

Reducing Inappropriate Outpatient Medication Prescribing in Older Adults across Electronic Health Record Systems

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Abstract

Background The American Geriatrics Society recommends against the use of certain potentially inappropriate medications (PIMs) in older adults. Prescribing of these medications correlates with higher rates of hospital readmissions, morbidity, and mortality. Vanderbilt University Medical Center previously deployed clinical decision support (CDS) to decrease PIM prescribing rates, but recently transitioned to a new electronic health record (EHR).

Objective The goal of this study was to evaluate PIM prescribing rates for older adults before and after migration to the new EHR system.

Methods We reviewed prescribing rates of PIMs in adults 65 years and older, normalized per 100 total prescriptions from the legacy and new EHR systems between July 1, 2014 and December 31, 2019. The PIM prescribing rates before and after EHR migration during November 2017 were compared using a U-chart and Poisson regression model. Secondary analysis descriptively evaluated the frequency of prescriber acceptance rates in the new EHR.

Results Prescribing rates of PIMs decreased 5.2% (13.5 per 100 prescriptions to 12.8 per 100 prescriptions; $p < 0.0001$) corresponding to the implementation of alternatives CDS in the legacy EHR. After migration of the alternative CDS from the legacy to the new EHR system, PIM prescribing rates dropped an additional 18.8% (10.4 per 100 prescriptions; $p < 0.0001$). Acceptance rates of the alternative recommendations for PIMs was low overall at 11.1%.

Conclusion The prescribing rate of PIMs in adults aged 65 years and older was successfully decreased with the implementation of prescribing CDS. This decrease was not only maintained but strengthened by the transition to a new EHR system.

Keywords

- ▶ electronic health records
- ▶ clinical decision support
- ▶ electronic prescribing
- ▶ geriatrics
- ▶ potentially inappropriate medication

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Background and Significance

Medications account for some of the most common interventions and adverse events in health care.¹ About 1.5 million adverse drug events (ADE) and tens of thousands of hospital admissions each year can be attributed to medications.¹ One particularly vulnerable population to these adverse effects is older adults,² compounded by the common use of medications in the older adults population. As an example, medications with anticholinergic and antihistaminergic properties are associated with increased morbidity and mortality with use in older adults. Consequences range from side effects affecting quality of life such as increased dizziness to more serious ADEs such as syncope and cardiac arrhythmias. To raise awareness for this prescribing behavior, the American Geriatrics Society (AGS) Beers Criteria lists potentially inappropriate medications (PIMs) to be avoided or considered with caution in patients 65 years and older.³ Several organizations and regulators, such as the Pharmacy Quality Alliance (PQA), LeapFrog, health insurance plans, and the Centers for Medicare and Medicaid Services, have adopted the Beers Criteria to designate high-risk medications as a quality measure in attempts to provide better care for patients and reduce the cost of this care on the health care system. Several clinical decision support (CDS) interventions have successfully improved medication safety while prescribing in the electronic health record (EHR)^{4,5}; however, past attempts at using CDS to guide prescribing patterns away from PIMs in older adults, with inconsistent and unreliable results.^{6,7} Not all EHR systems are created equal when it comes to configuration of alerts.⁸ Within the same EHR, different institutions and clinics can implement the same tools in different ways, and at different points in the EHR lifecycle. Finally, training and communication of end users to any new CDS can vary greatly from site to site.

There is cause for concern because older adults prescribed PIMs are at higher risk for readmissions and even death. One study showed 50.2% of patients prescribed PIMs died within a mean follow-up period of 41.5 months.⁹ In this same study, PIM presence on an older adult's medication regimen was correlated with three or more readmissions. It is challenging to discern from studies like this whether PIM prescribing has a causative effect on poor health care outcomes in older adult patients and to what extent, especially since PIMs can be appropriate or necessary treatment, depending on the clinical condition(s) being treated. For example, it could be appropriate to use opioids to control acute pain postsurgery in someone with a history of falls. Sometimes there is no effective alternative such as using hypnotics like zolpidem to treat insomnia. In one study, only 36% of PIMs were classified as actually inappropriate medications (AIMs).¹⁰ These investigators noted that certain drug classes or therapeutic categories correlated more strongly with AIMs, including nonbenzodiazepine hypnotics, benzodiazepines, atypical antipsychotics, and muscle relaxants. They determined that muscle relaxants were AIMs 100% of the time; however, that is a drug class with no clear alternatives. Additionally, medications that were classified as AIMs at discharge were

much more likely to be prescribed in the intensive care unit (ICU) (46–73%) versus being PIMs on preadmission medication lists (12–31%).¹⁰

Previous work at Vanderbilt University Medical Center's (VUMC) showed that CDS with dynamic alternative alerts can lead to decreased prescribing of PIMs in older adults.^{11,12} The CDS alerts warned prescribers about PIMs in older adults, following the 2015 Beers Criteria recommendations, and then provided alternative therapy options if available. In 2017, VUMC underwent an enterprise-wide transition of CDS from our legacy home-grown EHR to a commercial vendor EHR. It is difficult to perfectly recreate CDS from one system in another. The format, timing, presentation, user experience, and interaction are impossible to perfectly match. Other than the information presented, they are different alerts. These changes to the EHR and CDS systems could impact CDS and PIM prescribing rates. Therefore, the goal of this study was to evaluate PIM outpatient prescribing rates for older adults before and after migration to the new EHR system.

Methods

This retrospective study was designed to evaluate the effect of CDS interventions on the PIM outpatient prescribing rate in patients 65 years and older at VUMC between July 1, 2014 and December 31, 2019. The legacy e-prescribing system (RxStar) and the new EHR system (Epic Systems, Verona, Wisconsin) were widely used for generating and documenting outpatient prescriptions across all VUMC. Data were extracted from each system's respective data warehouse using SQL queries, transformed, and then loaded into a combined dataset. The dataset included all prescriptions documented during this timeframe from ambulatory visits as well as emergency department and hospital discharges.

Originally, CDS in the legacy e-prescribing system (RxStar) was developed based on the 2015 Beers criteria,¹³ and was limited to PIMs that had at least one evidence-based potentially safer alternative medication.¹⁴ The CDS triggered in the e-prescribing workflow when a PIM prescription was selected for a patient 65 years and older and subsequently displayed a list of potentially safer medications as alternatives. We designed the alerts to be actionable, provide alternatives, include standardized text, and display at medication selection instead of order signing.^{15,16} The prescriber was then allowed to select one of the suggested alternatives, continue with the original order, or cancel the order (→Fig. 1). The alerts were approved by VUMC Pharmacy, Therapeutics, and Diagnostic committee and were implemented in November 2015.^{11,12}

In 2017, VUMC was preparing to transition from a legacy EHR to a commercial vendor EHR system (Epic Systems, Verona, Wisconsin). Pharmacists, subject matter experts, and stakeholders reviewed existing CDS from the legacy system and the implementation team rebuilt most of the CDS into the new EHR system (including the PIM prescribing CDS). VUMC went live on the new EHR system across all its hospitals and clinics in November 2017. An example of CDS built in the new system is shown in →Fig. 2.

Potentially Safer Alternative Advisor**High Risk Medication in Patients ≥ 65 years old - Estrogen Hormones
Substitution Recommended Due to Increased Risk of Carcinogenic Potential****If not otherwise contraindicated:**

- ☐ For vasomotor symptoms - citalopram (Celexa)
- ☐ For vasomotor symptoms - escitalopram (Lexapro)
- ☐ For vasomotor symptoms - venlafaxine (Effexor)
- ☐ For vasomotor symptoms - gabapentin (Neurontin)
- ☐ For vaginal symptoms - estradiol vaginal cream (Estrace)
- ☐ For vaginal symptoms - estradiol vaginal ring (Estring)
- ☐ For vaginal symptoms - estradiol acetate vaginal ring (Femring)
- ☐ For bone density - alendronate (Fosamax)
- ☐ For bone density - risedronate (Actonel)
- ☐ For bone density - raloxifene (Evista)
- ☐ Continue with selected estrogen hormone prescription

Other therapy considerations include:

- Maximum recommended dose for citalopram is 20 mg/day

[Evidence Link](#)

The Vanderbilt Pharmacy, Therapeutics, and Diagnostic Committee has recommended that one of the above alternatives should replace the selected estrogen hormone for patients greater than or equal to 65 years old. Rationale from 2015 Beers Criteria Update: Evidence of carcinogenic potential (breast and endometrium); lack of cardioprotective effect and cognitive protection in older women. Evidence indicates that vaginal estrogens for the treatment of vaginal dryness are safe and effective; women with a history of breast cancer who do not respond to non-hormonal therapies are advised to discuss the risk and benefits of low-dose vaginal estrogen (dosages of estradiol $<25\text{mcg}$ twice weekly) with their health care provider.

Continue

Cancel

Fig. 1 E-prescribing alert for potentially inappropriate medications in legacy system (RxStar).

Overall, both CDS systems look similar, and function in a similar way, where the prescriber is provided a list of possible indications warranting the use of a PIM and then providing a potentially safer alternative medication instead. The prescriber can then select the new alternative order to replace their original order, continue with the original order, or cancel out of the alert and order altogether.

To evaluate the effect of the CDS systems, we reviewed the prescribing rate of PIMs between July 7, 2015 and December 31, 2019. PIMs for this study were determined using the 2019 AGS Beers Criteria³ and grouped into the following categories: androgens, antidepressants, anti-infective agents, antiparkinsonian agents, antipsychotics, antispasmodics, antithrombotics, barbiturates, benzodiazepines, central alpha-agonists, desiccated thyroid, desmopressin, estrogens, first-generation antihistamines, growth hormones, megestrol, meperidine, metoclopramide, nonsteroi-

dal anti-inflammatory drugs, other cardiovascular, other central nervous system, peripheral alpha-1 blockers, proton-pump inhibitors, skeletal muscle relaxants, and sulfonamides. To reflect recommendations made by the 2019 Beer's Criteria, orders were excluded for nifedipine extended and slow release oral formulations, nifedipine topical formulations, diclofenac topical formulations, and doxepin orders greater than 6 mg/day. Sliding scale insulin orders were not included in this analysis because we were not able to discriminate e-prescriptions for sliding scale insulin from the legacy system data compared with fixed dose or other types of insulin orders.

We used descriptive statistics to describe the PIM prescribing rate, as well as quality improvement control charts (U-chart).¹⁷ The U-chart shows the PIM prescribing rate over time, the average prescribing rates, confidence intervals, and implementation dates. To account for increases in clinic

Alternative Recommended

You selected:

esterified estrogens 1.25 mg tablet: Take 1 tablet (1.25 mg total) by mouth daily. Normal, Disp-90 tablet, R-1

Details

Potentially Safer Alternative Advisor

Substitution Recommended Due to Increased Risk of Carcinogenic Potential

References

Evidence Link

The Vanderbilt Pharmacy, Therapeutics, and Diagnostic Committee has recommended that one of the below alternatives should replace the selected estrogen hormone for patients greater than or equal to 65 years old. Rationale from 2015 Beers Criteria Update: Evidence of carcinogenic potential (breast and endometrium); lack of cardioprotective effect and cognitive protection in older women. Evidence indicates that vaginal estrogens for the treatment of vaginal dryness are safe and effective; women with a history of breast cancer who do not respond to non-hormonal therapies are advised to discuss the risk and benefits of low-dose vaginal estrogen (dosages of estradiol <25mcg twice weekly) with their health care provider.

Other therapy considerations include:

Maximum recommended dose for citalopram is 20 mg/day

Alternatives

Alternative

☐ For vasomotor symptoms - citalopram (Celexa)

☐ For vasomotor symptoms - escitalopram (Lexapro)

☐ For vasomotor symptoms - venlafaxine (Effexor)

☐ For vasomotor symptoms - gabapentin (Neurontin)

☐ For vaginal symptoms - estradiol vaginal cream (Estrace)

☐ For vaginal symptoms - estradiol vaginal ring (Estring)

☐ For vaginal symptoms - estradiol acetate vaginal ring (Femring)

☐ For bone density - alendronate (Fosamax)

☐ For bone density - risedronate (Actonel)

Continue with:

☐ esterified estrogens 1.25 mg tablet: Take 1 tablet (1.25 mg total) by mouth daily. Normal, Disp-90 tablet, R-1

Accept Alternative

Remove Order

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Fig. 2 E-prescribing alert for potentially inappropriate medications in Epic.

volume and population growth and aging over time, we normalized the number of PIM prescriptions per 100 prescriptions in patients 65 years and older. A Poisson regression model, adjusted for month of the year and with number of prescriptions as an offset, was used to detect changes in prescribing rates; the model was fit using R statistical software (version 3.5.1). We also used descriptive statistics to describe acceptance rates of the current CDS as a secondary endpoint. This study was reviewed and approved by the VUMC Institutional Review Board.

Results

There were very few updates from the 2015 and 2019 Beers Criteria from AGS.³ The changes discovered did not affect any of the alternative alerts already in place to prevent e-prescriptions of PIMs in the new EHR system. Patient age groups and the number of PIM prescriptions are shown in Table 1.

Prior to EHR migration, there were 1,130,977 encounters where a medication was prescribed for older adults (196,289 having at least one PIM prescribed). After EHR migration, there were 915,146 encounters where a medication was

prescribed for an older adult (126,409 having at least one PIM prescribed). The average prescribing rate of PIMs prior to the legacy CDS implementation (July 2014 to October 2015) was 13.5 PIMs per 100 prescriptions, which dropped to 12.8 PIMs per 100 prescriptions after implementation of the legacy + CDS alerts (November 2015 to October 2017). From November 2017 to December 2019, the PIM prescribing rate dropped again to 10.4 PIMs per 100 prescriptions, corresponding to the vendor EHR system implementation as shown in Fig. 3.

The reductions in average PIM e-prescriptions are statistically significant as determined by the Poisson regression model. The first intervention prescribing rate decreased by 5.2% (incidence rate ratio (IRR) = 0.953; 95% confidence interval (CI): 0.944–0.961; $p < 0.0001$). The decrease from the first intervention to the EHR transition was 18.5% (IRR = 0.809; 95% CI: 0.803–0.816; $p < 0.0001$). The overall change from the legacy EHR, before any interventions, to the current average in the new EHR was a decrease of 23.0% (IRR = 0.771; 95% CI: 0.765–0.778; $p < 0.0001$). It is important to note that the data reflects all the PIMs e-prescribed during the study period; however, there is not CDS in place

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Table 1 Number of potentially inappropriate medications in older adults by age

| Demographics | | Legacy n (%) | Legacy + CDS n (%) | New EHR n (%) | Total n (%) |
|---------------|-------|-----------------|-----------------------|------------------|----------------|
| Prescriptions | | 90,851 (25.3) | 128,637 (35.8) | 139,912 (38.9) | 359,393 (100) |
| Patient age | 65–69 | 34,954 (38.5) | 48,737 (37.9) | 50,401 (36) | 134,091 (37.3) |
| | 70–74 | 25,114 (27.6) | 37,045 (28.8) | 40,863 (29.2) | 103,021 (28.7) |
| | 75–79 | 15,312 (16.9) | 21,598 (16.8) | 25,174 (18) | 62,082 (17.3) |
| | 80–84 | 8,847 (9.7) | 12,171 (9.5) | 13,547 (9.7) | 34,565 (9.6) |
| | 85+ | 6,624 (7.3) | 9,086 (7.1) | 9,927 (7.1) | 25,637 (7.1) |

Abbreviations: CDS, clinical decision support; EHR, electronic health record.

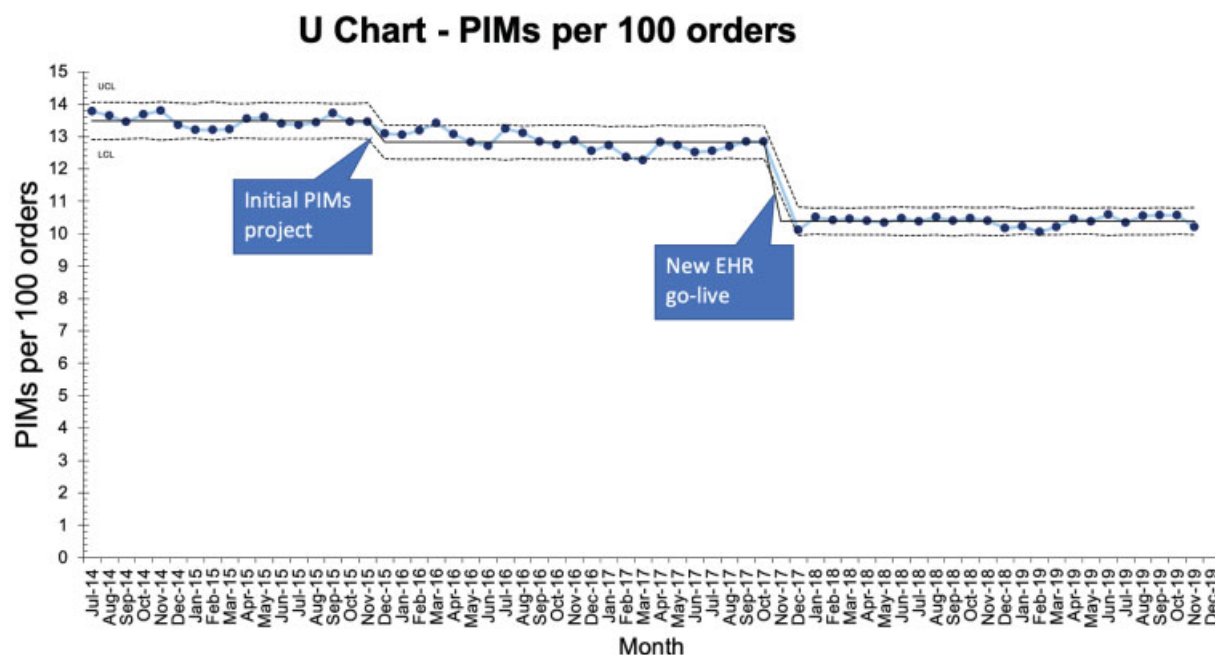


Fig. 3 Rate of PIM e-prescriptions over time. The rate of PIM e-prescriptions per 100 e-prescriptions in patients 65 years old and older per month from July 2014 to December 2019. Initial alternative CDS alerts for PIMs was implemented November 2015, and the new electronic health record with migrated alternative CDS was implemented in November 2017. CDS, clinical decision support; PIM, potentially inappropriate medication.

currently covering all the PIMs included in the 2019 Beers Criteria.

Overall, the acceptance rate for the alternative alerts in the system was low at 11.1% (from 5.8% for meperidine to 23.9% for other cardiovascular agents). The majority of the time prescribers continued with their original selection. The most common alternative alerts in the new EHR system (based on frequency) were for sedative hypnotics, muscle relaxants, tertiary amine and tricyclic antidepressants, first generation antihistamines, and oral/topical estrogens as shown in ▶Table 2.

Discussion

Before any interventions were made, PIMs were prescribed at a rate of approximately 13.5/100 prescriptions in adults 65 years and older. Based on our analysis, there was an

overall decrease in the number of PIMs e-prescribed after the two interventions. The first intervention was implemented within the legacy EHR system and introduced the alternative alerts for the first time. Before this intervention, prescribers were not warned or prevented from prescribing these medications through the EHR system. Once introduced, the alternative alerts had a significant effect in decreasing PIM prescribing as shown in ▶Fig. 3. The PIM prescribing rate further decreased to 10.4 PIMs per 100 prescriptions when we transitioned to the new EHR system. These alternative alerts proved to be effective in decreasing the PIM prescribing rate, as well as maintaining effectiveness while migrating to a new EHR. We expected to see the rate of PIM e-prescribing maintained at the level achieved by the first intervention; however, we discovered a second drop in the prescribing rates of PIMs within the new EHR system. Even with the decrease in PIM prescribing rates, the acceptance

Table 2 Alternative alert acceptance rates after electronic health record transition

| Alert | Decision | n (%) |
|------------------------------------------------|----------|---------------|
| Sedative hypnotics | Accept | 57 (0.3) |
| | Cancel | 1,147 (6.6) |
| | Override | 16,127 (93.1) |
| Muscle relaxants | Accept | 59 (0.5) |
| | Cancel | 1,208 (9.5) |
| | Override | 11,482 (90.1) |
| Antidepressants (tertiary amine and tricyclic) | Accept | 23 (0.4) |
| | Cancel | 692 (11.6) |
| | Override | 5,272 (88.1) |
| First-generation antihistamines | Accept | 58 (1.3) |
| | Cancel | 702 (15.7) |
| | Override | 3,703 (83.0) |
| Estrogens (oral and topical) | Accept | 3 (0.1) |
| | Cancel | 446 (10.4) |
| | Override | 3,838 (89.5) |
| Antiemetics | Accept | 138 (3.6) |
| | Cancel | 488 (12.9) |
| | Override | 3,163 (83.5) |
| Antitussives (promethazine and combos) | Accept | 164 (7.4) |
| | Cancel | 230 (10.4) |
| | Override | 1,810 (82.1) |
| Barbiturates | Accept | 8 (0.7) |
| | Cancel | 119 (9.9) |
| | Override | 1,075 (89.4) |
| Thyroid hormones | Accept | 1 (0.1) |
| | Cancel | 103 (11.2) |
| | Override | 812 (88.6) |
| Moderate analgesics | Accept | 34 (4.1) |
| | Cancel | 119 (14.4) |
| | Override | 675 (81.5) |
| Mild analgesics | Accept | 16 (2.0) |
| | Cancel | 103 (12.7) |
| | Override | 694 (85.4) |
| Other Cardiovascular (digoxin) | Accept | 24 (3.4) |
| | Cancel | 147 (20.6) |
| | Override | 543 (76.1) |
| Oral hypoglycemics | Accept | 19 (2.8) |
| | Cancel | 93 (13.9) |
| | Override | 556 (83.2) |
| Severe analgesics (meperidine) | Accept | 1 (0.4) |
| | Cancel | 15 (5.4) |
| | Override | 264 (94.3) |

Accept: The user accepted the alternative suggestion.

Cancel: The user closed the alternative alert to go back to the ordering screen.

Override: The user overrode the alert and continued with the original order.

rates of the alerts were low at 11.1%. This may be in part due to alert fatigue. While this phenomenon has become ubiquitous, it was not explicitly studied here.

Our findings are similar to those of other studies evaluating PIM prescribing before and after CDS intervention. The EQUIPPED trial is an ongoing quality improvement project, using a multimodal approach to decrease the rate of prescribing PIMs for 10 Department of Veterans Affairs (VA) hospital emergency departments (ED).¹⁸ Preliminary results were published in 2017 on four urban VA EDs that showed PIM prescribing rates between 7.4 and 11.9% before any interventions were made, which was similar to our 13.5%. During intervention implementation, all sites achieved a PIM rate reduction between 4.5 and 6.1% (11.9–5.1% Atlanta, Georgia; 8.2–4.5% Durham, North Carolina; 8.9–6.1% Birmingham, Alabama; and 7.4–5.7% Bronx, New York). There was a statistically significant decrease for all sites with *p*-values between less than 0.0001 and less than 0.04. This study provides support for the benefits of CDS interventions of decreasing prescribing rates of PIMs in older adults, and a benchmark for normal prescribing rates expected before and after using a multimodal approach including CDS intervention.

Additional studies have shown similar results and acceptance rates of CDS for PIM prescribing. One study demonstrated the use of dynamic CDS to recommend alternatives to PIM at the point of prescribing in the inpatient setting. The investigators showed a PIM prescribing decrease of 8.4% in older adults.¹⁹ This study also demonstrated that the rate of ADEs were lower with the CDS in place 3.4 versus 7.1% than without it (*p* = 0.02). One of the major challenges revealed in this study is that the use of alternative alerts in attempt to change prescribing patterns are often accepted at a very low rate. The investigators found that 92.5% of the recommendations for alternative medications were declined, which was similar to the 88.9% override rate seen in our study.

It is never certain what consequences there will be in the short term on patient safety and outcomes during an EHR transition, especially when considering medication prescribing. One study corresponding to the advent of Meaningful Use prospectively followed 17 physicians for prescribing errors in the ambulatory setting as they transitioned from one EHR, containing minimal to no CDS, to a certified EHR with robust CDS.²⁰ Overall, they saw a higher rate of prescribing errors at baseline compared with a year after new EHR implementation. However, they also saw a higher rate of nonabbreviation errors in prescribing during the short term, with 17.7 per 100 prescriptions (95% CI: 9.5–33.0) at 12 weeks postimplementation versus 8.5 per 100 prescriptions (95% CI: 4.6–15.9) at baseline (*p* < 0.001).²⁰ More research is needed to see if there is an immediate impact on prescribing errors in the acute phase of a transition between two EHRs, both with robust CDS versus a transition where the former EHR has little to no CDS in place to guide prescribing. While interesting, we cannot directly compare alternative alerts used to decrease PIM prescribing directly to general CDS for prevention of general prescribing errors. It is compelling, however, to identify previous studies which found a direct correlation between higher prescribing errors

up to 12 weeks after new EHR implementation as compared with this study with CDS transition resulting in lower prescribing of PIMs 1 month after implementation.

The literature contains very few examples of the impact of EHR transitioning on the effectiveness and safety of CDS. One group compared the rates of overridden alerts for allergies, drug–drug interactions, geriatric warnings, and renal warnings in their legacy and commercial EHR systems in ICU patients.²¹ They discovered a significantly larger number of unique alerts per patient in the new, commercial EHR system, owing in part to the loss of tailoring of alerts in the legacy EHR at the end of its life cycle and differences in timing of alert presentation in workflow between the two EHRs. These researchers found no evidence of ADEs in their post hoc analysis despite the significant differences in number of overridden alerts. Since we only have data comparing acceptance, continuation, and cancellation rates of alerts in our new EHR system, we are unable to conduct a before and after comparison between the two CDS interventions. We can say that the alerts displayed at the same points in workflow, and have similar appearance and functionality in both systems.

Limitations

One major limitation of our study is that while we know our prescribing rates of PIMs have decreased over time, we do not know the impact on patient outcomes in the older adults. We did not determine the number or severity of comorbidities in our patient population. Additionally, we did not conduct additional analyses for other independent variables that could have affected the primary outcome and so cannot fully attribute the decreases seen to our interventions, even though the decreases in the prescribing rates corresponded with the intervention dates. This would have included whether the prescriptions were new prescriptions or refills and if the patients had significant comorbidities. Further research is needed to better understand how this intervention impacted patient outcomes. We also know that the original intervention group only created alternative alerts for the top 25 PIMs, which accounted for 85% of all PIMs prescribed at that time. We did not differentiate in our analysis the types of PIMs being prescribed, and whether our CDS decreased PIM prescribing equally. Some PIMs are more concerning than others, especially if they put patients at increased risk of exacerbating their comorbidities, disease states, or likelihood of falling. Additionally, not all CDS improves patient safety, and some may even result in safety events or errors if not designed, implemented, or used correctly.^{22,23} We are not aware of any safety events as a result of this intervention. Similar to other institutions,²⁴ we have continuous quality improvement measures in place to address these discrepancies and future research will look to see if these new CDS interventions can further decrease the rate of PIM e-prescribing at VUMC. Finally, this study only looked at PIMs e-prescribed during the study time period; some PIM prescriptions could have been written out by hand, especially in the legacy EHR system.

Conclusion

The effectiveness of clinical decision support to reduce PIM prescribing in older adults was not only maintained but strengthened in the transition from legacy to a vendor EHR system. This study shows alternative alerts for PIMs in older adults have successfully decreased the overall e-prescribing rate of these medications in adults aged 65 years and older.

Clinical Relevance Statement

This study shows that e-prescribing clinical decision support has a significant effect on lower the rates of prescribing PIMs in older adults. This effect was not only maintained but strengthened after migrating to a new EHR system.

Multiple Choice Questions

- Which of the following best describes medications defined in the Beers' Criteria as ones to avoid using or consider use with caution in the older adult population?
 - Potentially toxic medications
 - Potentially inappropriate medications
 - Potentially adverse medications
 - Safer alternative medications

Correct Answer: The correct answer is option b. Medications defined in the Beers' Criteria are called potentially inappropriate medication.

- The implementation of alternative alerts clinical decision support (CDS) in this study was associated with what result regarding the prescribing rate of PIMs?
 - Increase
 - Decrease
 - No change
 - Unknown

Correct Answer: The correct answer is option b. The implementation of clinical decision support in this study resulted in a decrease in the prescribing rate of PIMs on two separate occasions.

- The utilization of PIMs in older adults results in which of the following?
 - Increased emergency room visits morbidity, and mortality
 - Decreased hospital readmissions, morbidity, and mortality
 - Increased hospital readmissions, morbidity, and mortality
 - Decreased emergency room visits, morbidity, and mortality

Correct Answer: The correct answer is option c. The unitization of PIMs in older adults has been shown to result in increased hospital readmissions, morbidity, and mortality.⁹

- The study revealed that a conversion from a legacy electronic health record (EHR) to a commercial vendor EHR yielded what impact on the prescribing of PIMs?

- a. Increase
- b. Decrease
- c. No change
- d. Unknown

Correct Answer: The correct answer is option b. The conversion from the legacy CDS to a vendor EHR system further decreased the prescribing rate of PIMs.

Protection of Human and Animal Subjects

The study was performed in compliance with the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects, and was reviewed by VUMC Institutional Review Board.

Conflict of Interest

None declared.

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