American Journal of Emergency Medicine 84 (2024) 59–67

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

The benefits of a virtual emergency department observation unit for hospital observation patients

Iyesatta M. Emeli, MD, MPH [a,*], Autherine Abiri, DNP, ENP-C [a,b], George Hughes, MD [a], Timothy P. Moran, Ph.D [a], Matthew T. Keadey, MD, MHA [a], Michael A. Ross, MD [a]

[a] Department of Emergency Medicine, Emory University School of Medicine, Atlanta, GA, USA
[b] Neil Hodgson Woodruff School of Nursing, Emory University, USA

A R T I C L E I N F O

Article history:
Received 3 March 2024
Received in revised form 16 July 2024
Accepted 23 July 2024

Keywords:
Telehealth
Virtual care
Telemedicine
Observation medicine
Emergency department observation unit

A B S T R A C T

Background: The benefit of virtual emergency department observation unit (EDOU) care relative to traditional observation care in an inpatient bed is unknown.
Objective: To determine if virtual observation care in an EDOU is associated with improved length of stay, cost, inpatient admission rate, and adverse events relative to traditional observation care in non-observation unit (NOU) inpatient bed.
Methods: This is a retrospective observational cohort study of observation patients managed over 24 months in two urban teaching hospitals. Following an ED visit, observation care occurred in a virtual-EDOU or NOU inpatient setting based on bed availability, physician discretion, and observation guidelines. Primary outcomes were length of stay, total cost, inpatient admission rate, and adverse events (death or ICU admission). Hospital cost and clinical databases were used. Analysis with a doubly-robust regression with entropy balancing and propensity scores was used to control for subgroup differences.
Results: 30,191 observation patients were divided into 13,753 NOU patients and 16,438 EDOU patients with similar distributions for age and gender, and differences in health insurance and diagnosis. For both discharged and admitted patients, the mean cost was higher in the NOU setting at $7989 than the virtual-EDOU setting at $4876 with an adjusted difference of $1951 (95% CI: $1762–$2133). The mean total length of stay was higher in the NOU setting (60.5 h) than the virtual-EDOU setting (36.4 h) with an adjusted difference of 20.4 h (95% CI: 19.2 h – 21.3 h). NOU inpatient admission rates were higher (25.3% vs 18.4%). Cost and length of stays were lower in discharged observation patients, with differences favoring the virtual-EDOU group. Adverse events were higher in the NOU setting (2.1% vs 0.8%). 30-day ED recidivism did not differ significantly between NOU and virtual-EDOU study groups. The virtual-EDOU saved the two hospitals $16,036,913 and 6986 bed-days annually.
Conclusion: Management of observation patients in a virtual-EDOU setting is superior to care in a traditional inpatient setting in terms of costs, length of stays, inpatient admission and adverse events rates.

1. Introduction

Observation services are provided to emergency department patients to determine their need for inpatient admission [1]. Patients receiving observation services represent roughly one quarter of all patients staying in a hospital for care following an ED visit [2].

The settings in which observation services are provided are defined by two variables: the use of a dedicated observation unit and the use of observation protocols. A protocol-driven emergency department observation unit (EDOU) has been defined as a type 1 setting. Alternatively, the most common setting for observation patients in the U.S. is in a bed scattered anywhere in a hospital with no protocols; otherwise referred to as a type 4 setting [3] and also known as an inpatient non-observation unit (NOU) setting. EDOUs have been shown to improve patient outcomes such as length of stay, inpatient admission rates, patient satisfaction, and cost when compared to NOU settings [3-8]. It has been shown that there are no significant differences in in cost, length of stay, inpatient admit rate or adverse event rates with virtual care in a EDOU when compared in-person EDOU care [4]. However, a more relevant question of this new practice model is – are there significant differences in outcomes between care in a virtual EDOU and care in the more common NOU setting? Although a study which randomizes all observation patients between a virtual EDOU and a NOU settings

* Corresponding author.
E-mail address: imassaq@emory.edu (I.M. Emeli).

https://doi.org/10.1016/j.ajem.2024.07.039
0735-6757/

might be ideal, randomizing one quarter of hospitalized patients is not feasible. Alternative statistical methods are needed to address this question.

The objective of this study is to determine if virtual observation care in an EDOU is associated with improved length of stay, cost, inpatient admission rate, and adverse events relative to traditional observation care in non-observation unit (NOU) inpatient bed.

2. Methods

This is a retrospective observational cohort study of all observation status patients managed over 24 consecutive months, between September 1, 2020 and August 31, 2022. The study was approved by the Emory University IRB. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines helped direct the research and reporting processes.

The setting was two urban academic teaching hospitals, Emory University Hospital (EUH) Hospital and Emory University Hospital Midtown (EUHM) Hospital. Both hospitals provided observation services following an ED visit in two distinct and separate setting: a protocol driven EDOU (13 beds at EUH hospital and 16 beds at EUHM hospital) and an inpatient non-observation unit (NOU) bed located anywhere in the hospital.

All patients had an initial emergency visit followed by the decision to provide observation services with the placement of an "admit to observation" order. The decision to observe patients was made by the treating emergency physician independently or in consultation with other hospital services. Patients who required care beyond 6 h in the ED but had a >70% likelihood of discharge within 18–24 were considered for observation services. The decision to observe, as opposed to admit as an inpatient, was based on standard observation criteria including the CMS two-midnight rule [7,9]. The assigned setting for the observation stay (EDOU or NOU) was driven by bed availability, the discretion of the ED and hospital attending physician, and condition specific inclusion and exclusion criteria [10]. Use of the EDOU or NOU was not compulsory. All NOU observation patients were managed by the respective hospital service. Patient outcomes were followed to the conclusion of their index visit hospital stay in a hospital observation patient database.

Patient care in the type 1 EDOU settings involved a designated emergency medicine board certified EDOU attending rounding with an assigned advance practice provider (APP, nurse practitioner or physician assistant) in the morning, followed by patient management guided by EDOU guidelines and protocols [4,10]. With the virtual EDOU model, the physician worked from a remote telehealth control room while the APP was located within the EDOU. Rounds involved joint review of electronic records, followed by bedside rounds where the APP rolled the telehealth cart to each room with the EDOU attending. The telehealth carts were either a tablet (Apple iPad or ThinkPad) attached to a rolling cart using a HIPPA compliant Zoom platform, or a cart with a larger screen and speaker with a point tilt zoom camera using a HIPPA compliant AmWell platform. Patient care in the NOU setting was at the discretion of the admitting NOU service.

The primary study outcomes were hospital length of stay, total hospital cost, inpatient admission rate, and adverse events defined as index visit death or admission to an intensive care unit. Length of stay is defined as the time from the observation admission order to the hospital departure. Total costs were defined as hospital facility costs incurred from the emergency and observation visits for discharged patients, with the additional of inpatient costs for admitted patients. Physician or professional costs were not included.

The variable of interest was the setting where the observation stays occurred: EDOU versus NOU. NOU included a bed anywhere in the hospital, most commonly an inpatient room, and excluded the ED observation patients. Potential confounding variables were selected a priori: age, gender, observation ICD10 diagnosis, health insurance payer, admitting service and inpatient unit. Because of the large number of ICD10 codes represented, ICD10 diagnoses were grouped into CCS categories as defined by the Healthcare Cost and Utilization Project.

Data were retrieved from the health system wide hospital cost accounting program *Enterprise Performance Systems Incorporated* (Chesterfield MO) as well as a health system clinical data warehouse, as has previously been reported [4,8].

2.1. Statistical analyses

Because this study was retrospective, the sample size was determined by data availability. Given a fixed sample size and a fixed level of power (80%), we can determine the range of effect sizes this study had sufficient power to detect. This study was sufficiently powered to detect standardized mean differences ≥0.03, correlations ≥0.02, and odds ratios ≥1.07.

Categorical variables were described using counts and percentages. Cost and length of stay were described using medians with interquartile ranges and means with 95% confidence intervals. Because cost and length of stay are positive values, positively skewed, and heteroscedastic, we computed means, 95% CIs, and comparisons between the NOU and EDOU using a mixed-effects Gamma regression. Intercepts were allowed to vary at the hospital level. Similarly, rates of admission were evaluated using mixed-effects logistic regressions. For the adjusted analyses, we used the doubly-robust regression approach [11]. First, the covariates described above were used to generate weights for EDOU status. Natural cubic splines were used to allow for non-linear effects of age. A variety of weighting procedures were compared; entropy-balancing [12] resulted in the best covariate balance. Second, outcomes (cost, LOS, admission, and adverse events) were evaluated using regressions which included both the weights and the covariates described above. The frequency of ICU admissions and mortality were quite low, especially when compared to the number of variables in the adjusted model. These outcomes were compared using the Cochran–Mantel–Haenszel odds ratio following stratification into 10 deciles based on the above-described propensity scores. Statistical analyses were conducted using R (v 4.3) [13].

2.2. Sensitivity analysis for unmeasured confounding

This study, like all observational studies, is limited by the lack of randomization. While the doubly-robust regression procedure mitigated the impact of those covariates included in the data set, it is possible that the effects observed in the present study are the result of an unmeasured confounder. This sensitivity analysis aimed to evaluate the potential for unmeasured confounding. The degree to which an unmeasured variable can influence the correlation between EDOU status and Cost/LoS depends primarily on two factors: 1) the strength of the association between EDOU status and the unmeasured confounder 2) the strength of the association between Cost/LoS and the unmeasured confounder. Thus, while it may not be possible to determine whether our findings can be accounted for by confounding, we can determine the range of associations a confounder would need to possess to result in our findings becoming non-significant [14,15]. Carnegie et al. recommend contextualizing the size of the sensitivity associations by presenting the associations between the intervention/outcome and the measured confounders in order to allow researchers to gauge how realistic it might be to find such an association [14].

For interpretability, the associations are presented on a standardized scale ranging from 0 (no linear association) to 1 (a perfect linear association). While negative values are possible as well, the results from negative values are the mirror image of those from positive values. Thus, all values are presented as ≥0. Outcomes were first subjected to a normal score transformation as many such sensitivity analyses assume Gaussian errors.

Emergency department return visits were defined as any ED return visit within 30-days of the date and time of the index visit discharge.

This analysis excluded non-emergency elective visits or hemodialysis patients (ICD-10 codes I12.x or I13.x,) who often had to return for dialysis due to a lack of access to clinic dialysis. Return visits were analyzed using a mixed-effects/multilevel logistic regression adjusted using the same doubly-robust covariate procedure as in the primary analysis.

3. Results

The final sample consisted of 30,191 patients. The sample was 42.1% male, 57.9% female, and had a median age of 57 (IQR: 41–69). This group was divided into 13,753 NOU patients, who had a median age of 59 and were 56.3% female, and 16,438 EDOU patients, who had a median age of 55 years and were 59.2% female. NOU and EDOU groups were similar in terms of insurance payers with the exception of private insurance (NOU 14.5% versus EDOU 3.9%), and Medicaid insurance (NOU 9.2% versus EDOU 13.6%). See Table 1 for more details.

The top five most common CCS Diagnoses for the entire group were: chest pain unspecified (5.0%), COVID-19 (3.2%), other chest pain (3.2%), Hypertensive chronic kidney disease with stage 5 chronic kidney disease (2.6%), and Syncope and collapse (2.3%). Proportions of each CCS category varied by setting, however both NOU and EDOU groups shared the top 30 most common categories. See Table 2 for more details.

Fig. 1 presents the results for the covariate balancing procedure for demographics as well as the most common CCS codes. Mean differences are presented for age; odds ratios are presented for all other variables. As can be seen in the difference between the unweighted and weighted comparisons, EDOU and NOU patients were quite similar following the weighting procedure.

The median cost was higher in the NOU setting at $4486 (IQR: $2832 - $7320) than the virtual-EDOU setting at $2873 (IQR: $2040–$4344). Similar differences existed when considering mean costs, with the NOU setting mean cost being higher at $7989 (95% CI; $6679–$9556) than the virtual-EDOU setting at $$4876 (95% CI; $4079–$5828). See Table 3 and Fig. 2A and B. The adjusted difference in mean costs was $1951 (95% CI: $1762–$2133) lower in the virtual-EDOU than the NOU setting. See Table 4. These costs included all observation patients, both discharged and admitted patients. When considering the costs for only observation patients that were discharged following a period of observation, similar differences existed. See Table 4 and Fig. 2C and D. Among the discharged observation subgroup, the adjusted difference in mean costs was $1743 (95% CI: $1624–$1857) lower in the virtual-EDOU than the NOU setting. Costs of admitted patients were similar in both groups. See Fig. 2E and F. Applying the adjusted mean cost difference between settings, over the study period the two hospitals saved $16,036,913 (95% CI: $14,478,590–$17,533,593) per year by managing patients via the virtual-EDOU program.

The mean length of stay was higher in the NOU setting at 60.5 h (95% CI: 58.7–62.4 h) than the virtual-EDOU setting at 36.4 h (95% CI: 35.4–37.4 h). See Table 3 and Fig. 3A and B. The adjusted difference in mean length of stay was 20.4 h (95% CI: 19.2–21.3 h) lower in the virtual-EDOU than the NOU setting. See Table 4. When considering the length of stay of only discharged observation patients, similar differences existed. See Table 4 and Fig. 3C and D. Among the discharged observation subgroup, the adjusted difference in mean length of stays was 19.2 h (95% CI; 18.4–20.0 h) lower in the virtual-EDOU than the NOU setting. Length of stay of admitted patients were similar and much higher in both admitted subgroups. See Fig. 3E and F. Applying the adjusted median length difference between settings, over the study period the two hospitals saved 167,668 (95% CI: 157,805–175,065) inpatient bed hours per year or 6986 bed days per year by managing observation patients using the virtual-EDOU program.

The proportion of observation patients that were converted from observation to a hospital inpatient admission was higher in the NOU group (25.3%) than the virtual-EDOU group (18.4%). However, this difference was not significant (Table 4).

Overall, adverse events were infrequent. Across the entire sample, 249 (0.8%) patients were sent to the ICU and 173 (0.6%) died. When combined, 408 (1.4%) patients suffered an adverse event. 182 (1.3%) patients in the NOU were sent to the ICU compared to 67 (0.4%) in the EDOU (OR = 0.31, 95% CI: 0.23–0.41). This difference remained significant after adjustment (OR = 0.41, 95% CI: 0.31–0.55). Similarly, death was less frequent in the EDOU (59, 0.4%) than in the NOU (114, 0.8%; OR = 0.43, 95% CI: 0.32–0.59). This was also significant following adjustment (OR = 0.62, 95% CI: 0.45–0.86). Finally, the rate of any adverse event was higher in the NOU (283, 2.1%) than in the EDOU (125, 0.8%). This was significant in both the unadjusted (OR = 0.37, 95% CI: 0.30–0.45) and adjusted (OR = 0.51, 95% CI: 0.41–0.63) analyses.

30-day return visit rates for all observation patients, admitted and discharged, were similar. The NOU total recidivism rate was 13.3% (95% CI: 9.6–18.1) and the virtual-EDOU recidivism rate was 18.5% (95% CI: 12.6–26.3). For all patients the odds ratio for 30-day recidivism was not significant, OR = 1.26 (95% CI: 0.93–1.72; $p = .37$). 30-day return visit rates were also similar for only discharged observation patients. The discharged NOU recidivism rate was 12.9% (10.4–16.0) and the discharged virtual-EDOU recidivism rate was 18.1% (14.1–23.0) which was not significant in the adjusted analysis ($p = .25$).

3.1. Sensitivity to unmeasured confounding

The results of the sensitivity analysis are shown in Fig. 4. The grey bands depict the combinations of associations that would render these effects and findings non-significant. Any unmeasured confounder below/to the left of the grey band would be insufficient to overturn the present results. For context, the measured confounders are presented as +'s. The distance between the measured confounders and the grey bands indicate that any unmeasured confounder would need to be considerably stronger than any measured confounder to result in our findings becoming non-significant.

4. Discussion

We found that observation visits managed using virtual care in an EDOU were associated with significantly shorter length of stays, lower hospital costs, lower inpatient admission rates and lower adverse events rates relative to patients managed in a traditional hospital inpatient bed. These differences remained even after accounting for multiple confounding variables.

While prior work has shown no significant difference in virtual EDOU rounding versus in-person EDOU rounding; as a new model of care, it is necessary to also determine if there is a difference between virtual EDOU care and observation care in a traditional inpatient bed [4].

Although the study did not involve patient randomization, the findings in this virtual-EDOU study are consistent with prior EDOU studies. The median length of stay of 19.9 h in the virtual-EDOU program is

Table 1
Patient characteristics.

Characteristic	NOU (N = 13,753)	EDOU (N = 16,438)	Full sample (N = 30,191)
Age, Md (IQR)	59 (43–71)	55 (40–68)	57 (41–69)
Sex, N (%)			
Female	7739 (56.3)	9733 (59.2)	17,472 (57.9)
Male	6014 (43.7)	6705 (40.8)	12,719 (42.1)
Insurance Status, N (%)			
Private PPO	697 (5.4)	958 (5.8)	1705 (5.7)
Other Private Insurance, N (%)	1990 (14.5)	641 (3.9)	2631 (8.7)
Govt Insurance	168 (1.3)	218 (1.3)	386 (1.3)
HMO	3807 (27.7)	4123 (25.1)	7930 (26.3)
Medicaid	1263 (9.2)	2238 (13.6)	3501 (11.6)
Medicare Part A	2018 (14.7)	1275 (7.8)	3293 (10.9)
Medicare Part B	4794 (34.9)	5119 (31.1)	9913 (32.8)
Self-Pay	956 (7)	2507 (15.3)	3463 (11.5)

Table 2
Frequency of CCS diagnoses.

CCS category	NOU # (%)	EDOU # (%)	Full sample	Cumulative frequency
Total	*13,753*	*16,438*	*30,191*	*(100)*
Chest pain, unspecified	204 (1.5)	1313 (8)	1517 (5)	1517 (5)
COVID-19	526 (3.8)	428 (2.6)	954 (3.2)	2471 (8.2)
Other chest pain	263 (1.9)	691 (4.2)	954 (3.2)	3425 (11.3)
Hypertensive CKD w/ stage 5 CKD	128 (0.9)	665 (4)	793 (2.6)	4218 (14)
Syncope and collapse	233 (1.7)	462 (2.8)	695 (2.3)	4913 (16.3)
Dehydration	86 (0.6)	452 (2.7)	538 (1.8)	5451 (18.1)
Hypertensive heart disease w/ HF	230 (1.7)	292 (1.8)	522 (1.7)	5973 (19.8)
COPD w/ (acute) exacerbation	165 (1.2)	308 (1.9)	473 (1.6)	6446 (21.4)
Transient cerebral ischemic attack	64 (0.5)	383 (2.3)	447 (1.5)	6893 (22.8)
Anemia	116 (0.8)	296 (1.8)	412 (1.4)	7305 (24.2)
Hypertensive heart and CKD w/ HF and stage 1–4 CKD, or unspecified CKD	209 (1.5)	187 (1.1)	396 (1.3)	7701 (25.5)
Acute kidney failure	204 (1.5)	136 (0.8)	340 (1.1)	8041 (26.6)
Urinary tract infection, site not specified	157 (1.1)	130 (0.8)	287 (1)	8328 (27.6)
Hypertensive heart and CKD w/ HF and w/ stage 5 CKD	108 (0.8)	175 (1.1)	283 (0.9)	8611 (28.5)
Unspecified abdominal pain	78 (0.6)	198 (1.2)	276 (0.9)	8887 (29.4)
Dizziness and giddiness	73 (0.5)	181 (1.1)	254 (0.8)	9141 (30.3)
Type 2 diabetes mellitus w/ hyperglycemia	86 (0.6)	159 (1)	245 (0.8)	9386 (31.1)
Fluid overload	87 (0.6)	155 (0.9)	242 (0.8)	9628 (31.9)
Nausea with vomiting	106 (0.8)	136 (0.8)	242 (0.8)	9870 (32.7)
Hydronephrosis w/ renal and ureteral calculous obstruction	142 (1)	96 (0.6)	238 (0.8)	10,108 (33.5)
Headache	39 (0.3)	183 (1.1)	222 (0.7)	10,330 (34.2)
Unspecified acute appendicitis	219 (1.6)	3 (0)	222 (0.7)	10,552 (35)
Unspecified asthma w/ (acute) exacerbation	56 (0.4)	161 (1)	217 (0.7)	10,769 (35.7)
Noninfective gastroenteritis and colitis	71 (0.5)	116 (0.7)	187 (0.6)	10,956 (36.3)
Hypokalemia	29 (0.2)	157 (1)	186 (0.6)	11,142 (36.9)
Pneumonia organism	97 (0.7)	80 (0.5)	177 (0.6)	11,319 (37.5)
Hyperkalemia	70 (0.5)	101 (0.6)	171 (0.6)	11,490 (38.1)
Sepsis organism	108 (0.8)	62 (0.4)	170 (0.6)	11,660 (38.6)
Other pulmonary embolism w/o acute cor pulmonale	118 (0.9)	45 (0.3)	163 (0.5)	11,823 (39.2)
Cerebral infarction	70 (0.5)	88 (0.5)	158 (0.5)	11,981 (39.7)
All Others[†]	9611 (69.9)	8599 (52.3)	18,210 (60.3)	30,191 (100)

[†] Table is limited to the 30 most common CCS codes for space.

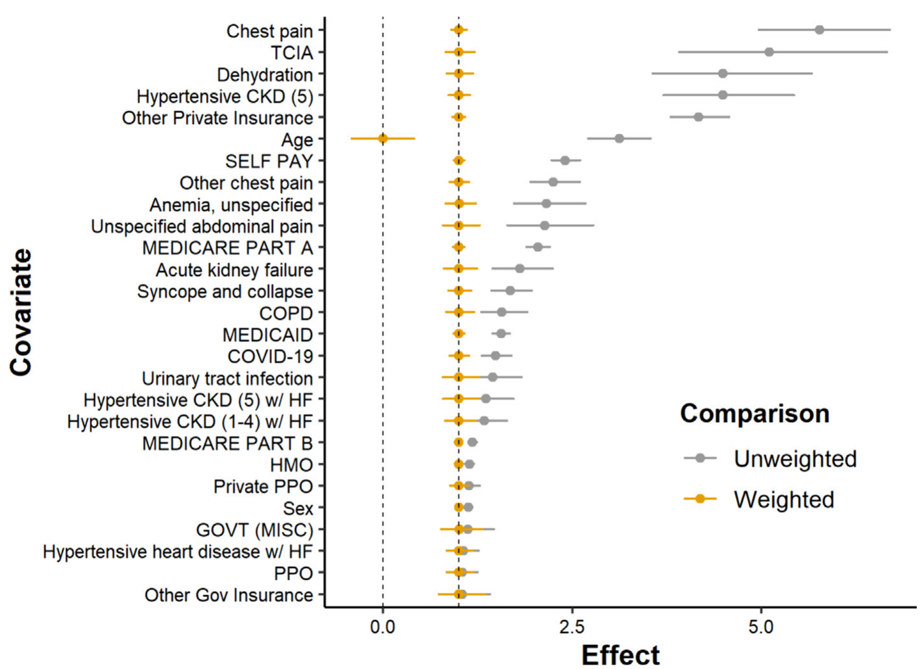

Fig. 1. Love plot depicting covariate balance before and after weighting.
The x-axis, "Effect", represents the difference between patients in the NOU and EDOU (i.e. a mean difference for age, odds ratios for all other variables). Thus, a value of 0 indicates no difference for age and a value of 1 indicates no difference for all other variables. Zero and one are identified by the dashed vertical lines. The results for age, sex, insurance status, and the most common diagnoses are included. All odds ratios are presented as ≥1. Horizontal lines extending from each effect represent the 95% confidence intervals.
Abbreviations: TCIA – Transient Cerebral Ischemic Attack, CKD – Chronic Kidney Disease, COPD – Chronic Obstructive Pulmonary Disease, COVID – Coronavirus Disease, HMO – Health Maintenance Organization, PPO – Preferred Provider Organization, GOVT – Governmental insurance, HF – Heart Failure.

Table 3
Outcomes as a function of group.

Outcome	NOU	EDOU	Full sample
Cost (USD), Md (IQR)	4486.3 (2831.7–7320.0)	2873.2 (2040.3–4343.5)	3441.0 (2277.4–5737.0)
Cost (USD), Mn (95% CI)	7989.0 (6678.7–9556.3)	4875.7 (4078.9–5828.1)	6292.2 (5293.8–7479.0)
LoS (Hrs), Md (IQR)	38.9 (22.1–60.7)	19.9 (13.2–27.8)	24.4 (15.7–47.3)
LoS (Hrs), Mn (95% CI)	60.5 (58.7–62.4)	36.4 (35.4–37.4)	47.4 (46.4–48.3)
Admission, *N* (%)	3475 (25.3)	2964 (18.0)	6439 (21.3)
ICU, *N* (%)	182 (1.3)	67 (0.4)	249 (0.8)
Death, *N* (%)	114 (0.8)	59 (0.4)	173 (0.6)
Either Adverse Event, *N* (%)	283 (2.1)	125 (0.8)	408 (1.4)

Md – Median, Mn – Mean, IQR – Interquartile Range, 95% CI – 95% Confidence Interval.

comparable to the EDOU stays of 14.7–19 h reported in previous studies [8,16-19]. Similar cost and length of stay differences between EDOU and NOU have been reported, with outcomes favoring the EDOU over the NOU setting [8]. Length of stay differences in the EDOU versus NOU have been reported in randomized trials for syncope (29 vs 47 h), chest pain (33 vs 45 h) and for transient ischemic attack (26 vs 61 h) [20-22]. A retrospective observational cross-sectional study of 48,145 observation patients found an 11.1 h median adjusted length of stay difference favoring the EDOU over the NOU setting with an unadjusted EDOU cost savings of $740 [8]. Cost savings of $1572 were reported by

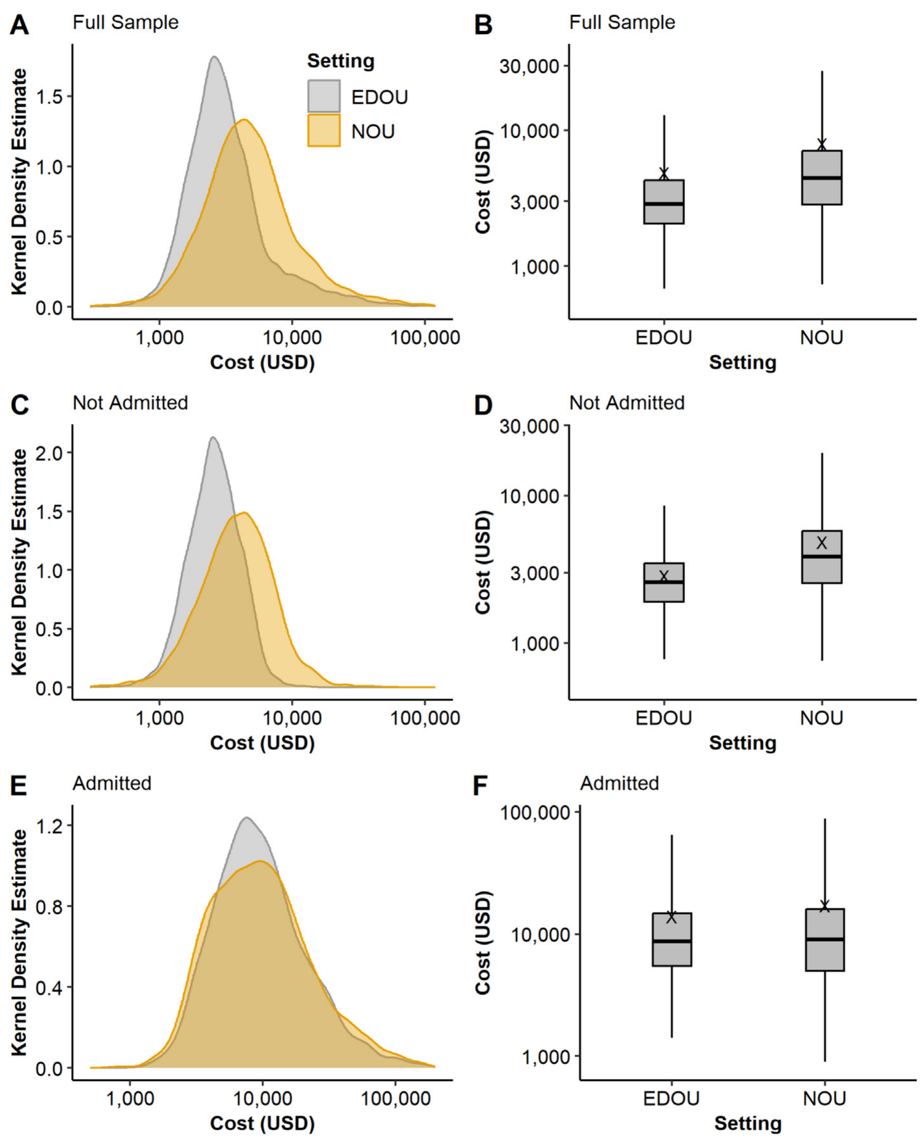

Fig. 2. Total cost as a function of virtual-EDOU group. A) kernel density plots of cost as a function of virtual-EDOU group for all patients, B) boxplots of cost as a function of virtual-EDOU group for all patients, C) kernel density plots of cost as a function of virtual-EDOU group for non-admitted patients, D) boxplots of cost as a function of virtual-EDOU group for non-admitted patients, E) kernel density plots of cost as a function of virtual-EDOU group for admitted patients, F) boxplots of cost as a function of virtual-EDOU group for admitted patients. Note that scales are logarithmic. The "X"'s in the boxplots denote the means of the sample.

Table 4
Regression results.

	Unadjusted		Adjusted	
	β	95% CI	β	95% CI
Full Sample				
Cost, Mn Diff (95% CI)	−3113.3	−3366.0; −2846.8	−1951.2	−2133.3; −1761.6
LoS, Mn Diff (95% CI)	−24.1	−26.1; −22.2	−20.4	−21.3; −19.2
Admission, OR (95% CI)	0.65	0.61; 0.69	1.06	0.99; 1.14
Only discharged subgroup				
Cost, Mn Diff (95% CI)	−2002.6	−2147.5; −1850.1	−1742.8	−1856.6; −1624.4
LoS, Mn Diff (95% CI)	−19.4	−20.2; −18.7	−19.3	−20.0; −18.4
Only admitted subgroup				
Cost, Mn Diff (95% CI)	−3193.5	−3895.2; −2454.5	−2554.8	−3050.5; −2038.9
LoS, Mn Diff (95% CI)	−9.3	−16.3; −1.7	−1.2	−5.9; 4.6

Baugh in 2012 and $1535 by Abbas in 2015 [23,24]. These savings are consistent with the adjusted difference in mean costs found in the present study. After controlling for multiple covariates (Fig. 3), our findings of lower cost and length of stay seem unlikely to be made non-significant by additional unknown confounders as demonstrated by the scatterplots in Fig. 4.

The admission rate of 18.4% in the EDOU group (as compared to 25.3% in the NOU group) is consisted with prior studies where EDOU admission rates have ranged from 10.9% to 23.5% [8,19,25].Adverse events were very infrequent across the study population in general, and adverse event rate was lowest in the EDOU group at 0.8%. EDOU resuscitation rates have previously been reported in the literature at similarly low rates of <1% [26].

We found that 30-day ED recidivism did not differ significantly between NOU and virtual-EDOU study groups. To put these rates in context, consider a 2017 analysis of all Medicare observation visits which

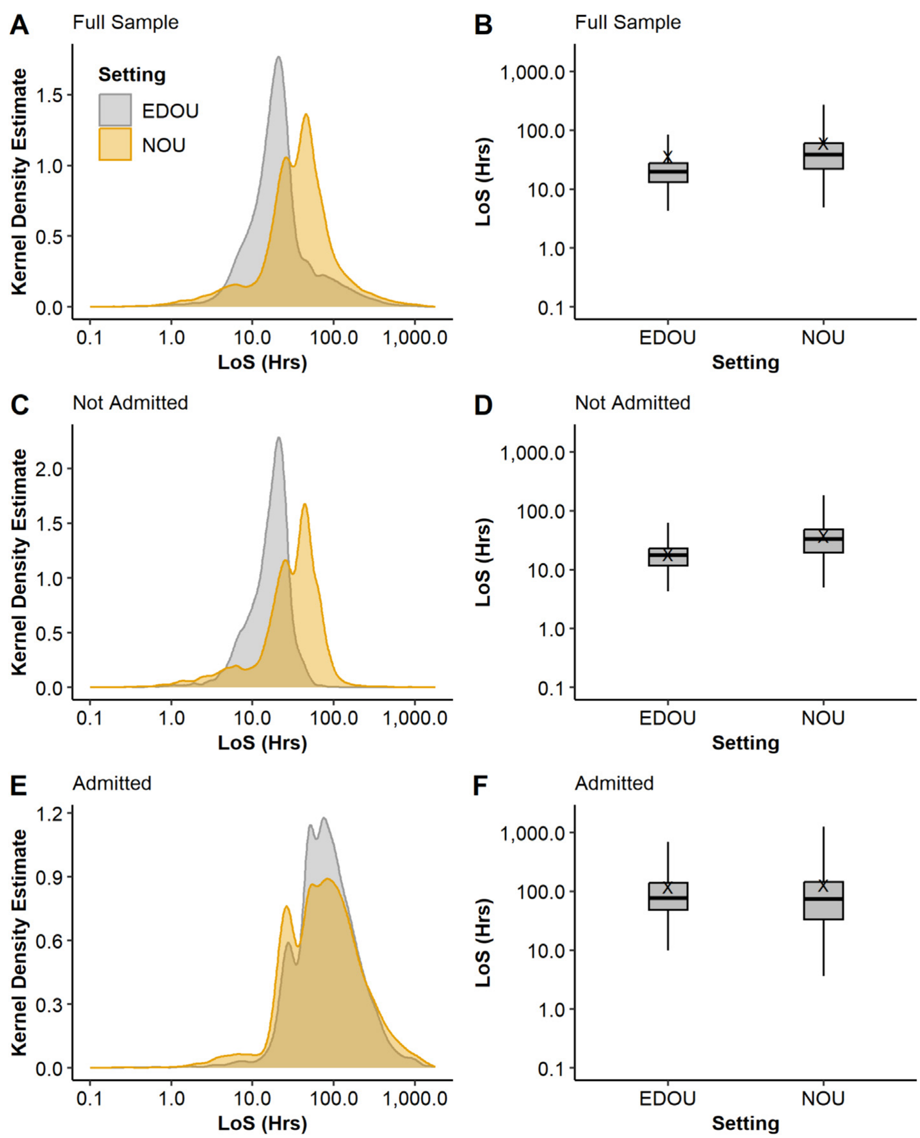

Fig. 3. Total length of stay as a function of virtual-EDOU group. A) kernel density plots of LoS as a function of virtual-EDOU group for all patients, B) boxplots of LoS as a function of virtual-EDOU group for all patients, C) kernel density plots of LoS as a function of virtual-EDOU group for non-admitted patients, D) boxplots of LoS as a function of virtual-EDOU group for non-admitted patients, E) kernel density plots of LoS as a function of virtual-EDOU group for admitted patients, F) boxplots of LoS as a function of virtual-EDOU group for admitted patients. Note that scales are logarithmic. The "X"'s in the boxplots denote the means of the sample.

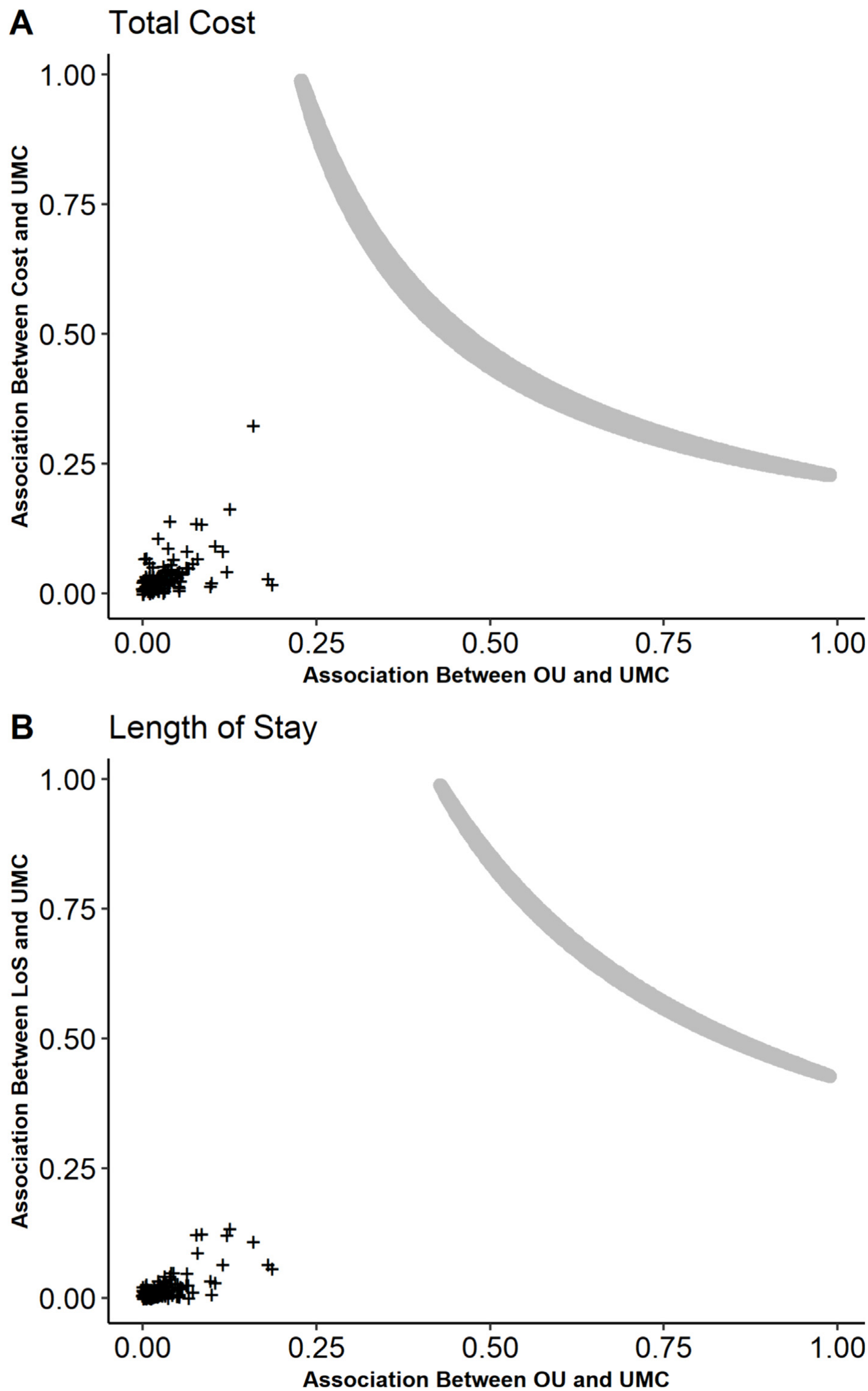

Fig. 4. Scatterplot depicting the range of correlations which would render the present findings non-significant. The grey bands depict the region of non-significance. An unmeasured confounder (UMC) that has a combination of associations within that region would render the findings of the present study non-significant. The "+" values depict the correlations of the observed confounders in the study. All confounders are clustered in the lower left of the figure, indicating small associations with both EDOU status and Cost / LoS.

reported an overall 30-day recidivism rate of 20.1% [27]. By comparison a study of 22,530 EDOU visits reported a 9.4% 30-day ED recidivism rate for patients over 65 years [17]. A subsequent 2022 study of 4179 EDOU patients also reported a 14-day ED recidivism rate of 9.4% [28]. A study 149 transient ischemic attack patients randomized to an EDOU versus a NOU setting reported the same 90-day related ED return rate in both groups (12%) [21]. A 2024 study of 188 observation patients treated for hyponatremia found similar 30-day ED recidivism rates for EDOU (13%) and NOU (15%) settings. A 2013 study of 327 EDOU heart failure patients reported a 30-day readmission rate of 13.8%, which was lower than the nationally reported 26.9% Medicare heart failure re-admission rate [29,30].

Telemedicine has been successfully adopted in similar clinical settings with similar virtual rounding models and has demonstrated positive outcomes [31,32]. Leibee et al. found that with the use of a virtual provider in an EDOU, clinical staff and patients found virtual care to be similar or improved when compared to having and in-person provider [33].

The findings of this study are significant in that they describe a new practice model for emergency physicians. One which provides significant cost and resource savings for hospitals, and at the same time improves support for emergency physicians. By covering multiple hospitals, emergency physicians are more likely to reach the 20-bed described by Baugh as the threshold for a financially sustainable “two-service” observation model [34]. Compared to the 20-bed one service model where physicians loose $315,382 per year, the 20-bed two service model covers costs with a $37,569 annual profit. Our physician group appreciated having a dedicated shift for observation patients and the work-life flexibilities that telemedicine offered.

The economic benefits quantified in this study have important healthcare delivery implications. The 2023 National Hospital Ambulatory Medical Care Survey (NHAMCS) publication of 2021 data indicated that only 35.3% of U.S. hospitals had an observation unit [35], similar to the 36% of U.S. hospitals reported ten years earlier by Wiler [2]. Virtual EDOU rounding might provide an opportunity to expand the reach of observation care and its associated economic benefits. Furthermore, there are increased physician efficiencies in a virtual care model that allows a single physician to round, virtually, at multiple hospital EDOUs.

Reports from the Center for Disease Control indicated that in 2021 there were an estimated 3,275,000 observation visits following an ED visit in the United States [35]. A 2019 study of Medicare Advantage observation patients by Lind found that between 2006 and 2014 there was a 327% increase (from 4.5% to 19.2%) in prolonged observation stays, defined as 2 days or more [36]. Adjusting for the 64.7.% of hospitals (NHAMCS data) that do not have an observation unit and applying our adjusted length of stay savings of 20.4 h to the 2021 CDC data suggests that virtual-EDOUs could save U.S. hospitals as much as 1,801,086 hospital bed days annually. Applying our adjusted cost savings of $1951 could potentially save U.S. hospitals $4.13 billion in annual hospital costs.

5. Limitations

This study, like all observational studies, is limited by the lack of randomization. While the doubly-robust regression procedure mitigated the impact of those covariates included in the data set, it is possible that the effects observed in the present study are the result of an unmeasured confounder. To address this, we have described a sensitivity analysis in which we evaluate the potential for such unmeasured confounding. Our analysis suggests that it is unlikely that unmeasured confounders would need to have a significant effect to change our results. We note that this sensitivity analyses is limited by the factors that limit all sensitivity analyses. First, it depends on the choice of sensitivity parameters. We chose to focus on the parameters that would result in non-significance as significance is often used as a decision-making tool regarding research findings. However, it is also possible that there is some unmeasured confounder which would substantially reduce the measured effect though without leaving it non-significant. Second, these analyses assume that there is no interaction between the observation group, the outcomes, and any unmeasured confounders [37,38].

This study involves only observation patients managed in a type 1 EDOU in two urban academic health facilities managed by emergency medicine providers and the findings might not be generalizable to other settings. In particular, the findings might not be applicable to other practice groups, such as hospital medicine services, where outcomes have been shown to differ [8].

Also of note is that this study occurred during the coronavirus disease (COVID-19) pandemic. Variations in care patterns with the pandemic can have an effect on this study or, for that matter, on any study that involves this time frame. Additionally, the benefits described in this paper have occurred in the post-pandemic telehealth landscape that saw pandemic-related policy changes that reduced barriers to the practice of telemedicine. The virtual-EDOU model described in this paper is contingent on payers continuing to honor telehealth supervision of APPs.

Finally, this study does not capture quality measures such as patient and provider satisfaction scores. In provider-to-provider tele-intensive care model, through a survey of 1213 ICU nurses, Kleinpell reported a largely favorable provider experience [31]. Further studies are needed to learn more about the virtual care experience in the observation patient population.

6. Conclusion

Management of observation patients in a virtual-EDOU setting is associated with improved costs, length of stays, inpatient admission and adverse events rates relative to observation care in a traditional inpatient setting.

Meetings/prior presentations

N/A.

Grant/other financial support

N/A.

Author contributions

MR, GH, AA, TM, MK and IE contributed to conceptualization. MR and TM contributed to data curation and analysis. MR and TM contributed to methodology. MR and IE contributed to discussion. MR and IE provided overall supervision. MR, GH, AA, TM, MK and IE contributed to writing and editing. MR is responsible for the entire paper as a whole.

CRediT authorship contribution statement

Iyesatta M. Emeli: Writing – review & editing, Writing – original draft, Conceptualization. **Autherine Abiri:** Writing – review & editing, Writing – original draft, Conceptualization. **George Hughes:** Writing – review & editing, Writing – original draft, Conceptualization. **Timothy P. Moran:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Matthew T. Keadey:** Writing – review & editing, Writing – original draft, Conceptualization. **Michael A. Ross:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Data availability

Patient sensitive administrative, quality, and clinical data was used which cannot be de-identified or made publicly available.

Declaration of competing interest

None.

Acknowledgments

N/A.

References

[1] CMS manual system pub 100-04 medicare claims processing transmittal 2282 August 26, 2011; 2011; 8–9.

[2] Wiler JL, Ross MA, Ginde AA. National study of emergency department observation services. Acad Emerg Med. Sep 2011;18(9):959–65. https://doi.org/10.1111/j.1553-2712.2011.01151.x.
[3] Ross MA, Hockenberry JM, Mutter R, Barrett M, Wheatley M, Pitts SR. Protocol-driven emergency department observation units offer savings, shorter stays, and reduced admissions. Health Aff (Millwood). Dec 2013;32(12):2149–56. https://doi.org/10.1377/hlthaff.2013.0662.
[4] Abiri A, Keadey M, Hughes G, Pitts SR, Moran TP, Ross MA. The impact of virtual care in an emergency department observation unit. Ann Emerg Med. Feb 2023;81(2):222–33. https://doi.org/10.1016/j.annemergmed.2022.07.003.
[5] Hadden DS, Dearden CH, Rocke LG. Short stay observation patients: general wards are inappropriate. J Accid Emerg Med. May 1996;13(3):163–5.
[6] Robinson DJ, Woods PG, Snedeker CA, Lynch JH, Chambers K. A comparison trial for stratifying intermediate-risk chest pain: benefits of emergency department observation centers. Prev Cardiol. 2002;5(1):23–30 Winter. https://doi.org/10.1111/j.1520-037x.2002.00550.x. Winter.
[7] Ross MA, Granovsky M. History, principles, and policies of observation medicine. Emerg Med Clin North Am. Aug 2017;35(3):503–18. https://doi.org/10.1016/j.emc.2017.03.001.
[8] Perry M, Franks N, Pitts SR, et al. The impact of emergency department observation units on a health system. Am J Emerg Med. Oct 2021;48:231–7. https://doi.org/10.1016/j.ajem.2021.04.079.
[9] Memorandum Report. Hospitals' use of observation stays and short inpatient stays for medicare beneficiaries, OEI-02-12-00040; 2013.
[10] Emergency department clinical decisions unit reference manual; 2022.
[11] Funk MJ, Westreich D, Wiesen C, Sturmer T, Brookhart MA, Davidian M. Doubly robust estimation of causal effects. Am J Epidemiol. Apr 1 2011;173(7):761–7. https://doi.org/10.1093/aje/kwq439.
[12] Hainmueller J. Entropy balancing for causal effects: a multivariate reweighting method to produce balanced samples in observational studies. Polit Anal. 2012;20(1):25–6.
[13] R Core Team. R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2023. https://www.R-project.org/ 2023.
[14] Carnegie N. Assessing sensitivity to unmeasured confounding using a simulated potential confounder. J Res Educ Effect. 2016;9(3):395–420. https://doi.org/10.1080/19345747.2015.1078862.
[15] Gastwirth J. Dual and simultaneous sensitivity analysis for matched pairs. Biometrika. 1998;85(4):907–20.
[16] Ross MA, Hemphill RR, Abramson J, Schwab K, Clark C. The recidivism characteristics of an emergency department observation unit. Ann Emerg Med. Jul 2010;56(1):34–41. https://doi.org/10.1016/j.annemergmed.2010.02.012.
[17] Ross MA, Compton S, Richardson D, Jones R, Nittis T, Wilson A. The use and effectiveness of an emergency department observation unit for elderly patients. Ann Emerg Med. May 2003;41(5):668–77.
[18] Southerland LT, Vargas AJ, Nagaraj L, Gure TR, Caterino JM. An emergency department observation unit is a feasible setting for multidisciplinary geriatric assessments in compliance with the geriatric emergency department guidelines. Acad Emerg Med. Jan 2018;25(1):76–82. https://doi.org/10.1111/acem.13328.
[19] Osborne A, Weston J, Wheatley M, et al. Characteristics of hospital observation services: a society of cardiovascular patient care survey. Crit Pathw Cardiol. Jun 2013;12(2):45–8. https://doi.org/10.1097/HPC.0b013e318285c2b900132577-201306000-00003. [pii].
[20] Roberts RR, Zalenski RJ, Mensah EK, et al. Costs of an emergency department-based accelerated diagnostic protocol vs hospitalization in patients with chest pain: a randomized controlled trial. Jama. Nov 26 1997;278(20):1670–6.
[21] Ross MA, Compton S, Medado P, Fitzgerald M, Kilanowski P, O'Neil BJ. An emergency department diagnostic protocol for patients with transient ischemic attack: a randomized controlled trial. Ann Emerg Med. 2007 Aug;50(2):109–19. https://doi.org/10.1016/j.annemergmed.2007.03.008. Epub 2007 May 9. PMID: 17490788.
[22] Sun BC, McCreath H, Liang LJ, et al. Randomized clinical trial of an emergency department observation syncope protocol versus routine inpatient admission. Ann Emerg Med. Aug 2014;64(2):167–75. https://doi.org/10.1016/j.annemergmed.2013.10.029.
[23] Baugh CW, Venkatesh AK, Hilton JA, Samuel PA, Schuur JD, Bohan JS. Making greater use of dedicated hospital observation units for many short-stay patients could save $3.1 billion a year. Health Aff (Millwood). Oct 2012;31(10):2314–23. https://doi.org/10.1377/hlthaff.2011.0926.
[24] Abbass IM, Krause TM, Virani SS, Swint JM, Chan W, Franzini L. Revisiting the economic efficiencies of observation units. Manag Care. Mar 2015;24(3):46–52.
[25] Southerland LT, Simerlink SR, Vargas AJ, et al. Beyond observation: protocols and capabilities of an emergency department observation unit. Am J Emerg Med. Oct 2019;37(10):1864–70. https://doi.org/10.1016/j.ajem.2018.12.049.
[26] Mace SE. Resuscitations in an observation unit. J Qual Clin Pract. Sep 1999;19(3):155–64.
[27] Dharmarajan K, Qin L, Bierlein M, et al. Outcomes after observation stays among older adult Medicare beneficiaries in the USA: retrospective cohort study. BMJ. Jun 20 2017;357:j2616. https://doi.org/10.1136/bmj.j2616.
[28] Berger D, King S, Caldwell C, et al. Returns after discharge from the emergency department observation unit: who, what, when, and why? West J Emerg Med. May 3 2023;24(3):390–5. https://doi.org/10.5811/westjem.59023.
[29] Taha JJ, Hughes GB, Keadey MT, et al. The feasibility of emergency department observation units in the management of mild to moderate hyponatremia. Am J Emerg Med. Jun 2024;80:11–7. https://doi.org/10.1016/j.ajem.2024.02.037.
[30] Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the medicare fee-for-service program. N Engl J Med. Apr 2 2009;360(14):1418–28.
[31] Kleinpell R, Barden C, Rincon T, McCarthy M, Zapatochny Rufo RJ. Assessing the impact of telemedicine on nursing care in intensive care units. Am J Crit Care. Jan 2016;25(1):e14–20. https://doi.org/10.4037/ajcc2016808.
[32] Boltz M, Cuellar NG, Cole C, Pistorese B. Comparing an on-site nurse practitioner with telemedicine physician support hospitalist programme with a traditional physician hospitalist programme. J Telemed Telecare. May 2019;25(4):213–20. https://doi.org/10.1177/1357633X18758744.
[33] Leibee C. Evaluation of a virtual provider program in an emergency department observation unit. Ann Emerg Med. 2022;80(4):S10–1. https://doi.org/10.1016/j.annemergmed.2022.08.046.
[34] Baugh CW, Suri P, Caspers CG, Granovsky MA, Neal K, Ross MA. Financial viability of emergency department observation unit billing models. Acad Emerg Med. 2019;26(1):31–40. https://doi.org/10.1111/acem.13452.
[35] National Hospital Ambulatory Medical Care Survey. 2021 emergency department summary tables; 2023.
[36] Lind KD, Noel-Miller CM, Sangaralingham LR, et al. Increasing trends in the use of hospital observation services for older medicare advantage and privately insured patients. Med Care Res Rev. Apr 2019;76(2):229–39. https://doi.org/10.1177/1077558717718026.
[37] Vanderweele TJ, Arah OA. Bias formulas for sensitivity analysis of unmeasured confounding for general outcomes, treatments, and confounders. Epidemiology. Jan 2011;22(1):42–52. https://doi.org/10.1097/EDE.0b013e3181f74493.
[38] Harding DJ. Counterfactual models of neighborhood effects: the effect of neighborhood poverty on dropping out and teenage pregnancy. Am J Sociol. 2003;109(3):676–719.