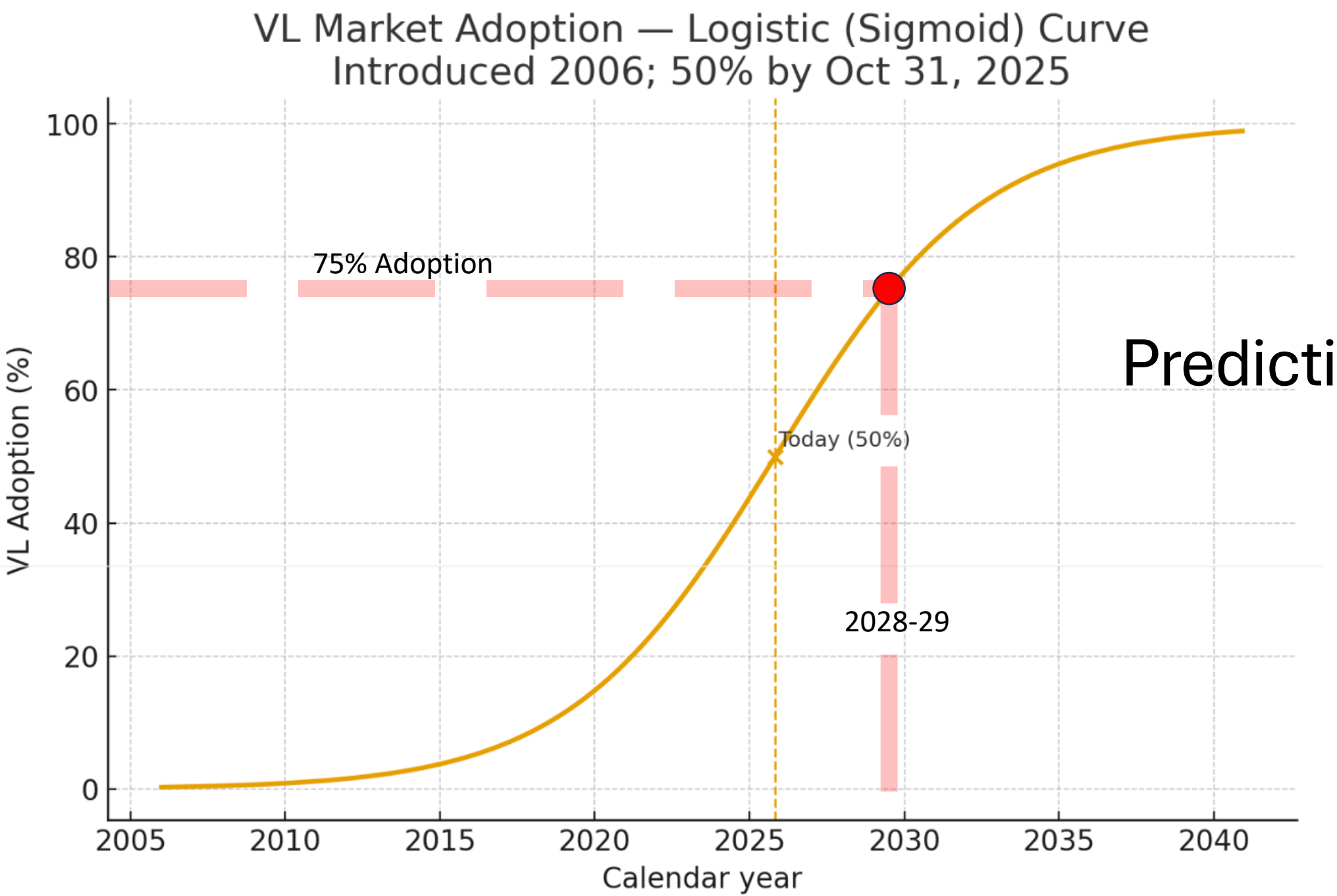
Total first pass failures decrease

First pass failure due to ***visualization*** decreases

First pass failure due to ***tracheal access issues*** increases

***When Will Failure of Tracheal Access Overtake Failure of Visualization As the Main Cause of First Pass Failure??***


Cause-Specific Rates of OR First-Pass Intubation Failure (per 50M)
Chart Area
Total Intubation Failures
7
6
5
4
3
2
1
0
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
75% VL Use
Visulization Failure
Tracheal Access Failure
VL Use Percent




Prediction

Ambu
Markets Day
Report2025

*What Is the Excess Cost of 3+ Intubation Attempts in OR per Year in the USA**??***

Economic Cost and Scale

# COST BURDEN ASSOCIATED WITH DIFFICULT INTUBATION IN THE UNITED STATES

Karen Phillips 1, Abstracts / Trends in Anaesthesia and Critical Care 30 (2020) e1ee192

| Inpatient Surgical Admissions | N[a] | Median Cost |
|---|---|---|
| Admissions with difficult intubations | 4,598 | $33,171 |
| Admissions without difficult intubations | 9,980,862 | $12,940 |
| Cost difference | | $20,231 |


**20% VL** $20,000 X 390,000 = ***$7.8 Billion***

**100% VL** $20,000 X 150,000 = ***$3.9 Billion***

***Savings….$3.9 Billion***

***Should I do 30% of my intubations with DL to keep up my DL skills??***

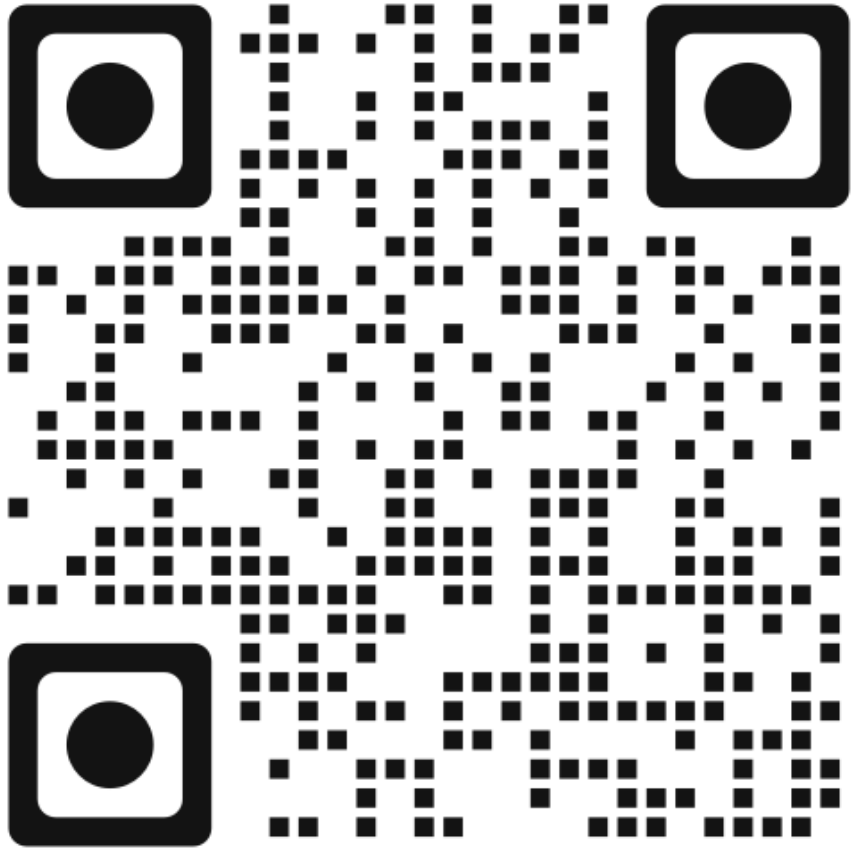
Decision Support

# The Cost of Retaining DL Skills

- 30% of intubations with DL

| | ED/ICU (10M) | OR (50M) |
|---|---|---|
| First Pass Failures @ 30% DL | 1,919,000 | 4,800,000 |
| First Pass Failures@ 100% VL | 1,490,000 | 3,000,000 |
| Excess First Pass Failures | 429,000 | 1,800,000 |
| Excess Deaths and costs | | |

# Link to Calculator

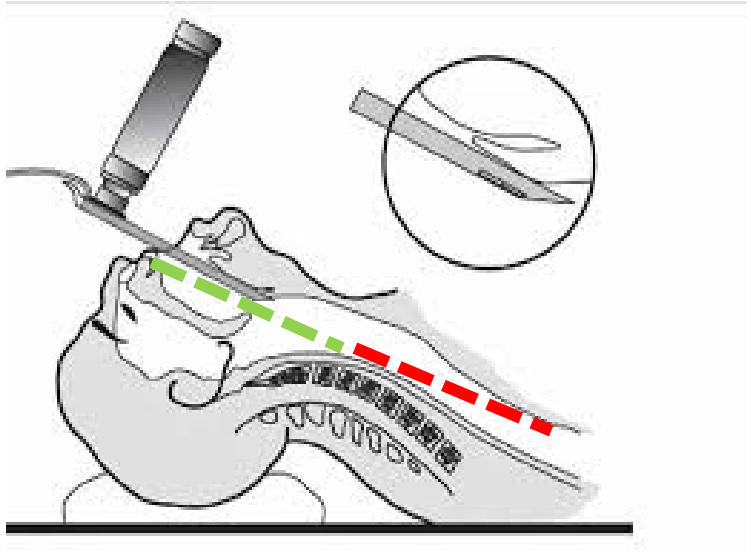


https://sites.google.com/view/intubation-calculator/edicu-intubation-calculator

*What Is the cost in 28-day ICU mortality at 20% VL use and 100% VL use?*

Clinical Cost and Scale

# VL vs DL *Prekker 2023 (ED ICU)*



*First pass rate*

- VL 85.1%
- DL 70.8%

## Failure Mode

| | DL | VL |
|---|---|---|
| Visualization | 71% | 34% |
| Tracheal access | 29% | 66% |

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

# Intubation Practices and Adverse Peri-intubation Events in Critically Ill Patients From 29 Countries

Vincenzo Russotto, MD; Sheila Nainan Myatra, MD; John G. Laffey, MD, MA; Elena Tassistro, MS;

**Linked**

**# of intubation attempts**

**major adverse events**

***28 Day ICU mortality***

# National Scale Critically Ill (5 Million Per Year)

## ED/ICU Critically Ill Intubations

Only **G3** (Total number of intubations) is editable. Results update instantly.

**G3 — Total number of intubations** editable: 5000000

| Scenario | Total First Pass Failures | Major Adverse Events | 28-Day Deaths | Visualization Failures | Tracheal Access Failures |
|---|---|---|---|---|---|
| **20% VL + 80% DL** | 1,310,000 | 694,300 | 90,953 | 874,600 | 435,400 |
| **100% VL + 0% DL** | 750,000 | 397,500 | 52,073 | 255,000 | 495,000 |
| **Difference** | 560,000 | 296,800 | 38,881 | 619,600 | -59,600 |

Definitions: FP Failures = total × (VL%×VL_FP + DL%×DL_FP). MAE = FP Failures × 0.53. 28-day deaths = MAE × 0.131. Visualization/Tracheal Access split uses VL/DL-specific proportions.