Prevention of Ventilator-Associated Events

Presented by:

Michel Klompas MD, MPH, FIDSA, FSHEA
Hospital Epidemiologist, Brigham and Women's Hospital, Boston, MA
Professor, Harvard Medical School and Harvard Pilgrim Health Care Institute

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Disclosures

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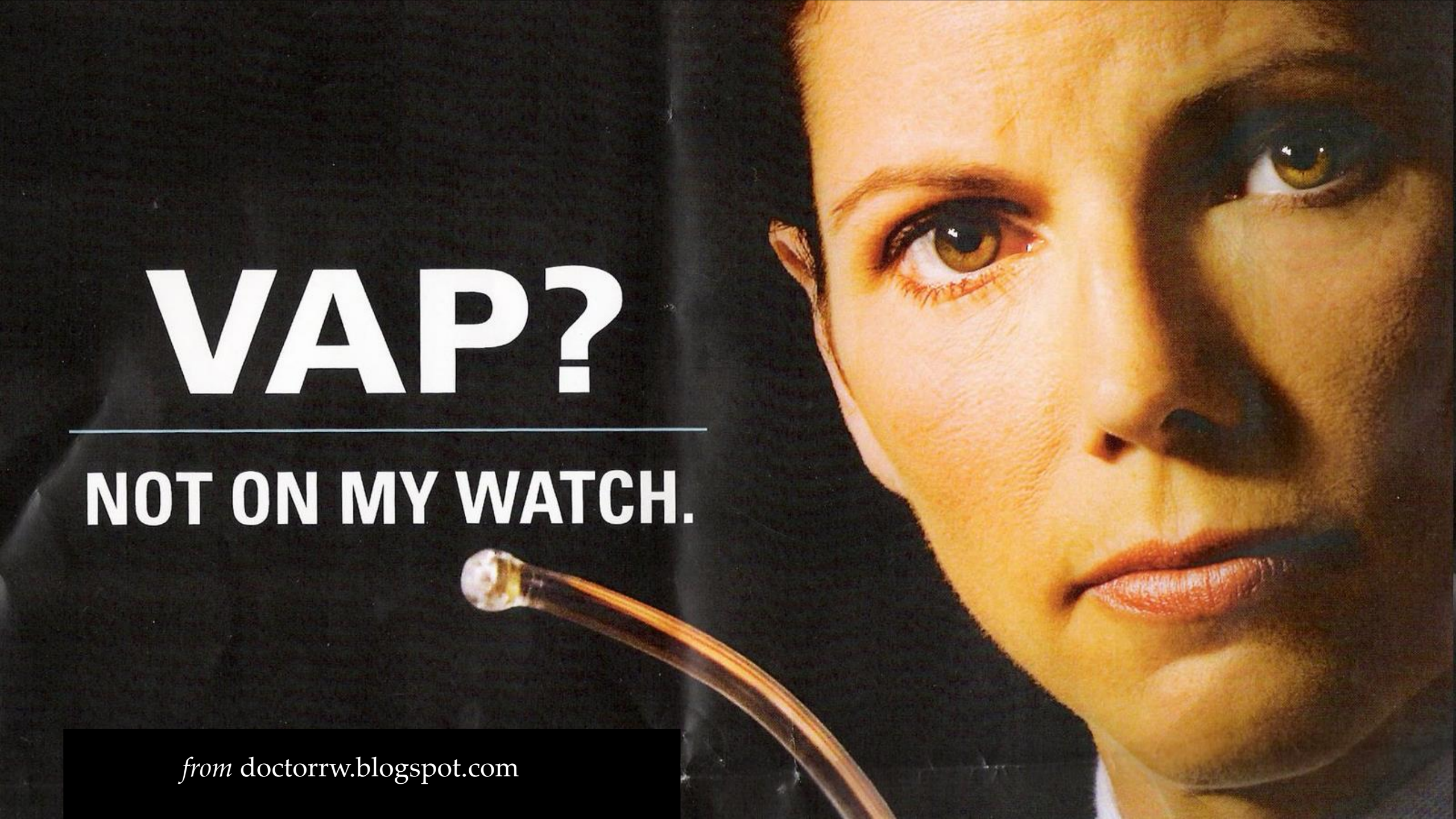
  - Centers for Disease Control and Prevention
  - Massachusetts Department of Public Health
  - Agency for Healthcare Research and Quality

- **Royalties**
  - UpToDate Inc.


VAP?
NOT ON MY WATCH.
from doctorrw.blogspot.com

Why did CDC replace VAP with VAE?

The Challenge of VAP Diagnosis

- **Many complications of critical care present with the same clinical signs as VAP**
  - Radiographic opacities
  - Fever
  - Abnormal white blood cell count
  - Impaired oxygenation
  - Increased pulmonary secretions

“Diffuse patchy airspace disease right greater than left with obliteration of both hemi-diaphragms. Opacities possibly slightly increased since yesterday accounting for changes in patient position and inspiration. This could represent atelectasis, pneumonia, or effusion.”

Sources of fever and infiltrates

- **ARDS**
- **Thromboembolic disease**
- **Hemorrhage**
- **Infarction**
- **Fibrosis**
- **Carcinoma**
- **Lymphoma**
- **Contusion**

Tracheobronchitis

CLABSI

UTI

Drug fever

PLUS

Pulmonary edema

Atelectasis

Contusion

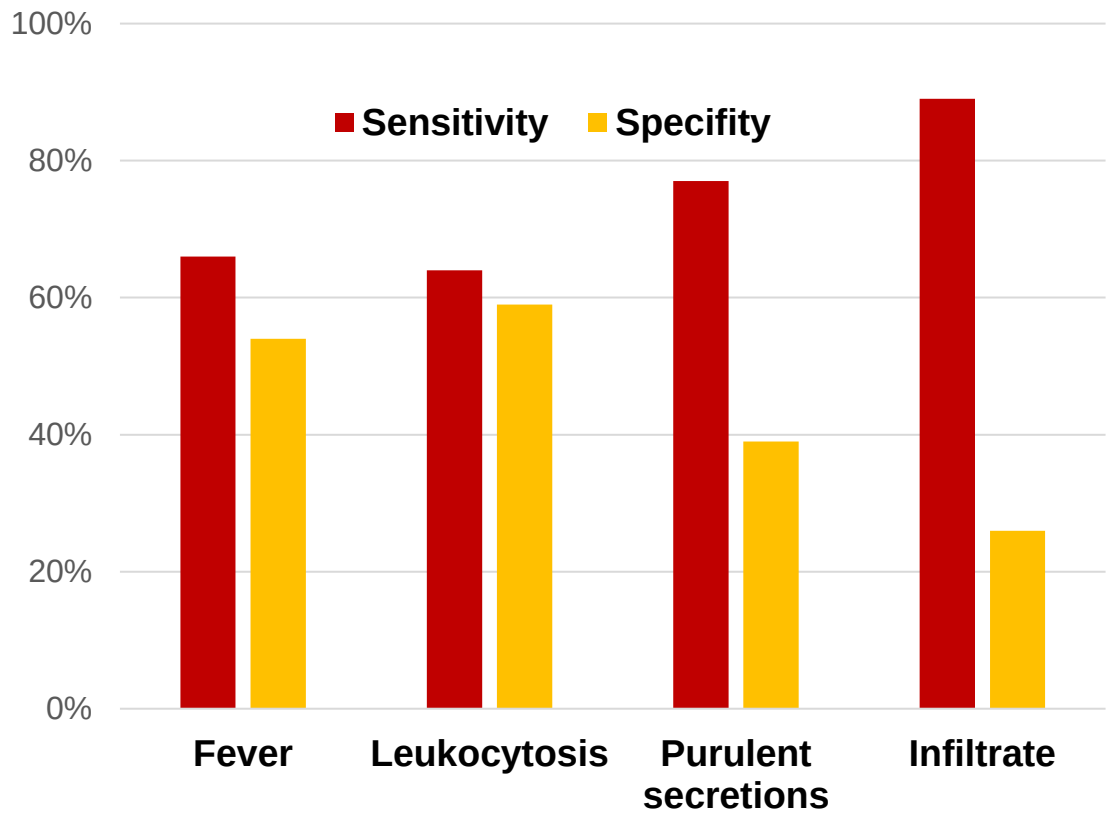
Fibrosis

Meduri, *Chest* 1994; 106:221-235
Petersen, *Scand J Infect Dis* 1999; 31:299-303

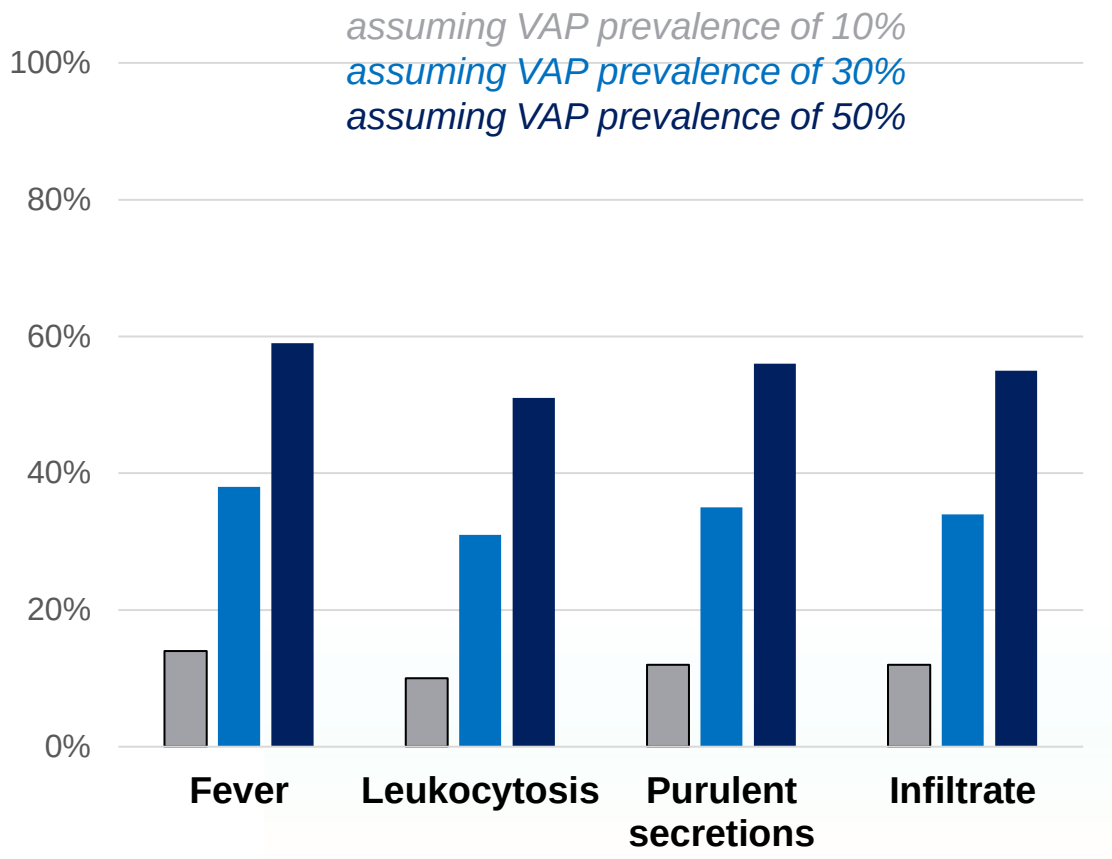
Accuracy of Clinical Signs for VAP

Meta-analysis of 25 studies examining accuracy of clinical signs for VAP relative to histology, N=75 to 336 per sign

Sensitivity and Specificity



Positive Predictive Value

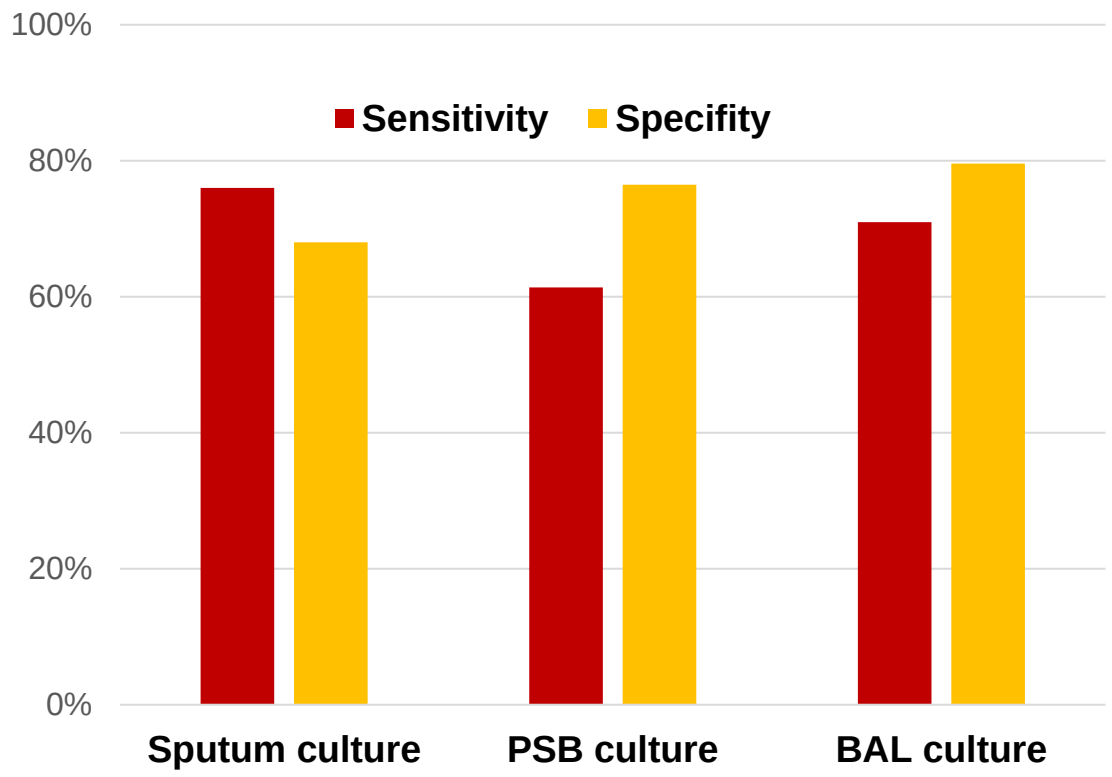


Fernando, *Intensive Care Med* 2020;46:1170-9

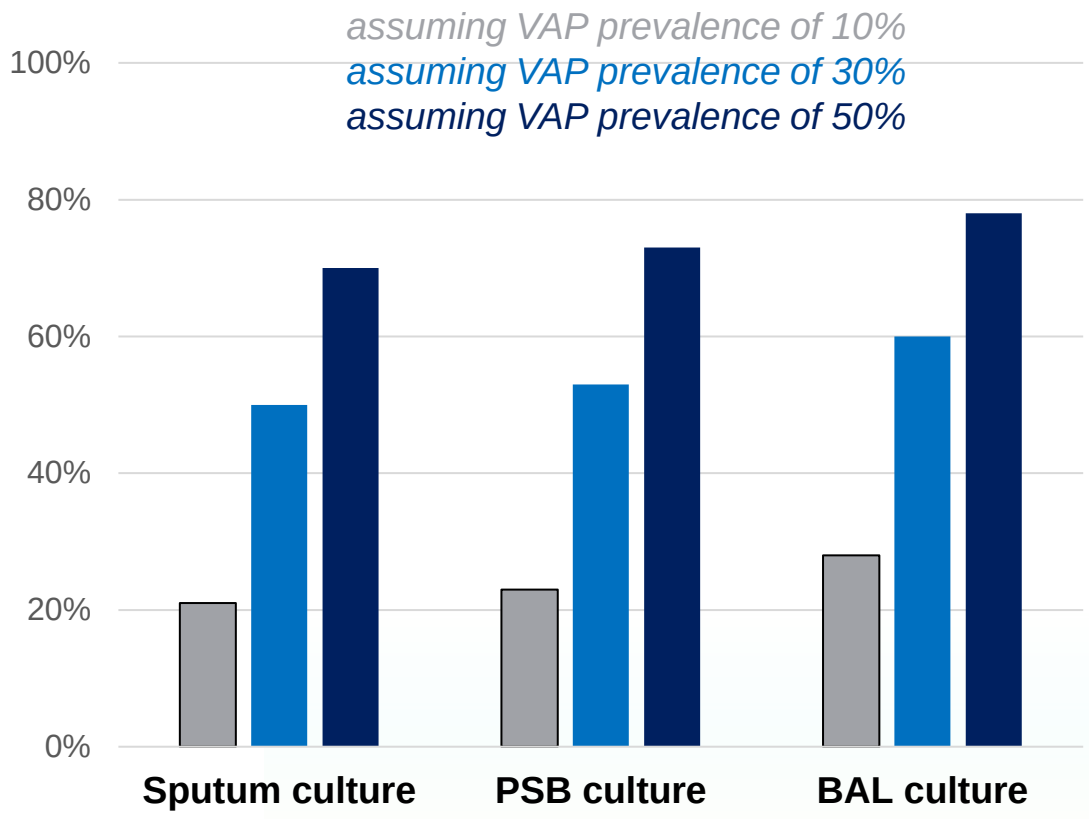
Accuracy of Respiratory Cultures for VAP

Meta-analysis of 25 studies examining accuracy of clinical signs for VAP relative to histology, N=75 to 336 per sign

Sensitivity and Specificity



Positive Predictive Value



Fernando, *Intensive Care Med* 2020;46:1170-9

Implications for Prevention

The Classic Ventilator Bundle

Elevate the head of the bed

Daily sedative interruptions

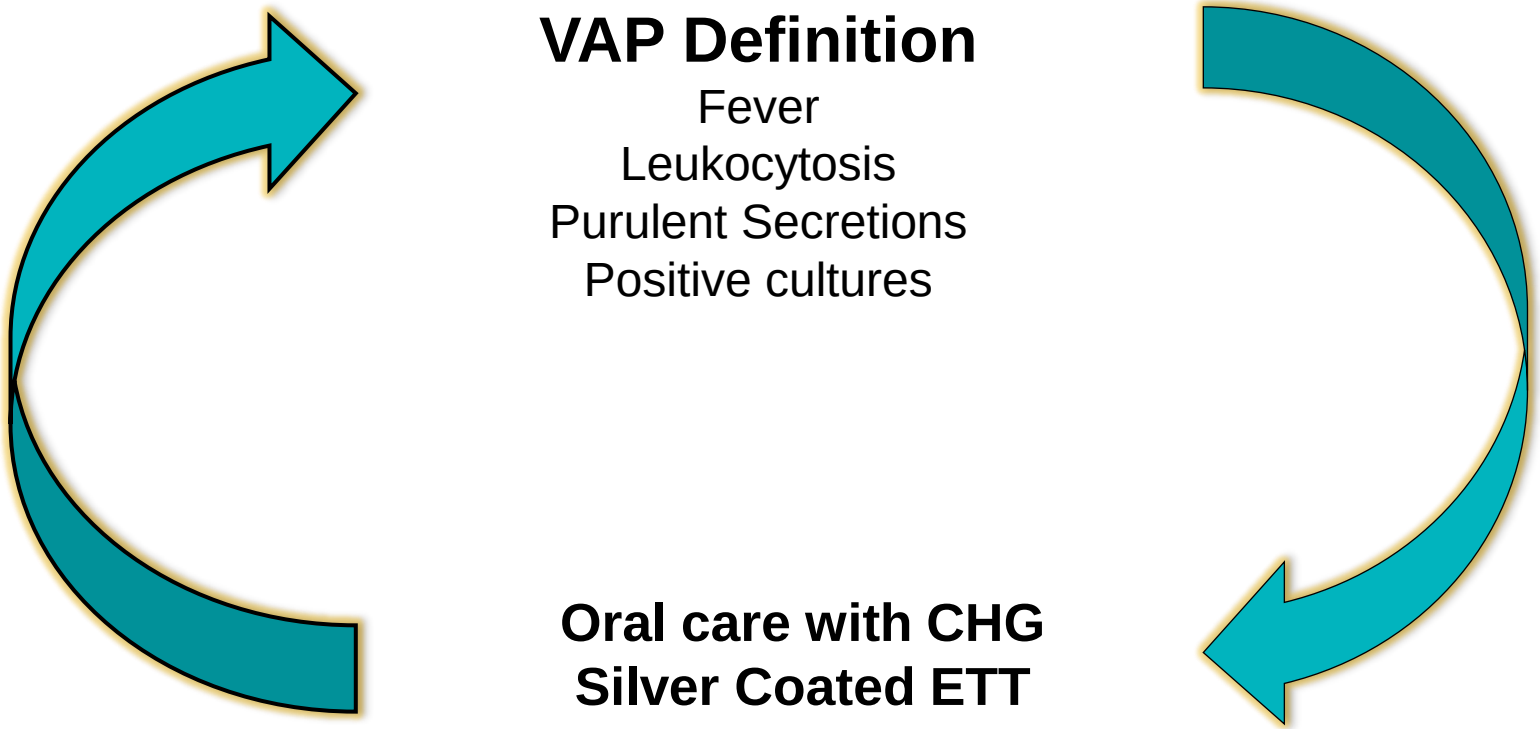
Spontaneous breathing trials

Stress ulcer prophylaxis

DVT prophylaxis

Oral care with chlorhexidine

Circularity Between VAP Prevention Practices and the VAP Definition



Stress Ulcer Prophylaxis

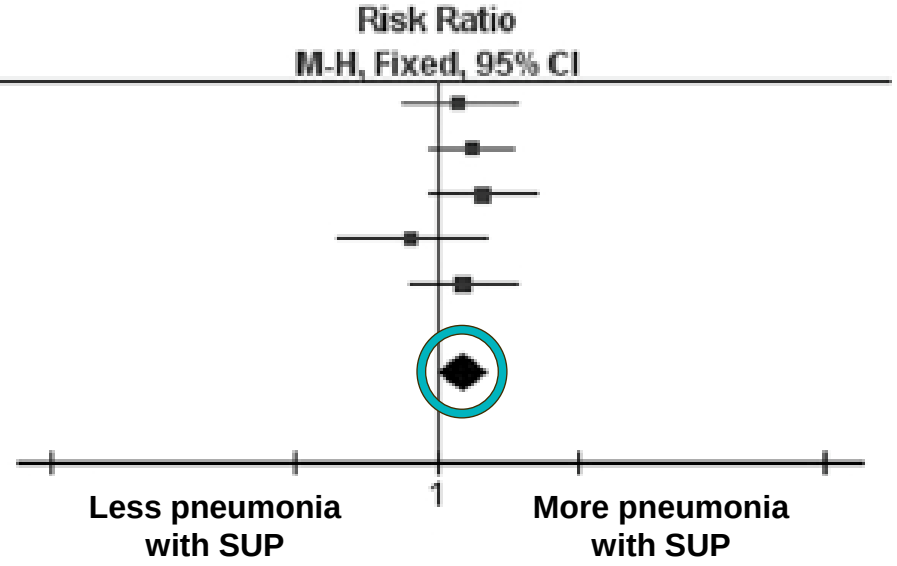
Randomized controlled trials of ulcer prophylaxis vs placebo in patients getting enteral nutrition

Ventilator-associated pneumonia

	Antacid		Placebo			Risk Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% CI
Alhazzani 2017	10	49	6	42	18.5%	1.43 [0.57, 3.60]
Apte 1992	11	16	7	18	18.8%	1.77 [0.91, 3.44]
Ben-menachem 1994	25	200	6	100	22.9%	2.08 [0.88, 4.91]
Lin 2016	4	60	6	60	17.2%	0.67 [0.20, 2.24]
Selvanderan 2016	12	106	8	108	22.7%	1.53 [0.65, 3.59]
Total (95% CI)		**431**		**328**	**100.0%**	**1.53 [1.04, 2.27]**
Total events	62		33			

Heterogeneity: $Chi^2 = 2.50$, $df = 4$ ($P = 0.65$); $I^2 = 0\%$

Test for overall effect: $Z = 2.14$ ($P = 0.03$)



Significantly higher risk for VAP!

Crit Care 2018;22:20

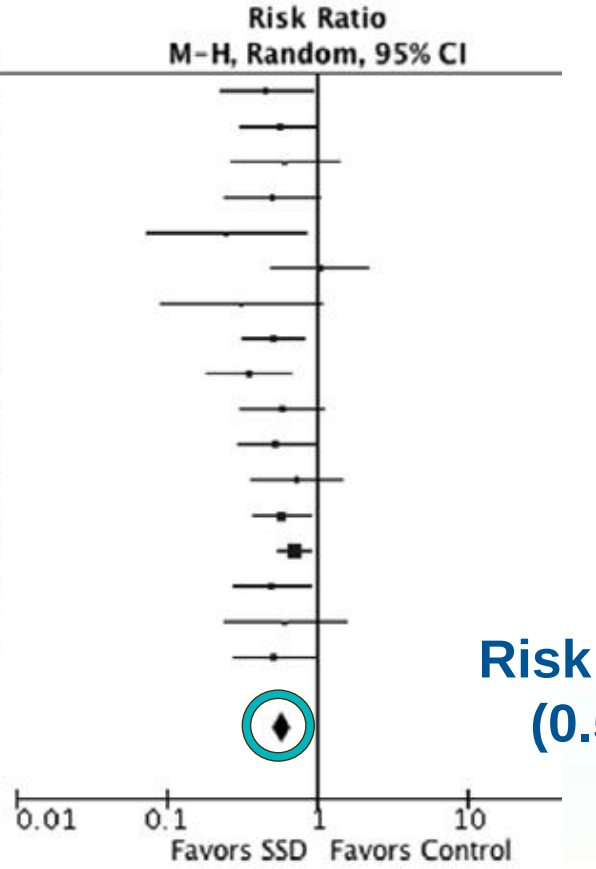
Subglottic Secretion Drainage

Meta-Analysis of randomized trials: ***Significantly Lower VAP Rates***

Study or Subgroup	SSD Events	SSD Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI	Year
Mahul 1992	9	70	21	75	3.8%	0.46 [0.23, 0.93]	1992
Valles 1995	14	95	25	95	5.5%	0.56 [0.31, 1.01]	1995
Kollef 1999	8	160	15	183	2.8%	0.61 [0.27, 1.40]	1999
Bo 2000	8	35	15	33	3.7%	0.50 [0.25, 1.03]	2000
Smulders 2002	3	75	12	75	1.3%	0.25 [0.07, 0.85]	2002
Girou 2004	5	8	6	10	3.5%	1.04 [0.50, 2.18]	2004
Liu S 2006	3	48	10	50	1.3%	0.31 [0.09, 1.07]	2006
Liu Q 2006	14	41	30	45	8.5%	0.51 [0.32, 0.82]	2006
Lorente 2007	11	140	31	140	4.6%	0.35 [0.19, 0.68]	2007
Zheng 2008	9	30	16	31	4.6%	0.58 [0.31, 1.11]	2008
Yang 2008	12	48	20	43	5.6%	0.54 [0.30, 0.97]	2008
Bouza 2008	13	345	19	369	4.0%	0.73 [0.37, 1.46]	2008
Lacherade 2010	25	169	42	164	9.6%	0.58 [0.37, 0.90]	2010
Tao 2014	52	102	34	47	28.3%	0.70 [0.54, 0.91]	2014
Damas 2014	15	170	32	182	5.7%	0.50 [0.28, 0.89]	2014
Koker 2014	5	23	10	28	2.3%	0.61 [0.24, 1.53]	2014
Gopal 2015	13	120	25	120	5.0%	0.52 [0.28, 0.97]	2015
Total (95% CI)		**1679**		**1690**	**100.0%**	**0.58 [0.51, 0.67]**	
Total events	219		363				

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 12.12$, df = 16 (P = 0.74); $I^2 = 0\%$

Test for overall effect: Z = 7.71 (P < 0.00001)



Risk Ratio 0.58 (0.51- 0.67)

Crit Care Med 2016;44:830-840

Subglottic Secretion Drainage

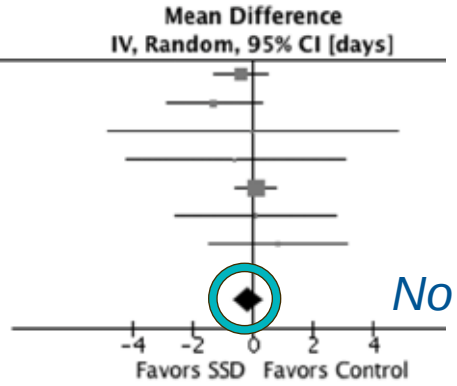
Meta-Analysis of randomized trials: ***No Impact on Ventilator Days or ICU Days***

Ventilator Days

	SSD			Control				Mean Difference	
Study or Subgroup	Mean [days]	SD [days]	Total	Mean [days]	SD [days]	Total	Weight	IV, Random, 95% CI [days]	Year
Kollef 1999	1.5	3.3	160	1.9	5.1	183	29.1%	-0.40 [-1.30, 0.50]	1999
Smulders 2002	5.8	4.4	75	7.1	5.4	75	9.5%	-1.30 [-2.88, 0.28]	2002
Liu S 2006	15	14	48	15	10	50	1.0%	0.00 [-4.83, 4.83]	2006
Lorente 2007	10.5	15.91	140	11.1	15.19	140	1.8%	-0.60 [-4.24, 3.04]	2007
Bouza 2008	2	5.3	345	1.9	3.8	369	50.8%	0.10 [-0.58, 0.78]	2008
Lacherade 2010	10.9	10.6	169	10.8	14	164	3.3%	0.10 [-2.57, 2.77]	2010
Damas 2014	11.71	11.87	170	10.87	9.79	182	4.5%	0.84 [-1.44, 3.12]	2014
Total (95% CI)			**1107**			**1163**	**100.0%**	**-0.16 [-0.64, 0.33]**	

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 3.68$, df = 6 (P = 0.72); $I^2 = 0\%$

Test for overall effect: Z = 0.64 (P = 0.52)



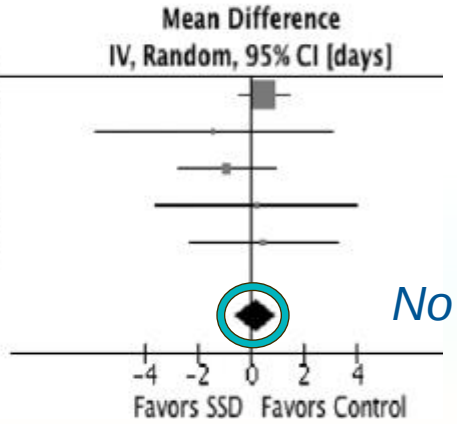
No difference!

ICU Days

	SSD			Control				Mean Difference	
Study or Subgroup	Mean [days]	SD [days]	Total	Mean [days]	SD [days]	Total	Weight	IV, Random, 95% CI [days]	Year
Kollef 1999	3.7	4.6	160	3.2	4.5	183	66.3%	0.50 [-0.47, 1.47]	1999
Lorente 2007	14.1	17.91	140	15.5	19.93	140	3.1%	-1.40 [-5.84, 3.04]	2007
Bouza 2008	5.6	10.7	345	6.5	14.2	369	18.3%	-0.90 [-2.74, 0.94]	2008
Lacherade 2010	15.9	14.4	169	15.7	20.4	164	4.3%	0.20 [-3.60, 4.00]	2010
Damas 2014	16.2	13.52	170	15.76	13.15	182	8.0%	0.44 [-2.35, 3.23]	2014
Total (95% CI)			**984**			**1038**	**100.0%**	**0.17 [-0.62, 0.95]**	

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 2.27$, df = 4 (P = 0.69); $I^2 = 0\%$

Test for overall effect: Z = 0.41 (P = 0.68)



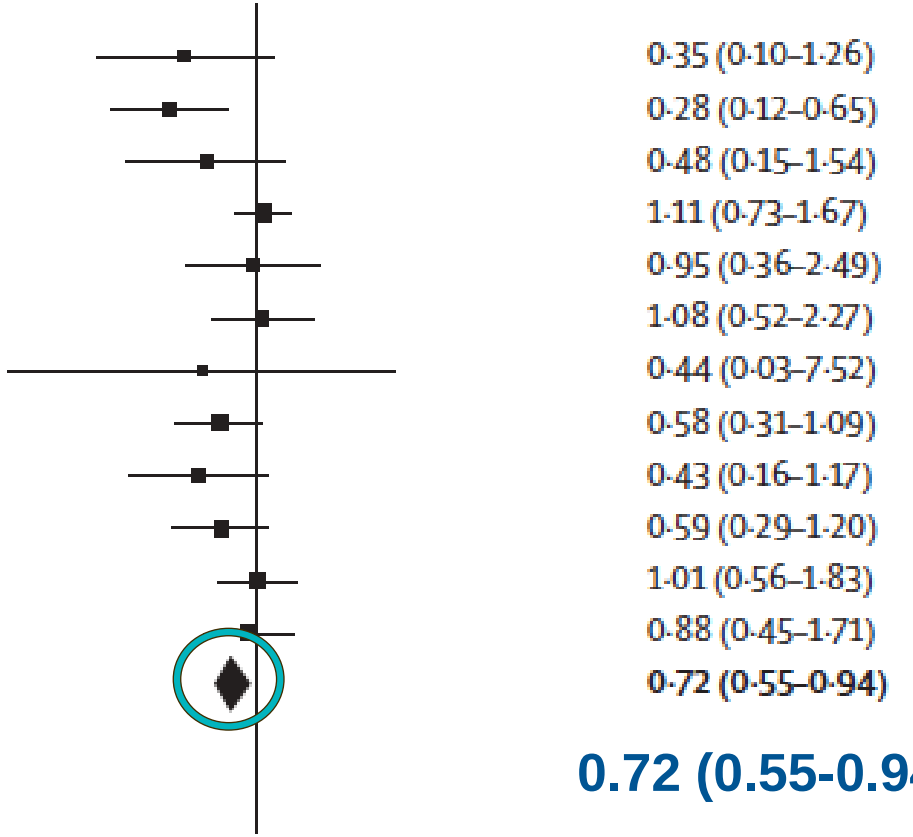
No difference!

Crit Care Med 2016;44:830-840

Oral Care with Chlorhexidine: Significantly *Lower* VAP Rates

Chlorhexidine					
De Riso et al (1996)[18]	3	173	9	180	3·8%
Fourrier et al (2000)[13]	5	30	18	30	7·0%
Houston et al (2002)[20]	4	270	9	291	4·4%
MacNaughton et al (2004)[22]	32	91	28	88	14·1%
Grap et al (2004)[14]	4	7	3	5	5·9%
Fourrier et al (2005)[19]	13	114	12	114	8·3%
Bopp et al (2006)[17]	0	2	1	3	0·9%
Koeman et al (2006)[21]	13	127	23	130	9·9%
Tantipong et al (2008)[23]	5	102	12	105	5·5%
Scannapieco et al (2009)[26]	14	116	12	59	8·8%
Bellisimo-Rodriguez et al (2009)[24]	16	64	17	69	10·6%
Panchabhai et al (2009)[25]	14	88	15	83	9·4%
Subtotal (95% CI)		**1184**		**1157**	**88·5%**
Total events	123		159		
Heterogeneity: τ^2=0·06, χ^2=15·54, df=11 (p=0·16); I^2=29%					
Test for overall effect: Z=2·40 (p=0·02)					

Ventilator-Associated Pneumonia



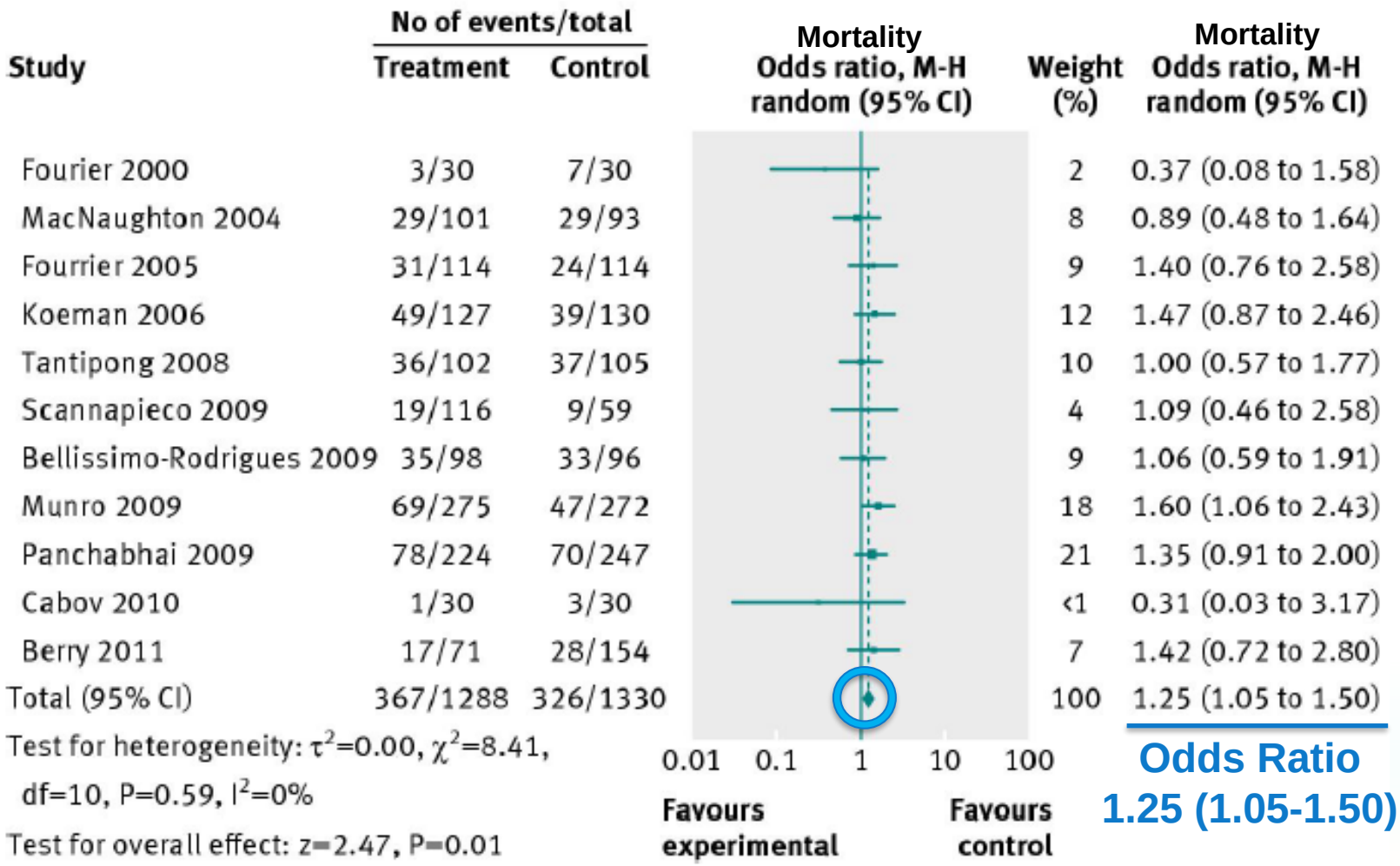
	0·35 (0·10–1·26)
	0·28 (0·12–0·65)
	0·48 (0·15–1·54)
	1·11 (0·73–1·67)
	0·95 (0·36–2·49)
	1·08 (0·52–2·27)
	0·44 (0·03–7·52)
	0·58 (0·31–1·09)
	0·43 (0·16–1·17)
	0·59 (0·29–1·20)
	1·01 (0·56–1·83)
	0·88 (0·45–1·71)
	0·72 (0·55–0·94)

0.72 (0.55-0.94)

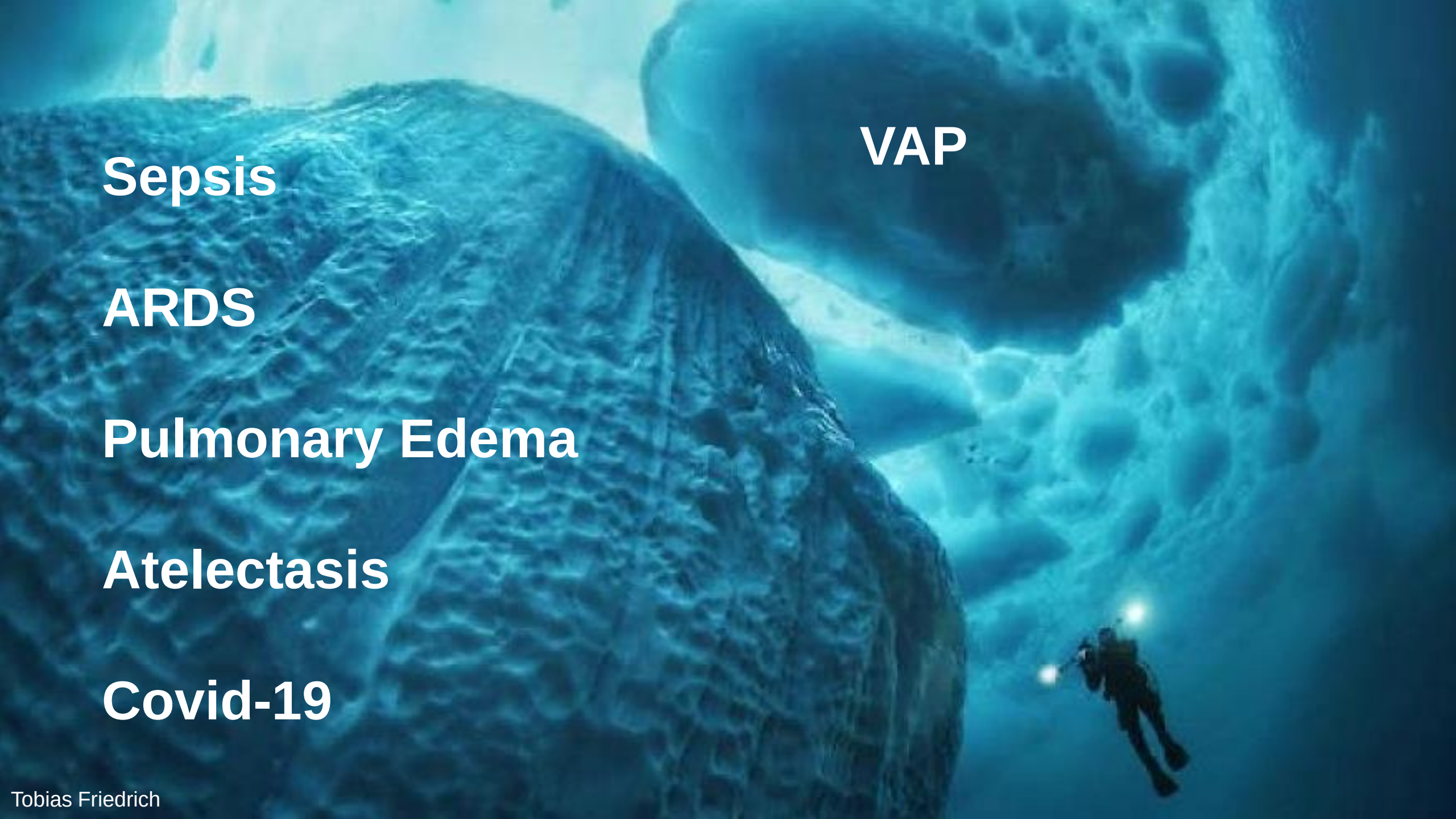
Significantly lower VAP rates!

Lancet Infectious Disease 2011;11:845

Oral Care with Chlorhexidine: Significantly *Higher* Mortality Rates



BMJ 2014;348:g2197


VAP
Sepsis
ARDS
Pulmonary Edema
Atelectasis
Covid-19

Implications for Surveillance

CDC's VAP Surveillance Definition

2008

Patient must fulfill each of the three categories below:

Chest Radiograph	*Any one of the following:* 1. New, progressive, or persistent infiltrate 2. Consolidation 3. Cavitation
Systemic Signs	*Any one of the following:* 1. Temperature >38°C 2. WBC <4,000 or >12,000 WBC/mm^3 3. For adults 70 years old, altered mental status with no other recognized cause
Pulmonary Signs	*Any two of the following:* 1. New onset of purulent sputum, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements 2. New onset or worsening cough, or dyspnea, or tachypnea 3. Rales or bronchial breath sounds 4. Worsening gas exchange, increased oxygen requirements, or increased ventilation demand

Complicated

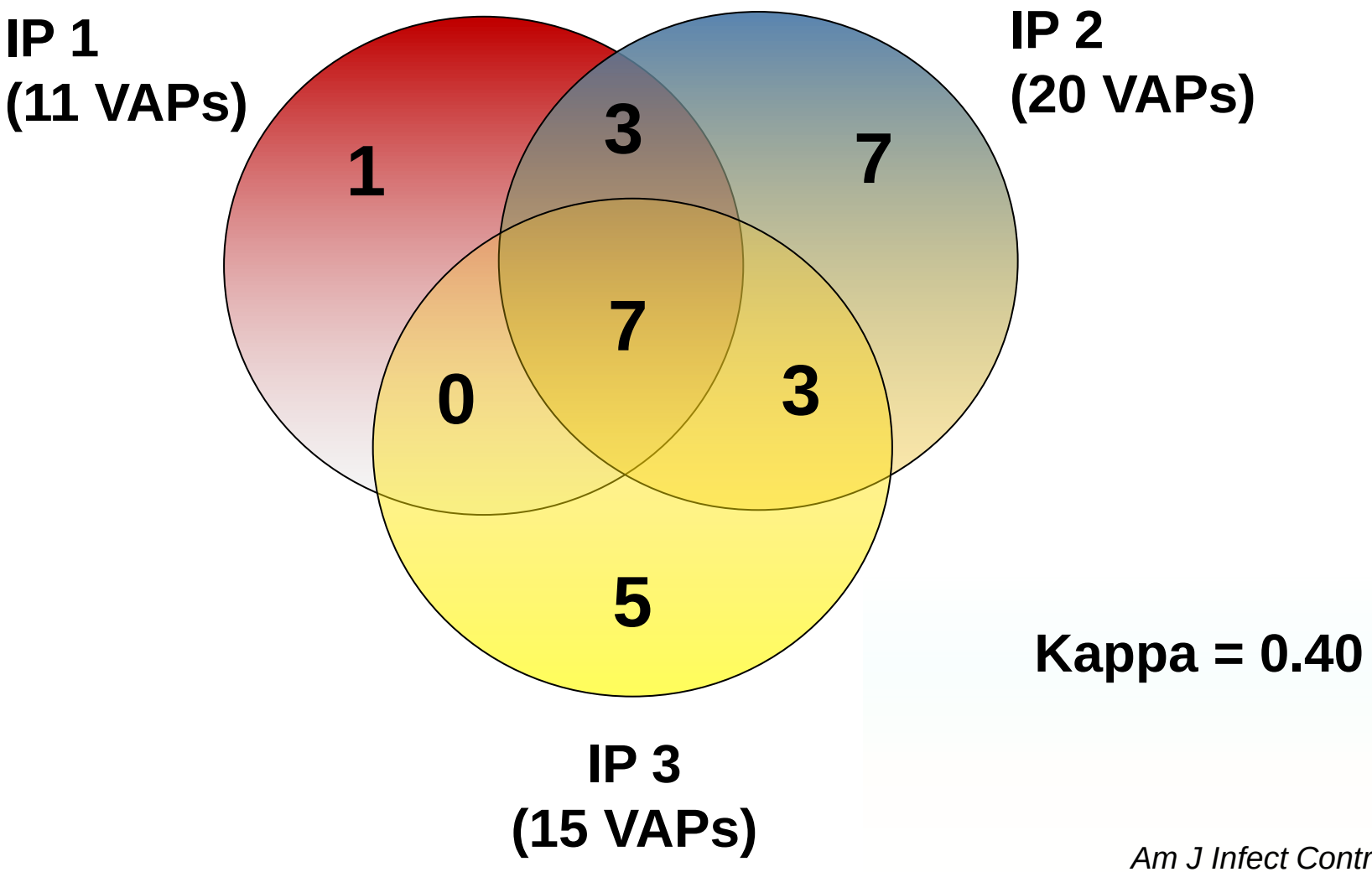
Labor Intensive

Subjective

Non-Specific

Interobserver Agreement in VAP Surveillance

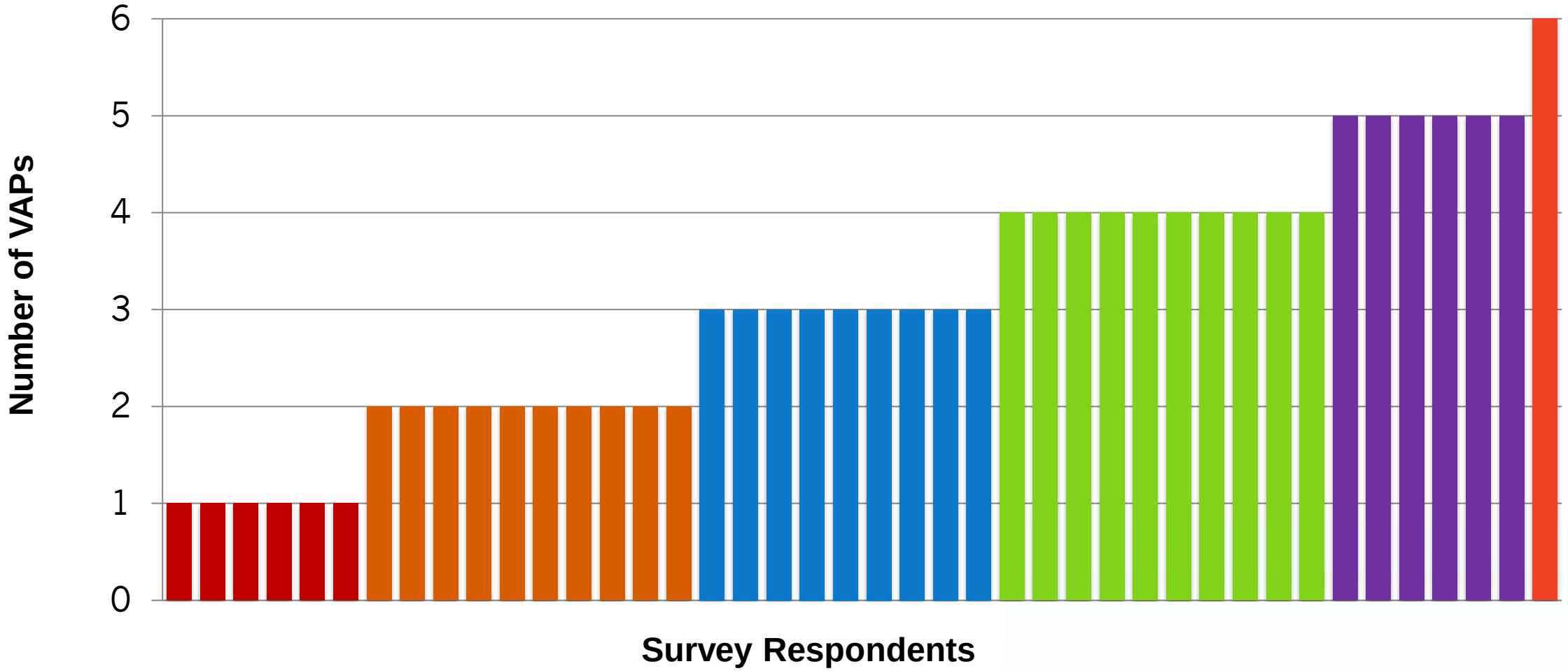
50 ventilated patients with respiratory deterioration



Kappa = 0.40

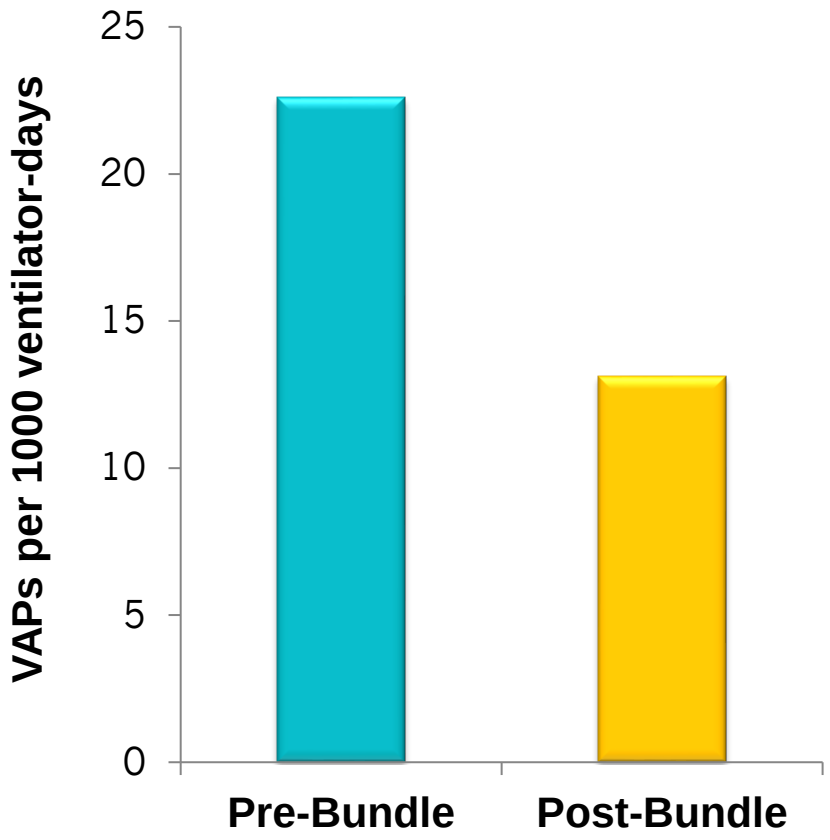
Am J Infect Control 2010:38:237

6 Case Vignettes Presented to 43 Reviewers



Crit Care Med 2014;42:497

How do we interpret a drop in VAP rates?



Better Care?

Stricter Surveillance?

Less colonization vs less VAP?

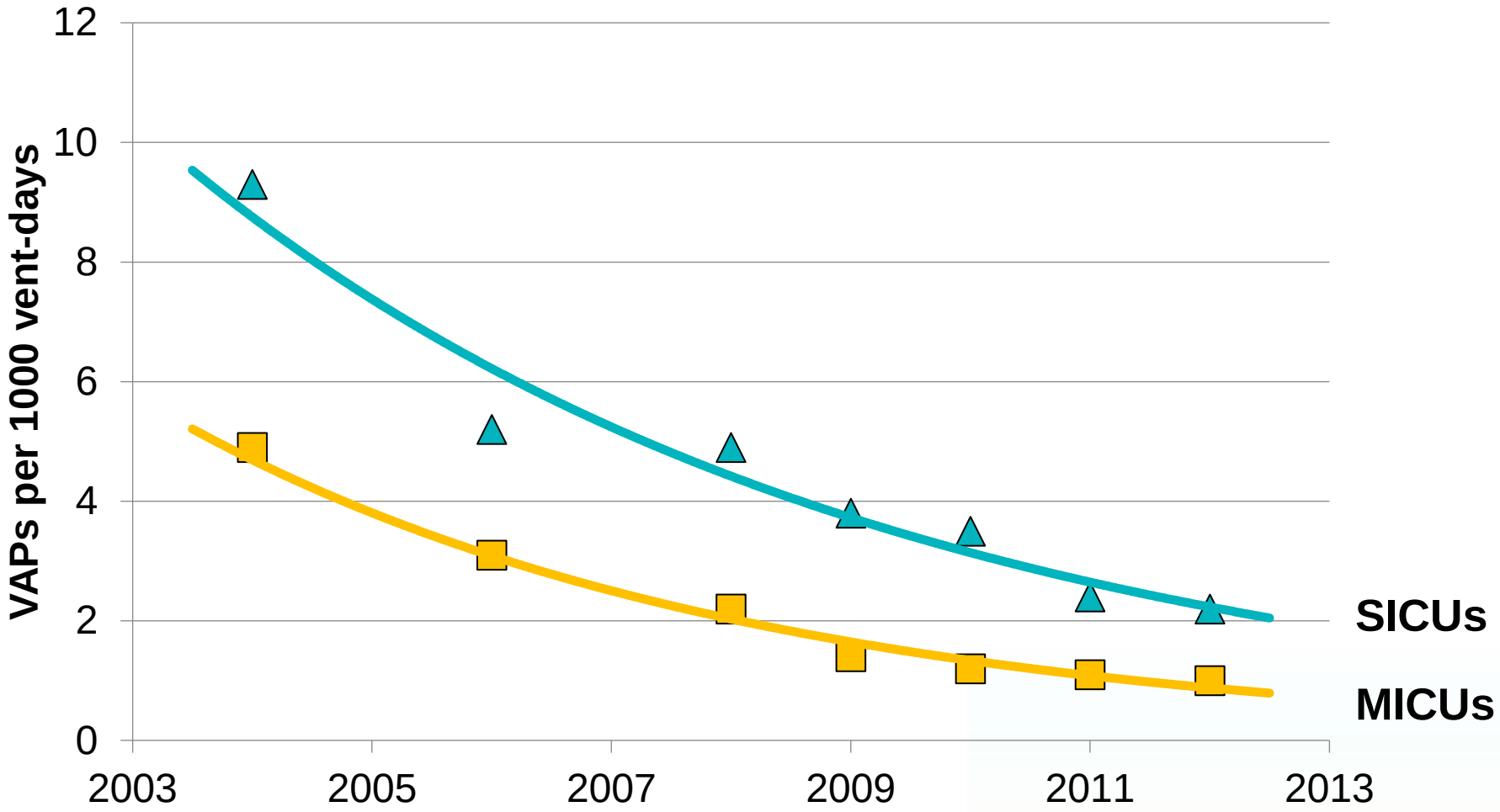
Change in case mix?

Some combination of the above?

Am J Infect Control 2012;40:408-410

U.S. National VAP Rates

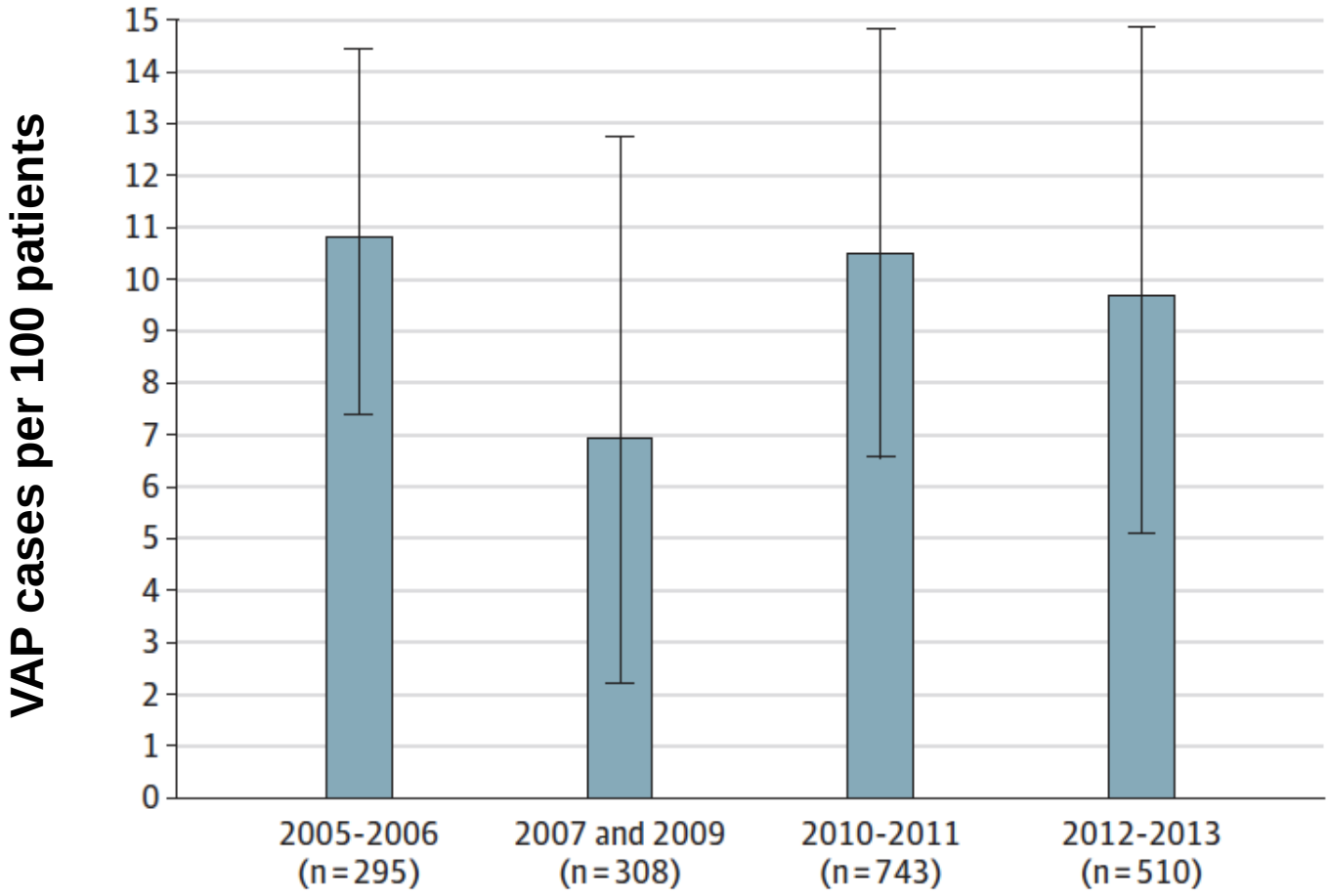
Cases Reported to CDC by Hospitals, 2004-2012



Source: CDC NNIS and NHSN

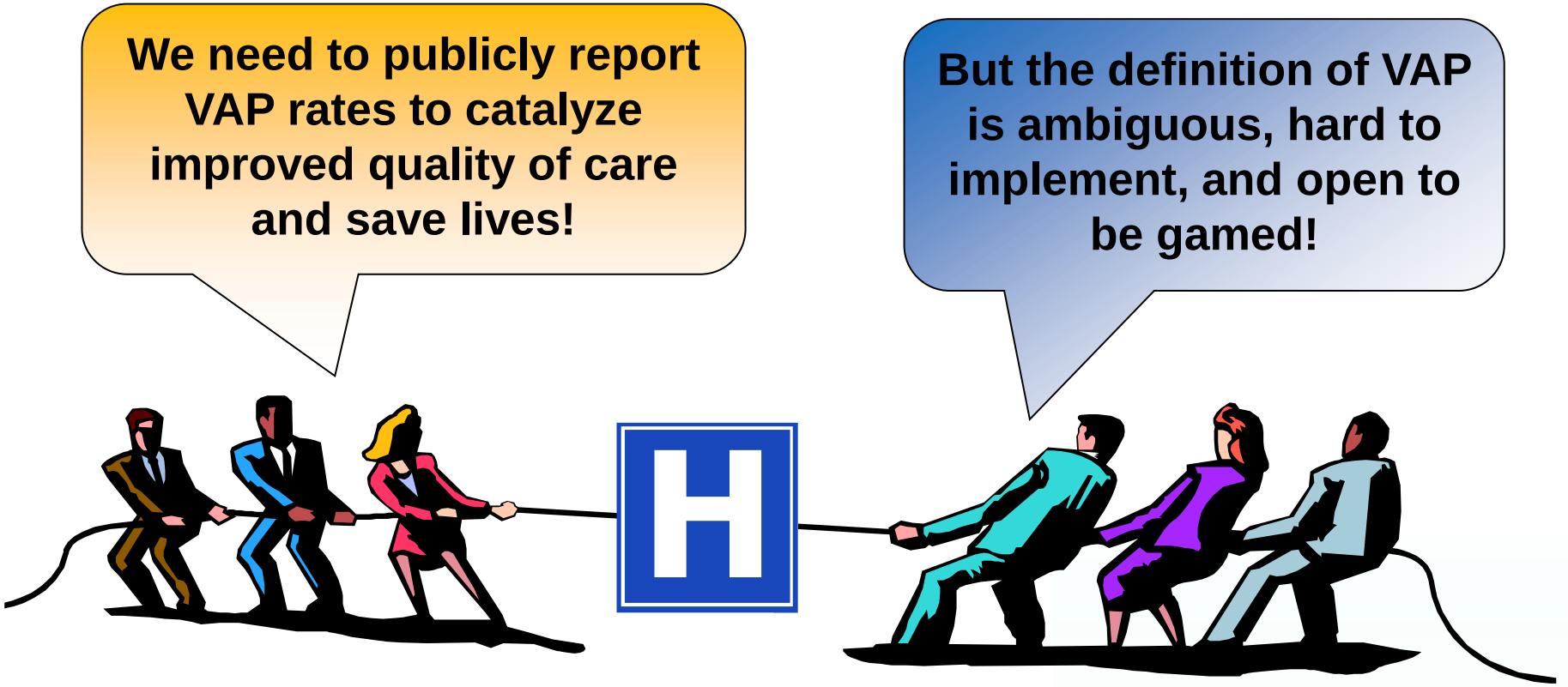
U.S. National VAP Rates, 2005-2013

Centers for Medicare and Medicaid Services Audits



JAMA 2016;316:2427-2429

Where does this leave hospitals?



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Special Point of View Article

Developing a New, National Approach to Surveillance for Ventilator-Associated Events*

Shelley S. Magill, MD, PhD[1]; Michael Klompas, MD, MPH[2,3,4]; Robert Balk, MD[5,6]; Suzanne M. Burns, RN, ACNP, MSN, RRT[6,7]; Clifford S. Deutschman, MS, MD[6,8]; Daniel Diekema, MD[9,10]; Scott Fridkin, MD[1]; Linda Greene, RN, MPS[11,12]; Alice Guh, MD, MPH[1]; David Gutterman, MD[6,13]; Beth Hammer, RN, MSN, ANP-BC[6,14]; David Henderson, MD[15]; Dean Hess, PhD, RRT[16,17,18]; Nicholas S. Hill, MD[6,19]; Teresa Horan, MPH[1]; Marin Kollef, MD[6,20]; Mitchell Levy, MD[6,21]; Edward Septimus, MD[22,23]; Carole VanAntwerpen, RN, BSN[24,25]; Don Wright, MD, MPH[26]; Pamela Lipsett, MD, MHPE[6,27]

Critical Care Medicine 2013;41:2467-2475

VAE: An Alternative Approach to Surveillance

- **Broaden the focus of surveillance from pneumonia alone to the syndrome of ventilator complications in general**
  - More accurate description of what can be reliably determined using surveillance definitions
  - Emphasizes the importance of preventing ***all*** complications of mechanical ventilation, not just pneumonia

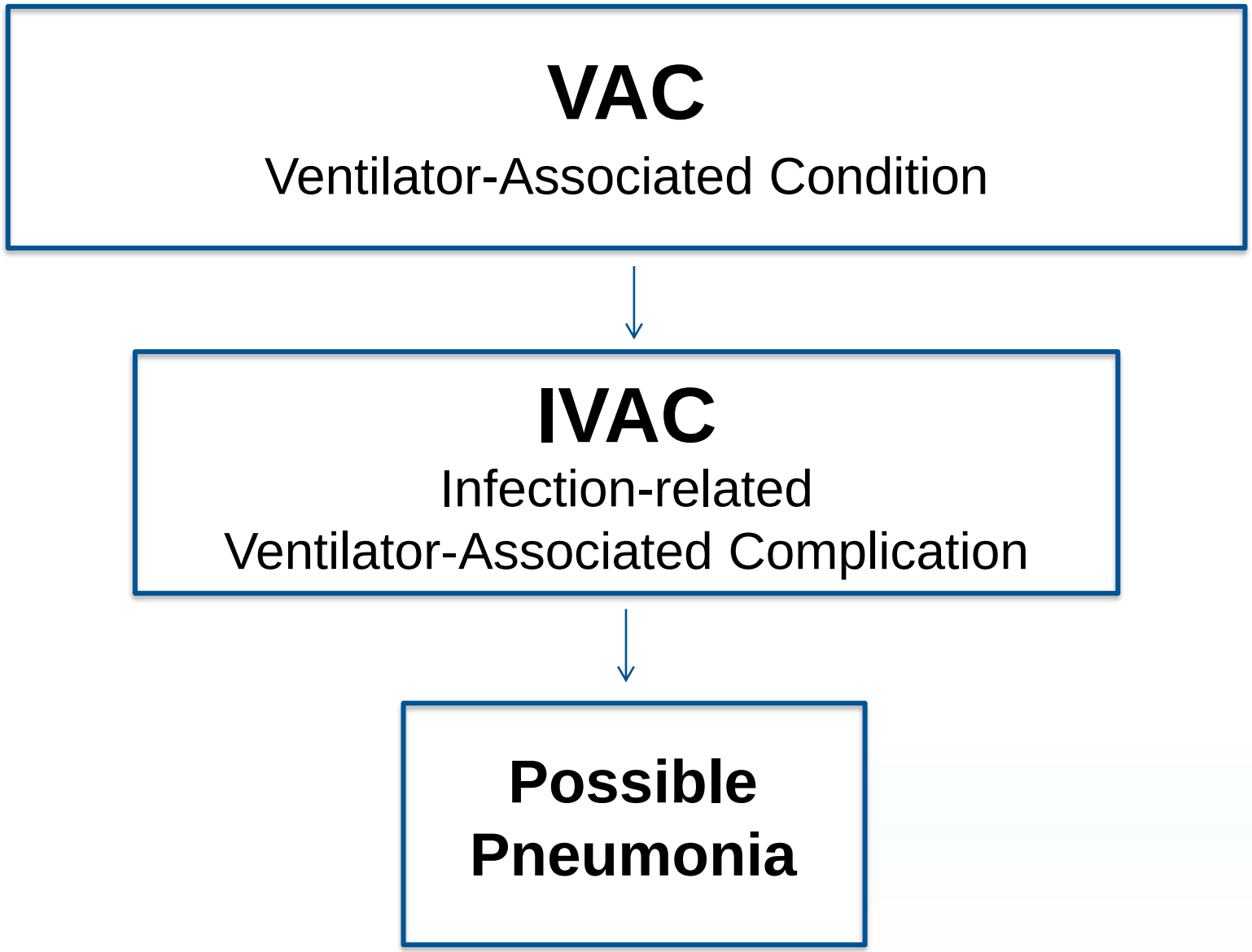
- **Streamline the definition using quantitative criteria**
  - Reduce ambiguity
  - Improve reproducibility
  - Enable electronic collection of all variables

Ventilator-Associated Events (VAE)

Sustained rise in daily minimum PEEP ≥3cm or FiO2 ≥20 points after a period of stable or improving daily minimum PEEP or FiO2

Date	PEEP (min)	FiO2 (min)
Jan 1	10	100
Jan 2	5	50
Jan 3	5	40
Jan 4	5	40
Jan 5	5	50
Jan 6	8	60
Jan 7	8	40
Jan 8	5	40
Jan 9	5	40

VAE


VAC
Ventilator-Associated Condition
IVAC
Infection-related
Ventilator-Associated Complication
Possible
Pneumonia

Pediatric Ventilator-Associated Events (PedVAE)

Sustained rise in daily minimum MAP ≥4cm or FiO2 ≥25 points after a period of stable or improving daily minimum MAP or FiO2

Date	MAP (min)	FiO2 (min)
Jan 1	7	100
Jan 2	7	50
Jan 3	8	40
Jan 4	8	40
Jan 5	8	60
Jan 6	12	50
Jan 7	12	40
Jan 8	5	40
Jan 9	5	40

PedVAE

https://www.cdc.gov/nhsn/vae-calculator/index.html

National Healthcare Safety Network (NHSN)

Start Over | Calculate IVAC | Explain... | Go to PVAP

MV Day	Date	Hide... Min. PEEP (cmH_2O)	Hide... Min. FiO_2 (21 - 100)	VAE	T<36° or T>38°	WBC ≤ 4,000 or WBC ≥ 12,000 cells/mm^3	Add... Remove... Choose a Drug: CEFEPIME	QAD
1	12/3/2023	5	60				☐	
2	12/4/2023	5	40				☐	
† 3	12/5/2023	5	40		☐	☐	☐	
† 4	12/6/2023	10	70	‡ IVAC	☑	☐	☑	¶ yes
† 5	12/7/2023	8	50		☐	☑	☑	¶ yes
† 6	12/8/2023	8	40		☐	☐	☑	¶ yes
7	12/9/2023	5	40				☑	¶ yes
8	12/10/2023	5	40				☑	¶ yes
9	12/11/2023	5	40				☑	¶ yes
10	12/12/2023						☑	¶ yes

Legend: † - VAE Window | ‡ - VAE Date | ¶ - Qualifying Antimicrobial Day (QAD)

Brief report

Assessment of an automated surveillance system for detection of initial ventilator-associated events

Dooshanveer Nuckchady MD[a], Michael G. Heckman MS[b], Nancy N. Dieh
Tara Creech RN[c], Darlene Carey RN, MSN[c], Robert Domnick BS[d],
Walter C. Hellinger MD[a,*]

Major Article

Development and validation of an automated ventilator-associated event electronic surveillance system: A report of a successful implementation

Courtney Hebert MD, MS [a,b,*], Jennifer Flaherty RN, MPH, CIC [c]
Justin Smyer MLS (ASCP)CM, MPH, CIC [d], Jing Ding PhD [e]
ngino MD [b,c]

Electronic Implementation of a Novel Surveillance Paradigm for Ventilator-associated Events

Feasibility and Validation

Peter M. C. Klein Klouwenberg[1,2,3*], Maaike S. M. van Mourik[1*], David S. Y. Ong[1,2,3], Janneke H
Marcus J. Schultz[4], Olaf L. Cremer[2], and Marc J. M. Bonten[1,3]; on behalf of the MARS C

Building and Validating a Computerized Algorithm for Surveillance of Ventilator-Associated Events

[1,6] Joseph Ellsworth, BSHA;[2] Najia Huda, MD;[3] Anupama Neelakanta, MD, MPH;[4] Thomas Chevalier, BSN, CIC;[2]
Sims, MPH, CIC;[5] Sorabh Dhar, MD;[6] Mary E. Robinson, BSBA;[2] Keith S. Kaye, MD, MPH[6]

Development, Implementation and Use of Electronic Surveillance for Ventilator-Associated Events (VAE) in Adults

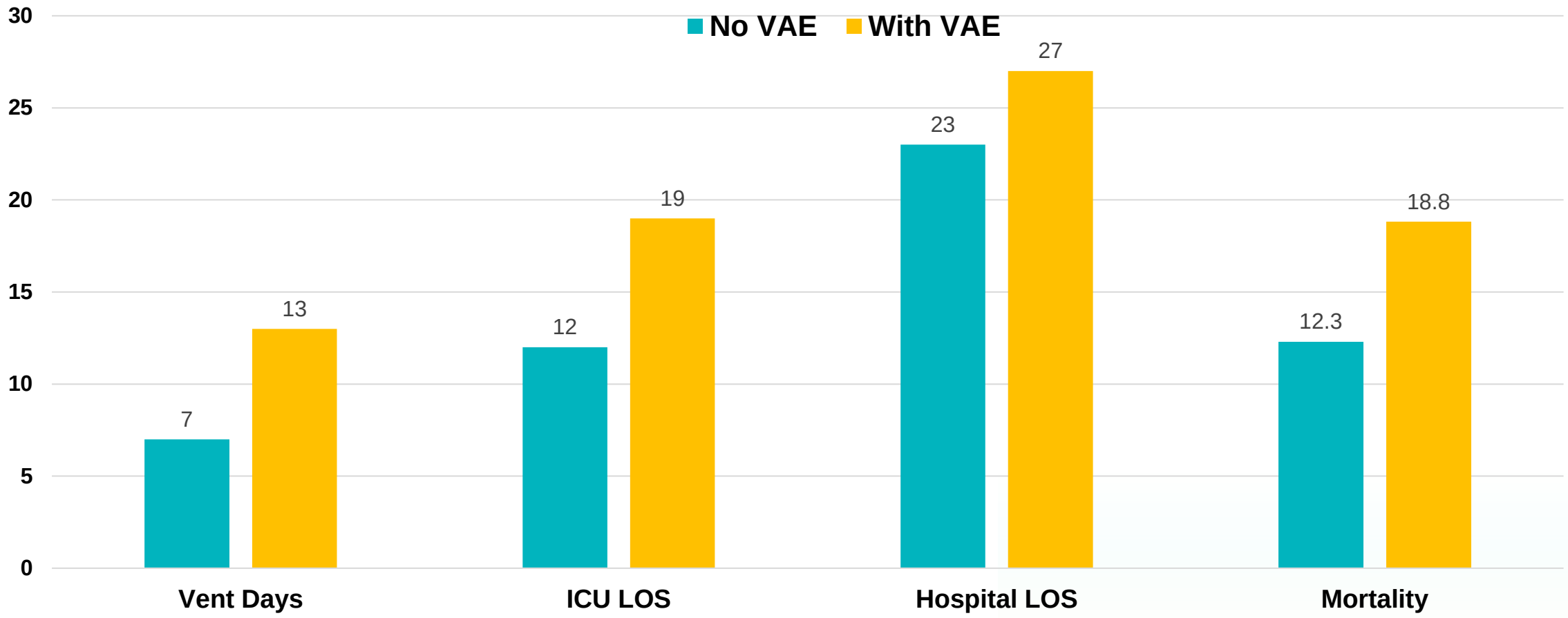
Ervina Resetar, MIM, PMP[1,3], Kathleen M. McMullen, MPH, CIC[2], Anthony J. Rus
MPH[2], Joshua A. Doherty, BS[3], Kathleen A. Gase, MPH, CIC[3], Keith F. Woeltje, MD,

An automated retrospective VAE-surveillance tool for future quality improvement studies

Oliver Wolffers[1,2✉], Martin Faltys[3], Janos Thomann[1], Stephan M. Jakob[3], Jonas Marschall[1],
Tobias M. Merz[3,4] & Rami Sommerstein[1,5✉]

VAE Associated with Poor Outcomes

Propensity matched analysis of 1803 VAEs vs 2,319 patients without VAEs, West China Hospital, 2015-2018*



*Variables in propensity score included age, APACHE II, comorbidities, pneumonia, organ failure, surgery, transfusions, immunosuppressives, central lines, IMV after ICU admission

Zhu, *Infect Control Hospital Epidemiol* 2022;1:48-55

VAE Associated with Poor Outcomes

- **Meta-analysis**
  - 18 studies
  - 61,489 patients

VAE Patients

2x

More Likely to Die
Compared to Non-VAE Patients

VAE

1.5x

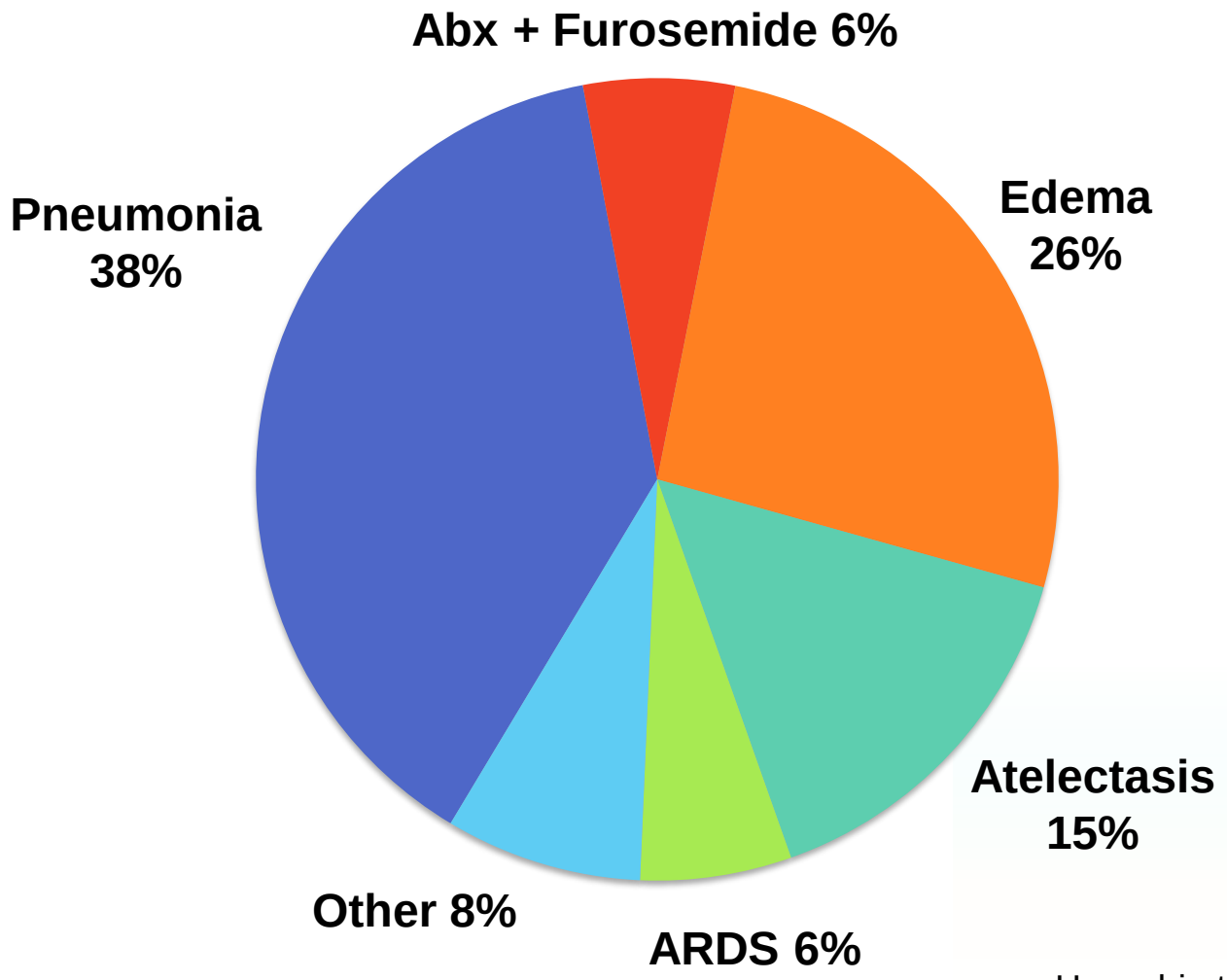
More Deadly
than VAP

Fan, *Crit Care* 2016;20:338


VAE ≠ VAP

Qualitative analysis of 153 VAEs

Royal Brisbane & Women's Hospital, Queensland, Australia

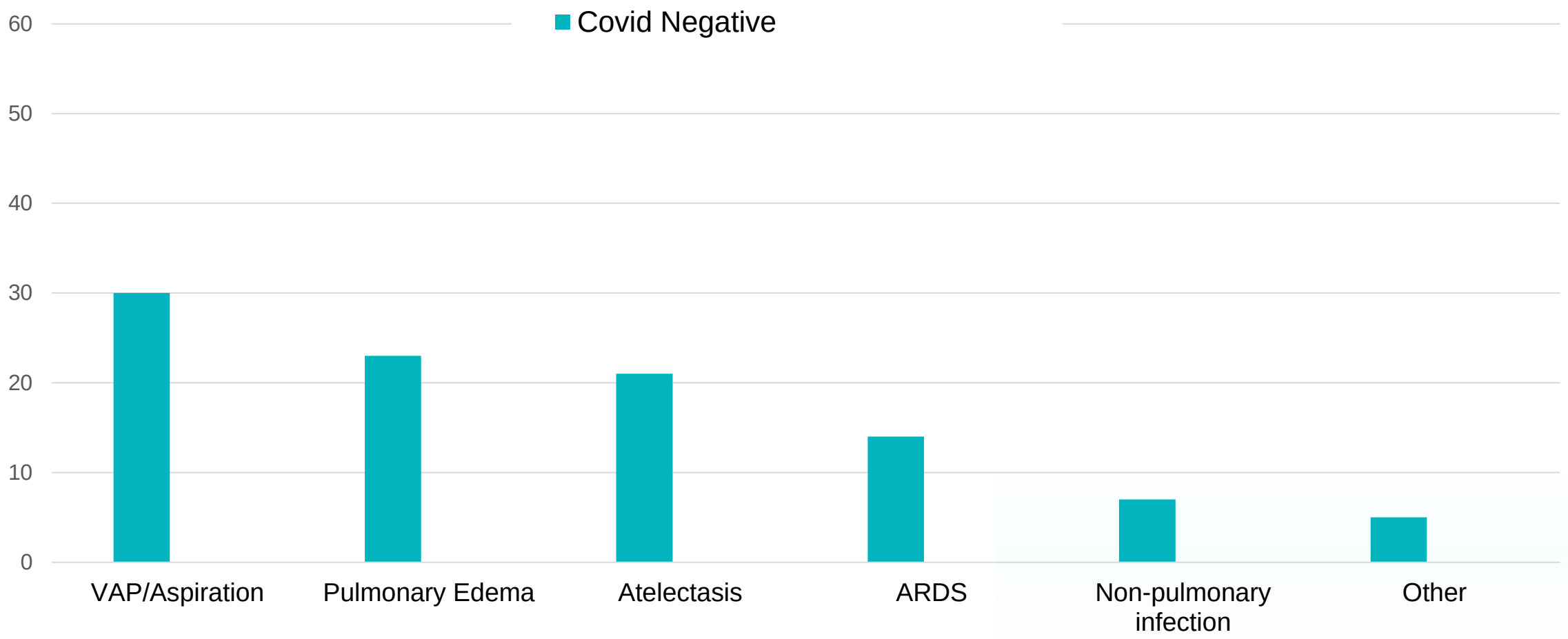


Hayashi et al. *Clin Infect Dis* 2013;56:471-477

VAE = VAP +
Fluid +
ARDS +
Atelectasis

Impact of Covid on VAE

Clinical events leading to VAE in 200 randomly selected VAEs (½ with Covid, ½ without), March-Aug 2020, Mass General Brigham Hospitals



Weinberger, *Annals ATS* 2022;19:82-89

Impact of Covid on VAE

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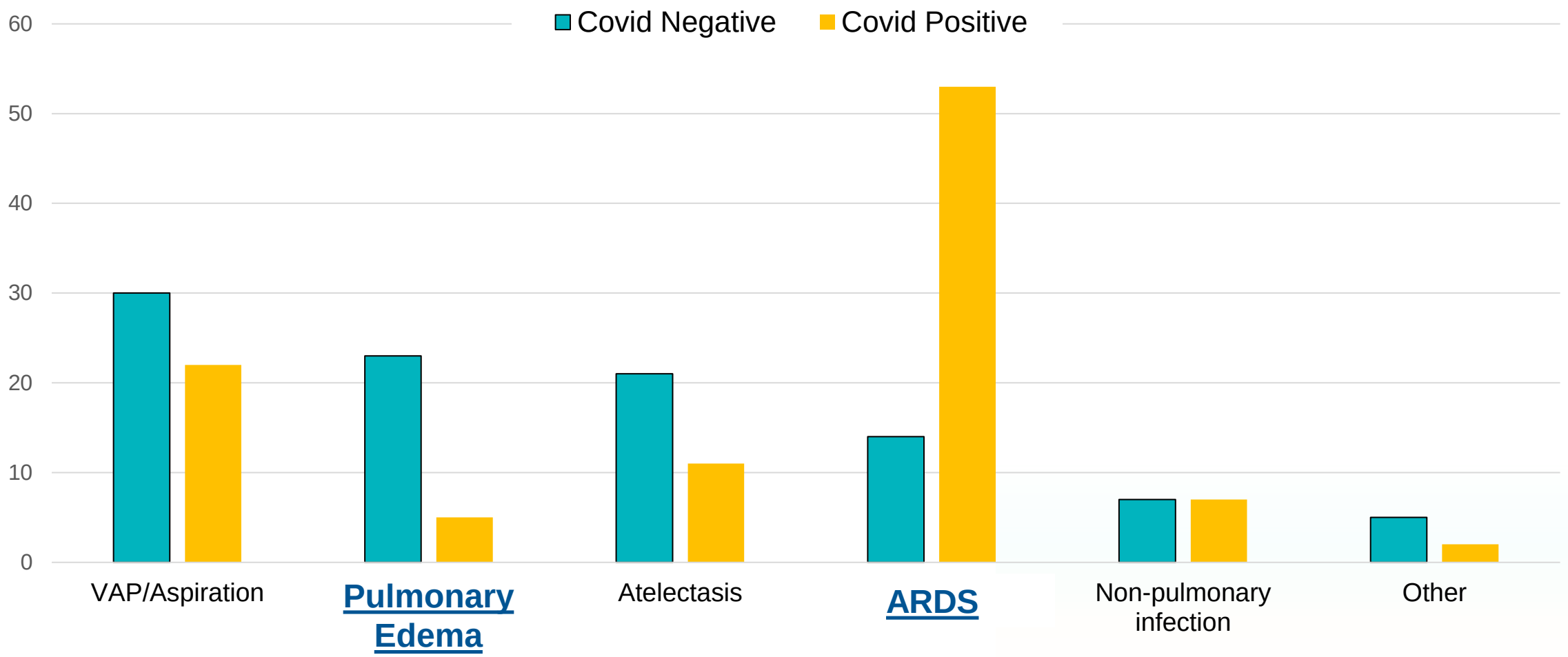
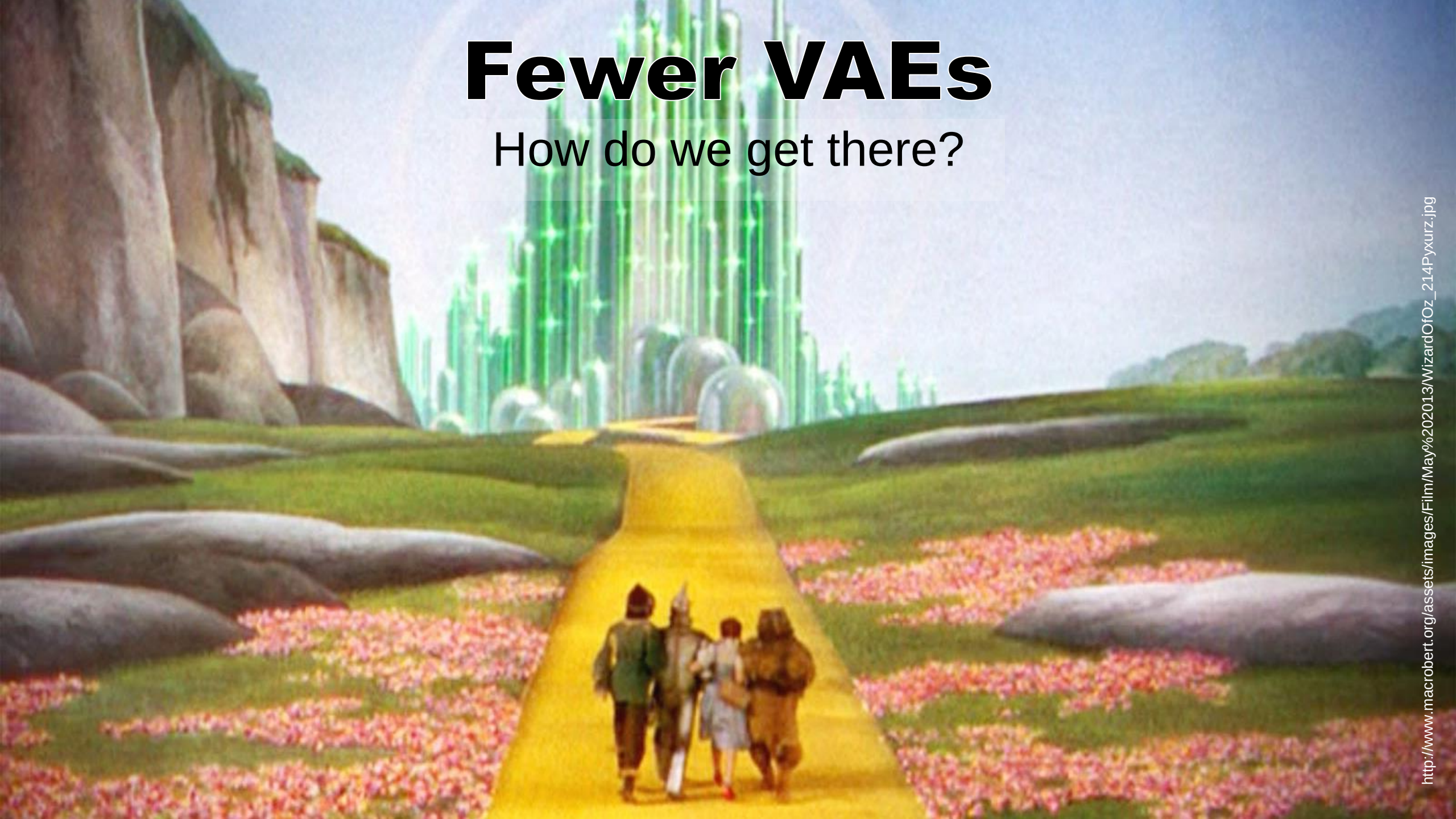


Weinberger, *Annals ATS* 2022;19:82-89

Fewer VAEs

How do we get there?



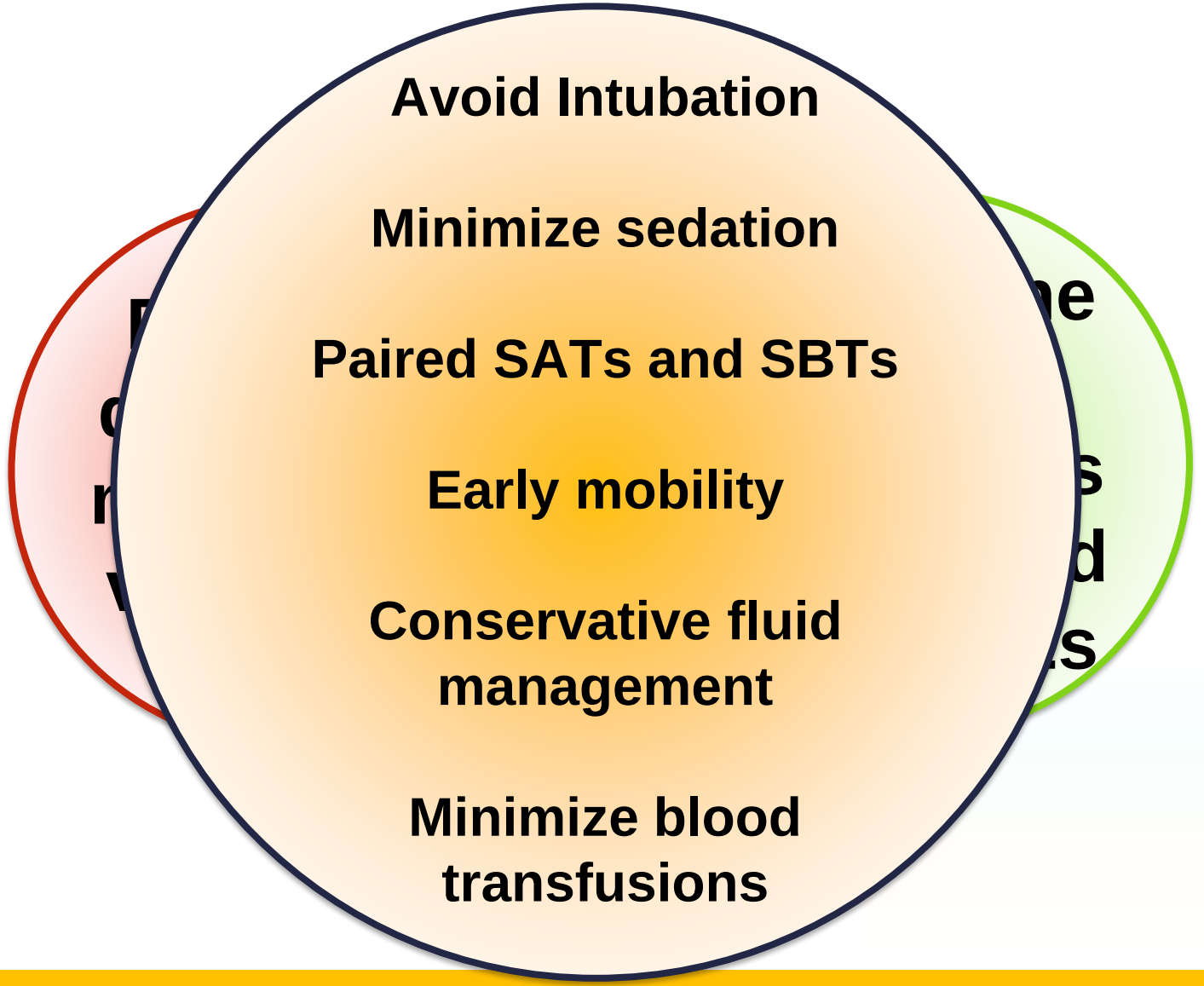
http://www.macrobert.org/assets/images/Film/May%202013/WizardOfOz_214Pyxurz.jpg

Strategies for Preventing VAEs

Decrease duration of mechanical ventilation

Target the primary conditions associated with VAEs

Strategies for Preventing VAEs



VAE Prevention Strategies

Well aligned with other best practice initiatives

	ABCDEF	Choosing Wisely	PAD Guidelines	Surviving Sepsis	Strategies to Prevent VAP
Minimize sedation	✓	✓	✓	✓	✓
Paired SATs and SBTs	✓	✓	✓	✓	✓
Early Mobility	✓		✓	✓	✓
Conservative fluid management				✓	
Conservative transfusion thresholds		✓		✓	

Ventilator Bundle Compliance and VAEs

Retrospective analysis of 5,539 patients on mechanical ventilation

adjusted for comorbidities, severity of illness, contraindications, etc.

Spontaneous breathing trials

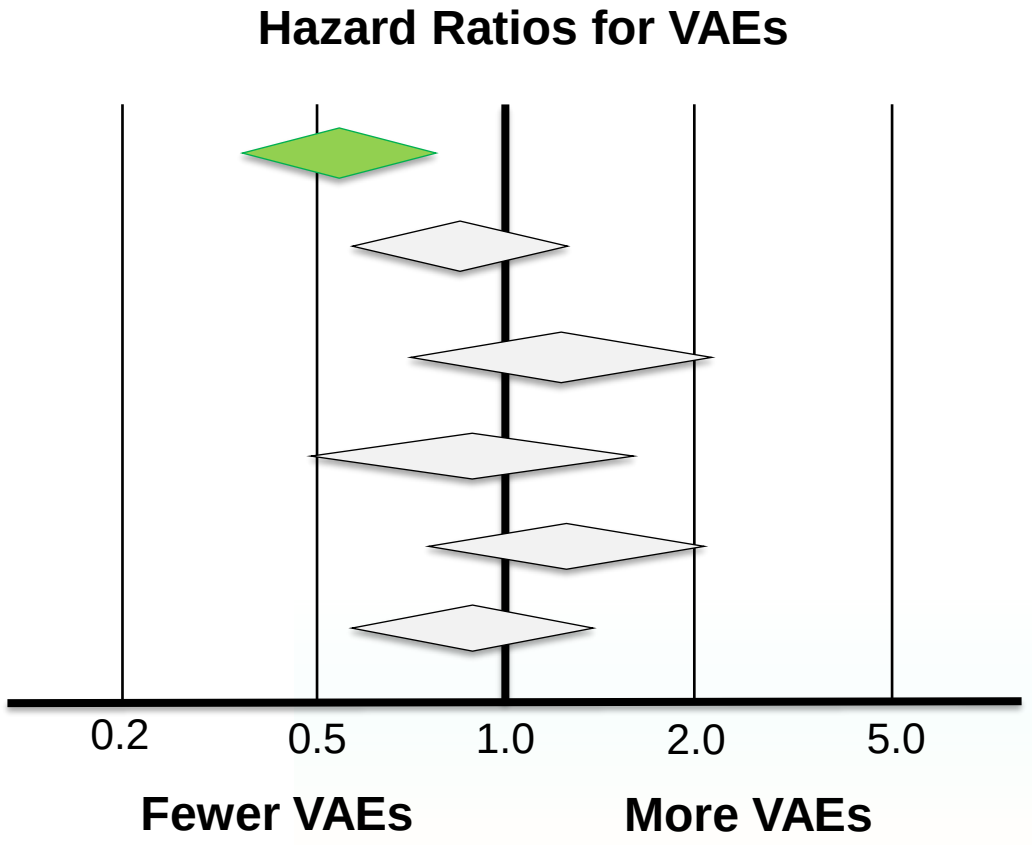
Spontaneous awakening trials

Head of bed elevation

Thromboprophylaxis

Stress ulcer prophylaxis

Oral care with chlorhexidine



JAMA Internal Med 2016;176:1277-1283

Ventilator Bundle Compliance and Death

Retrospective analysis of 5,539 patients on mechanical ventilation

adjusted for comorbidities, severity of illness, contraindications, etc.

Spontaneous breathing trials

Spontaneous awakening trials

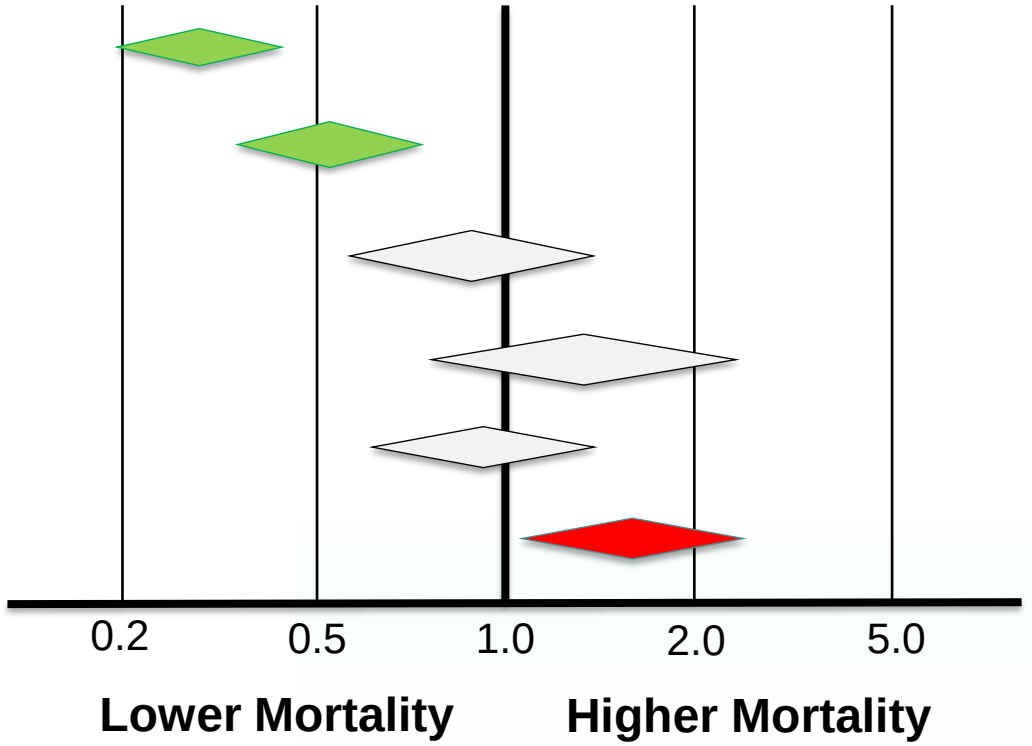
Head of bed elevation

Thromboprophylaxis

Stress ulcer prophylaxis

Oral care with chlorhexidine

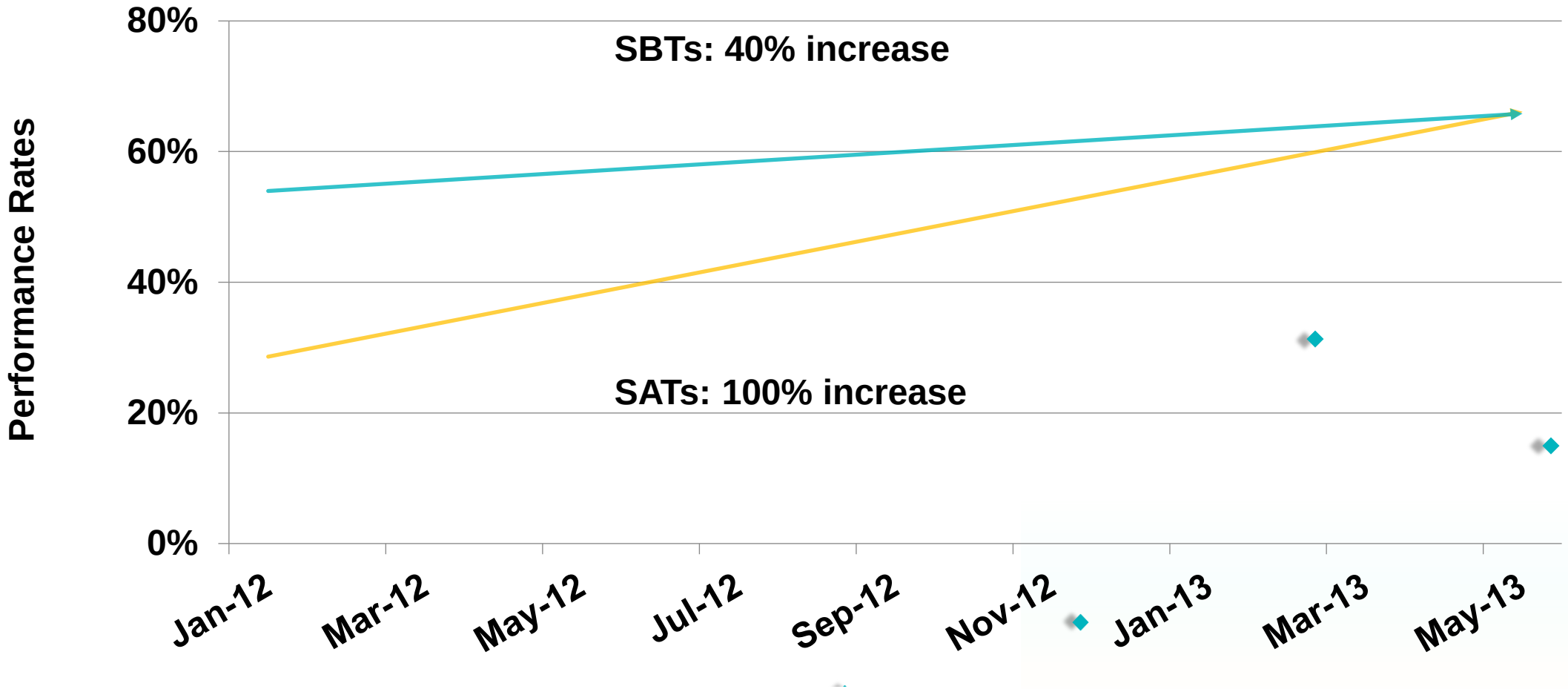
Hazard Ratios for Ventilator Death



JAMA Internal Med 2016;176:1277-1283

SATs and SBTs Lower VAE Rates

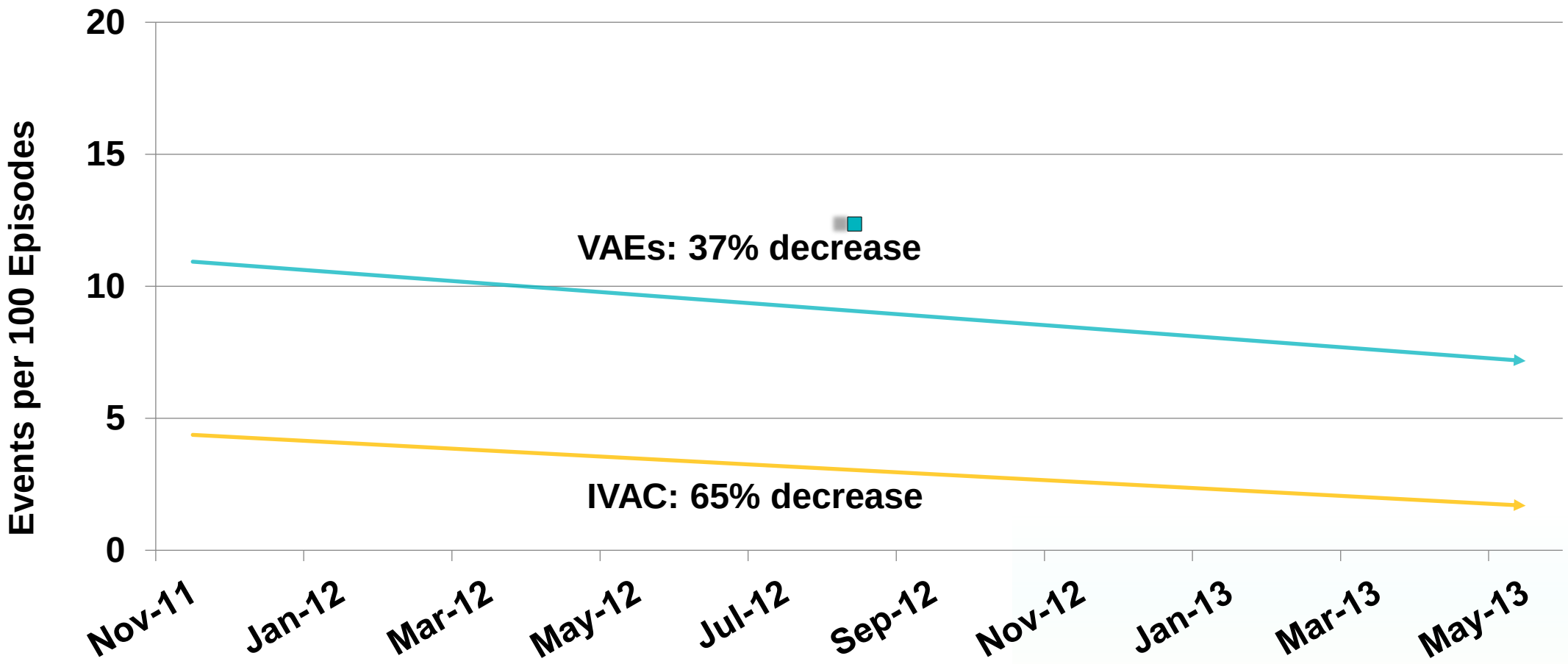
CDC Prevention Epicenters care improvement collaborative, 12 ICUs, 5164 patients, 2011-2013



Am J Resp Crit Care Med 2015;191:292-301

Ventilator-Associated Events

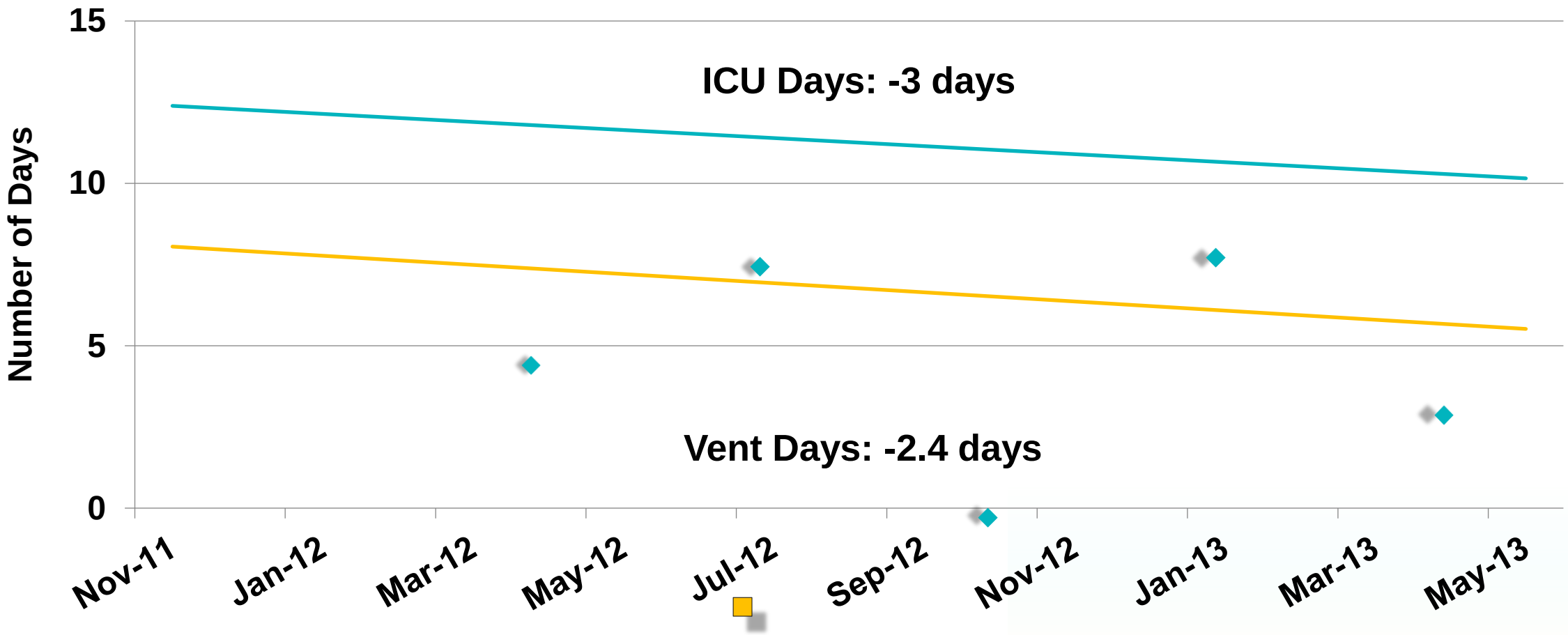
CDC Prevention Epicenters care improvement collaborative, 12 ICUs, 5164 patients, 2011-2013



Am J Resp Crit Care Med 2015;191:292-301

Ventilator Days and ICU Days

CDC Prevention Epicenters care improvement collaborative, 12 ICUs, 5164 patients, 2011-2013

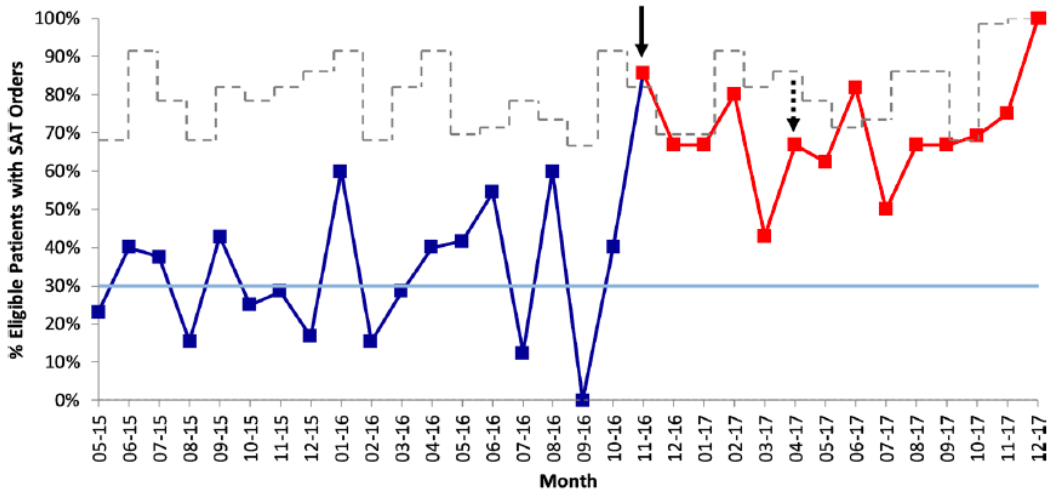


Am J Resp Crit Care Med 2015;191:292-301

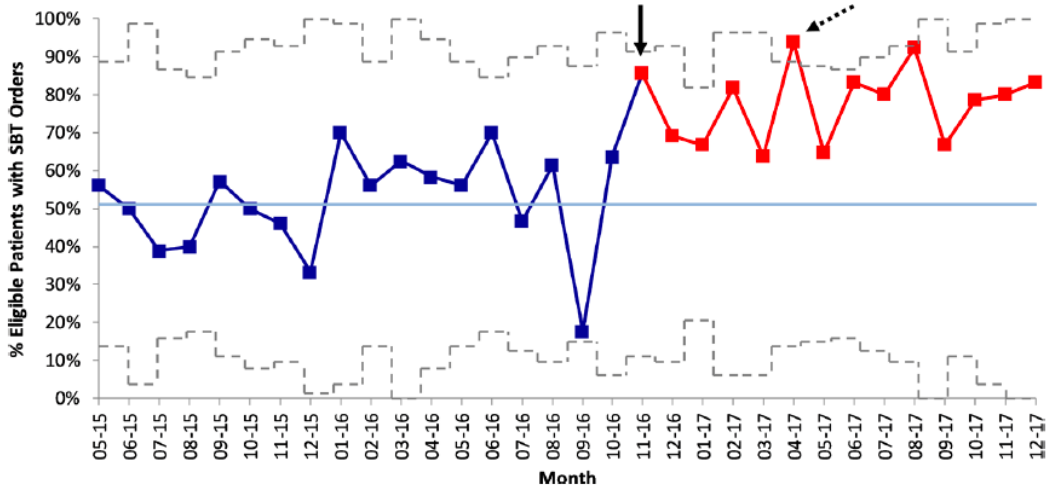
Increase in SATs & SBTs associated with Fewer VAEs

Quality improvement initiative, Veterans Affairs Greater Los Angeles, 2015-2017

Spontaneous Awakening Trials



Spontaneous Breathing Trials



Chumpia, *BMJ Open Quality* 2019;8:e000426

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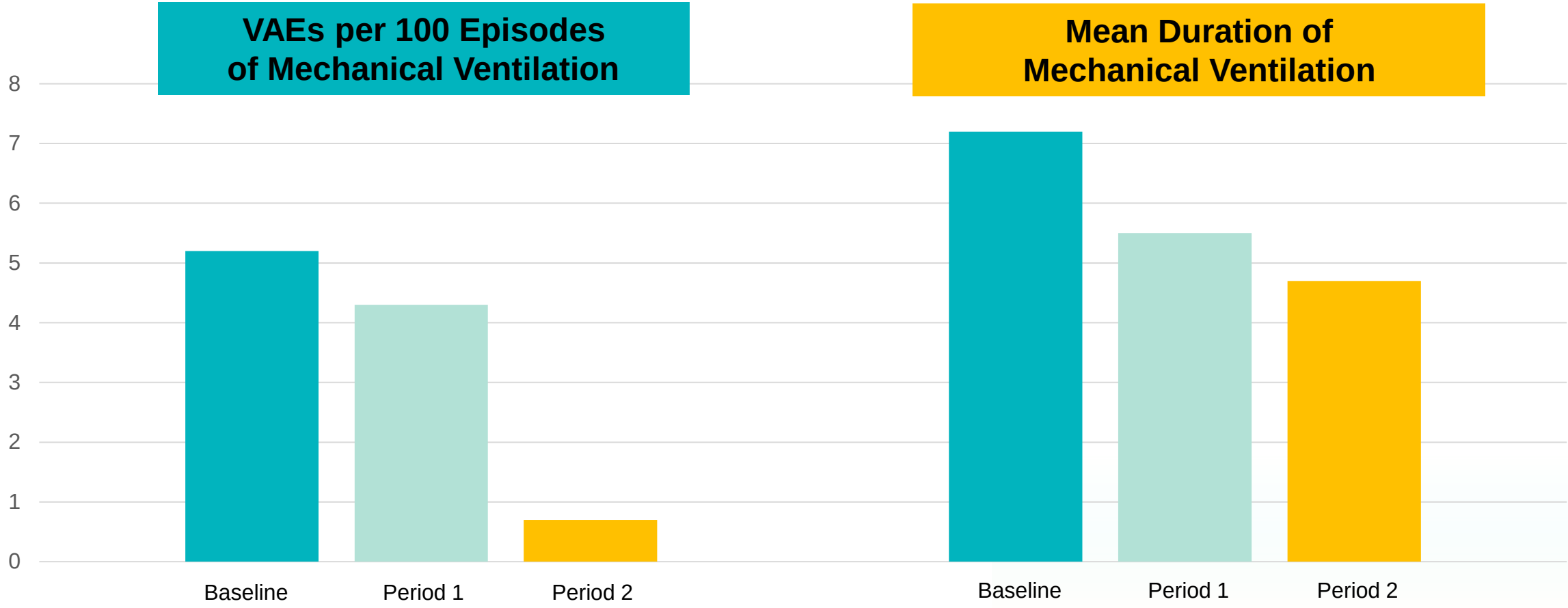


Chumpia, *BMJ Open Quality* 2019;8:e000426

Bedside Prompts on SATs, SBTs, and Impending VAEs

Population Summary (fake data)

All Markers

Missed SBT
3 patients

Late SAT
2 patients

Missed SAT
1 patient

Short SAT
1 patient

Long SAT
1 patient

SAT w/o Titration
1 patient

Eckland, Erin **(71 F)**
ICU A RM 01 BD 01 Visit **V67960**
Number of Active Markers: 5

SAT Occurred Outside the Configured Protocol Period	03/13/15	10:19
Set Ve high alarm limit is non-compliant with operational	03/13/15	06:48

Underhurst, Uw
ICU A RM 01 BD 0
Number of Active Ma
SAT Duration Great
Maximum Configure
Increased Sedation

Odelfield, Octavian **(85 M)**
ICU A RM 02 BD 04 Visit **V67980**
Number of Active Markers: 1

Patient is Trending Toward a VAE Event - Day 1	03/13/15	00:00

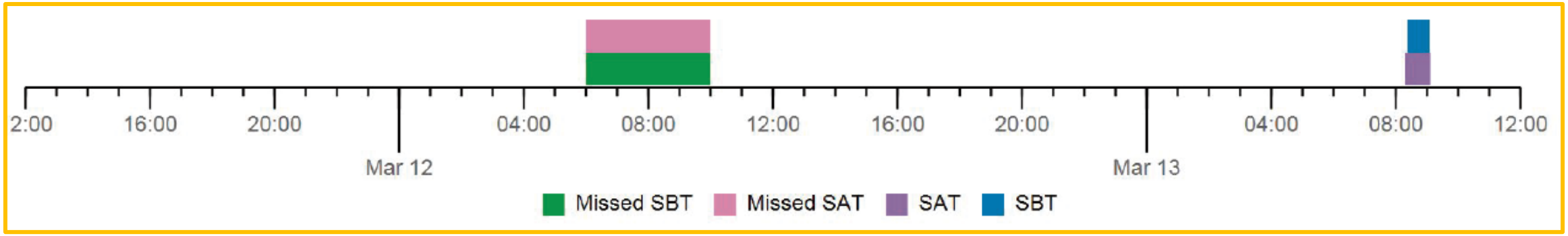
Tamarack, Tim
ICU A RM 04 BD 1
Number of Active Ma
Increased Sedation
Set Ve high alarm li
compliant with oper
policy

Impending VAEs

VAE Surveillance

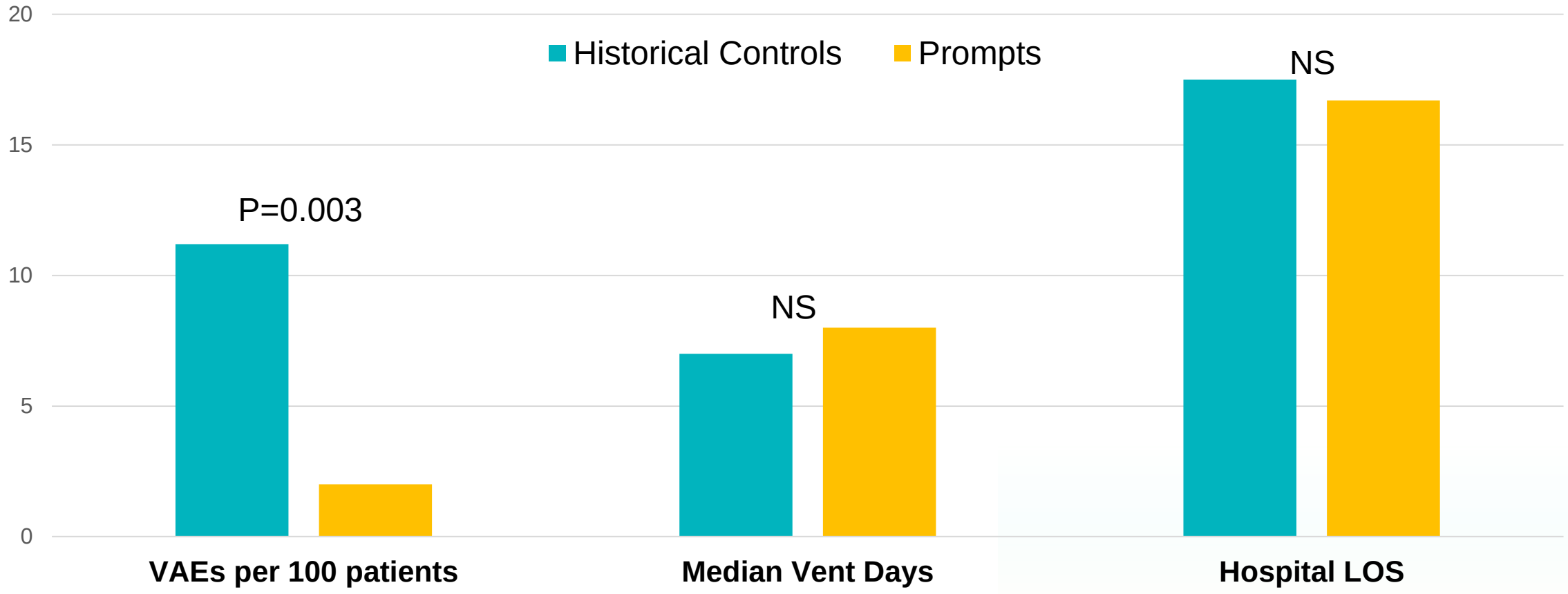
Patient		03/11/15	03/12/15	03/13/15
Smith, James 5 days on vent	FiO2	→	↑	↗
	PEEP	→	↗	↗
Townsley, Peter 7 days on vent	FiO2	→	↑	→
	PEEP	aprv	aprv	aprv
Adams, Roger 3 days on vent	FiO2	→	→	→
	PEEP	→	→	↑
Sanders, Henry 9 days on vent	FiO2	↗	↗	→
	PEEP	→	→	↑

Missed SAT or SBT



Bedside Prompts on SATs, SBTs, and Impending VAEs

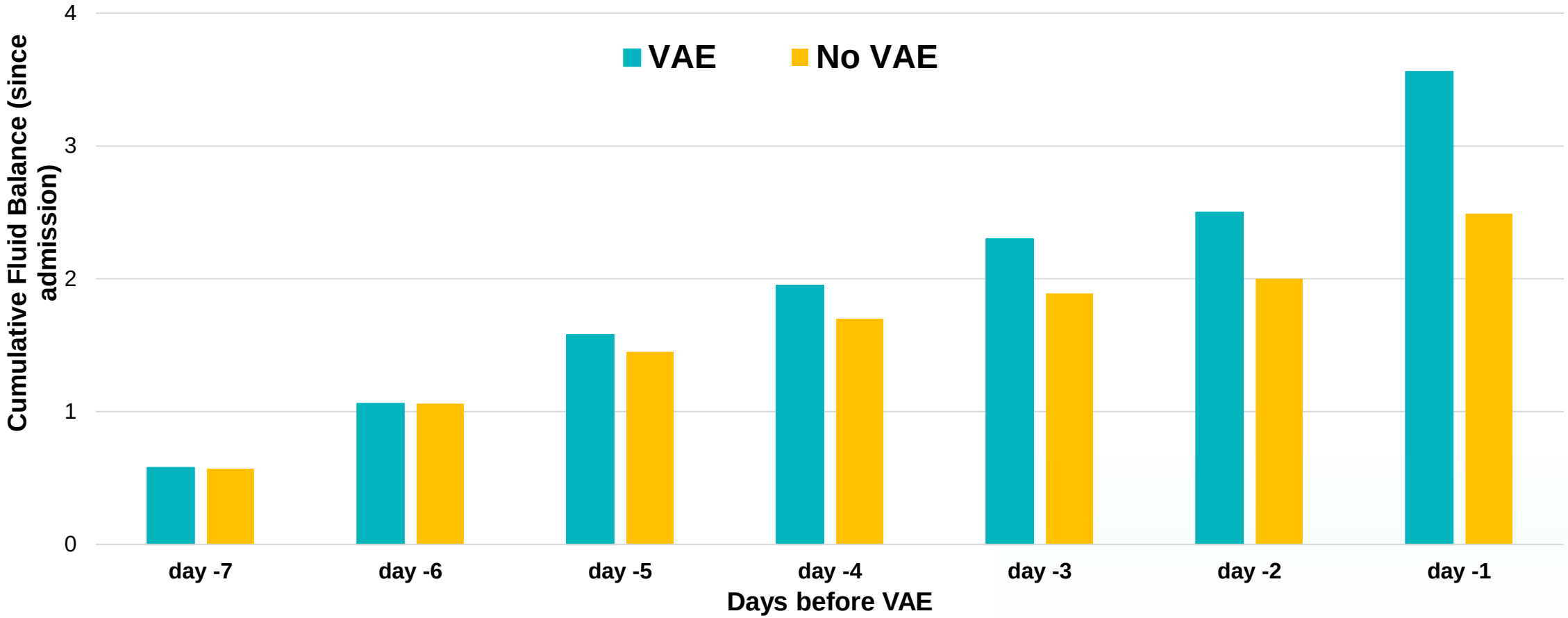
Retrospective evaluation of use of bedside electronic rounding tool with SAT, SBT, and impending VAE prompts on outcomes amongst 150 intervention patients vs 187 historical control patients



Oglesby, *Critical Care Explorations* 2021;3(4):e0379

Strong Association between Fluid Balance and VAEs

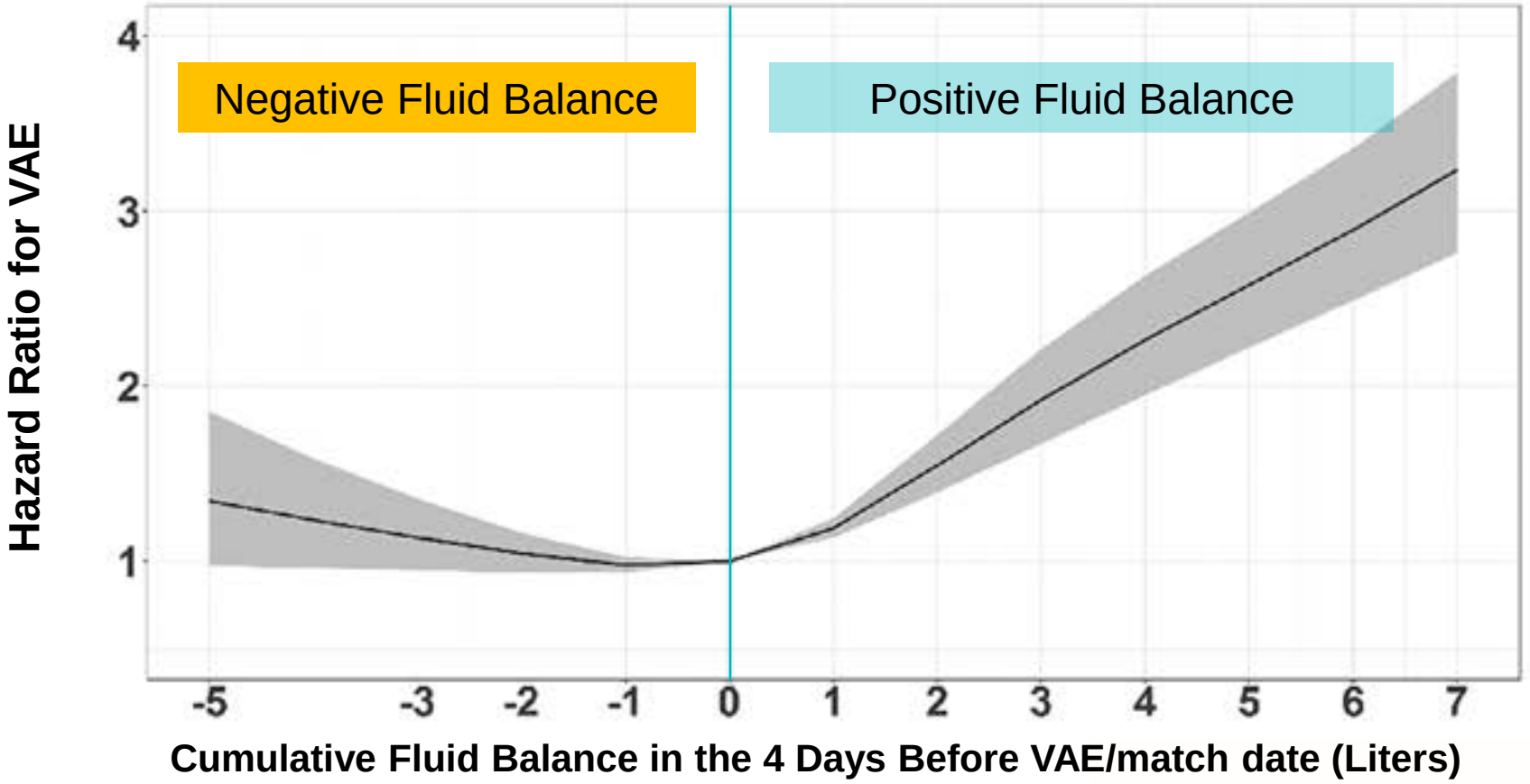
Cumulative fluid balance amongst 1,528 VAE patients matched to 3,038 non-VAE patients on basis of age, time to VAE, and time from ICU admission until initiation of mechanical ventilation, West China Hospital, 2015-2018.



Wang, *Critical Care Medicine* 2022;50:307-316

Strong Association between Fluid Balance and VAEs

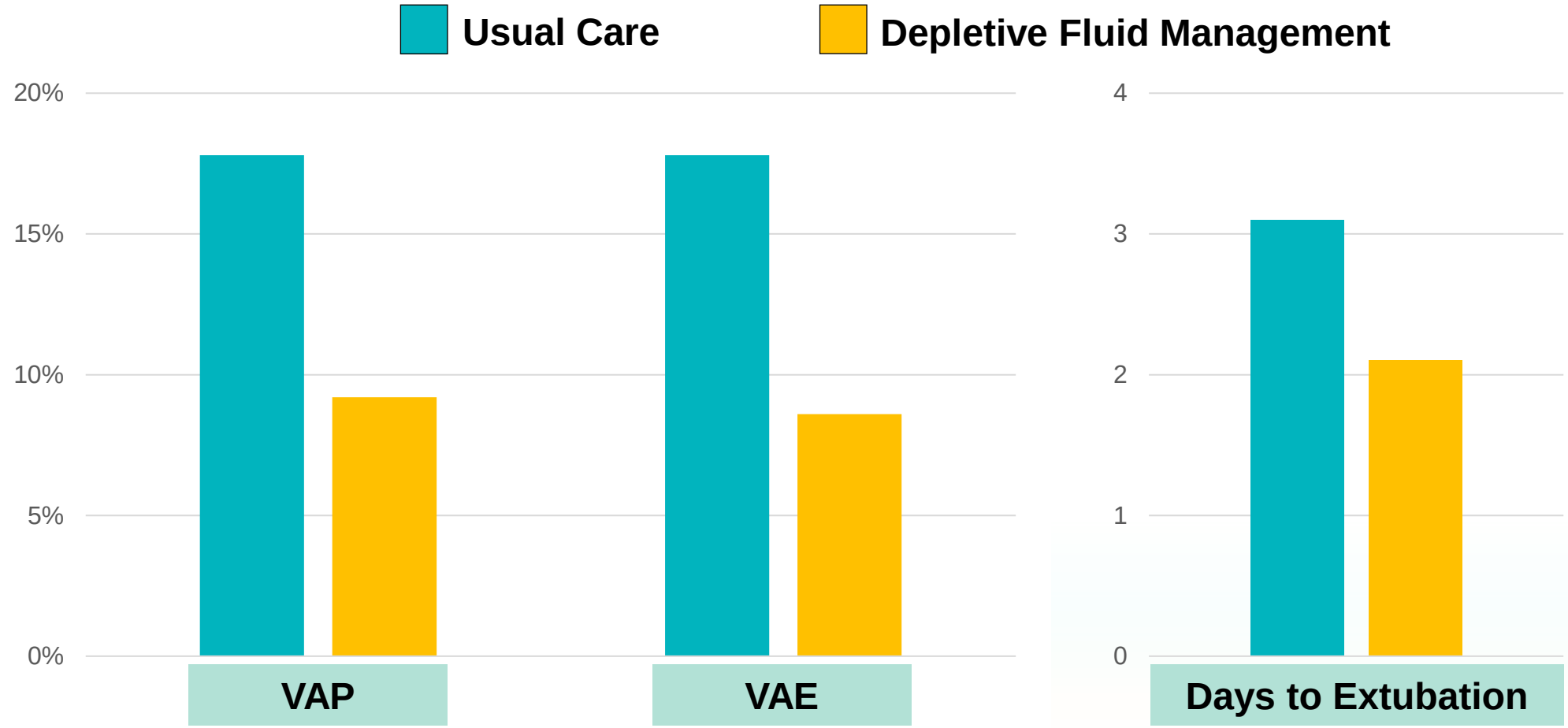
Cumulative fluid balance amongst 1,528 VAE patients matched to 3,038 non-VAE patients on basis of age, time to VAE, and time from ICU admission until initiation of mechanical ventilation, West China Hospital, 2015-2018.
Adjusted for demographics, ICU type, comorbidities, ICU diagnosis, APACHE II, meds, procedures, and others.



Wang, *Crit Care Med* 2022;50:307-316

Depletive Fluid Management Lowers VAE Rates

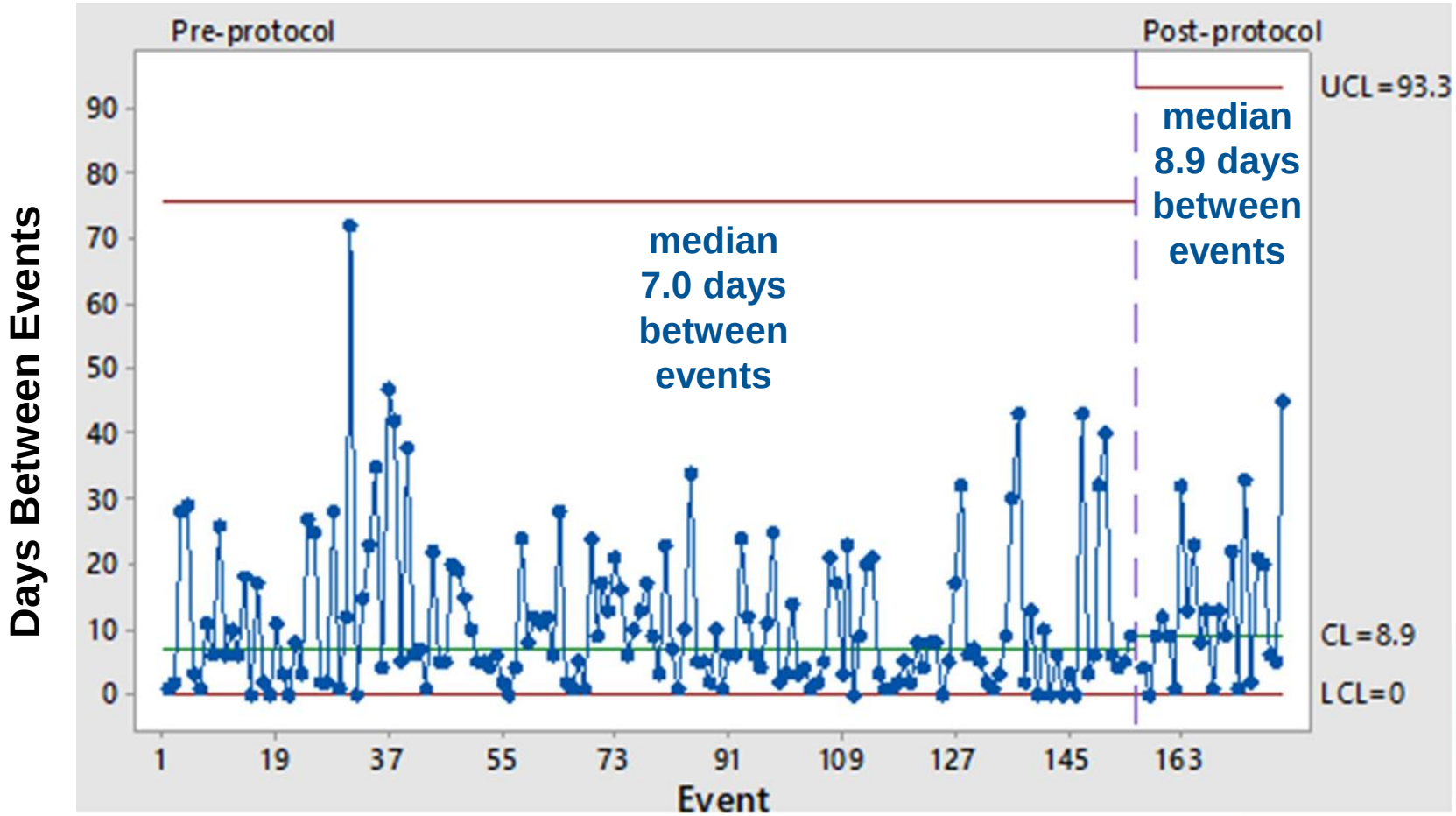
Randomized controlled trial of depletive fluid management during ventilator weaning (smaller volume infusions, more diuresis), N=304



Chest 2014;146:58-65

Change Default PEEP from 5 to 8cm H_2O

Retrospective analysis of change in starting PEEP from 5 to 8cm H_2O, University of Toledo, 2014-2019



VAC Rates Before

7.1

per 1000 vent-days

VAC Rates After

4.4*

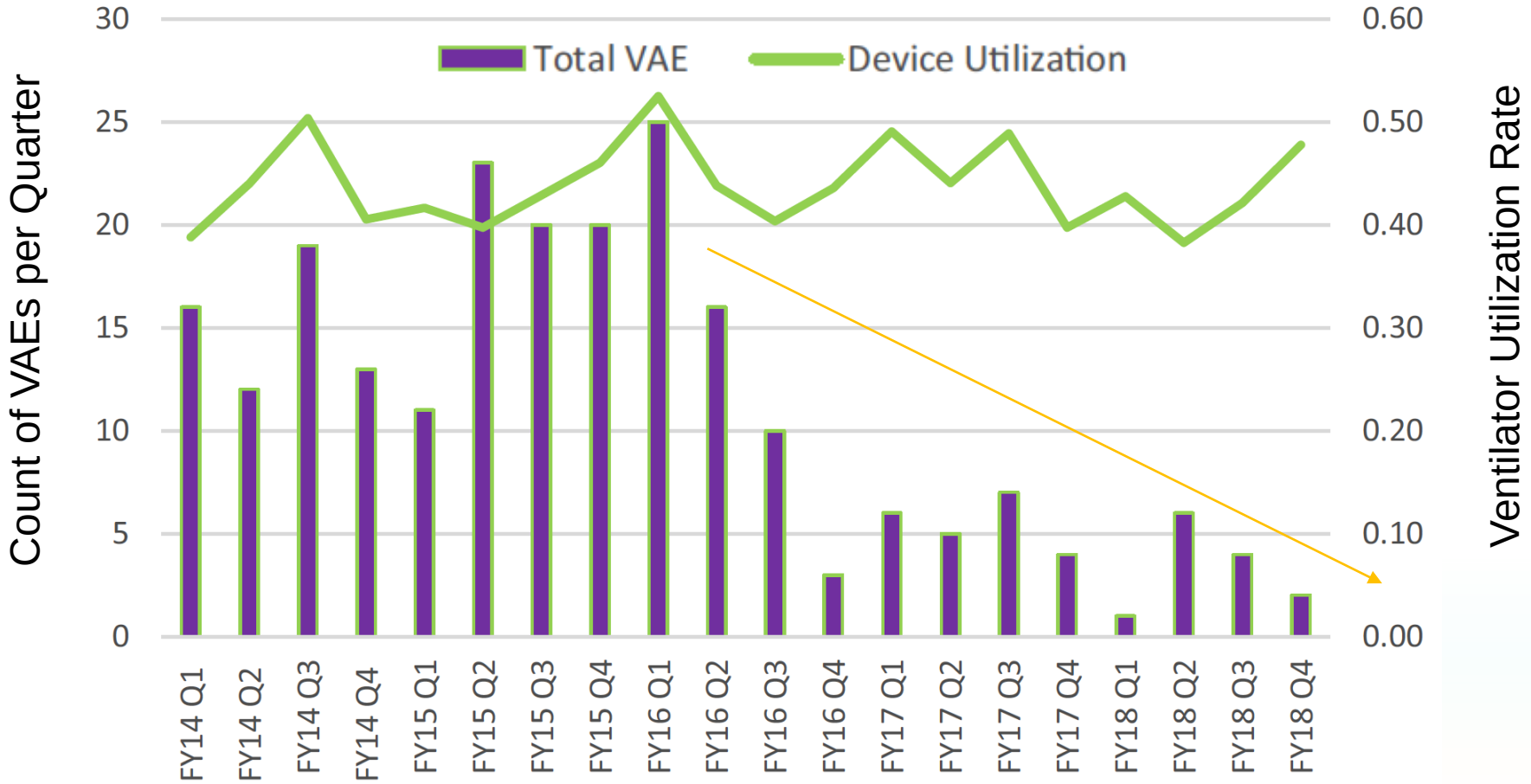
per 1000 vent-days

** non-significant*

Barnett, *Frontiers in Medicine* 2021;8:744651

Change Default PEEP from 5 to 6cm H_2O

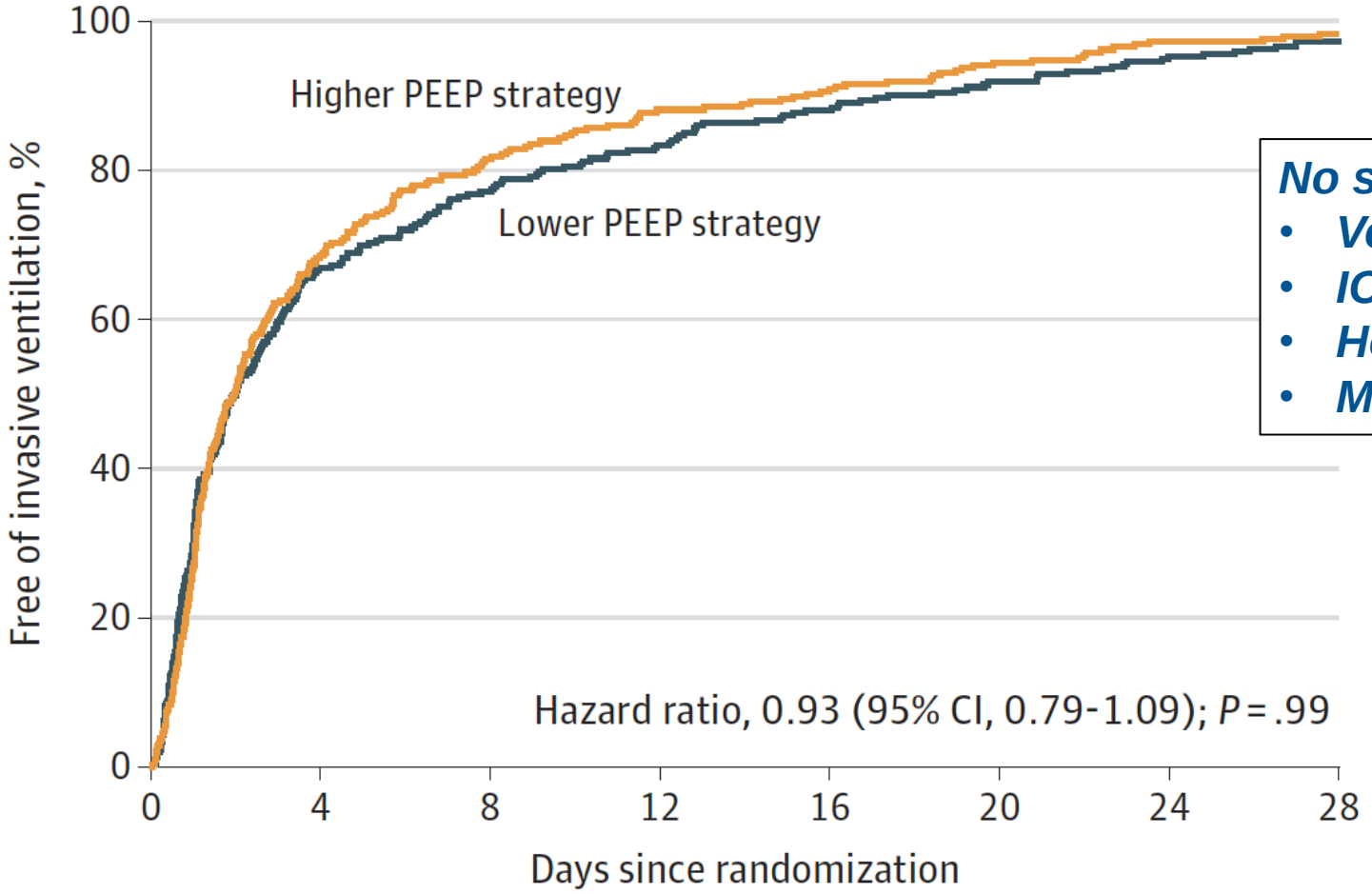
Serial implementation of readiness to wean protocols, change in default PEEP from 5 to 6, increased emphasis on mobilizing patients, root cause analyses on all VAEs, 2015-2018, Saint Francis Hospital, CT



Seaver, *Am J Infect Control* 2020;48:828-30

Is there any benefit associated with higher vs lower default PEEP?

980 ICU patients <u>without</u> ARDS randomized to PEEP 0-5cm H2O vs 8cm H2O, 8 hospitals, Netherlands



No significant differences in:

- ***Ventilator-free days***
- ***ICU length-of-stay***
- ***Hospital length-of-stay***
- ***Mortality***

RELAx Collaborative, JAMA. 2020;324:2509-2520

What about PedVAE?

Multicenter Quality Improvement Initiative

Members of the Children's Hospital Solutions for Patient Safety network created a PedVAE reporting and quality improvement bundle. Uptake varied across the network. Outcomes compared in adopters vs non-adopters.

Multidisciplinary Apparent Cause Analyses	Daily Discussion of Extubation Readiness	Daily Discussion of Fluid Balance Goals

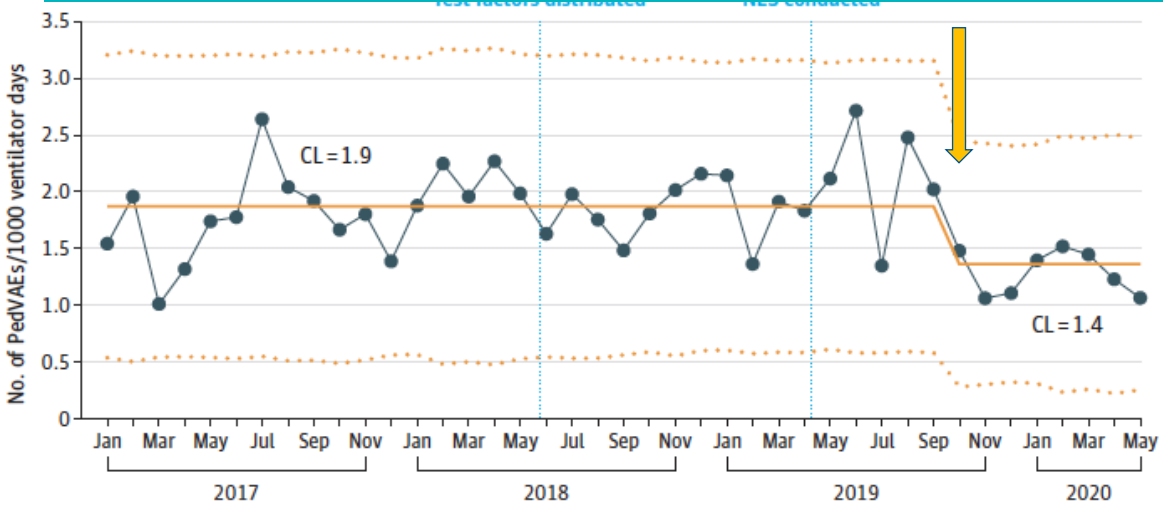
• Multidisciplinary ACA event form completed for each PedVAE
• ACA used to inform Pareto charts of institution-specific causes of PedVAE to identify areas for improvement
	• Discussion included:
	  • Necessity for ETT
	  • Target extubation time
	  • Respiratory support plan
	  • Pre-extubation sedation, or analgesics, or restraints
	  • Post-extubation sedation or analgesic plan
	  • Scheduled re-evaluation time
		• Discussion of patient-specific fluid balance goals
		• Documentation of fluid balance goal at least daily

Wu, *JAMA Network Open* 2023;6(12):e2346545

Multicenter Quality Improvement Initiative

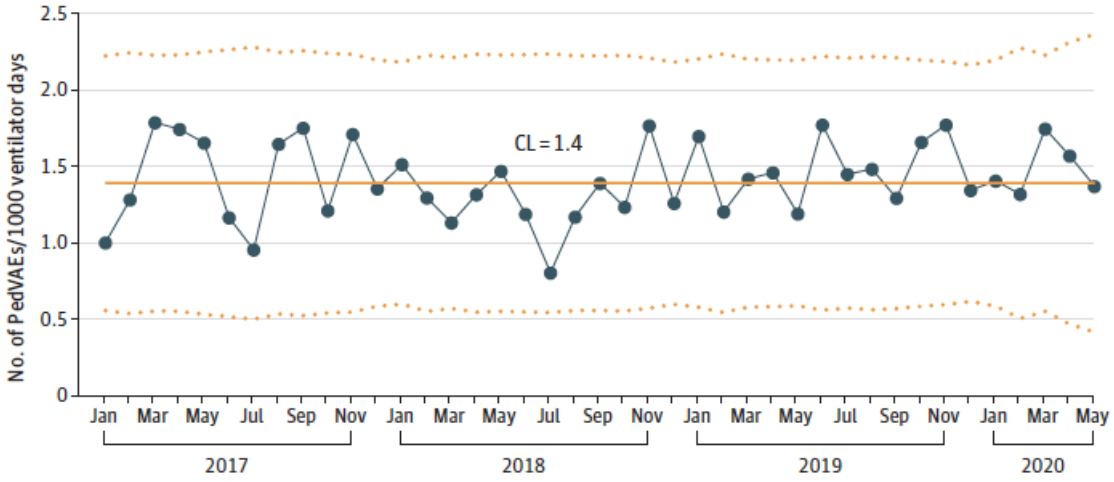
Members of the Children's Hospital Solutions for Patient Safety network created a PedVAE reporting and quality improvement bundle. Uptake varied. Outcomes compared in 12 adopting vs 33 non-adopting hospitals.

Adopters of ≥1 Bundle Component



26% drop in PedVAE rates from 1.9 to 1.4 events per 1000 ventilator-days

Bundle Non-Adopters



No change in PedVAE rates

Wu, *JAMA Network Open* 2023;6(12):e2346545

Ventilator-associated events

A patient safety opportunity

- **Broaden Awareness**
  - Provides hospitals with a fuller picture of serious complications in mechanically ventilated patients
- **Catalyze Prevention**
  - A significant portion of VAEs are preventable through well-accepted best practices in critical care
- **Reflect and Inform Progress**
  - VAE surveillance provides an efficient and objective yardstick to measure and benchmark progress

NEJM 2013;368:1472

Summary

- VAP is a **poor metric for benchmarking** and quality improvement
  - Diagnosis subjective and inaccurate
  - High interobserver variability
  - Poor guide to selecting prevention practices that will improve patient outcomes

- CDC created **ventilator-associated event definitions** to enhance objectivity, automation, and expand prevention efforts
  - Suitable for automated surveillance

- Strategy to lower VAE rates and improve outcomes is to **reduce ventilator days & prevent the primary conditions associated with VAEs** (pneumonia, ARDS, atelectasis, fluid overload)
  - Avoid intubation
  - Minimize sedation
  - Paired daily SATs and SBTs
  - Early mobility
  - Conservative fluid management
  - Minimize blood transfusions

Thank You!

mklompas@bwh.harvard.edu