Improved Vitamin D Supplementation in Hospitalized Breastfed Infants Through Electronic Order Modification and Targeted Provider Education

abstract

OBJECTIVE: To examine effectiveness of an intervention promoting vitamin D supplementation in hospitalized breastfed infants.

METHODS: Our urban tertiary care hospital instituted a 2-part intervention: brief education for providers on vitamin D guidelines and insertion of an opt-in order for vitamin D supplements into electronic admission order sets. Data downloads on admissions of patients aged <1 year were obtained. We excluded those not breastfed, with a dietary restriction, or admitted to intensive care. Intervention effects were compared from 6 months postintervention to the 6 same months 1 year earlier. We applied χ² and logistic regression, including the patient as a random effect to adjust for repeated admissions.

RESULTS: Data on 471 exclusively or partially breastfed admissions (441 infants) were analyzed (221 preintervention, 250 postintervention). Admission characteristics did not differ by period: 55.0% boys; 40.6% Medicaid; 63.7% hospitalized ≤2 days; 72.0% on a general medical service; 16.6% received nutritionist consultation. In-hospital vitamin D prescribing rates significantly increased postintervention (19.5% vs 44.4%; \( P < .001 \)). Postintervention admissions were more than twice as likely to receive vitamin D supplementation (adjusted odds ratio 2.3, 95% confidence interval 1.6–3.2). Other associated factors included vitamin D as a medication used before admission (adjusted odds ratio 14.3, 95% confidence interval 4.9–41.6), nutritionist consultation during admission, hospitalization ≥3 days, and admission to a general medical service. Prescribing of vitamin D at discharge increased significantly (9.0% vs 19.6%; \( P < .001 \)).

CONCLUSIONS: Medical provider education and modification of electronic ordering templates significantly increased use of vitamin D supplementation in hospitalized breastfed infants.

Vitamin D deficiency in infants and children is a frequent problem in the United States and internationally. In particular, breastfed infants are at risk for vitamin D deficiency due to inadequate amounts of vitamin D present in breast milk. The positive health benefits of vitamin D sufficiency have been studied extensively, ranging from the prevention of vitamin D–dependent rickets to decreased risk of acute lower respiratory tract infections, including respiratory syncytial virus bronchiolitis, childhood respiratory infections, and wheezing. Multiple
studies have shown higher prevalence of vitamin D deficiency in critically ill children admitted to ICUs, suggesting that vitamin D deficiency may be associated with greater risk of critical illness.9,10

In 2008, the American Academy of Pediatrics (AAP) issued guidelines to recommend 400 IU of vitamin D supplementation daily for all breastfed infants and all formula-fed infants who ingest <1 L of vitamin D–fortified formula per day.11 This recommendation was supported by the Institute of Medicine 2011 dietary reference for calcium and vitamin D.12 However, many US infants are not receiving adequate amounts of vitamin D, in part due to physician provider knowledge gaps surrounding current recommendations.13–15

To our knowledge, no studies to date have addressed the opportunity to use electronic medical record (EMR)-based interventions to improve the in-hospital prescribing rate of vitamin D for breastfed infants. This study fills that gap, with the specific aim of increasing prescribing rates of vitamin D supplementation for hospitalized breastfed infants in compliance with AAP guidelines.11 The intervention components included education of providers and insertion of computer-based ordering prompts.

METHODS

Subjects

Data on admissions of children admitted to age <1 year to a large urban tertiary care children’s hospital over two 6-month periods (April 18, 2012–October 18, 2012 and April 18, 2013–October 18, 2013) were obtained through an EMR download. The dates were chosen to reflect 6-month periods for preintervention and post-intervention evaluations and to reduce biases resulting from variations in seasonal admissions. Admissions to ICUs (including pediatric, neonatal, and cardiac) were excluded. Data downloaded were reviewed and admissions with dietary restrictions including nothing by mouth at the time of admission, total parenteral nutrition, and ketogenic diet were excluded. This study was approved by the Ann & Robert H. Lurie Children’s Hospital of Chicago Institutional Review Board.

Intervention

A multifaceted intervention aimed at increasing the frequency of ordering vitamin D supplementation for hospitalized breastfed infants in compliance with AAP guidelines was designed and applied. Intervention components included education of providers and insertion of computer-based ordering prompts.

From April 23, 2013, to May 16, 2013, educational sessions were completed to review AAP guidelines on vitamin D supplementation by using a 5-slide PowerPoint presentation. The presentation discussed the current guidelines, patients to which the guidelines applied, and how providers could appropriately prescribe correct vitamin supplementation to meet these guidelines. The presentation was shown at a pediatric resident noon conference, an advanced practice nursing grand rounds, and the May 2013 monthly meeting of the Division of Hospital-based Medicine. The attendance records from these meetings were not available for review, but the presentation was distributed electronically via E-mail to all pediatric residents and hospitalists to ensure that those not in attendance were able to self-review the slides for educational purposes.

On April 18, 2013, an electronic intervention was implemented in the EMR used for patient care and electronic ordering. In the “Diet” section of 10 frequently used admission order sets, an informational prompt was inserted at the top. The prompt stated: “American Academy of Pediatrics Recommendation: All infants LESS than one year old who are exclusively breastfed or who drink less than 33oz of formula per day should receive 400 IU of vitamin D supplementation daily. Please consider supplementation with 1mL Poly-Vi-Sol daily if applicable.” An opt-in order for Poly-Vi-Sol (Mead Johnson Nutrition, Glenville, IL) with the recommended dosage was inserted beneath the prompt. An “opt-in” order requires the provider to select the medication by clicking on a box, as opposed to a preselected medication that is automatically provided to each patient without provider action. Poly-Vi-Sol was chosen because it was the vitamin D–containing supplement already on pharmacy formulary at our institution. An E-mail with a screen shot of the new Diet section and a description of its purpose was sent to all prescribing providers within the institution to introduce the modification.

Data

Data on each admission in the selected period were evaluated. Data included patient demographics, admission and discharge dates and diagnoses, electronic admission order set used, admitting service, initial diet order, nutrition consultation order, vitamin D serum laboratory order, and vitamin supplementation prescribed during inpatient stay. Additionally, we evaluated
preamendment medications to determine whether vitamin D supplementation had been used before admission, as well as discharge prescriptions for evidence of vitamin D supplementation. These medications were identified by either record of the prescription in our EMR if the prescribing physician was a staff member at our institution, or based on parental report of home medications prescribed by outside physicians. Infants were deemed to be breastfeeding during the admission if free-text data fields where nursing staff describe current diet and feeding schedule/instructions included notations indicating current breastfeeding, either exclusively or in combination with formula or solid foods. Breastfeeding specifically refers to those infants being fed human milk, encompassing both those infants feeding at the mother’s breast, or bottle-feeding the mother’s pumped breast milk. Classification of breastfeeding infants did require that the parent or guardian was able to accurately describe the infant’s diet, including the presence of any human milk, as this free text field was the sole electronic data field to categorize these patients.

Data Analysis

Analyses were conducted by using the IBM SPSS Statistics, version 20.0.0 (IBM Corporation, Chicago, IL) and Stata 9.2 (Stata Corp, College Station, TX). Admission demographics, clinical factors, and vitamin D supplementation rates were summarized, and preintervention and postintervention periods were compared by using $\chi^2$ and Fisher’s exact tests, as appropriate. Vitamin D supplementation was defined as any medication containing ergocalciferol (vitamin D2) as a single ingredient, or any combination multivitamin that included vitamin D as a component. In an admission encounter-based analysis, we used $\chi^2$ tests to perform univariate analyses of vitamin D supplementation rates versus demographic and clinical factors, including nutrition consultation, length of hospital stay, admission service, vitamin D as a medication used before admission, and patient age.

We next applied a multivariate model to evaluate the relative strength of factors associated with receiving vitamin D supplementation during admission. The demographic and clinical factors with associations of $P < .05$ in the univariate analyses were entered into a logistic regression model, including study period (preintervention versus postintervention), length of hospital stay ($\leq 2$ days versus $\geq 3$ days), nutritionist consultation during hospitalization, vitamin D supplementation before admission, and admitting service. Additionally, because of the known associations between race and vitamin D deficiency, race/ethnicity was retained in the final multivariate model. The logistic regression model included patient as a random effect to account for clustering.

RESULTS

Subjects

In the study period, there were 1281 admissions of children age <1 year. Of these, 789 (61.6%) admissions were excluded because the admitted child was not breastfed, and an additional 21 (1.6%) were excluded because of dietary restrictions (11 limited to nothing by mouth, 6 total parenteral nutrition, and 6 ketogenic diet). The remaining 471 admissions (221 preintervention and 250 postintervention) included data on 441 exclusively or partially breastfed infants. Overall, 30 infants had 2 or more admissions (Table 1). No infant had an admission during both study periods.

Most patients were white or Hispanic, more than half were boys, and more than half were privately insured (Table 1). About three-quarters of patients were admitted to a general medical service and 16.6% had a nutritionist consult during their admission. During the postintervention period, admitted infants were more often noted to already be taking vitamin D supplementation (Table 1).

Vitamin D Supplementation

In-hospital vitamin D supplementation prescribing significantly increased after the intervention (preintervention 19.5%, postintervention 44.4%; $P < .001$; Table 2). The rate of prescribing vitamin D at discharge for continued home use also was significantly increased (preintervention 9.0%, postintervention 19.6%; $P < .001$, Table 2).

We identified 4 additional factors that were significantly associated with vitamin D prescribing rates: nutritionist consultation during hospitalization, hospitalization lasting $\geq 3$ days, admission to a general medical service, and presence of vitamin D as a medication used before admission (Table 3).

Multivariate Regression Model

We next developed multivariate logistic regression models to better understand the strength of factors associated with in-hospital vitamin D supplementation (Table 4). The models included patient as random effect to account for clustering (ie, repeated hospitalizations). Postintervention admissions were 2.3 times more likely to receive vitamin D supplementation in the adjusted analysis. The most significant predictor for
in-hospital vitamin D supplementation was identification of vitamin D supplementation as a preadmission medication (adjusted odds ratio 14.3, confidence interval 4.9–41.6). Admissions to a general medical service more often had in-hospital vitamin D supplementation than did admissions to a subspecialty or surgical service. Race/ethnicity was retained in the final multivariate model, but was not significant.

**DISCUSSION**

This study is the first to look at strategies to increase vitamin D supplementation in hospitalized breastfed infants. We found that both the inpatient and discharge prescribing rates of vitamin D can be more than doubled by brief provider education and use of EMR-based order set reminders.

The age of EMRs and computerized provider order entry has seen an increased usage of EMR-based interventions to improve medical care and augment clinical performance. Preliminary work has shown that computerized physician prompts and standing orders improve health maintenance and preventive care practices during inpatient admissions. Quality improvement interventions have been successful in increasing vitamin D supplementation in nursing home and elderly long-term care patients to a similar degree as our study, but no studies on pediatric populations are available for comparison.

Our study showed that the combination of brief medical provider education and EMR-based order set modification was successful in more than doubling the rate of vitamin D supplementation in hospitalized breastfed infants at our institution. However, at an only 44% prescribing rate, our intervention still missed a majority of breastfed infants. There are many potential reasons that our intervention fell short of our ultimate goal of 100% prescribing rate. Perhaps the more pressing complex issues of inpatient hospitalization made vitamin supplementation a low-priority intervention. Perhaps hospitalist

**TABLE 1** Characteristics of Admissions and Differences Between Pre- and Postintervention Samples

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total n = 471</th>
<th>Preintervention n = 221 (47%)</th>
<th>Postintervention n = 250 (53%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission no. for infant in sample</td>
<td></td>
<td></td>
<td></td>
<td>.02</td>
</tr>
<tr>
<td>First</td>
<td>441 (93.6)</td>
<td>214 (96.8)</td>
<td>227 (90.8)</td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>25 (5.3)</td>
<td>7 (3.2)</td>
<td>18 (7.2)</td>
<td></td>
</tr>
<tr>
<td>Third</td>
<td>4 (0.8)</td>
<td>0 (0)</td>
<td>4 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Fourth</td>
<td>1 (0.2)</td>
<td>0 (0)</td>
<td>1 (0.4)</td>
<td></td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
<td></td>
<td>.14</td>
</tr>
<tr>
<td>White</td>
<td>223 (47.3)</td>
<td>95 (43.0)</td>
<td>128 (51.2)</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>42 (8.9)</td>
<td>17 (7.7)</td>
<td>25 (10.0)</td>
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</tr>
<tr>
<td>Hispanic</td>
<td>146 (31.0)</td>
<td>81 (36.7)</td>
<td>65 (26.0)</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>28 (5.9)</td>
<td>14 (6.3)</td>
<td>14 (5.6)</td>
<td></td>
</tr>
<tr>
<td>Other/Unknown</td>
<td>32 (6.8)</td>
<td>14 (6.3)</td>
<td>18 (7.2)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td>.92</td>
</tr>
<tr>
<td>Boys</td>
<td>259 (55.0)</td>
<td>121 (54.8)</td>
<td>138 (55.2)</td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>212 (45.0)</td>
<td>100 (45.2)</td>
<td>112 (44.8)</td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td></td>
<td></td>
<td></td>
<td>.12</td>
</tr>
<tr>
<td>Medicaid</td>
<td>191 (40.6)</td>
<td>98 (44.3)</td>
<td>93 (37.2)</td>
<td></td>
</tr>
<tr>
<td>Non-Medicaid</td>
<td>280 (59.4)</td>
<td>123 (55.7)</td>
<td>157 (62.8)</td>
<td></td>
</tr>
<tr>
<td>Admission Service</td>
<td></td>
<td></td>
<td></td>
<td>.60</td>
</tr>
<tr>
<td>General medical</td>
<td>339 (72.0)</td>
<td>160 (72.3)</td>
<td>179 (71.6)</td>
<td></td>
</tr>
<tr>
<td>Subspecialty medical</td>
<td>74 (15.7)</td>
<td>37 (16.7)</td>
<td>37 (14.8)</td>
<td></td>
</tr>
<tr>
<td>Surgical</td>
<td>58 (12.3)</td>
<td>24 (10.9)</td>
<td>34 (13.6)</td>
<td></td>
</tr>
<tr>
<td>Nutritionist consultation</td>
<td></td>
<td></td>
<td></td>
<td>.52</td>
</tr>
<tr>
<td>Yes</td>
<td>78 (16.6)</td>
<td>34 (15.4)</td>
<td>44 (17.6)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>393 (83.4)</td>
<td>187 (84.6)</td>
<td>206 (82.4)</td>
<td></td>
</tr>
<tr>
<td>Length of hospital stay, d</td>
<td></td>
<td></td>
<td></td>
<td>.96</td>
</tr>
<tr>
<td>≤ 2</td>
<td>300 (63.7)</td>
<td>141 (63.8)</td>
<td>159 (63.6)</td>
<td></td>
</tr>
<tr>
<td>≥ 3</td>
<td>171 (36.3)</td>
<td>80 (36.2)</td>
<td>91 (36.4)</td>
<td></td>
</tr>
<tr>
<td>Vitamin D supplement before admission</td>
<td></td>
<td></td>
<td></td>
<td>.04</td>
</tr>
<tr>
<td>Documented</td>
<td>58 (12.3)</td>
<td>20 (9.0)</td>
<td>38 (15.2)</td>
<td></td>
</tr>
<tr>
<td>Not documented</td>
<td>413 (87.7)</td>
<td>201 (91.0)</td>
<td>212 (84.8)</td>
<td></td>
</tr>
</tbody>
</table>

* Fisher’s exact test.

in-hospital vitamin D supplementation was identification of vitamin D supplementation as a preadmission medication (adjusted odds ratio 14.3, confidence interval 4.9–41.6). Admissions to a general medical service more often had in-hospital vitamin D supplementation than did admissions to a subspecialty

**TABLE 2** Vitamin D Supplementation Rates

<table>
<thead>
<tr>
<th>Vitamin D supplement prescribed for in-hospital stay</th>
<th>Total n = 471</th>
<th>Preintervention n = 221</th>
<th>Postintervention n = 250</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>154 (32.7)</td>
<td>43 (19.5)</td>
<td>111 (44.4)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>No</td>
<td>317 (67.3)</td>
<td>178 (80.5)</td>
<td>139 (55.6)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Received vitamin D prescription at discharge</th>
<th>Total n = 471</th>
<th>Preintervention n = 221</th>
<th>Postintervention n = 250</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>69 (14.6)</td>
<td>20 (9.0)</td>
<td>49 (19.6)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>No</td>
<td>402 (85.4)</td>
<td>201 (91.0)</td>
<td>201 (80.4)</td>
<td></td>
</tr>
</tbody>
</table>
providers preferred to allow primary care providers to initiate vitamin supplementation in the outpatient setting, where compliance can be followed on a regular basis. Regardless, there remains much room for improvement. In future work, we could consider a best practice alert, such that if the physician does not prescribe vitamin D for an eligible patient based on age and diet, the EMR would have an alert “pop-up” to remind the physician of the vitamin D recommendations and allow another opportunity to prescribe a vitamin D–containing supplement. Although this strategy runs the risk of creating alert fatigue, a concept highly studied in research on preventing drug-drug interactions when multiple medications are prescribed, it would allow the provider a second chance to correctly identify infants in need of vitamin supplementation.

An alternative strategy for improvement could invoke the use of “opt-out” orders as opposed to our strategy of “opt-in” ordering. Opt-out ordering is supported in the reliability science literature by taking the impetus off the provider to remember to order a vitamin supplement, instead relying on the EMR to identify and select vitamin supplementation for patients. This idea has been trialed with in-hospital vaccination against influenza and Streptococcus pneumonia. Our initial strategy did not include opt-out

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**TABLE 3** Factors Associated With Vitamin D Supplementation During In-Hospital Stay

<table>
<thead>
<tr>
<th>Factor</th>
<th>Total n = 471</th>
<th>Vitamin D Prescribed n = 154 33%</th>
<th>No Vitamin D Prescribed n = 317 67%</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td></td>
</tr>
<tr>
<td>Nutritionist consultation during hospitalization</td>
<td></td>
<td></td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Yes</td>
<td>78 (16.6)</td>
<td>39 (25.3)</td>
<td>39 (12.3)</td>
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</tr>
<tr>
<td>No</td>
<td>393 (83.4)</td>
<td>115 (74.7)</td>
<td>278 (87.7)</td>
<td></td>
</tr>
<tr>
<td>Length of hospital stay, d</td>
<td></td>
<td></td>
<td></td>
<td>&lt;.01</td>
</tr>
<tr>
<td>≤2</td>
<td>300 (63.7)</td>
<td>83 (53.9)</td>
<td>217 (68.5)</td>
<td></td>
</tr>
<tr>
<td>≥3</td>
<td>171 (36.3)</td>
<td>71 (46.1)</td>
<td>100 (31.5)</td>
<td></td>
</tr>
<tr>
<td>Admission Service</td>
<td></td>
<td></td>
<td></td>
<td>&lt;.01</td>
</tr>
<tr>
<td>General medical</td>
<td>339 (72.0)</td>
<td>123 (79.9)</td>
<td>216 (68.1)</td>
<td></td>
</tr>
<tr>
<td>Subspecialty medical</td>
<td>74 (15.7)</td>
<td>23 (14.9)</td>
<td>51 (16.1)</td>
<td></td>
</tr>
<tr>
<td>Surgical</td>
<td>58 (12.3)</td>
<td>8 (5.2)</td>
<td>50 (15.8)</td>
<td></td>
</tr>
<tr>
<td>Vitamin D supplementation before admission</td>
<td></td>
<td></td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Documented</td>
<td>58 (12.3)</td>
<td>38 (24.7)</td>
<td>20 (6.3)</td>
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</tr>
<tr>
<td>Not documented</td>
<td>413 (87.7)</td>
<td>116 (75.3)</td>
<td>297 (93.7)</td>
<td></td>
</tr>
<tr>
<td>Age group, mo</td>
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<td></td>
<td></td>
<td>.86</td>
</tr>
<tr>
<td>&lt;6</td>
<td>411 (87.3)</td>
<td>135 (87.7)</td>
<td>276 (87.1)</td>
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</tr>
<tr>
<td>6–12</td>
<td>60 (12.7)</td>
<td>19 (12.3)</td>
<td>41 (12.9)</td>
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</tr>
</tbody>
</table>

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**TABLE 4** Multivariate Logistic Regression Assessing Strength of Associations With Vitamin D Supplementation During Hospital Stay

<table>
<thead>
<tr>
<th>Factor</th>
<th>Unadjusted</th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio (95% CI)</td>
<td>Odds Ratio (95% CI)</td>
</tr>
<tr>
<td>Study period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preintervention</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Postintervention</td>
<td>6.6 (3.1–14.3)</td>
<td>2.3 (1.6–3.2)</td>
</tr>
<tr>
<td>Length of hospital stay, d</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤2</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>≥3</td>
<td>2.5 (1.3–5.1)</td>
<td>2.1 (1.1–4.1)</td>
</tr>
<tr>
<td>Nutritionist consultation during hospitalization</td>
<td></td>
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</tr>
<tr>
<td>Not obtained</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Obtained</td>
<td>4.2 (1.7–10.3)</td>
<td>2.7 (1.2–6.3)</td>
</tr>
<tr>
<td>Vitamin D supplementation before admission</td>
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<td></td>
</tr>
<tr>
<td>Not documented</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Documented</td>
<td>10.4 (3.9–279)</td>
<td>14.3 (4.9–41.6)</td>
</tr>
<tr>
<td>Admission service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General medical</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Subspecialty medical</td>
<td>0.6 (0.2–1.4)</td>
<td>0.2 (0.1–0.6)</td>
</tr>
<tr>
<td>Surgical</td>
<td>0.1 (0.0–0.4)</td>
<td>0.0 (0.0–0.2)</td>
</tr>
<tr>
<td>Race/ethnicity group</td>
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<td></td>
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<tr>
<td>White</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Black</td>
<td>1.6 (0.5–5.3)</td>
<td>1.6 (0.6–4.6)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>0.3 (0.1–0.7)</td>
<td>0.5 (0.3–1.1)</td>
</tr>
<tr>
<td>Asian</td>
<td>0.2 (0.0–1.0)</td>
<td>0.3 (0.1–1.0)</td>
</tr>
<tr>
<td>Other/Unknown</td>
<td>1.3 (0.3–4.8)</td>
<td>1.6 (0.5–5.2)</td>
</tr>
</tbody>
</table>

CI, confidence interval.

* Included patient as a random effect to account for clustering.
ordering for vitamin D because our current EMR was unable to correctly identify breastfed infants. Additionally, although an opt-out order may have achieved higher vitamin D prescribing rates, the fact that most infants (63.2%, 810/1281) in our sample did not meet criteria for vitamin D supplementation made opt-in ordering a more suitable initial approach. Moving forward, developing a specific “breastfeeding” order within the EMR to identify breastfed infants could allow for opt-out ordering, and a less failure-prone process for prescribing vitamin D to infants meeting criteria.

In addition to our educational intervention and EMR-based order set reminders, we identified other factors associated with higher rates of vitamin D supplementation. The presence of vitamin D as a medication used before admission was the most significant variable to positively increase the rate of in-hospital vitamin D supplementation by more than 14 times. This is likely due to the structure of the EMR ordering system. On admission, providers have the option to “order” all home medications to be administered during the inpatient stay; thus it is possible that a child would be continued on the home medication more often than for a provider to independently identify the need for vitamin supplementation and initiate it during hospitalization. The fraction of infants on vitamin D supplementation as a medication before admission was higher in the postintervention group, possibly related to increased knowledge of AAP guidelines by outpatient practitioners with an extra year of time between the study samples.

Other associated factors were identified as well. A nutritionist consultation was associated with an increased rate of in-hospital vitamin D supplementation, possibly because nutritionists, by profession, are familiar with current dietary guidelines for different pediatric populations. At our institution, a nutritionist consult can be enacted by a physician, bedside nurse, or parent for guidance around any aspect of the patient’s diet or nutritional health. In our study, the nutritionists were not able to activate the vitamin D supplementation order themselves, but could provide recommendations regarding multivitamin supplementation to the physician caring for the patient. Longer hospitalizations (≥3 days) also were associated with higher in-hospital vitamin D supplementation rates. Perhaps a patient’s nutritional status receives more attention the longer he or she remains out of the natural dietary environment. Admission to a general medical service was associated with an increased rate of vitamin D supplementation, as general pediatricians supervising these services may be more familiar with AAP pediatric guidelines for vitamin D supplementation.

The discharge prescribing rate of vitamin D supplementation also was more than doubled after our EMR-based intervention. This is likely a direct result of increased prescription rates of vitamin D during inpatient admissions. Again, based on the structure of the EMR ordering system, at the time of discharge, physicians have the option to “order” all inpatient medications as outpatient prescriptions for continued home use. Thus, if the inpatient vitamin D supplementation rate is greater, the discharge prescription rate likely follows suit.

Strengths of our study include the large sample size and access to a complete EMR system. Our hospital exclusively uses Epic (Madison, WI) for inpatient order entry, so there is consistency across medical and surgical services allowing for the ability to extract a complete data set for analysis.

Limitations of our study include the inability to achieve universal education for all providers involved in patient care. We provided education under real-world circumstances, and did not perform posteducational quizzing of participants to assess the gain in knowledge attributable to the educational process. Although educational sessions were presented at multiple mandatory meetings, not all providers attended. No surgical residents received in-person educational sessions; however, the advanced nurse practitioners who work on surgical services were educated at a nursing grand rounds meeting. No surgical or subspecialty pediatric attending physicians received in-person education; however, these providers infrequently order medications due to the presence of resident physicians working under their supervision to care for patients.

Distribution of our brief educational presentation via E-mail was attempted to reach providers not present in person; however, we did not assess whether providers read the E-mail in its entirety. Education was performed in April and May 2013, thus new resident and faculty hires were not exposed to educational sessions, but were guided to desired order entry by supervising residents who had received the vitamin D training.

An additional limitation includes the time frame of our study. Our sampling frame was limited by a window of time that encompassed mostly summer months. Further analyses will be
needed to assess prescription rates during winter months. A final limitation is that vitamin D is not a prescription medication, and as such, it is possible that our data underreported patients receiving vitamin D supplementation before admission or at the time of discharge. Parents may potentially have forgotten to mention the presence of this supplement if they bought it over the counter. Providers at our institution will often prescribe medications despite being over the counter so that the medication will appear in the EMR; however, it is possible that families were given verbal directions to purchase a vitamin D supplement without any documentation entered into the EMR. Thus, the percentage of patients receiving vitamin D before admission or at the time of hospital discharge may be higher than our data show.

Longevity of our intervention to increase in-hospital vitamin D supplementation prescribing practices is possible, as the EMR modification used to introduce vitamin D supplementation into admission order sets is a fixed change. Thus, despite the conclusion of scheduled educational sessions, providers have the opportunity to continue to identify breastfed patients and order the appropriate vitamin supplement when the patient is admitted. Future directions include a continuing analysis of vitamin D prescribing rates and the development of unique identifiers for breastfed infants to allow for EMR decision support and an opt-out ordering modification to achieve higher supplementation rates.

CONCLUSIONS
This study is the first to apply and evaluate a strategy to increase vitamin D supplementation in hospitalized breastfed infants. Through brief medical provider education and a single EMR-based opt-in order set modification, the vitamin D supplementation rate was more than doubled at our tertiary care institution. In the era of greatly increasing EMR adoption, EMR-based interventions appear to be an effective and likely reproducible way to improve inpatient clinical care and quality improvement, and warrant a breadth of future research to maximize results.

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REFERENCES


