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Orders for intravenous proton pump inhibitors decrease after implementation of an electronic alert

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TO THE EDITOR

Proton pump inhibitors (PPIs) are highly effective in treating gastric acid-related disorders but are often overused.[1] Intravenous (IV) PPIs are expensive compared to oral PPIs and have few absolute indications; over half of hospitalized patients prescribed IV PPIs could instead receive oral PPIs.[2] Health information technologies have the potential to improve physician ordering of medications, but have not been applied to IV PPIs.[3]

METHODS

On October 21, 2011, our institution introduced an alert that was triggered by all IV PPI orders, excluding continuous infusion PPIs. Esomeprazole is our institution's only formulary PPI. The alert explains that oral PPIs cost one-tenth as much as IV PPIs, yet are 90% bioavailable (Supplementary Figure). Provider response to the alert was automatically captured. Our primary outcome was a change in the proportion of all PPIs given intravenously during one year before the alert compared to one year after the alert, assessed

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retrospectively using an interrupted time series analysis.[4] There were no other interventions related to PPI ordering during the study period. Multivariable logistical regression modeling was performed to assess predictors of an IV compared to oral PPI order, stratified by alert period. To characterize orders in terms of indications, we randomly selected 50 charts from before and 50 charts from after alert implementation, and classified IV PPI orders as indicated or not indicated based on criteria derived from current guidelines.

RESULTS

During the two year study period there were 65,078 completed orders for PPIs, including 10,050 (30.0%) orders for IV PPIs before alert implementation and 7,247 (23.0%) orders for IV PPIs after implementation (chi-squared $p < 0.001$), representing a 7.0% absolute and 23.4% relative reduction in the proportion of PPIs given intravenously (Figure). During the year before the alert, the proportion of PPIs ordered intravenously decreased an average of 0.7% monthly ($p = 0.049$). After adjusting for the trend in IV PPI use before the alert, the proportion of PPIs given intravenously remained significantly decreased after implementation of the alert ($p < 0.001$). Provider-level factors were significant predictors of IV compared to oral route of PPI administration, including the presence of the PPI within an order set (Table). There was a non-significant trend towards improved indication after implementation of the alert (88.0% indicated after vs. 74.0% before; $p = 0.074$). Based on the institutional cost differences between IV and oral PPIs and the observed reduction in IV PPI orders during the year after the alert, we estimate a $450,692 annual decrease in institutional costs related to IV PPI use.

DISCUSSION

Intravenous PPIs are frequently given in situations where oral PPIs would suffice. We found that implementation of an electronic alert for IV PPI orders was associated with a 23% relative decrease in the proportion of PPIs with IV route of administration. This result was significant after adjusting for the trend in the proportion of PPIs ordered intravenously before implementation of the alert. The decrease in the proportion of PPIs ordered intravenously was immediate, sustained, accompanied by an overall decrease in IV PPI orders, and associated with significant cost savings. There was also a trend towards improved indications for IV PPIs after the alert.

There is little prior data evaluating electronic interventions seeking to improve PPI use.[5] In the outpatient setting, pharmacist-based electronic interventions may reduce overall PPI use.[6] Inpatient studies have evaluated use of computerized decision support in changing IV to oral medication orders, but have not targeted IV PPIs.[7] Our findings suggest that, if providers are educated to make a clearly defined change with a simple but focused alert, oral PPIs will frequently be substituted for IV PPIs. Provider-level factors were also an important determinant of PPI route of administration. Compared to the medical service, the surgical or obstetrics services were more likely to order IV versus oral PPIs. This was true both before and after the alert, and after adjusting for patient diet status; however, this study was not designed to address the reasons underlying these differences. Notably, presence of the IV

PPI within an order set strongly predicted IV compared to oral PPI use both before and after alert implementation.

Our study highlights the potential for electronic alerts to alter ordering behavior for IV PPIs. Institutions seeking to decrease IV PPI use should consider removing IV PPIs from order sets, and future studies should test whether additional targeted interventions using clinical decision support systems can improve PPI overuse.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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REFERENCES

1. Heidelbaugh JJ, Goldberg KL, Inadomi JM. Overutilization of proton pump inhibitors: a review of cost-effectiveness and risk [corrected]. Am J Gastroenterol. 2009; 104(Suppl 2):S27–S32. [PubMed: 19262544]
2. Kaplan GG, Bates D, McDonald D, et al. Inappropriate use of intravenous pantoprazole: extent of the problem and successful solutions. Clin Gastroenterol Hepatol. 2005; 3(12):1207–1214. [PubMed: 16361046]
3. Chin HL, Wallace P. Embedding guidelines into direct physician order entry: simple methods, powerful results. Proc AMIA Symp. 1999:221–225. [PubMed: 10566353]
4. Wagner AK, Soumerai SB, Zhang F, et al. Segmented regression analysis of interrupted time series studies in medication use research. J Clin Pharm Ther. 2002; 27(4):299–309. [PubMed: 12174032]
5. Smeets HM, Hoes AW, de Wit NJ. Effectiveness and costs of implementation strategies to reduce acid suppressive drug prescriptions: a systematic review. BMC Health Serv Res. 2007; 7:177. [PubMed: 17983477]
6. Curtain C, Peterson GM, Tenni P, et al. Outcomes of a decision support prompt in community pharmacy-dispensing software to promote step-down of proton pump inhibitor therapy. Br J Clin Pharmacol. 2011; 71(5):780–784. [PubMed: 21480953]
7. Galanter W, Liu XF, Lambert BL. Analysis of computer alerts suggesting oral medication use during computerized order entry of i.v. medications. Am J Health Syst Pharm. 2010; 67(13):1101–1105. [PubMed: 20554597]

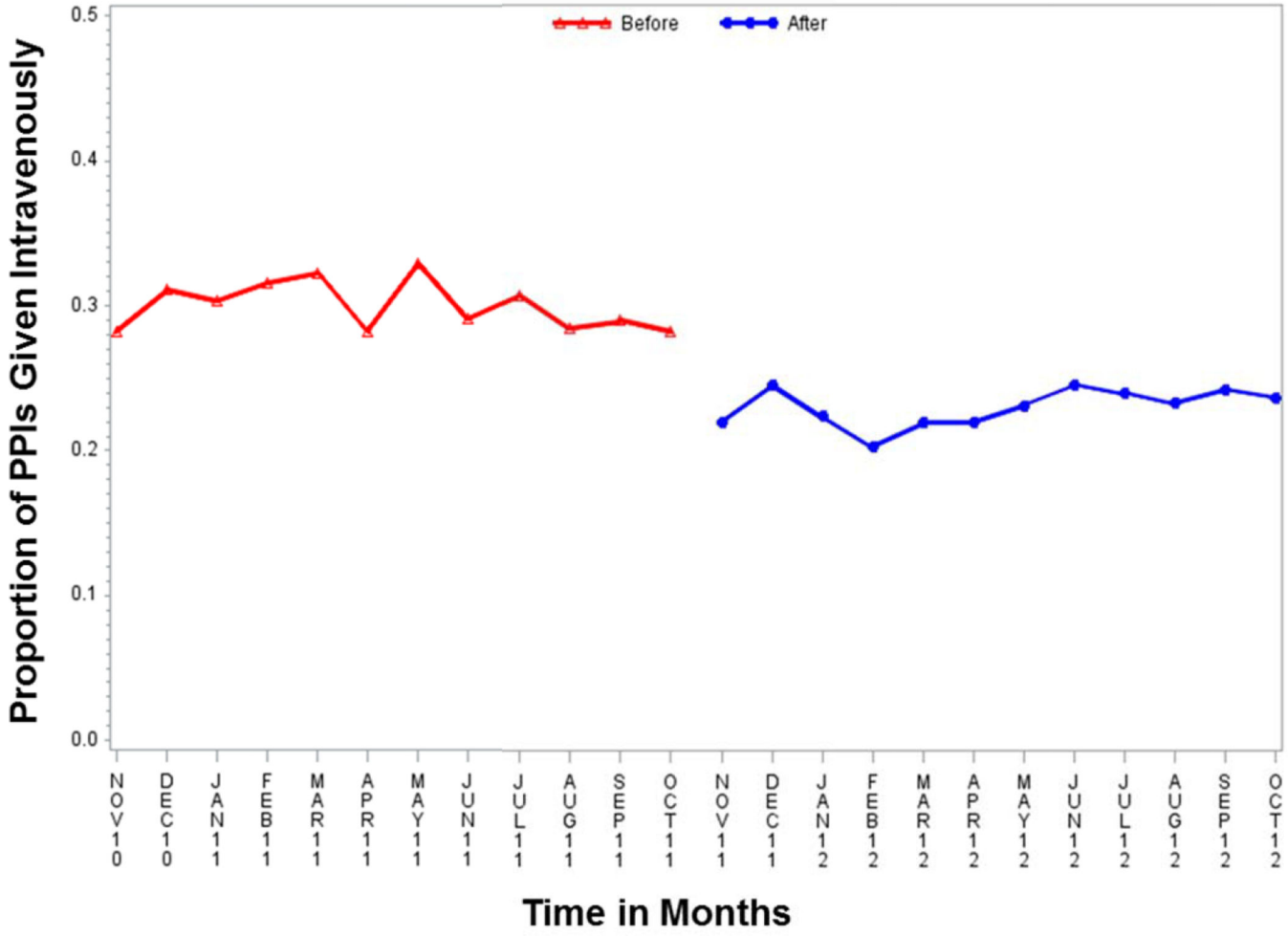

Figure. Proportion of proton pump inhibitors (PPIs) given intravenously before and after implementation of an electronic alert, November 2010 – October 2012

Red line with triangles indicates the proportion of PPIs given intravenously before the alert was implemented on October 21, 2011; blue line with squares indicates the proportion of PPIs given intravenously after the alert.

Table

Multivariable logistic regression analysis for odds of completing an intravenous compared to oral proton pump inhibitor order, stratified by alert period

	Before Alert Implementation			After Alert Implementation		
Risk factor	**Total PPI orders**	**IV orders (% total)**	**Adjusted OR (95% CI)**	**Total PPI orders**	**IV orders (% total)**	**Adjusted OR (95% CI)**
Total	33520	10050 (30.0%)	N/A	31558	7247 (23.0%)	N/A
Order frequency						
Once daily or less	30142	8474 (28.1%)	Reference	28464	6131 (21.5%)	Reference
More than daily	3378	1576 (46.7%)	2.95 (2.72–3.21)	3094	1116 (36.1%)	2.61 (2.39–2.85)
Service						
Medicine	19796	5637 (28.5%)	Reference	18265	3627 (19.9%)	Reference
Surgery	9783	3599 (36.8%)	1.18 (1.11–1.25)	9797	3193 (32.6%)	1.47 (1.38–1.56)
Neurology	2953	526 (17.8%)	0.60 (0.54–0.68)	2600	265 (10.2%)	0.46 (0.40–0.53)
Ob/gyn	647	280 (43.3%)	3.72 (3.10–4.47)	529	159 (30.1%)	2.70 (2.18–3.33)
Psychiatry	341	8 (2.3%)	0.11 (0.05–0.22)	367	3 (0.8%)	0.06 (0.02–0.19)
Provider role						
Physician	25950	8023 (30.9%)	Reference	23169	5364 (23.1%)	Reference
NP/PA	7480	2019 (27.0%)	0.75 (0.70–0.81)	8277	1878 (22.3%)	0.82 (0.76–0.88)
Medical student	90	8 (8.9%)	0.26 (0.12–0.59)	112	5 (4.5%)	0.27 (0.11–0.68)
Order set						
No	27583	6700 (24.3%)	Reference	25957	4773 (18.4%)	Reference
Yes	5937	3350 (56.4%)	3.93 (3.65–4.23)	5601	2474 (44.2%)	2.91 (2.70–3.14)
Diet Status						
Any diet	14272	1542 (10.8%)	Reference	14084	1052 (7.5%)	Reference
NPO	7859	5164 (65.7%)	14.0 (13.0–15.0)	6821	3812 (55.9%)	12.0 (11.0–13.0)
No order	11389	3344 (29.4%)	4.07 (3.79–4.38)	10653	2383 (22.4%)	3.88 (3.57–4.21)

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