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Are we asking right questions? Mode of Intensivist model delivery and Patient Cost

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Are we asking right questions ?
Mode of Intensivist model delivery and Patient Cost

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Disclosure

No conflict of interest to disclose

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Background

Leapfrog group's standard of critical care recommended 24/7 coverage of a board certified intensivist in all ICUs (Leapfrog Factsheet: ICU physician staffing)

Adding of Intensivist providing critical care by Telemedicine- Tele critical care will satisfy the guideline recommended by the leapfrog group.

In 2015, Leapfrog's Hospital survey of 1750 US hospital which account for 60% of inpatient beds nationwide , reported only 47% of hospitals have implemented the ICU physician staffing model

In, 2015, American Hospital Association Annual Survey suggests of all acute care hospitals (2814) only 50% had intensivists., however 75% of ICU bed had intensivist coverage. (Crit Care Med. 2019;47(4):517-525)

Problem is Multifaceted:

- ICU expenditure steadily rising with as population continue to age (Crit Care Med. 2019;47(8):1011-1017)
- Harmful bonus & Penalty Schemes: Pay for performance has led to increased ICU volume by Low risk patients (*Ann Intern Med.* 2018;168(4):255-265., Cochrane Database of Systematic Reviews 2011, 9(CD008451).
- Medicare reimbursement falls short of care delivery cost
- Low compliance Hospital administration
- Shortage of Critical care intensivist (Crit Care Med. 2013;41(12):2754–2761)

Gap

Current literature comparing patient outcomes with

- Intensivist with no intensivist (*JAMA*. 2002;288(17):2151–2162) (*Crit Care Med*. 2013;41(10):2253–2274)
- Intensivist with other specialist like hospitalists (J. Hosp. Med. 2012 March;7(3):183-189)
- Daytime versus Nighttime intensivist(N Engl J Med 2012; 367(10):971–972),(Crit Care Med. 2015 43(11):2275-82) (N Engl J Med. 2013;368(23):2201–2209)
- Alternative to Intensivist in different type of ICU(open versus closed) (Curr Opin in Anaes 2019 32(2):123–128

Role of Tele-ICU

- Evidence of consistent quality and efficiency outcomes (Crit Care Med. 2016 Feb;44(2):265-74)
- Lowering the cost of patient care (Mil Med. 2017;182(5):e1702-e1707)
- Tele-ICU beds account for 11% of total ICU beds in US (Arch Intern Med 2011; 171:498-506)

Currently there are no outcomes research on critical care provided by 24/7 Bedside Intensivist versus Tele-Intensivist.

Objective of the study

To compare 24/7 Bedside Intensivist versus Tele-Intensivist critical care delivery models and examine the difference in COST using conventional and innovative statistical methods.

Study Setting

12 ICUs from 5 hospitals were selected from a non teaching, not for profit, health system in south Florida from Oct 2016- June 2019

Study Design

Retrospective Cohort design using Health System's EHR data between Oct 2016-June 2019

Dependent Variable: Cost defined in 3 categories: total Cost/Case, Fixed Cost, Variable cost

Independent Variable:
Model A: Intervention Group: presence of 24/7 Bedside Intensivist with standard of care universal to health system ICU Tele-Critical Care intensivist model

Model B: Only standard of care – Tele intensivist model of delivery.

Prognostic Risk score: used APACHE IVa
Covariates: Case Mix index, APACHEIVaAdmitting diagnosis, Gender, Age, Race/Dethnicity, ED level of acuity, discharge disposition. Annualized ICU volume, Anualized hospital volume

Flowchart & Analytic plan

Step 1
Conventional statistics

Step 2
Popular statistics

Cohort 1
Patients admitted into critical care units in any of the five hospitals(ICU_EHR
(n=14743)

Patients excluded (n=5216):
Age<18 years (n=3)
ICU LOS > 30 days (n=55)
Missing data (n=774)
Managed in PCU (n=4384)

Patients with first ICU admission during study period
(n=9527)

(Model A)
(n = 6536)

(Model B)
(n=2991)

Propensity Score Matched Patients from Model A
(n=1349)

Propensity Score Matched Patients from Model B
(n=1349)

Cohort 2
Patients admitted into critical care units in any of the five hospitals(ICU_EHR
(n=27783)

Patients excluded (n=16499)
Age<18 years (n=3)
Itransfer cases 2
Managed in PCU (5585)
Multiple encounters 2191

Patients with first ICU admission during study period
(n=19519)

(Model A)
(n = 13993)

(Model B)
(n=5526)

Innovative Approach

Step 1. Direct Risk Standardization with CaseMix Adjustment using complex models

Step 2: Multilevel Multivariate Generalized Linear Regression with Generalized estimating equation

Patient Characteristics of two CCModels

Characteristics		OVERALL	CCD MODEL A	CCD MODEL B	Difference[¥]
Number of patients	N	19519	13993(71.7%)	5526(28.3%)	
Age	Mean(95% CI)	67.28 (66.24-67.88)	67.66 (67.37-67.94)	66.34 (65.84-66.84)	<0.001
	IQR (25 %-75%)	57-81	57-81	54-82	
Gender	Female	9620(49.3%)	6713(49.3%)[a]	2907(49.3%)[a]	0.987
	Male	9899(50.5%)	7280(50.7%)[a]	2619(50.7%)[a]	
Race/ethnicity	White	4013(20.6%)	2929(19.6%)$_{a}$	1084(20.6%)$_{a}$	<0..001
	Black	1937(9.9%)	1414(10.1%)$_{a}$	523(9.5%)$_{a}$	
	Hispanic	10905(56.3%)	7874(54.8%)$_{a}$	3031(55.9%)$_{a}$	
	Other	2664(12.7%)	1776(16.1%)$_{a}$	88816.1%)$_{b}$	
APS	Mean(SE)	41.82(0.15)	42.66(0.18)[a]	39.68(0.28)[a]	<0.001
APACHE IVa Score	Mean(SE)	55.19(0.17)	56.19(0.20)[a]	52.65(0.31)[a]	<0.001
APACHE IVa Predicted ICU Mortality	Mean	0.125(0.001)	0.133(0.001)	0.105(0.001)	<0.001
	Median	0.062	0.066	0.054	<0.001
	Interquartile Range	0.123	0.135	0.100	<0.001
APACHE IVa Predicted Hospital Mortality	Mean	0.125 (0.001)	0.133 (0.001)	0.105 (0.001)	<0.001
	Median	0.062	0.066	0.054	<0.001
	Interquartile Range	0.123	0.135	0.1	<0.001
APACHE IVa Diagnosis	Non-operative	12282(62.9%)	7900(56.5%)	4382(79.3%)	<0.001
	Operative	7233(37.1%)	6089(43.55)	1144(20.7%)	
APACHE system diagnosis	Cardiovascular	5179(26.5%)	3703(26.5)[a]	1476(26.7%)[a]	<0.001
	Sepsis	3013(15.4%)	2172(15.5%)[a]	841(15.2%)[a]	
	Respiratory	2789(14.3%)	1976(14.1%)[a]	813(14.7%)a	
	Neurologic	2613(13.4%)	1871(13.4%)[a]	742(13.4%)a	
	Digestive	1573(26.5%)	1136(26.7%)[a]	437(26.5%)a	
	Metabolic	999(5%)	725(5.1%)[a]	274(5%)a	
Prior admission Emergency Department Visit	Yes	17079(87.5%)	11757(84%)	5322(96%)	<0.001
ICU admission ≤24hrs of Hospital Admission	Number cases (%)	13482(69.1%)	9247(66.1%)	4235(76.6%)	<0.001
Pre-ICU-LOS	Mean (SE) days	1.91(0.05)	2.20 (0.71)	1.12 (0.05)	<0.001
Mechanical Ventilator	(%)	5191(26.6%)	4154(29.6%)	1037(18.7%)	
	Mean (SE) days	3.76 (0.069)	3.71(0.078)	3.98(0.142)	0.107

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Results

Table 3. Linear Regression With Unadjusted and Adjusted Mean Difference in Lengths of Stay (ICU and Hospital) and Cost in Critical Care Delivery Models A vs. B

	Unadjusted Linear Regression	Linear Regression Model 1	Linear Regression Model 2	Linear Regression Model 3
	Mean Difference (95% CI)			
ICU LOS (Days)	-1.03 (-1.19 to -0.87)	-1.03 (-1.2 to -0.87)	-0.86 (-1.02 to -0.70)	**-0.75 (-0.91 to -0.59)**
Hospital LOS (Days)	-3.5 (-4.1 to -3)	-3.7 (-4.2 to -3.1)	-3.4 (-3.9 to -2.8)	**-3.3 (-3.8 to -2.7)**
Cost of Admission (USD)	-10814 (-11922 to -9706)	-10907 (-12046 to -9768)	-9933 (-11054 to -8812)	**-9280 (-10410 to -8150)**

Linear Regression Model 1: Adjusted for Age, Sex, and Race/ethnicity

Linear Regression Model 2: Adjusted for Age, Sex, Race/ethnicity and APACHE

Linear Regression Model 3: Adjusted for Age, Sex, Race/ethnicity and APACHE, APACHE diagnosis

Abbreviations: ***APACHE,*** Acute Physiologic and Chronic Health Evaluation; ***95% CI***, 95% Confidence Interval; ***ICU***, Intensive Care Unit; **LOS**, Length of Stay; **USD**, United States Dollars

Propensity Score Matching

Table 4. Comparison of Patient Characteristics Between Two Different ICU Critical Care Delivery Models Matched on Propensity Scores

Characteristic	All ICU Patients (n=2698)		*P Value*
	Critical Care Delivery Model A (n=1349)	Critical Care Delivery Model B (n=1349)	
Age, median (IQR), yrs	70 (56, 80)	69 (54, 81)	0.218
Age Categories [yr], n (%)			
18-40	118 (8.8)	152 (11.3)	
41-65	425 (31.5)	437 (32.4)	**0.001**
66-85	597 (44.3)	503 (37.3)	
85+	209 (15.5)	257 (19.1)	
Female, n (%)	654 (48.5)	654 (48.5)	>0.999
Race, n (%)			
Caucasian	319 (23.7)	310 (23)	
Black	137 (10.2)	120 (8.9)	0.54
Hispanic	871 (64.6)	901 (66.8)	
Other	22 (1.6)	18 (1.3)	
APS, mean (SE)	**41.7 (0.57)**	**41.7 (0.60)**	**0.673**
APACHE, mean (SE)	**55.0 (0.63)**	**54.6 (0.65)**	**0.983**

Table 4. Comparison of Patient Characteristics Between Two Different ICU Critical Care Delivery Models Matched on Propensity Scores

Characteristic	All ICU Patients (n=2698)		*P Value*
	Critical Care Delivery Model A (n=1349)	Critical Care Delivery Model B (n=1349)	
Total Direct Cost [USD], mean (SE)	26544 (762)	17246 (566)	**<0.001**
Average No. TeleMD Interventions	2.5 (0.13)	5.2 (0.60)	**<0.001**
LOS, mean (SE) days			
ICU	3.2 (0.11)	2.5 (0.09)	**<0.001**
Hospital	10.9 (0.44)	7.4 (0.20)	**<0.001**
Mortality, n (%)			
ICU	73 (5.4)	48 (3.4)	**0.002**
Hospital	182 (13.5)	127 (9.4)	**0.001**

Abbreviations: ***APACHE***, Acute Physiologic and Chronic Health Evaluation; ***APDRG-ROM***, All Patient Refined Diagnosis-Related Group - Risk of Mortality; ***APDRG-SOI***, APDRG - Severity of Illness; ***95% CI***, 95% Confidence Interval; ***ICU***, Intensive Care Unit; ***LOS***, Length of Stay; **USD**, United States Dollar

Innovative statistics- step 1

Table 5: Risk adjusted cost/case difference between two models of critical care delivery

Outcomes	Total N	Model A $US(95% CI)	Model B $US(95% CI)	Difference $US(95% CI)	P value
	19519	13993	5526		
Unadjusted Total cost/Case		$40613	37114	$3499	<0.0001
Cost- US $ LS mean¶					
Total Cost/case [g]	19391	$39434 (38468-40400)	$37933 (36530-39335)	$1501 (-70, 3072)	0.06
Fixed Cost /Case [h]	19391	20905 (20418, 21391)	$20061 (19354, 20767)	$844 (52,1635)	0.03
Variable Cost/ Case [i]	19015	$18529 (18028, 19029)	$17872 (17145, 18599)	$657 (-157, 1471)	0.11

¶:Generalized linear Model analysis

[g-I] Direct risk standardization with Casemix adjustment applying complex model; Variables entered in each model APACHE score, Predicted risk of mortaliy APACHE IVa , Case mix index, Gender, ethnicity/Race, Age in groups, annualized ICU volume, Risk groups of increasing order

Direct Standardization technique: BMC Medical Research Methodology 2013, 13:133

Innovative method-step 2

Generalized linear model analysis with repeated measures performed with covariates as fixed and individual model as a random effect (Risk group*CCDM)

		Difference in LS Mean (Risk groups * Model A) - (Riskgroups*Model B)							
		≤ 5	***6-10***	***11-25***	***26-50***	***51-75***	***76-90***	***91-95***	***96+***
Frequency		1095	1002	2853	4836	4868	2914	976	975
Outcomes	Metric								
Cost-Total US $	LS Mean (95% CI)	1700 (-3455,6856)	-1744 (-7146,3657)	2520.6 (-789.2,5830)	2781 (244.4,5318)	2371 (-174,4917)	2982 (-307,6271)	2832 (-3017,8682)	-1435 (-7153, 4283)
	P value	0.52	0.53	0.135	0.03	0.06	0.07	0.34	0.62
Cost –Fixed US$	LS Mean (95% CI)	755 (-1840,3352)	-848 -3568,1871	1506 (-160,3173)	1541 (264,2819)	1170 -111,2452	1741 (85,3398)	1390 (-1555, 4336)	-505 (-3256, 850)
	P value	0.56	0.54	0.07	0.01	0.07	0.03	0.35	0.73
Cost-Variable US $	LS Mean (95% CI)	689 (-1009,2143)	-895 (-3694, 1903)	$1014 (-700, 2729)	1239 (-74, 2554)	1200 (-118, 2519)	1240 (-464, 2944)	1441 (-1589, 4472)	-930 (-3893, 2033)
	P value	0.73	0.53	0.24	0.06	0.07	0.15	0.35	0.53

Summary

All three statistical methods suggests that total cost/case was higher in Model A than Model B

General Linear Model: Cost in Model A was higher than B Statistically significant

Propensity Score Matching: Model A was higher than B Statistically significant

Generalized linear model analysis Direct risk standardization by adjusting for case mix index and covariates : statistically not significant

Generalized linear model with repeated measure covariate as fixed and model as random effect: suggest Model A had higher cost than Model B in those 3 groups.

Conclusion

- Difference in Cost per case among provided by A 24/7 bedside intensivist providing Critical care with presence of standard of care and Standard of care only (tele-intensivist) was $1501 which did not achieve statistical significance using complex modelling.

- Conventional and popular utilized technique did show statistical difference they accompanied with several limitation of not adjusting for case mix index and poorly fitted models with small number of matched cases.

- Multicenter single health system conduceted study cannot be generalized tp the whole teleICU population so research studies using multicenter data, utilizing randomizatized control trial is recommended,

- Tele-intensivist model is an intensivist model of care should be included as best practices

Thank you/Questions

Continued discussion on other outcomes

Exploring LOS in Tele-Intensivist Delivery Models With and Without 24/7 Bedside Intensivists: Monday 2/17 @ 11:15 - 12:15 Theater 13

Exploring Mortality in Tele-Intensivist Delivery Models With and Without 24/7 Bedside Intensivists: Tuesday, February 18, 2020 - 8:45 AM - 9:45, am during