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INTRODUCTION

Coronavirus disease 2019 (COVID-19) is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and has spread rapidly throughout the world since its discovery in 2019. Three vaccines (Pfizer-BioNTech, Moderna/NIAID/BARDA, and Johnson & Johnson’s Janssen) have been developed for use in the U.S. to aid in the fight against this virus, but have been scrutinized intensely for their efficacy and safety. It is important to understand and interpret the adverse events or reactions (AERs) associated with these vaccines in an objective and analytical manner. The goal of this descriptive study was to provide a resource outlining AERs associated with the three available vaccines in Kansas.

METHODS

Reports were obtained from the Vaccine Adverse Event Reporting System (VAERS), representing AERs observed in Kansas from December 11, 2020 to May 13, 2021. All data were screened and coded, and descriptive statistics were used to describe AERs based on vaccine manufacturer, patient age and biological sex, and reported deaths.

RESULTS

Only 0.00068% of COVID-19 vaccine doses given in Kansas were associated with an AER (1,445/2,120,350). There were 4,297 individual AERs reported, and the most common were fatigue/tiredness (266; 6.2%), tingling/itching (251; 5.9%), fever (226; 5.3%), hives (223; 5.2%), and muscle/joint pain (209; 4.9%). Only 0.002% of COVID-19 vaccine doses in Kansas were associated with a death (38/2,120,350). The majority of VAERS reports were by females (1,139; 78.8%) and those aged 30 to 39 years (297; 20.6%).

CONCLUSIONS

No reported AERs were unexpected compared to national data, and no VAERS report provided a causal relationship between vaccine administration and death. Vaccines are, and will continue to be, essential tools to fight COVID-19 in the quest to reach herd immunity. Providing a resource of potential AERs could aid in individual decisions to receive a vaccine and may help in the control of COVID-19. Future studies may include describing reported AERs for children under age 12 as the vaccines become available for those age groups, as well as reporting AERs for those who have received the vaccine after our study time period.

CONCLUSION

On December 31, 2019, a respiratory virus of unknown etiology was detected in Wuhan City, Hubei Province of China and reported to the World Health Organization. The virus, called Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), was linked to the development of the 2019 novel coronavirus (2019-nCoV), more commonly referred to as the “coronavirus” or “COVID-19.” This novel coronavirus spread rapidly in the first months of 2020, with the first reported case in the U.S. on January 21, 2020. By March 20, 2020 there were a total of 250,000 confirmed cases of COVID-19 worldwide. As of August 31, 2021, the confirmed global case count of COVID-19 was more than 271.3 million people infected, with over 4.5 million deaths. In the U.S., there have been approximately 39.1 million confirmed cases and over 639,900 deaths. Due to the morbidity and mortality rates associated with the proliferation of the virus, the U.S. Department of Health and Human Services (DHHS) launched a program called “Operation Warp Speed” to collaborate with the private sector to develop and distribute a vaccine to be used against COVID-19 quickly and effectively on March 30, 2020.

On December 11, 2020, the U.S. Food and Drug Administration (FDA) announced an emergency use authorization (EUA) for the first COVID-19 vaccine approved for use in the U.S., manufactured by Pfizer-BioNTech. An EUA is awarded by the FDA when the public health benefit of a medical product, such as a vaccine, outweighs the known and potential harm. Officially named “Comirnaty” with the international non-proprietary name (INN) “tozinameran”, the Pfizer-BioNTech COVID-19 vaccine is colloquially known as the “Pfizer vaccine.” With an efficacy rate of up to 95%, the Pfizer vaccine was approved conditionally for use in persons aged 16 and older in the U.S. and requires two doses given three weeks apart. Recently, the U.S. Centers for Disease Control and Prevention (CDC) has been monitoring reports of myocarditis and pericarditis following vaccination, however, no suspension or pause in the use of the Pfizer vaccine has been issued.

On December 18, 2020, just a week after the authorization of the Pfizer vaccine, a second COVID-19 vaccine from Moderna Therapeutics, the National Institute of Allergy and Infectious Diseases (NIAID), and Biomedical Advanced Research and Development Authority (BARDA) also received an EUA. The Moderna/NIAID/BARDA vaccine has the brand name “SpikeVax”, INN “elasomeran”, and is colloquially known as the “Moderna vaccine”. This vaccine requires two doses to achieve a vaccine efficacy of 94.1%; however, the Moderna vaccine only was authorized for use in individuals 18 years of age and older. On June 25, 2021, the FDA revised fact sheets related to the Moderna vaccine and disclosed that there may be an increased risk of myocarditis and pericarditis following vaccination, however, no suspension or pause in the use of the Pfizer vaccine has been issued.

On February 27, 2021, the FDA released the EUA for Johnson & Johnson’s Janssen single dose COVID-19 vaccine (INN Ad26.COV2.S) colloquially known as the “J&J vaccine”. This marked the third vaccine approved for use in the U.S. Following use for more than a month, the CDC and FDA recommended a temporary suspension for the use of the J&J vaccine on April 13, 2021, due to reports of cerebral venous sinus thrombosis (CVST) in vaccinated individuals, particularly women under age 50. After a thorough safety review of the vaccine and the rare cases of CVST, the FDA and CDC lifted the pause on April 23, 2021. Although shown to be effective in combatting COVID-19, the
the day prior to the Pfizer vaccine receiving FDA EUA approval for COVID-19 vaccines. The study team chose this ending date as it was December 11, 2020 to May 13, 2021 for AERs related to the three vaccines in the State of Kansas.

**METHODS**

The VAERS database was searched from vaccine inception on December 11, 2020 to May 13, 2021 for AERs related to the three COVID-19 vaccines. The study team chose this ending date as it was the day prior to the Pfizer vaccine receiving FDA EUA approval for use in adolescents 12 to 15 years old. Results were grouped by vaccine manufacturer, whether the impacted patient resided in Kansas, patient age and gender, and included information on AER description, as well as any relevant or available data regarding labs, current illnesses, AERs after prior vaccinations, medications at time of vaccination, and medical history and/or allergies. The full description of the search strategy is available from the authors upon request. This study was approved by the University of Kansas School of Medicine Institutional Review Board as non-humans subject research.

**Data Screening.** The search identified 1,705 separate patient entries in VAERS. The initial data file was screened by two of the authors (AT and KN) for entries that needed to be removed. KN initially removed 270 entries and AT initially removed 239 entries, with an agreement rate of 96.3%. After discussion, a consensus was reached to remove 222 entries (Cohen’s $\kappa = 0.85$, $p = 0.16$, 95% CI -0.7% to 4.1%). Entries were removed for four reasons, “unknown” vaccine manufacturer (four removed), report of unapproved administration (23 removed), duplicate entries (15 removed), and those entries that were not COVID-19 vaccine related AERs (180 removed). The break-down of the screening criteria by vaccine manufacturer is shown in Table 1.

**Table 1. VAERS COVID-19 vaccine entry data screening procedure.**

<table>
<thead>
<tr>
<th>Removed &quot;unknown&quot; vaccines</th>
<th>Pfizer</th>
<th>Moderna</th>
<th>J&amp;J</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>676</td>
<td>818</td>
<td>207</td>
<td>1,701</td>
</tr>
<tr>
<td>Removed - underage population</td>
<td>1</td>
<td>9</td>
<td>13</td>
<td>23</td>
</tr>
<tr>
<td>Removed - duplicate report</td>
<td>8</td>
<td>5</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Removed - not COVID vaccine AER</td>
<td>102</td>
<td>58</td>
<td>20</td>
<td>180</td>
</tr>
<tr>
<td>Total after non-AER entries removed</td>
<td>565</td>
<td>746</td>
<td>172</td>
<td>1,483</td>
</tr>
<tr>
<td>Removed if death was indicated</td>
<td>16</td>
<td>18</td>
<td>4</td>
<td>38</td>
</tr>
</tbody>
</table>

Of the 180 entries related to the COVID-19 vaccines that did not indicate an AER occurred: 68 reported a patient had a positive COVID-19 diagnosis but no vaccine AER; 60 reported an unauthorized use of the vaccine (e.g., incorrect dose, incorrect vaccine given for second dose); 21 had another diagnosis after vaccination that accounted for the report (e.g., ruptured appendix, strep throat); 19 were unclear as to the specific AER experienced (e.g., “seen at ER”, “just didn’t feel right”); 11 were unremarkable clinic progress notes of follow-up calls to patients who had received a vaccination; and one was removed because the submitter indicated it was a report based on a friend’s social media post. This left a total of 1,483 separate patient entries. Thirty-eight entries that reported the patient’s death were removed and discussed separately below. This left a total of 1,445 VAERS entries to be coded by the research team.

**Data Coding.** Each VAERS entry was screened by one of the three authors, coded by another, and reviewed by the third, with a rotating list of entries for each author, ensuring that each entry was seen and checked by all three members of the authorship team. Any entries that were unclear were resolved by discussion. Each identified AER that appeared two or more times was coded into a separate category, for a
total of 58 identified categories of AERs related to the COVID-19 vaccines. Twenty-eight category names utilized wording obtained from the side effects listed on the information sheets provided by the manufacturer for each vaccine.9,10 The additional 30 categories were named based on medical and lay terms for the AER identified (i.e., arrythmia/abnormal heart rhythm). Additionally, there was a category named “other” for 16 individual entries that did not fall into the identified AER categories. Within all 59 categories there were a total of 4,287 separate AERs reported. Table 2 shows the AER categories identified with the breakdown of number of coded entries in each.

Table 2. COVID-19 vaccine reported adverse events or reactions categories identified from 1,445 patient entries.

<table>
<thead>
<tr>
<th>AER Category</th>
<th>Total</th>
<th>Pfizer</th>
<th>Moderna</th>
<th>J&amp;J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue/tiredness</td>
<td>266</td>
<td>84</td>
<td>144</td>
<td>38</td>
</tr>
<tr>
<td>Tingling/itching</td>
<td>251</td>
<td>80</td>
<td>153</td>
<td>18</td>
</tr>
<tr>
<td>Fever</td>
<td>226</td>
<td>12</td>
<td>163</td>
<td>51</td>
</tr>
<tr>
<td>Hives</td>
<td>223</td>
<td>18</td>
<td>199</td>
<td>6</td>
</tr>
<tr>
<td>Muscle/joint pain</td>
<td>209</td>
<td>136</td>
<td>6</td>
<td>67</td>
</tr>
<tr>
<td>Nausea</td>
<td>189</td>
<td>79</td>
<td>88</td>
<td>22</td>
</tr>
<tr>
<td>Headache</td>
<td>187</td>
<td>126</td>
<td>6</td>
<td>55</td>
</tr>
<tr>
<td>Chills/shaking</td>
<td>175</td>
<td>101</td>
<td>26</td>
<td>48</td>
</tr>
<tr>
<td>Confusion</td>
<td>175</td>
<td>8</td>
<td>163</td>
<td>3</td>
</tr>
<tr>
<td>Seizure</td>
<td>174</td>
<td>8</td>
<td>163</td>
<td>3</td>
</tr>
<tr>
<td>Rash</td>
<td>146</td>
<td>50</td>
<td>90</td>
<td>6</td>
</tr>
<tr>
<td>Numbness</td>
<td>142</td>
<td>21</td>
<td>112</td>
<td>9</td>
</tr>
<tr>
<td>Dizziness</td>
<td>136</td>
<td>107</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>Bruising at injection site</td>
<td>133</td>
<td>4</td>
<td>124</td>
<td>5</td>
</tr>
<tr>
<td>Redness at injection site</td>
<td>131</td>
<td>25</td>
<td>101</td>
<td>5</td>
</tr>
<tr>
<td>Dyspnea/hypoxia (Shortness of breath)</td>
<td>118</td>
<td>17</td>
<td>101</td>
<td>0</td>
</tr>
<tr>
<td>Pain at injection site</td>
<td>98</td>
<td>57</td>
<td>30</td>
<td>11</td>
</tr>
<tr>
<td>Eye pain</td>
<td>88</td>
<td>82</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Arrythmia (abnormal heart rhythm)</td>
<td>81</td>
<td>31</td>
<td>34</td>
<td>16</td>
</tr>
<tr>
<td>Weakness</td>
<td>76</td>
<td>29</td>
<td>36</td>
<td>11</td>
</tr>
<tr>
<td>Blood clot</td>
<td>75</td>
<td>1</td>
<td>71</td>
<td>3</td>
</tr>
<tr>
<td>Syncope (light-headedness/fainting)</td>
<td>75</td>
<td>28</td>
<td>34</td>
<td>13</td>
</tr>
<tr>
<td>Diaphoresis (sweating)</td>
<td>70</td>
<td>24</td>
<td>34</td>
<td>12</td>
</tr>
<tr>
<td>Vomiting</td>
<td>69</td>
<td>19</td>
<td>36</td>
<td>14</td>
</tr>
<tr>
<td>Sore throat</td>
<td>65</td>
<td>51</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>60</td>
<td>20</td>
<td>34</td>
<td>6</td>
</tr>
<tr>
<td>Cough/congestion</td>
<td>56</td>
<td>34</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>Lymphadenopathy (swollen lymph nodes)</td>
<td>56</td>
<td>23</td>
<td>29</td>
<td>4</td>
</tr>
<tr>
<td>Arm pain</td>
<td>54</td>
<td>32</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Xerostomia (dry mouth)</td>
<td>52</td>
<td>39</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

**Data Analysis.** Descriptive statistics were used to describe AERs reported by vaccine manufacturer (Pfizer, Moderna, and J&J), age category (29 and younger, 30 to 39, 40 to 49, 50 to 59, 60 to 64, and 65 and older), and gender (male and female), as well as any reported deaths in the data file. Traditional statistical analyses were not performed beyond calculating the inter-rater reliability as this is a purely descriptive study of reported AERs and causal inferences are unable to be performed due to the nature of the VAERS system.
RESULTS

Information from the Kansas Department of Health and Environment (KDHE) was obtained to determine how many people in Kansas had received at least one dose of the available COVID-19 vaccines (Andrea May, MPH, email communication, June 2021). From December 11, 2020 to May 13, 2021, the KDHE indicated that a total of 1,191,204 initial vaccine doses had been given, which translated to approximately 41% of the total population receiving at least one dose (1,191,204/2,911,641). VAERS did not indicate if someone submitted multiple reports, but this roughly indicated that for each vaccine dose given in Kansas, one in every 1,467 led to a report in VAERS (2,120,350/1,445), and one AER occurred per every 495 doses given in Kansas (2,120,350/4,287; Table 3). Of the 1,445 VAERS entries, 215 (14.9%) concerned patients younger than 29 years, 297 (20.6%) were for male patients, 1,139 (78.8%) female patients, and 10 were unknown gender (0.7%).

Table 3. COVID-19 vaccines given in Kansas (December 11, 2020 to May 13, 2021).

<table>
<thead>
<tr>
<th>Vaccine Manufacturer</th>
<th>Total Doses</th>
<th>Pfizer</th>
<th>Moderna</th>
<th>J&amp;J</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total doses</td>
<td>1,130,089</td>
<td>922,728</td>
<td>67,308</td>
<td></td>
<td>2,120,350</td>
</tr>
<tr>
<td>Dose 1</td>
<td>624,528</td>
<td>499,808</td>
<td>67,308</td>
<td></td>
<td>1,191,056</td>
</tr>
<tr>
<td>Dose 2</td>
<td>505,561</td>
<td>422,920</td>
<td></td>
<td></td>
<td>929,069</td>
</tr>
<tr>
<td>Unknown vaccine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>225</td>
</tr>
</tbody>
</table>

Prevalence

<table>
<thead>
<tr>
<th>VAERS entry (one per every)</th>
<th>2,058 doses</th>
<th>1,267 doses</th>
<th>401 doses</th>
<th>1,467 doses</th>
</tr>
</thead>
<tbody>
<tr>
<td>AER (one per every)</td>
<td>753 doses</td>
<td>415 doses</td>
<td>119 doses</td>
<td>495 doses</td>
</tr>
</tbody>
</table>

Adverse Events or Reactions Reported. Overall, there were a total of 4,287 AERs reported, with an average of 3.0 (± 1.9) AERs reported per VAERS entry, with a median number of 3 (range 1 to 12). The Pfizer vaccine had a total of 1,500 AERs reported with an average of 2.7 (± 1.8) AERs per patient entry, with a median number of 2 (range 1 to 11). The Moderna vaccine had a total of 2,222 AERs reported with an average of 3.1 (± 1.9) AERs reported per patient entry, with a median number of 3 (range 1 to 10). The J&J vaccine had a total of 565 AERs reported, with an average of 3.4 (± 2.0) AERs per patient entry, with a median number of 3 (range 1 to 12). Table 2 shows the breakdown of each AER by vaccine manufacturer.

**Pfizer-BioNTech Vaccine.** The Pfizer vaccine had a total of 549 entries in the VAERS system as of May 13, 2021, and 1,500 separate AERs. Of these entries, 92 (16.8%) included patients younger than 29 years, 117 (21.3%) were age 30 to 39 years, 93 (16.9%) were between 40 and 49 years, 91 (16.6%) were age 50 to 59 years, 37 (6.7%) were age 60 to 64 years, and 92 (16.8%) entries were 65 years and older. Twenty-seven had no age noted. In terms of gender, 103 (18.8%) were male patients, 1,139 (80.3%) were female patients, and 5 (0.9%) were unknown gender. The highest AER count was in female patients aged 30 to 39 reporting muscle/joint pain. The top five AERs for age and gender are shown in Tables 4 and 5.

**Moderna/NIAID/BARDA Vaccine.** The Moderna vaccine had a total of 728 entries in the VAERS system as of May 13, 2021, and 2,222 separate AERs. Of these entries, 91 (12.5%) concerned patients younger than 29 years, 141 (19.4%) were age 30 to 39 years, 155 (21.3%) were between 40 and 49 years, 115 (15.8%) were age 50 to 59 years, 66 (9.1%) were age 60 to 64 years, and 149 (20.5%) were 65 years and older. Eleven had no age noted. In terms of gender, 144 (19.8%) entries were for male patients, 580 (79.7%) female patients, and 4 (0.5%) were unknown gender. The highest AER count was for female patients aged 40 to 49 who reported hives (Tables 4 and 5).

**Johnson & Johnson’s Janssen Vaccine.** The J&J vaccine had a total of 168 entries in the VAERS system as of May 13, 2021, and 565 separate AERs. Of the VAERS entries, 32 (19.0%) were reports for patients younger than 29 years, 39 (23.2%) were age 30 to 39, 29 (17.3%) were between 40 and 49 years, 24 (14.3%) were age 50 to 59 years, 15 (8.9%) were age 60 to 64 years, and 22 (13.1%) were 65 years and older. Seven had no age noted. In terms of gender, 49 (29.2%) entries concerned male patients, 118 (70.2%) female patients, and one (0.6%) had an unknown gender. The highest AER count was for female patients aged 30 to 39 reporting muscle/joint pain (Tables 4 and 5).

Other Adverse Events or Reactions Reported. Overall, there were 16 AERs that were outliers, meaning they were only reported in VAERS once and they did not fall into one of the 58 identified categories. There were six patients who received the Pfizer vaccine who reported “other” AERs: anemia, severe acid reflux, onychorrhexis (unexplained breaking of fingernails), flaring of Fothergill’s disease (trigeminal neuralgia), Takotsubo cardiomyopathy (apical ballooning syndrome), and development of Willis-Ekbom disease (restless leg disease). There were four patients who received the Moderna vaccine who reported either the development of pyelonephritis (kidney infection), hemorrhoids, constipation, or a report of a pulmonary embolism (blood clot in lung). There were six patients who received the Pfizer vaccine who reported “other” AERs: anemia, severe acid reflux, onychorrhexis (unexplained breaking of fingernails), flaring of Fothergill’s disease (trigeminal neuralgia), Takotsubo cardiomyopathy (apical ballooning syndrome), and development of Willis-Ekbom disease (restless leg disease). There were four patients who received the Moderna vaccine who reported either the development of pyelonephritis (kidney infection), hemorrhoids, constipation, or a report of a pulmonary embolism (blood clot in lung). There were six patients who received the Pfizer vaccine who reported “other” AERs: anemia, severe acid reflux, onychorrhexis (unexplained breaking of fingernails), flaring of Fothergill’s disease (trigeminal neuralgia), Takotsubo cardiomyopathy (apical ballooning syndrome), and development of Willis-Ekbom disease (restless leg disease).

Deaths. There were 38 patient deaths identified in the VAERS system from December 20, 2020 to May 13, 2021 (38 [1,483; 2.6%]. Of these, 16 had received Pfizer, 18 received Moderna, and four received the J&J vaccine. No deaths were reported in patients under age 39, and the majority (11/38; 28.9%) were 65 years or older. Fifteen of these deaths were due to unknown causes at time of report, but were not suspected to be related to the vaccines; 17 deaths were related to other verifiable diagnoses, such as cancer or falls, and were also not suspected to be related to the vaccine; five deaths were related to COVID-19 complications in between vaccine doses; and one death is being reported by KDHE as related to an allergic reaction from the Pfizer vaccine. Figure 1 shows the breakdown of deaths by age group, gender, and vaccine manufacturer.
Table 4. Top five reported adverse events or reactions for each COVID-19 vaccine by age group.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Pfizer Vaccine</th>
<th>Moderna Vaccine</th>
<th>J&amp;J Vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 years and younger</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle/joint pain</td>
<td>37 40.2%</td>
<td>Hives 24 26.4%</td>
<td>Fever, headache* 14 43.8%</td>
</tr>
<tr>
<td>Headache</td>
<td>27 29.3%</td>
<td>Confusion 23 25.3%</td>
<td>Muscle/joint pain 13 40.6%</td>
</tr>
<tr>
<td>Nausea</td>
<td>21 22.8%</td>
<td>Fever 22 24.2%</td>
<td>Chills/shaking 10 31.3%</td>
</tr>
<tr>
<td>Fatigue, dizziness*</td>
<td>17 18.5%</td>
<td>Numbness 20 22.0%</td>
<td>Dizziness 6 18.8%</td>
</tr>
<tr>
<td>Eye pain</td>
<td>15 16.3%</td>
<td>Fatigue, seizure* 18 19.8%</td>
<td>Chest pain, fatigue* 5 17.6%</td>
</tr>
<tr>
<td>30 to 39 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle/joint pain</td>
<td>46 39.3%</td>
<td>Hives 44 31.2%</td>
<td>Muscle/joint pain 22 56.4%</td>
</tr>
<tr>
<td>Chills/shaking</td>
<td>28 23.9%</td>
<td>Confusion 40 28.4%</td>
<td>Headache 19 48.7%</td>
</tr>
<tr>
<td>Headache</td>
<td>26 22.2%</td>
<td>Seizure 37 26.2%</td>
<td>Fever 12 30.8%</td>
</tr>
<tr>
<td>Eye pain, fatigue*</td>
<td>23 19.7%</td>
<td>Tingling/itching 33 23.4%</td>
<td>Chills/shaking 11 28.2%</td>
</tr>
<tr>
<td>Chills/shaking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 to 49 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle/joint pain</td>
<td>32 34.4%</td>
<td>Hives 46 29.7%</td>
<td>Muscle/joint pain 10 34.5%</td>
</tr>
<tr>
<td>Headache</td>
<td>22 23.7%</td>
<td>Seizure 41 26.5%</td>
<td>Fatigue 9 31.0%</td>
</tr>
<tr>
<td>Chills/shaking</td>
<td>21 22.6%</td>
<td>Tingling/itching 37 23.9%</td>
<td>Headache 7 24.1%</td>
</tr>
<tr>
<td>Dizziness, eye pain*</td>
<td>17 18.3%</td>
<td>Fatigue 35 22.6%</td>
<td>Chills/shaking, fever, pain at injection site* 6 20.7%</td>
</tr>
<tr>
<td>Tingling/itching</td>
<td>15 16.1%</td>
<td>Numbness 33 21.3%</td>
<td>Arm pain/syncope* 5 17.2%</td>
</tr>
<tr>
<td>50 to 59 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle/joint pain</td>
<td>41 45.1%</td>
<td>Hives 40 34.8%</td>
<td>Muscle/joint pain 8 33.3%</td>
</tr>
<tr>
<td>Headache</td>
<td>25 27.5%</td>
<td>Confusion 31 27.0%</td>
<td>Chills/shaking, headache* 7 29.2%</td>
</tr>
<tr>
<td>Tingling/itching</td>
<td>21 23.1%</td>
<td>Fatigue 30 26.5%</td>
<td>Fatigue, tingling/itching* 6 20.6%</td>
</tr>
<tr>
<td>Dizziness</td>
<td>18 19.8%</td>
<td>Bruiing at injection site 29 25.2%</td>
<td>Dizziness, fever* 5 20.8%</td>
</tr>
<tr>
<td>Chills/shaking</td>
<td>13 14.3%</td>
<td>Fever 28 24.3%</td>
<td>Ear pain/tinnitus 4 16.7%</td>
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<tr>
<td>60 to 64 years</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Muscle/joint pain</td>
<td>10 27.0%</td>
<td>Fever 18 27.3%</td>
<td>Fever 4 26.7%</td>
</tr>
<tr>
<td>Nausea</td>
<td>6 16.2%</td>
<td>Hives 17 25.8%</td>
<td>Muscle/joint pain 4 26.7%</td>
</tr>
<tr>
<td>Dizziness, headache, tingling/itching*</td>
<td>5 13.5%</td>
<td>Confusion 14 21.2%</td>
<td>Nausea 4 26.7%</td>
</tr>
<tr>
<td>Diarrhea, fatigue/pain at injection site/rash*</td>
<td>4 10.8%</td>
<td>Fatigue, seizure, tingling/itching* 13 19.7%</td>
<td>Chills/shaking, headache* 3 20.0%</td>
</tr>
<tr>
<td>Arm pain, cough/congestion, difficulty walking/weakness*</td>
<td>3 8.1%</td>
<td>Dyspnea/hypoxia, nausea 9 13.0%</td>
<td>Abdominal pain, dizziness, numbness/weakness* 2 13.3%</td>
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<td>65 years and older</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dizziness</td>
<td>27 29.3%</td>
<td>Tingling/itching 38 25.5%</td>
<td>Muscle/joint pain 9 40.9%</td>
</tr>
<tr>
<td>Muscle/joint pain</td>
<td>20 21.7%</td>
<td>Seizure 32 21.5%</td>
<td>Chills/shaking 8 36.4%</td>
</tr>
<tr>
<td>Headache</td>
<td>14 15.2%</td>
<td>Fever 30 20.1%</td>
<td>Fatigue 7 31.8%</td>
</tr>
<tr>
<td>Chills/shaking</td>
<td>13 14.1%</td>
<td>Hives 26 17.4%</td>
<td>Fever 6 27.3%</td>
</tr>
<tr>
<td>Eye pain</td>
<td>12 13.0%</td>
<td>Confusion 24 16.1%</td>
<td>Headache 5 22.7%</td>
</tr>
<tr>
<td>65 years and older</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle/joint pain</td>
<td>196 35.7%</td>
<td>Hives 197 27.1%</td>
<td>Muscle/joint pain 67 39.9%</td>
</tr>
<tr>
<td>Headache</td>
<td>125 22.8%</td>
<td>Confusion 164 22.5%</td>
<td>Headache 55 32.7%</td>
</tr>
<tr>
<td>Dizziness</td>
<td>107 19.5%</td>
<td>Fever 163 22.4%</td>
<td>Fever 51 30.4%</td>
</tr>
<tr>
<td>Chills/shaking</td>
<td>100 18.2%</td>
<td>Seizure 161 22.1%</td>
<td>Chills/shaking 48 28.6%</td>
</tr>
<tr>
<td>Fatigue</td>
<td>82 14.9%</td>
<td>Tingling/itching 152 20.9%</td>
<td>Fatigue 38 22.6%</td>
</tr>
</tbody>
</table>

*Tie between reported AER type.
**Table 5. Top five reported adverse events or reactions for each COVID-19 vaccine by gender.**

<table>
<thead>
<tr>
<th>AER</th>
<th>Male</th>
<th>%</th>
<th>Female</th>
<th>%</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle/joint pain</td>
<td>34</td>
<td>33.0%</td>
<td>162</td>
<td>36.7%</td>
<td>196</td>
<td>35.7%</td>
</tr>
<tr>
<td>Headache</td>
<td>20</td>
<td>19.4%</td>
<td>105</td>
<td>23.8%</td>
<td>125</td>
<td>22.8%</td>
</tr>
<tr>
<td>Dizziness</td>
<td>17</td>
<td>16.5%</td>
<td>90</td>
<td>20.4%</td>
<td>107</td>
<td>19.5%</td>
</tr>
<tr>
<td>Eye pain, nausea*</td>
<td>14</td>
<td>13.6%</td>
<td>87</td>
<td>19.7%</td>
<td>125</td>
<td>22.8%</td>
</tr>
<tr>
<td>Chills/shaking, fatigue*</td>
<td>13</td>
<td>12.6%</td>
<td>97</td>
<td>23.7%</td>
<td>157</td>
<td>27.4%</td>
</tr>
</tbody>
</table>

* Tie between reported AER type.

**DISCUSSION**

The information presented in this study can be used as a resource for those who are curious about the potential side effects of the three COVID-19 vaccines, especially those who may be hesitant for various reasons, such as fear of unknown risks, lack of trust in production, or personal safety. As of August 31, 2021, only 53.0% of the U.S. population and approximately 27.5% of the world population are fully vaccinated. As of August 31, 2021, Kansas has had 369,890 confirmed cases of COVID-19 and 5,560 COVID-19 related deaths. Vaccine rates in Kansas were also slightly higher than previously reported on May 13, 2021, with 48.2% of the population being fully vaccinated. However, with more than 50% of the population of Kansas remaining unvaccinated, this indicated that many Kansans are either unable to get vaccinated (i.e., they are underage or have medical barriers) or they are unwilling. This hesitancy also may affect parental willingness to allow their children to get vaccinated, as uncertainty regarding the adverse effects of vaccines has been cited as a major barrier to adolescent vaccination in Kansas.

Results from a June 2020 global survey of COVID-19 vaccine acceptance indicated that 71.5% of participants would be “very or somewhat likely” to receive a vaccine. However, the survey results also indicated that the potential side effects and AERs related to the COVID-19 vaccines, as well as lack of trust in government and public health officials, have contributed to vaccine hesitancy. Despite the acceleration of the development of these three vaccines, the FDA has taken substantial and appropriate steps to ensure the validity and efficacy of these COVID-19 vaccines.

Highlighting the fact that mild and likely short term side effects were present most often may aid individuals in their decision to receive a vaccine. The Pfizer vaccine mainly saw reports of mild AERs, including high incidences of muscle/joint pain and headache were somewhat consistent with manufacturer reports, with 21 of the 41 identified AERs listed on the supplied FDA fact sheet. A prior study by Johnston and colleagues in 2021 reported allergic and neurologic reactions associated with the Moderna vaccine, with hives and seizure commonly reported. Colloquially known as “COVID arm”, hives at the vaccine site frequently have been reported with the Moderna vaccine. Cases of seizure have been reported with other common vaccines, such as tetanus, pertussis, poliovirus, and influenza, especially in children; however, these cases were extremely rare and the vast majority of which were short and did not cause any long-term damage. Confusion/delirium in the Moderna vaccine, like many other AERs, may be related to the systemic inflammatory response associated with COVID-19 vaccines as this response may be associated with modification in brain physiology. Overall, 18 of the AERs identified in this study were indicated on the provided patient...
facult sheet for the Moderna vaccine, while 40 of the AERs identified were not.20 The presence of additional AERs indicated that there may be additional side effects that will need to be monitored with two mRNA vaccines.

The Johnson & Johnson vaccine saw very similar AERs compared to the Pfizer vaccine. Of the AERs reported for the Johnson & Johnson vaccine, 19 of the AERs identified are listed on the patient fact sheet, while 30 were not.21,22 Additionally, no reported cases of CVST were found through the VAERS system in Kansas for the study period.15,16 Reported blood clots of any kind after receiving the vaccine were limited to just three cases total with the J&J vaccine, and unfortunately no specification of what kind of blood clot was indicated in VAERS. Additionally, on July 13, 2021, the FDA announced revisions to the fact sheets of the J&J vaccine to include an observed risk of Guillain-Barre Syndrome (GBS) following vaccination.23 These cases are again exceedingly rare among J&J vaccine recipients as only 100 out of 12.5 million recipients reported cases of GBS after J&J vaccination, and no cases were noted in this study. Most people with GBS make a full recovery and as it stands there has been no definitive causal relationship established between the J&J vaccine and GBS.10

One of the most important AERs that must be investigated rigorously was the prevalence of death among those who receive a COVID-19 vaccine. Our study reported that there were 38 deaths reported in the VAERS system from December 20, 2020 to May 13, 2021. This translated to 0.0002% (38/2,120,350) of persons in Kansas who had received a COVID-19 vaccine being associated with a death. None of these cases provided a causal relationship between vaccine administration and death, but there was one report that is being investigated. Given the nature of the VAERS system, it is difficult to determine relationships from the reports and data that were available; however, the FDA and CDC follow-up on any reported deaths in the VAERS system and make a further determination in conjunction with state health departments.17

When weighing the choice of receiving any sort of medication, vaccine, or health-related intervention, the benefits and the risks must be weighed in any case.23 All too often individuals suffer from omission bias, or the idea of favoring inaction over action when it comes to receiving a medical intervention, especially when it comes to vaccines. Additionally, the benefits and risks associated with other vaccines must also be considered. The flu vaccine, for instance, has common side effects including soreness, redness, and/or swelling from the shot, headache, fever, nausea, and muscle aches, which are very similar to the AERs reported with the COVID-19 vaccines.24

Combatting vaccine hesitancy is not a new phenomenon. However, given themes related to the COVID-19 vaccine hesitancy, such as vaccine efficacy, safety, pace of development, and fear of side effects, it is important for health care providers and public health officials to have information available as these groups play a critical role in combating vaccine hesitancy.23,33-35 Of note, only 0.00068% (1,445/2,120,350) of COVID-19 vaccine doses given from December 11, 2021 to May 13, 2021 were associated with a report in VAERS, showing a particularly low rate of reactions associated with these vaccines thus far. By providing a clear statistical overview of the AERs associated with these vaccines, this study may be utilized as a resource for individuals and their medical providers to make informed and educated decisions on whether to receive a COVID-19 vaccine.

CONCLUSIONS

On June 10, 2021, Moderna petitioned the FDA to approve its vaccine for adolescents aged 12 to 17; and as of August 23, 2021, the Pfizer/BioNTech COVID-19 was given full approval by the FDA for use in people ages 16 and older.29 While Moderna has yet to be approved for adolescents, the EUA approval of the Pfizer/BioNTech vaccine for those aged 12 to 17 highlighted the confidence that the FDA has in the vaccine’s efficacy and safety.16 In addition, beginning in March 2021, Pfizer/BioNTech began conducting randomized control trials in children aged 6 months to 11 years old, which hopefully will cement the “tolerability, immunogenicity, and safety” of this vaccine in virtually all age groups.27 With the first COVID-19 vaccine receiving full FDA authorization, there is the expectation that some of those who are vaccine hesitant may cease to be so.

One way to combat a virus is through herd immunity.38,39 Herd immunity occurs when the majority of the population gets infected by a disease and, as a result, develops immunity and antibodies that makes the spread of the disease unlikely. Another way to reach herd immunity is through the use of vaccines. Prior to Spring 2021, when the global base reproduction number (\(R_0\)) of COVID-19 remained around 2.5, herd immunity was set at approximately 60%.40 However, as the SARS-CoV-2 virus continues to mutate into variants of interest (VOIs), such as the Delta variant (B.1.617.2 lineage) and Lambda variant (C.37 lineage),28 the global \(R_0\) also has been increasing and was estimated at 4.1 (95% CI, 3.09-5.39), which pushed the need for global herd immunity close to 90%.41 To approach herd immunity in the U.S., it is crucial to provide accurate and credible information to educate and encourage those who can be vaccinated to do so. The more people who can achieve natural immunity through infection (less desirable) or through vaccination (more desirable), the greater chance there is to lower the emergence of new VOIs that current vaccines may be less effective against.

With the augmentation and distribution of safe and effective COVID-19 vaccines, along with other mitigation efforts, the societal effects of COVID-19 will diminish. It is important for public health experts, health care providers, and elected officials to provide consistent and reliable information to the public to increase vaccine uptake.32,42 Knowing that vaccine safety is an issue contributing to vaccine hesitancy, informing the public about the potential AERs of the COVID-19 vaccines is one step closer to fulfilling that gap.

ACKNOWLEDGEMENTS

The authors thank the Kansas Department of Health and Environment for their help in accessing vital vaccine related data, as well as the Vaccine Adverse Event Reporting System (VAERS) operated and maintained for public use by the U.S. Centers for Disease Control and Prevention and the Food & Drug Administration.
Keywords: vaccination, adverse drug events, COVID-19 vaccines, vaccination refusal, Kansas
Qualitative Assessment of Access to Perinatal Mental Health Care: A Social-Ecological Framework of Barriers

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2Department of Pediatrics
3Center for Research for Infant Birth and Survival (CRIBS), Wichita, KS
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5Sedgwick County Health Department, Wichita, KS

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ABSTRACT

**Introduction.** Psychological distress affects up to 25% of pregnant women and contributes to poor birth outcomes. Screening with appropriate referral or treatment is critical, yet many women do not access services. This project aimed to identify knowledge of and barriers to mental health services in the perinatal period.

**Methods.** Interviews with low-income pregnant or postpartum women, primary care providers (PCPs), and mental health care providers were conducted in Sedgwick County, Kansas. Interviews were transcribed, independently reviewed using grounded theory, and stratified using a social-ecological model framework.

**Results.** Thirty-three interviews were conducted with 12 (36%) pregnant or postpartum women, 15 (45%) PCPs, and 6 (18%) mental health care providers. Barriers were categorized into three levels: individual, social, and society. Individual level barriers, including cost or lack of insurance and transportation, were consistent across groups, however, women identified barriers only at this level. Provider groups identified barriers at all levels, including lack of support, poor communication between providers, and Medicaid limitations.

**Conclusions.** Multi-level interventions are needed to improve access to mental health care for low-income women in the perinatal period.

**Kans J Med 2022;15:48-54**

**INTRODUCTION**

Psychological distress during pregnancy, including depression, anxiety, and stress, can lead to poor birth outcomes, including preterm birth and low birthweight.1,2 Perinatal mood and anxiety disorders (PMADs) lead to increased medical expenses, cessation of breastfeeding, and increase the risk of child abuse and neglect.3 Perinatal depression, the most common pregnancy complication in the U.S., impacts the social, emotional, and cognitive development of infants, increases stress hormone levels,4 negative reactivity to stress,5 sleep disturbance, attention-deficit hyperactivity disorder, conduct disorders, and cognitive deficits.6 Perinatal women with depression are more likely to be uninsured, of low socioeconomic status, and have increased use of psychiatric and non-psychiatric services.7

The ability to identify and mitigate perinatal psychological distress properly is of utmost importance. Screening women for PMADs is recommended by the American College of Obstetricians and Gynecologists (ACOG),8 the American Academy of Family Physicians (AAFP),9 and the American Academy of Pediatrics (AAP).10 Women who screen positive should be treated or referred to services. Yet, access to mental health services was an identified treatment barrier for women with lower socioeconomic status.10 Other barriers included lack of knowledge, cultural complexities, and stigma around diagnosis.11

Previous studies assessed barriers to mental health care access based on perspectives of pregnant and postpartum women, health care providers, and mental health providers.12-15 However, no identified studies assessed perceived barriers both within and across these three groups. As such, the aim of this project was to triangulate themes16 from interviews with low-income pregnant or postpartum women, primary care providers (PCPs), and perinatal mental health providers regarding knowledge of and barriers to perinatal mental health services.

**METHODS**

This qualitative study evaluated knowledge of and perceived barriers to accessing perinatal mental health services in Sedgwick County, Kansas. The study was approved by the University of Kansas School of Medicine Institutional Review Board.

**Participants.** Pregnant (greater than 19 weeks) or postpartum women (infant less than one year of age) 18 years of age or older, able to understand English, and living in Sedgwick County were recruited from existing maternal and child health programs (e.g., prenatal education, home visitation, case management). Program staff, which were considered trusted sources of information, described the study and provided written information to participants. To reach women not connected to services, recruitment fliers were distributed through other community organizations (e.g., churches, schools).

PCPs practicing in Sedgwick County and able to understand English were recruited from the University of Kansas School of Medicine-Wichita, the Medical Society of Sedgwick County, and federally qualified healthcare centers. Perinatal mental healthcare (MHC) providers practicing in Sedgwick County and able to understand English were recruited through the University of Kansas School of Medicine-Wichita Department of Psychiatry and Behavioral Sciences, the Wichita State University Psychology Department, Postpartum Support International (Kansas Chapter), United Way 211 resource hotline, internet searches, and professional societies. Snowball sampling methods identified additional PCP and MHC providers from participants.

Structured interviews were completed over the telephone between October 2019 and March 2020. Participation was voluntary and informed consent was obtained prior to participation. Calls were recorded and lasted approximately 20 minutes. A standardized interview script for each participant group was followed. Interviews within each group were conducted until saturation of themes was reached.17 Interview questions for participants included demographics (e.g., age, insurance), mental health (e.g., diagnosis, knowledge), mental health in terms of recent pregnancy (e.g., screening, comfort level), and knowledge of and access to mental health services (i.e., barriers or successes to accessing). PCP interviews included specialty and practice, standard
practice for screening women for PMADS, knowledge of mental health services (e.g., medications, referral process, location, follow-up), and barriers or success in connecting women to resources. MHC provider interviews addressed specialty and practice, referral sources and follow-up, mental health medications, and barriers or successes in connecting women to resources.

Recordings were transcribed and identifying information removed. Transcripts were reviewed independently by researchers and community partners using grounded theory approach.\(^{18}\) Within group themes were discussed until consensus was reached and crosscutting themes were identified by triangulation.\(^{16}\) Reported barriers to accessing mental health care were organized using a social-ecological model,\(^{19}\) distinguishing individual, social (interpersonal and community), and society (organizational and public policy) level barriers.

### RESULTS

Thirty-four interviews were conducted. However, a discrepancy in gestation by weeks was identified for one interview and removed from analysis. A total of 33 interviews were included, 12 (36%) pregnant or postpartum women, 15 (45%) PCPs, and 6 (18%) MHC providers.

**Pregnant and Postpartum Women.** Of the 12 women interviewed, 17% (n = 2) were pregnant and 83% (n = 10) were postpartum with an infant less than one year of age. The average participant age was 24 years (range 18 - 33 years). One quarter of participants (25%; n = 3) had been diagnosed with a mental illness (Table 1). Participants described general stress and anxiety regarding pregnancy and fear of something happening to their child during pregnancy or after birth. One stated, “It’s a scary feeling, we are looking into an abyss. I have no idea what I am getting myself into. Not only the physical caring for my child but the emotional. That’s what’s scary.” Several mentioned breastfeeding challenges as a major contributor to stress and anxiety in the postpartum period. One reported, “I was struggling because I couldn’t breastfeed. She wouldn’t latch. Yeah. And I wanted to breastfeed. So, I was like, I planned on it and I didn’t plan on nothing else.”

Women reported varied experiences regarding screening and discussion of PMADS with healthcare providers. Only 67% (n = 8) reported ever completing a screening tool (e.g., Edinburgh Postpartum Depression Scale (EPDS), Patient Health Questionnaire (PHQ)); of those, 25% (n = 2) had the screening results discussed with them. One participant who completed a screening but was not given the results stated, “That’s pretty annoying. I feel like it was a waste of time. But I feel like if they were concerned about something then maybe they would have went over it with me.” Another shared dissatisfaction with the lack of information, stating, “I’ve never had anyone actually talk about perinatal mental health] … I’m thinking like yeah, why hasn’t the doctor asked these specific questions? And it’s kind of just, they sweep it under the rug, and these are normal feelings.” Although most (83%; n = 10) were postpartum, no participants reported being screened by their child’s doctor.

<table>
<thead>
<tr>
<th>Race/ethnicity</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic</td>
<td>4 (33%)</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>3 (25%)</td>
</tr>
<tr>
<td>Non-Hispanic Black</td>
<td>2 (17%)</td>
</tr>
<tr>
<td>Asian</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>American Indian</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>Multiracial</td>
<td>1 (8%)</td>
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<table>
<thead>
<tr>
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</thead>
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<td>High school or less</td>
<td>6 (50%)</td>
</tr>
<tr>
<td>Some college</td>
<td>4 (33%)</td>
</tr>
<tr>
<td>College degree</td>
<td>2 (17%)</td>
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<td>Unemployed</td>
<td>5 (42%)</td>
</tr>
<tr>
<td>Part-time</td>
<td>5 (42%)</td>
</tr>
<tr>
<td>Full-time</td>
<td>2 (17%)</td>
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<td>3 (25%)</td>
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<td>Separated</td>
<td>1 (8%)</td>
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<tr>
<td>Partnered</td>
<td>2 (17%)</td>
</tr>
<tr>
<td>Married</td>
<td>6 (50%)</td>
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</table>

<table>
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<th>Insurance</th>
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</thead>
<tbody>
<tr>
<td>None</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>Medicaid</td>
<td>5 (42%)</td>
</tr>
<tr>
<td>Military</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>Private or parent’s</td>
<td>5 (42%)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Financial status</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Struggling to keep up with the cost of living</td>
<td>4 (33%)</td>
</tr>
<tr>
<td>Comfortable keeping up with the cost of living</td>
<td>5 (42%)</td>
</tr>
<tr>
<td>Keeping up with the cost of living with extra money</td>
<td>2 (17%)</td>
</tr>
<tr>
<td>Missing</td>
<td>1 (8%)</td>
</tr>
</tbody>
</table>

aData presented as f (%).

Despite differences in experience, all (100%; n = 12) women reported they would feel comfortable being asked about or completing a screening tool related to their perinatal mental health. One stated, “To me it was good. It was them showing they do care about us, the patients.” However, responses were mixed regarding preference for face-to-face assessment or use of a paper or digital screening tool. Some expressed concern about receiving feedback from a paper screening, “Because there is no guarantee they will even look at the paper. Because if feels like when you do that, it feels like they just don’t.”

In terms of accessing mental health care, participants identified barriers only at the individual level; these included lack of transportation, cost or lack of insurance, issues with childcare while accessing services, lack of knowledge of available mental health resources, and scheduling difficulties with services (Table 2). Few (17%; n = 2) identified free or low-cost perinatal mental health care providers, and most (75%; n = 9) would use the internet to locate local resources. Others reported community organizations, pamphlets, doctor, or
family as means to locate resources. Several women also identified an interpersonal level success with social support from their husband or family, as making it easier to access care.

**Table 2. Perinatal mental health access barriers as identified by interview cohorts.**

<table>
<thead>
<tr>
<th>Theme</th>
<th>Women</th>
<th>FM providers</th>
<th>OB providers</th>
<th>Peds providers</th>
<th>MHC providers</th>
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<tbody>
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</table>

*Women = pregnant and recently delivered; *FM = Family Medicine; *OB = Obstetricians; *Peds = Pediatricians; *MHC = mental health care

"My patients definitely have issues with transportation. Transportation is a huge issue for a lot of people." (FM) "I am on a schedule, I can’t be transported [by bus system] at certain times." (Postpartum)

"Cost is probably the biggest issue with my patients." (FM). "There is a lot of anxiety with the cost." (OB).

"It’s kind of hard to bring a 4-year-old into a therapy session. She may not have anyone to watch." (MHC)

"[It would be helpful if] somebody could help me take care of my baby while I went to therapy." (Postpartum)

"Having that knowledge of available resources would be [a positive] change." (Peds)

"Finding [time] in my schedule with work." (Postpartum)

"There is really no mental health help, like on the weekends or late in the afternoon when I have time to do these things." (Postpartum)

"Just knowing it is an issue and knowing how severe it can be. And then, understanding how to screen and what to do with positive screens." (Peds)

"A lot of patients don’t have continuous cell phone service or have limited data plans...that’s really an issue and they will tell us about that." (FM)

"There’s a definite reluctance from the moms themselves who just don’t want to go there. Or from their family members who don’t think it is a big deal." (Peds)

"What I hear from my patients is that they feel alone. They feel like they are the only ones going through things." (FM)

"I feel that there’s still this stigma of depression/anxiety. Not being terrible happy about being pregnant...You’re still not allowed to not be happy that you’re pregnant," (OB)

"There needs to be more networking events. There needs to be more just opportunity to come together and talk about what we do." (MHC)

"I would at least like some acknowledgement that the mom has made contact and that some sort of support is being given." (Peds)

"[There needs to be] better communication, increased communication between physician and mental health providers. Both ways, honestly." (MHC)

"There’s just not enough providers. Not enough mental health providers in the city. Not in Sedgwick; I would say there are definitely not enough." (MHC)

"Women on Medicaid lose their Medicaid. That’s a big one. After six weeks." (MHC)

"It would be great for them to have access to healthcare and to be the healthiest they can be before pregnancy." (Peds)
Obstetrics Providers. Of the five obstetrics (OB) providers interviewed, four (80%) were practicing obstetrician-gynecologists, and one (20%) was a certified nurse midwife. All (100%; n = 5) were part of a group or hospital practice. Their length of practice in Sedgwick County ranged from 6 months to 36 years.

Regarding screening tools for PMADs, all (100%; n = 5) used the EPDS, and 20% (n = 1) also used the PHQ. Most (60%; n = 3) reported screening prenatally (at 28- or 36-weeks gestation) and at six weeks postpartum. One OB (20%) reported screening after delivery, prior to hospital discharge, and at two and six weeks postpartum, as well as administering the PHQ-2 for every patient (regardless of partum status) at every appointment. Those who screen positive on the PHQ-2 are screened further with the PHQ-9. The final provider (20%; n = 1) reported screening postpartum patients at every visit in the first year postpartum.

OB providers identified access to care barriers within all social-ecological levels. Formal training in PMADs was reported by 40% (n = 2) and varied levels of comfort were reported in prescribing medications. Transferring care between two members of the same healthcare team, known as a warm handoff, and integrated mental health services were perceived to improve access to care.

Regarding follow-up after a positive screening, OBs observed the challenges women who do not have a working telephone face in navigating the referral system. They also reported having a transient population can sometimes pose a barrier to follow-up.

Family Medicine Providers. All (100%; n = 4) family medicine (FM) providers were physicians and belonged to large group practices. Most (75%; n = 3) obtained additional certification beyond their family medicine residency, specifically, in maternal child health (50%; n = 2) or obstetrics (25%; n = 1). Length of time practicing in Sedgwick County ranged from 1.5 to 9 years. All FM providers (100%; n = 4) reported screening with a version of the PHQ; 75% (n = 3) screen at every visit and 25% (n = 1) screen at six weeks postpartum and the infant’s one month well-check. If patients express additional concerns, one provider (25%) reported utilizing the Generalized Anxiety Disorder (GAD) screen and the Anxiety Symptoms Questionnaire (ASQ). Frustration was expressed related to screening. One stated, “Sometimes I don’t want to screen” due to challenges connecting women to services.

The FM provider group reported barriers across all levels of the social-ecological model and identified warm handoffs and integrated mental health services as improving access to care. FM providers identified preconception counseling on the use of psychotropic medication during pregnancy as a positive factor in addressing PMADs.

Pediatric Providers. All (100%; n = 6) pediatric providers interviewed were physicians in group practices, ranging from small (17%; n = 1) to large (67%; n = 4); one (17%; n = 1) group practice size was unspecified. Years practicing in Sedgwick County ranged from 6 to 30. PMAD screening practices were focused on mothers of patients: 50% (n = 3) used the EPDS at varying intervals, including one, two, four, and six months postpartum, and unspecified time periods; 33% (n = 2) utilized a single question which was built into the electronic medical record (EMR) at two weeks and two months postpartum; and 16% (n = 1) used the PHQ for every patient in their predominantly adolescent practice, regardless of partum status. One (n = 16%) provider reported screening fathers as well.

As with the other PCPs, pediatricians identified barriers across all socio-ecological model levels. However, pediatric providers emphasized the importance of communication between providers, especially in cases where the mother’s mental health status might have adverse effects on her ability to care for her child. Some pediatric providers (66%; n = 4) reported notifying the mother’s PCP of a positive screen in addition to offering a list of resources. Warm handoffs and integrated mental health services remained ways to improve access.

Perinatal Mental Health Care Providers. The Mental Health Care (MHC) provider group (n = 6) included two clinical psychologists (33%) specializing in eating disorders, generalized anxiety, depression, and perinatal mental health, two (33%) licensed clinical social workers (one of whom specializes in trauma), one (16%) physician certified in general psychiatry, and one (16%) licensed master social worker specializing in perinatal mental health. Length of time practicing in Sedgwick County ranged from 1 month to 16 years. Most (66%; n = 4) were part of a large group practice, with 33% (n = 2) in small group practices. Regarding PMAD screening practices, 33% (n = 2) did not use a screening tool. The remaining 67% (n = 4) had varied practices: one used the EPDS; one used the EPDS and the Perinatal & Anxiety Screening Scale (PASS); one used the PHQ in conjunction with the GAD; and one used a specialized postpartum intake tool from Postpartum Support International (PSI).

Most (83%; n = 5) received referrals for PMAD treatment from OBs, other PCPs, hospitals, or self-referrals. All but one (83%; n = 5) MHC provider accepted Medicaid payments. One (n = 16%) mentioned that Medicaid patients were often not aware of the full scope of services that their insurance covers.

Consistent with PCPs, MHC providers identified access to care barriers across all levels of the socio-ecological model. All MHC providers (100%; n = 6) described processes or policies to address individual level barriers, such as letting children (especially infants) come to the appointment and providing space to breastfeed, and one offered in-home services. This group also echoed the need for warm handoffs and integrated mental health services, and identified home visitation as an avenue to improve access to services.

In addition, several talked specifically about the impact of birth trauma on maternal mental health. One also addressed the impact on PCPs, stating, “I think that if we could wrap around what we consider perinatal mental health is not just something that affects the mom. But partner and then extended family and then obviously the medical provider is part of that picture as well.”
The purpose of this qualitative study was to identify the knowledge of and barriers to perinatal mental health services based on the perspectives of low-income pregnant or postpartum women, PCPs, and MHC providers. It was imperative to identify key drivers to accessing mental health services that can be leveraged for successful interventions to reduce negative birth outcomes.

Screening and Care Practices. Routine screening is recommended by ACOG, AAP, and AAP as only 18 - 25% of PMADs (specifically postpartum depression and postpartum psychosis) are diagnosed without screening. All interviewed PCP and MHC providers reported routinely screening women for mental health disorders in the perinatal period. However, a variety of protocols and tools were reported, which was reflected by the varied screening experiences reported by women. This variability may be a barrier to identifying women who have or are at risk for PMADs and is not unique to the community. A survey of Washington Academy of Family Physicians members found that while 70% (n = 254) always or often screened for postpartum depression, only 22% used a validated screening tool. In the United Kingdom, PCPs perceived 7% of 176 women to be depressed, but EPDS scores were abnormal for 17%. ACOG recommends screening for PMADs at least once during the perinatal period: using a tool that has been validated for perinatal use, specifically EPDS, PHQ-9, Beck Depression Inventory, or Postpartum Depression Screening Scale. ACOG further recommends having systems in place to ensure follow-up care when a diagnosis is made.

Providers should avoid screening due to perceived patient concerns, as women reported being open to PMAD screening, and those who had been screened reported providing honest responses. In addition, women reported feeling as though mental health concerns were brushed aside if the provider failed to raise the subject, and lack of feedback was interpreted as a negative screening result, which may not have been accurate. Educational interventions with providers, changes in EMRs, and use of standardized patient exercises regarding PMAD screening have improved screening adherence and referral/treatment for women who screened positive.

Management practices of women who screened positive varied widely, with OB and FM providers more likely to manage, pediatric providers more likely to refer, and MHC providers’ management depending on patient needs and expertise of the provider. Yet, Kansas Perinatal Risk Assessment and Monitoring (PRAMS) data suggested 17% of mothers who thought they needed treatment for depression did not receive it, indicating barriers to perinatal health care remained.

Barriers to Access to Care. Barriers to perinatal mental health care access were identified at all levels of the social-ecological model. However, pregnant and postpartum women identified barriers only at the individual level. Individual level barriers, including cost or lack of insurance and transportation, were consistent across all respondent groups. These were expected as Sedgwick County has a very limited public transportation system and Kansas does not have Medicaid expansion. In contrast, half of women reported scheduling as a barrier, while no PCPs or MHC providers identified this barrier. Scheduling issues included conflict with work, lack of weekend and evening appointments, and long wait times to get an appointment. These barriers could be mitigated by increasing flexibility in scheduling, such as expanding or adjusting office hours to accommodate drop-in appointments and include more evenings and weekends. Another individual level barrier cited by women (25%; n = 3) was a lack of knowledge of existing perinatal mental health services. Based on strategies reported by participants, MHC providers should partner with trusted community programs to promote their services and make sure organizations are optimized to be found in internet searches. Finally, childcare was a barrier to attending appointments and appointments were more difficult to navigate if a young child was present. Findings were consistent with PRAMS data, where over 50% of respondents did not get help for depression due to cost and childcare concerns. However, all MHC providers reported allowing children when needed. Promotion of such accommodations may increase women’s willingness to engage in services.

An interpersonal level barrier identified by all provider groups was lack of social support from the woman’s family and friends. While not identified as a barrier, several women described the importance of family support in navigating mental health issues. An inverse relationship has been reported between social support levels and both perinatal depression screening scores and postpartum depression diagnosis. Due to the significant impact, providers should consider the following strategies to increase social support for women in the perinatal period:

1. Provide education to the woman’s partner on how to support her, including communication and practical support strategies.
2. Connect women with other pregnant women and expectant couples.
3. Provide adequate information on pregnancy, childbirth, and parenting, that is consistent and accurate.

At the organizational level, lack of communication between providers regarding patients was identified across all provider groups. The majority (> 70%) of pediatricians, OB providers, and FM providers expressed a desire for feedback and closed-loop communication from MHC providers. However, MHC providers reported being intentional about providing feedback to PCPs and reported PCPs could be more effective following up on patients receiving perinatal mental health services, indicating there are likely significant communication gaps between medical and mental health providers. In general, closing the referral loop is a complex problem in health systems. Feedback regarding the outcome of a referral is important for patient safety because patients are medically vulnerable in the period of transition between providers; longer wait times can lead patients to forget about the referral appointment, seek out-of-network specialists, or forgo the referral due to perceived resolution of clinical concern. Integrated behavioral health services and developing systems to support communication between providers better should be prioritized to enhance patient outcomes.
Stigma was a theme at the community level identified by all provider groups. No women cited this barrier, despite public stigma being a well-identified obstacle to seeking mental health services in the U.S. Providers may address stigma through use of standardized screening questions, avoiding language that creates an “us” and “them” division, and paying adequate attention to mental health needs of perinatal women.

At the public policy level, most providers (71%) identified being uninsured (i.e., being on Medicaid) as a barrier. For insurance purposes, postpartum depression belongs to the broader category of mental illness and many insurance companies do not cover mental illness. When coverage is provided, it is often below other categories of illness. ACOG supports the expansion of pregnancy-related Medicaid coverage to one-year postpartum and provides tools for advocacy at the state level. Even with Medicaid expansion, not having an adequate number of trained providers to support mental health in the perinatal period will lead to more demands on the limited providers comfortable to provide care in this area.

A major strength of this study was the use of triangulation between participant cohorts and the inclusion of researchers and community partners in the review and interpretation of the data. Limitations are also present. Selection bias was possible, especially among the pregnant and postpartum women groups, which may have excluded women who were uncomfortable discussing perinatal mental health. Further, while this study focused on physicians in the clinical setting, often nurses and social workers facilitate mental health screening and referral. As such, future research should include these critical groups in assessment of processes and barriers. Findings of stigma being a barrier within the PCP and MHC provider groups but not in the women group may be a result of this selection bias. Recall bias also may have influenced responses. Finally, though the focus of the study was on identifying barriers, many participants shared factors that improved access to perinatal mental healthcare services. Further study of facilitators (i.e., social support) may shed additional light on strategies to improve access.

CONCLUSIONS

Inadequate access to perinatal mental health care can lead to untreated PMADs, which may contribute to poor birth outcomes. This study identified barriers to accessing care from the perspectives of three unique groups and stratified these barriers across the social-ecological model. Interviews identified areas for improvement, including expanding scheduling options, standardizing screening practices to align with advisory organization guidelines, and advocating for legislation to expand Medicaid. Identification of perceived barriers can inform action steps, which may aid in the development of interventions to improve access to perinatal mental health care. Further, engaging community members in identifying and understanding barriers at various social-ecological levels enhances engagement in identifying and implementing interventions to address these barriers.

ACKNOWLEDGEMENTS

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REFERENCES


Keywords: perinatal care, anxiety disorders, access to health care, postpartum depression, maternal health services

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ACCESS TO PERINATAL MENTAL HEALTH CARE

continued.
A Preliminary Study of Clinical Practice and Prenatal Nutrition in Rural Kansas

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ABSTRACT

Introduction. The primary purpose of this study was to determine if new recommendations for prenatal supplements of docosahexaenoic acid (DHA) and choline have been implemented into care by physicians who care for pregnant women in rural Kansas communities. Both nutrients are inadequate in the diet of most pregnant women in the U.S., and not all prenatal supplements provide DHA and choline.

Methods. A cross sectional web-based survey was developed and provided by the University of Kansas Medical Center (KUMC) students to 44 rural Kansas clinics believed to have physicians who provide obstetrical care. Questions about DHA and choline were embedded in a larger survey focused on prenatal care. A total of 29 surveys were returned, however, only 21 were completed by physicians who provided obstetrical care.

Results. DHA (3/21) and choline (0/21) rarely were singled out for recommendation in contrast to folic acid (16/21) and iron (14/21). Participants stated that most women sought prenatal care during the first trimester of their pregnancy and indicated that they recommended prenatal vitamins at the first visit. Eleven gave patients a prescription for prenatal vitamins. The remaining patients either chose traditional over the counter prenatal vitamin capsules or less traditional chewable (gummy) vitamins, which provided lower concentrations of nutrients. Common barriers to nutritional counseling were limited resources and time constraints. Clinicians assessed their confidence and ability to provide nutritional counseling as moderate and competent, respectively.

Conclusions. New nutritional recommendations for DHA and choline have not been implemented into standard of care in rural Kansas.


INTRODUCTION

Access to prenatal care is linked to infant mortality and morbidity. The factors that were associated with infant mortality included preterm delivery, low birth weight, congenital malformations, and other maternal complications such as preeclampsia. Infant mortality in rural counties was higher (6.55 deaths per 1,000 births) than in large urban counties (3.44 deaths per 1,000 births). Many rural counties are considered health professional shortage areas (HPSA); however, a study has not been done linking HPSA and infant mortality.

The standard of care for prenatal counseling set forth by the American College of Obstetrics and Gynecology (ACOG) included education regarding labor and delivery, nutrition, exercise, and working during pregnancy: ACOG recommended a daily prenatal vitamin which includes folic acid; however, the market contains a variety of prenatal vitamin supplements of varying quality. Most prenatal vitamins contain the important supplement folic acid, which is recommended by ACOG and the National Institute of Health (NIH), and minerals including iron, iodine, and zinc; all of which have important roles in pregnancy and fetal development.

Recent studies supported the recommendation to supplement pregnant women with docosahexaenoic acid (DHA) and choline. A 2018 Cochrane Review on the topic of DHA supplementation during pregnancy found a decrease in early preterm births from 4.6% to 2.7% and in all preterm births from 13.4% to 11.9%. This was a relative risk reduction of 42% in early preterm birth (< 34 weeks gestation), and 11% in all preterm births (< 37 weeks gestation). Though this review clearly stated the benefits of DHA supplementation during pregnancy, it is important that gestation > 42 weeks was increased, as was large for gestation age (LGA) babies with DHA supplementation. While an optimal amount of DHA was not defined, the results largely were due to studies in which women were assigned randomly to a supplement of at least 500 mg/day of DHA. Meanwhile, two recent studies showed early preterm birth and preterm birth were reduced by doses of 800 and 1000 mg DHA/day in women starting pregnancy with low DHA status. Dietary intake of DHA was low in women in the U.S., providing approximately 60 mg per day. While DHA is included with some over the counter prenatal supplements, most provide 200 mg/day or less per dose.

The American Academy of Pediatrics highlighted choline and long chain polyunsaturated fatty acids, including DHA, as key nutrients to support fetal brain development during pregnancy and lactation; however, choline was ranked last among common nutrients that doctors recommend for a healthy diet. Only 6% of obstetricians and gynecologists reported they are likely to recommend foods that are good choline sources or supplements for pregnant women. A similar study has not been performed in family medicine physicians providing obstetric care. The Adequate Intake (AI) for choline during pregnancy is 450 mg/day, while pregnant women consume only about 322 mg from food and supplements. Evidence for the importance of ensuring good choline intake during the perinatal period continues to grow. Meanwhile, there was also evidence that choline and DHA act synergistically in brain and eye development.

Physicians can ensure that policy recommendations are implemented in patient care. However, it takes an average of 17 years for significant research to be implemented in clinical practice. A delay in uptake of new findings by physicians can delay further implementation. This study was designed to determine if pregnant women in rural Kansas received information about the need for additional DHA and choline, as well as general information on prenatal nutrition counseling and resources. The study results will identify possible opportunities to amend prenatal
nutrition counseling provided to women by obstetrical providers. We hypothesized that recommendations for DHA and choline have not been implemented into standard of care in rural Kansas.

METHODS

The study was approved by the Institutional Review Board at the University of Kansas Medical Center (KUMC). The survey used a cross-sectional design. Prior to releasing the survey, nine physicians providing obstetrical care at KUMC completed the survey and made recommendations for clarifying the survey prior to implementation. Their data were not analyzed.

All 44 KUMC medical students in the Summer Training Option in Rural Medicine (STORM) program provided the web-based “Prenatal Nutrition Survey” as a REDCap link to rural Kansas preceptors. Preceptors were considered rural if their practice took place in counties outside of the top six urban counties of Johnson, Wyandotte, Leavenworth, Sedgewick, Shawnee, and Douglas. All student researchers received basic interview training the week before the program began and completed a Human Subjects Committee (HSC) on-line training course.

Informed consent was sought at the beginning of the survey. Participants were asked about their practice demographics, patient choices on prenatal care, prenatal supplements, and barriers in providing that care in rural settings. Lastly, participants were asked about their confidence and self-assessed ability to provide patients with nutrition guidance. To be included in the analysis, surveys needed to be completed by participants with either a Doctor of Medicine (M.D.) or Doctor of Osteopathic (D.O.) degree and who provided prenatal care. A total of 29 of the 44 surveys were returned, however, eight were excluded from our analysis. Specifically, one was excluded because the individual who completed the survey did not provide informed consent, two others were excluded as they were not an M.D. or D.O., and five respondents did not provide obstetrical care. Statistical analysis included descriptive statistics and frequencies. Statistical Analysis Software (SAS) version 9.4 was used to complete data analysis.

RESULTS

Results are reported in frequency or sample size for each question and percentages. Of the 44 obstetric providers in rural Kansas, a total of 21 responses were used in analysis, giving a 47.7% response rate. The professions of the sample included 20 M.D.s and 1 D.O. Length of practice ranged from less than 1 year to 33 years. Of the 21 participants, five (23.8%) reported caring for one to ten pregnant women per year, six (28.6%) reported caring for 11–25, nine (42.9%) reported caring for 26–50, and one (4.8%) reported caring for 51–100. These physicians reported providing pre-pregnancy counseling, prenatal care, delivery services, and postpartum care. Nineteen participants (90.5%) reported that greater than half of their patients seek prenatal care in the first trimester.

Eighteen participants (85.7%) reported they would recommend prenatal supplements during pre-pregnancy counseling; although, most participants (90.5%) reported that less than 25% of their patients sought pre-pregnancy counseling. A comment by one participant clarified that they selected pre-pregnancy counseling on the questionnaire as the time they would recommend a prenatal supplement or vitamin, but so few women seek pre-pregnancy counseling that the recommendation for prenatal supplements or vitamins usually occurred at the first appointment patients are seen during the pregnancy.

Physicians were asked to select the type of supplements and vitamin options that patients in their practice choose. Eleven participants (52.4%) responded that women choose prescription prenatal supplements and 17 (81%) selected that women choose over-the-counter prenatal supplements. All 11 who chose prescription also selected over-the-counter supplements. Only one participant (4.8%) selected women choose to consume no prenatal supplements or vitamins. When asked to comment on preference on type of prenatal vitamin, respondents reported a preference for prescription prenatal supplements or vitamins, due to the increased amount of folic acid and preference and tolerance of patient. Most women selected over-the-counter prenatal supplements with about half selecting gummy prenatal supplements.

Participants were asked if they recommend specific nutrients to be included in prenatal supplements and could choose more than one option (Table 1). Folic acid and iron were chosen most frequently, with 16 (76.2) and 14 (66.7) of the participants, respectively. Less frequently recommended were vitamin B6 (8/21, 38.1%), vitamin D (6/21, 28.6%), and DHA (3/21, 14.3%). Choline and iodine were not chosen by participants. Two participants reported recommending other nutrients but did not offer comments. A comment by one participant stated that they sometimes recommended many of the nutrients, but on a case-by-case basis. As for herbal supplements, 19 participants reported that their patients do not choose to use herbal supplements during pregnancy. Comments on this topic included: herbal supplements are not safe or recommended as they are not well researched or regulated, and safety has not been established.

Table 1. Physician’s recommendations for prenatal nutritional supplements.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>N (%)</th>
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<tbody>
<tr>
<td>Folic acid</td>
<td>16/21 (76.2)</td>
</tr>
<tr>
<td>Iron</td>
<td>14/21 (66.7)</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td>8/21 (38.1)</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>6/21 (28.6)</td>
</tr>
<tr>
<td>DHA</td>
<td>3/21 (14.3)</td>
</tr>
<tr>
<td>Choline</td>
<td>0/21 (0)</td>
</tr>
<tr>
<td>Iodine</td>
<td>0/21 (0)</td>
</tr>
<tr>
<td>Other</td>
<td>2/21 (9.5)</td>
</tr>
</tbody>
</table>

Counseling on nutritional information in pregnancy was completed by a variety of clinic personnel (Table 2). All participants (100%) selected physicians provide education on nutrition. Nurses (12/21, 57.1%), midwives (2/21, 9.5%), and registered dietitians (7/21, 33.3%) were less frequently selected as providing additional counseling. The reported format of informational material provided to women were written handouts (17/21, 81%), prenatal classes (16/21, 76.2%), and guided internet searches (6/21, 29%). Barriers to providing
information on nutrition to patients included time constraints (13/21, 61.9%), lack of community resources (7/21, 33.3%), and other (1/21, 4.8%). Participants commented that limited community services and time are the chief barriers. Resources available to patients included a hospital or clinic registered dietitian (14/21, 66.7%), a referral less than 50 miles away (4/21, 19%), and a referral greater than 50 miles (3/21, 14.3%).

Table 2. Nutritional counseling during pregnancy.

<table>
<thead>
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<th>Who provides counseling</th>
<th>N (%)</th>
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<tbody>
<tr>
<td>Physician</td>
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</tr>
<tr>
<td>Nurse</td>
<td>12/21 (57.1)</td>
</tr>
<tr>
<td>Midwife</td>
<td>2/21 (9.5)</td>
</tr>
<tr>
<td>Registered dietitian</td>
<td>7/21 (33.3)</td>
</tr>
<tr>
<td><strong>Counseling format</strong></td>
<td></td>
</tr>
<tr>
<td>Written handouts</td>
<td>17/21 (81.0)</td>
</tr>
<tr>
<td>Prenatal classes</td>
<td>7/21 (33.3)</td>
</tr>
<tr>
<td>Guided internet searches</td>
<td>6/21 (28.6)</td>
</tr>
<tr>
<td><strong>Barriers to counseling</strong></td>
<td></td>
</tr>
<tr>
<td>Time constraints</td>
<td>13/21 (61.9)</td>
</tr>
<tr>
<td>Lack of community resources</td>
<td>7/21 (33.3)</td>
</tr>
<tr>
<td>Other</td>
<td>1/21 (4.8)</td>
</tr>
<tr>
<td><strong>Additional resources</strong></td>
<td></td>
</tr>
<tr>
<td>Registered dietitian</td>
<td>14/21 (66.7)</td>
</tr>
<tr>
<td>Referral less than 50 miles</td>
<td>4/21 (19.0)</td>
</tr>
<tr>
<td>Referral more than 50 miles</td>
<td>3/21 (14.3)</td>
</tr>
</tbody>
</table>

Participants answered questions on organizations and resources used to keep up-to-date on new information. The American Academy of Family Physicians/Kansas Academy of Family Physicians was the most frequently selected with 18 participants (85.7%) referring to this source, followed by ACOG being referred by 17 participants (81%), and 7 participants (33.3%) referring to the U.S. Centers for Disease Control and Prevention. No participants reported use of resources from the Academy of Nutrition and Dietetics or the World Health Organization (WHO). UpToDate® was reported as the most used resource with 90.5% (19/21) of participants selecting this option, followed by academic journals (8/21, 38.1%). Live continuing medical education was selected by 57.1% (12/21) of participants as a format of obtaining new knowledge. Other resources reported by participants included additional publication and texts, and their partners.

Finally, participants were asked to self-assess their ability to provide information on nutritional requirements during pregnancy and their confidence on this topic (Table 3). Self-assessed ability was rated from beginner, developing, competent, and advanced. Most participants reported competent ability (16/21, 76.2%), with three participants (14.2%) rating themselves developing and two (9.5%) as advanced. Confidence was rated as minimally, somewhat, moderately, and very confident. Most (14/21, 66.7%) reported they are moderately confident on nutritional requirements of pregnancy, five (23.8%) reported feeling very confident, and two (9.5%) were somewhat confident in their ability to provide prenatal nutritional counseling.

Table 3. Physician’s confidence in their ability to provide prenatal nutritional counseling.

<table>
<thead>
<tr>
<th>Confidence</th>
<th>N (%)</th>
<th>Self-assessed ability</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimally confident</td>
<td>0/21 (0)</td>
<td>Beginner</td>
<td>0/21 (0)</td>
</tr>
<tr>
<td>Somewhat confident</td>
<td>2/21 (9.5)</td>
<td>Developing</td>
<td>3/21 (14.3)</td>
</tr>
<tr>
<td>Moderately confident</td>
<td>14/21 (66.7)</td>
<td>Competent</td>
<td>16/21 (76.2)</td>
</tr>
<tr>
<td>Very confident</td>
<td>5/21 (23.8)</td>
<td>Advanced</td>
<td>2/21 (9.5)</td>
</tr>
</tbody>
</table>

**DISCUSSION**

These findings correlated to the hypothesis that new nutritional recommendations have not been implemented into standard practice in rural Kansas. Recent studies have shown that DHA is an important nutrient during pregnancy,4 and the National Academy of Medicine has set a choline intake of 450 mg as an AI during pregnancy,13 however, few of the respondents to our survey recommended DHA and none recommended choline. These results could be related to the time it takes for new information to become a standard of care. Even though an AI was set for choline during pregnancy in 1998,13 implementation could have been delayed because it was understood only recently that dietary intake of choline did not meet the AI for most women.14 The reported confidence and ability levels could be referring to nutrients like folic acid and iron that have been studied and in standard practice for many years. It also was possible that those surveyed misunderstood the question, considering one physician said each nutrient could be recommended on a case-by-case basis.

Americans living in rural communities face barriers in access to healthcare, especially women seeking prenatal care. According to the 2010 U.S. Census Bureau data, 17% of the U.S. population lives in rural communities, while only 9% of physicians practice in these areas.17 The situation is similar in Kansas, where 25 of the 105 counties are designated as a whole county primary care HPSA and an additional 89 counties have some level of HPSA. This was reflected in the small number of physicians providing obstetrical care in rural Kansas. The work by Kennedy et al.19,20 has identified just 44 physicians providing obstetrical care in this area, which was the sample we sought to obtain for this study.

A limitation of the research was the small sample size. Results were obtained from only 29 of the 44 physicians whose practice includes obstetrics, with only 21 of the 29 respondents meeting all inclusion criteria to be included in the study. The COVID-19 pandemic meant that not all physicians were able to be contacted in-person, decreasing the intended sample size. However, the sample size was large enough to serve as a starting point for further investigation and to consider how to best provide information on the importance of DHA and choline to physicians caring for pregnant women in Kansas. Our findings cannot be generalized to physicians practicing in urban and suburban settings, although there was evidence to suggest that the findings for choline could be similar.22
According to our study, rural physicians were using UpToDate®, ACOG, and the American Academy of Family Physicians most commonly for knowledge acquisition. Physicians have cited barriers of journal use to include “time, resource reliability, data credibility, and information overload”.21 With these barriers in mind, options for research dissemination in rural Kansas could include: open access to journal articles, increased time and funds for conference attendance (e.g., Kansas Academy of Family Physician conferences), continuing education courses specific to prenatal nutrition, and virtual education meetings from the academic research communities to rural Kansas providers. The efficacy and interest in these options would need to be assessed in further studies.

This preliminary study showed the need for further research, as well as offering educational ideas for shortening the time gap between evidence from research and recommendations for practice becoming standard of care. Bridging this gap can have more significant impacts such as reducing infant morbidity and mortality in the rural U.S.

ACKNOWLEDGEMENTS

The authors thank the obstetricians/gynecologists at the University of Kansas Medical Center’s Obstetrics and Gynecology department for participating in our pilot study. This work would not have been possible without the STORM students assisting our participants to complete the survey. Finally, we thank the practicing physicians in rural Kansas who took the time out of their day to be a part of this project.

REFERENCES


Keywords: obstetrics, prenatal nutrition physiology, rural health services, docosahexaenoic acids, choline
Cut Cortical Screw Purchase in Diaphyseal Bone: A Biomedical Study

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ABSTRACT

Introduction. During fracture osteosynthesis, traumatologists may remove screws which are too long, cut the excess length from the screw tip, then reinsert the cut screw (CS) to minimize implant waste. The purpose of this study was to determine if this practice influences screw purchase.

Methods. Using an axial-torsion load device, the maximal insertion torque (MIT) required to insert 3.5 mm stainless steel cortical screws into normal and osteoporotic bone models was measured. MIT was determined in three different test conditions: (1) long screw (LS) insertion; (2) LS insertion, removal, and insertion of a normal-length screw (NS); and, (3) LS insertion, removal, cutting excess length from the screw tip, and reinserting the CS.

Results. In the normal bone model, mean (± SD) MIT of LS insertion was 546 ± 6 Newton-centimeters (N-cm) compared to 496 ± 61 N-cm for NS reinsertion and 465 ± 69 N-cm for CS reinsertion. In the osteoporotic bone model, MIT of LS insertion was 110 ± 11 N-cm, whereas the values for NS and CS reinsertions were 98 ± 9 N-cm and 101 ± 12 N-cm, respectively. There was no significant difference in MIT between CS and NS reinsertions in the osteoporotic bone analog.

Conclusions. Cutting excess length from a 3.5 mm stainless steel cortical screw did not decrease its purchase regardless of bone density. During osteosynthesis, orthopaedists may remove screws which are too long, cut the screw tip, and reinsert the shortened screw as a cost-saving measure without compromising fracture fixation.

INTRODUCTION

Fracture fixation using plate osteosynthesis is a well-established treatment employing basic principles of biomechanics such as compression and torque. A successful fracture reconstruction depends largely upon the orthopaedist’s ability to achieve adequate plate compression by maximizing torque applied to a screw. Many factors affecting screw purchase, including patient characteristics, such as bone density, and mechanical factors, such as screw and plate design features, are not within the surgeon’s control. However, the surgical technique used to apply plate and screws to the fractured bone, including possible modification of the screw tip, is determined by the operating orthopaedist.

When cortical screws used during osteosynthesis are too long, they may protrude from the far cortex of bone, potentially causing pain and injury to adjacent soft tissue structures. In this setting, a shorter screw is warranted. How this is accomplished varies as some surgeons discard the long screw (LS) and replace it with a new screw (NS) of appropriate length, whereas others choose to remove the long screw, cut it to the required length, and reinsert the cut screw (CS). In the latter scenario, the orthopaedist saves the cost associated with wasting the LS, which may not be reused in another patient. One hospital system found that 3.5% of all trauma implant costs were due to wasted materials, adding an average of $83 to the cost of each case.¹ Incorrectly measured screw lengths were one of the most common reasons for wasted materials, the cumulative cost of which may be significant for a health care system.²

ABSTRACT

Introduction. During fracture osteosynthesis, traumatologists may remove screws which are too long, cut the excess length from the screw tip, then reinsert the cut screw (CS) to minimize implant waste. The purpose of this study was to determine if this practice influences screw purchase.

Methods. Using an axial-torsion load device, the maximal insertion torque (MIT) required to insert 3.5 mm stainless steel cortical screws into normal and osteoporotic bone models was measured. MIT was determined in three different test conditions: (1) long screw (LS) insertion; (2) LS insertion, removal, and insertion of a normal-length screw (NS); and, (3) LS insertion, removal, cutting excess length from the screw tip, and reinserting the CS.

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METHODS

Experimental Design. Stainless steel screws designed for fracture fixation were inserted into surrogate bone materials approximating normal and osteoporotic femoral diaphyseal bone to determine MIT in three different test conditions (Figure 1). In Condition A, a LS was introduced into each predrilled and untapped hole in the model specimen, MIT was measured, and the LS was removed. In Condition B, a LS was inserted and removed and then a screw of appropriate length, so-called “normal screw” (NS), was inserted, and MIT was measured. In Condition C, a LS was placed into a predrilled and untapped hole and then removed. The LS was then shortened by cutting the screw tip and the resulting cut screw (CS) was reinserted and MIT was remeasured. The values obtained for the three test conditions were statistically analyzed for both bone models.

Test Materials. The two bone analog models intended to simulate normal and osteoporotic bone in this study were like those used in previous biomechanical experiments.⁷ A fourth generation Sawbones® (Pacific Research Laboratories, Vashon Island, WA) model with an outer diameter of 30 mm, wall thickness of 7 mm, and an internal fill of 20# density foam was used to mimic the normal bone of a mid-shaft femur. The common cylindrical shape of the specimen improved test repeatability as compared to testing with an anatomic model of varying geometry. To simulate osteoporotic bone, a custom Sawbones® foam laminate of 16 mm, thick 10# solid foam laminated on both sides with 5.5 mm 30# solid foam was used. Each test block had a finished size 120 mm wide, 170 mm long, and 27 mm thick.

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Figure 1. Testing algorithm. a) In Condition A, LS is inserted and test is done to determine MIT. b) In Condition B, LS is inserted, removed, NS is inserted, and MIT is determined. c) In Condition C, LS is inserted, removed, and screw tip is cut to shorten the screw. The resulting CS is reinserted and MIT is determined.

The stainless-steel cortical screws were 3.5 mm diameter screws manufactured by Stryker® (Mahwah, NJ). The LS measured 40 mm, CS 34 mm, and NS 34 mm. Images of a cut stainless steel screw are shown in Figure 2.

Figure 2. Two views of a stainless-steel cut screw showing mechanical deformation of the screw tip.

Maximal Insertion Torque Testing. Insertional torque was measured continuously on a Bose (Framingham, MA) ElectroForce® 3220 Axial-Torsion load frame (Figure 3). An axial preload of 10 N was applied and held constant for the duration of the screw insertion test. The test was driven at a rotational rate of five revolutions per minute. The time, axial load, axial displacement, rotation angle, and torque were recorded at a data acquisition rate of 10 Hz. The test was performed until failure of the bone-screw interface, screw head stripping, screw head fracture, or a machine torque limit was reached.

The torque measuring load frame limit of 550 N-cm is well above the torque applied to screws during osteosynthesis. If the screw MIT was greater than 300 N-cm, the screw was considered not stripped under clinical conditions. To prepare the bone models for testing, 2.5 mm diameter holes were drilled perpendicular to the longitudinal axis of the test cylinder. A hole spacing of 12.5 mm was used to give a five times the diameter spacing between holes as specified by the American Society for Testing and Materials (ASTM). The intent was to insert all screws perpendicular to the long axis of the test cylinder, penetrating both near and far sides of the specimen. A matched washer was used with each screw to simulate a standard bone fracture plate. Screws were started by hand and inserted until the screw head was approximately 4 mm from contacting the washer.

In the first series of tests using the normal cortical bone model, five replicates of LS, NS, and CS were tested to see if differences in MIT could be found. In the second series using the osteoporotic bone model, seven replicates were tested. Tested screws were removed by hand and each screw was examined for damage. The number of screws tested in each group of the study met or exceeded the number of screws tested in the published literature on MIT.

Statistical Analysis. Statistical analysis of the results was performed by one-way ANOVA test with the Least Significant Difference formula for post hoc multiple comparisons (IBM® SPSS v23, Chicago, IL). Seven independent tests per test condition were summarized for analysis. A p value of less than 0.05 was considered as significant difference. Data were expressed as mean ± standard deviation (SD) of the mean.

RESULTS

Normal Bone Analog. The mean ± SD MIT of initial LS insertion was 546 ± 6 N-cm and the MIT values for NS and CS reinsertions were 496 ± 61 N-cm and 465 ± 69 N-cm, respectively (Table 1). The mean value for each test condition in the normal cortical bone model was significantly above the MIT clinically relevant threshold of 300 N-cm (p < 0.05). For the cortical bone surrogate, 70% of the screw heads broke prior to reaching the MIT machine limit of 550 N-cm.

Osteoporotic Bone Analog. The MIT of initial LS insertion was 110 ± 11 N-cm and the MIT values for NS and CS reinsertions were 98 ± 9 N-cm and 101 ± 12 N-cm, respectively (Table 1). There was no significant difference in MIT between CS and NS in osteoporotic bone.

Table 1. Maximal insertion torque (MIT).

<table>
<thead>
<tr>
<th>Test condition</th>
<th>Screw type</th>
<th>Normal bone model*</th>
<th>Osteoporotic model*</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Long screw (LS)</td>
<td>546 ± 6</td>
<td>111 ± 11</td>
</tr>
<tr>
<td>B</td>
<td>Normal screw (NS)</td>
<td>496 ± 61</td>
<td>98 ± 9</td>
</tr>
<tr>
<td>C</td>
<td>Cut screw (CS)</td>
<td>465 ± 69</td>
<td>101 ± 12</td>
</tr>
</tbody>
</table>

* Tabulated values are mean ± standard deviation in N-cm.
Within osteoporotic bone, insertional torque recorded 180° prior to MIT and 180° after MIT were compared in CS and NS screws (Figure 4). At each measurement in the 360° arc, there were no significant differences in torque (p < 0.05).

**DISCUSSION**

Based on the initial hypothesis, a decrease in MIT after CS reinsertion compared to NS reinsertion was anticipated. Since no statistically significant reduction in MIT was found, this hypothesis must be rejected. The results supported the surgeon's practice of cutting screws which are determined to be too long during osteosynthesis as a cost savings measure, as CS reinsertion did not compromise MIT in either the normal cortical bone or osteoporotic bone models. Based on these data, we believed that surgeons may reintroduce screws which were cut or shortened during fracture fixation without regard to a patient's bone quality.

The health care costs saving resulting from this practice may be substantial as long screws were present in approximately 25% of constructs. If an orthopaedic surgeon performs 500 cases per year, then an estimated 125 cases have potential cost savings associated with cutting a screw. For nonlocking cortical screws at $20 per screw, there could be a cost savings of $2,500 per year. For interlock screws, cutting a screw may produce more deformation of the distal threads and lead to a different test result. Likewise, cutting screws of different sizes may have an impact on MIT. A final study limitation was that bone analogs were used instead of human cadaver bone. The results, therefore, may not be extrapolated directly to in vivo human bone.

In conclusion, this study showed that cutting a 3.5 mm stainless steel cortical screw did not decrease its purchase as determined by maximal insertion torque in normal cortical bone or osteoporotic cortical bone models. During osteosynthesis, orthopaedists may choose to remove screws which are too long, cut the screw tip to remove excess length, and reinsert the screw without compromising the fracture reconstruction, while at the same time avoiding implant waste and saving health care dollars.

**REFERENCES**


Keywords: biomechanics, fracture fixation, medical waste, bone screws, torque
Stacked 1/3 Tubular Plates for Fixation of Pediatric Forearm Fractures: A Biomechanical Study

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2Department of Orthopaedics
3Wichita State University, Wichita, KS
National Institute for Aviation Research

ABSTRACT

Introduction. Among operatively treated pediatric forearm fractures, many different fixation constructs are described. The goal of this study was to define the biomechanical properties of a double stacked 1/3 tubular plate construct used by the senior author for some fractures and to review available literature regarding the use of stacked plates.

Methods. Biomechanical testing was performed by 4-point bending of three different plate constructs: 1/3 tubular plate, stacked 1/3 tubular plates, and 2.7 mm LC-DCP plate. Five test specimens were evaluated for each of the three plate constructs. From stress-strain curves, flexural stiffness (N/mm), force to cause plastic deformation (N), and force to cause 10° bend (N) were calculated and compared using standard t-test statistics.

Results. Key outcome parameter means (± SD) for the three plate constructs (1/3 tubular plate, stacked 1/3 tubular plates, and 2.7 mm LC-DCP plate) were reported respectively as follows: flexural stiffness (55.4 ± 3.5 N/mm, 131.7 ± 3.5 N/mm, 113.3 ± 12.1 N/mm), force to cause plastic deformation (113.6 ± 11.0 N, 242.1 ± 13.0 N, 192.2 ± 17.9 N), and force to cause a 10° bend (1400 ± 84 N, 2994 ± 14.1 N, 265.5 ± 21.2 N). Mean values of all three measures were significantly larger for the stacked 1/3 tubular plates than for the other plate constructs.

Conclusions. The stacked 1/3 tubular plate construct was biomechanically superior to the other plate constructs tested. Stacked plating significantly improved stiffness of the fracture fixation construct supporting the use of this technique in selected trauma cases.


INTRODUCTION

Forearm fractures are among the most common fractures in pediatric patients. While many of these fractures can be managed nonoperatively, much controversy exists with regards to indications for operative treatment.1,2 Indications for fixation can include open fractures, inability to achieve adequate reduction, loss of reduction, and limited remaining growth/remodeling. Once operative fixation is chosen, hardware selection for fracture fixation includes numerous different implants and often there is no clear indication to choose one type over another.3,4 Even when selecting a plate and screw construct, many different geometries, materials, thicknesses, screw types, and other variables are available from numerous vendors. Surgeons must consider characteristics of the fracture being treated along with other patient and treatment factors when selecting the appropriate construct for fixation. Biomechanical research offers some insight into properties of plate and screw selection and provides clinicians objective information to guide clinical practice.

The inspiration for this study was the senior author’s use of stacked 1/3 tubular plates in the treatment of pediatric forearm fractures. This work specifically aimed to perform a biomechanical analysis between fixation constructs using two different plates, as well as the stacked plate construct, to define the mechanical properties quantitatively. While the study design was chosen with this clinical application in mind, the results could be applied more generally. The mechanical properties and comparison between various commercially available plates are not well described by industry product guides or in the orthopaedic literature. Anecdotally, a thicker or larger plate, as well as stacking two plates, would increase the stiffness, but quantitative data were lacking.

The goal of this study was to characterize the mechanical properties of three different plate constructs and provide quantitative data which could be used by providers to guide clinical practice decisions. What evidence exists in current literature with regards to stacking plates for fracture fixation? How does quantitative biomechanical performance (flexural stiffness, force to cause plastic deformation, and force to cause 10° bend) by 4-point bending compare between the 1/3 tubular plate, stacked 1/3 tubular plate, and 2.7 mm LC-DCP plate? This study presents and discusses possible applications of the stacked plating construct, as well as limitations and potential for further work.

METHODS

Sawbones® (part #3403-24, cylinder 10 mm OD x 2.5 mm wall thickness) were acquired and used for this fracture model (Pacific Research Company; Vashon, WA, USA). A transverse fracture was created with a saw and plate fixation was applied leaving a 1-mm fracture gap. Plate constructs included three different groups: 6-hole 1/3 tubular plate (Synthes® item # 241.36), double stacked 6-hole 1/3 tubular plates (item # 241.36), and 7-hole 2.7-mm LC-DCP plate (Synthes® item # 242.207); 2.7-mm cortical screws of appropriate length were used for fixation of all groups (Synthes®; West Chester, PA, USA). The 6-hole 1/3 tubular and 7-hole 2.7-mm LC-DCP plates were chosen due to similarity in overall construct length due to the symmetry of hole spacing in the 2.7-mm plate versus elongated span between central holes on the 1/3 tubular plate (Figure 1).

Figure 1. Plate constructs used in this study included: (A) 2.7 mm LC-DCP plate, (B) 1/3 tubular plate, and (C) stacked 1/3 tubular plates.

Testing was performed at the National Institute for Aviation Research mechanical testing lab (NIAR, Wichita State University, Wichita, KS) on an 810 Material Test System (MTS®, Eden Prairie, MN). The test system is shown in Figure 2. The 4-point bending setup was adapted to fit the specimens from testing specifications of
the American Society for Testing and Materials (ASTM). Support span was set at 81 mm; load span was set between 25.5 mm and 27 mm based upon screw location to ensure load was applied between screw heads and would not interact with screws during bending (Figure 3). While changing the load span would introduce variability in the results, a change within 1.5 mm over the 81-mm support span would be minimal and allow the benefit of not loading directly onto a screw head, which would lead to slippage during loading. Load rate was 0.015 mm/sec; load and deflection were sampled at 60 Hz. Specimens were tested through elastic and plastic deformation to a deflection of at least 5 mm. A representative plot from testing of a double stacked 1/3 tubular plate is shown in Figure 4.

Analysis was performed on data to calculate the flexural stiffness (N/mm) based on the linear region of the stress/strain curve. Force to cause a plastic deformation was defined as a deviation of greater than 5% from the linear stress/strain relationship. Force to cause a 10° bend was identified along the stress/strain data based upon the geometry of the test setup, as shown in Figure 2, to provide a clinical corollary of construct strength. Data were compared with standard t-test statistics with a selected significance value of $p = 0.05$. T-tests were run for the following comparisons: 1/3 tubular vs. stacked 1/3 tubular, 1/3 tubular vs. 2.7-mm LC-DCP, stacked 1/3 tubular vs. 2.7-mm LC-DCP.

**RESULTS**

The three plate constructs (1/3 tubular plate, stacked 1/3 tubular plate, and 2.7-mm LC-DCP plate) were each tested with $n = 5$ and the following results are reported respectively with standard deviations (Table 1): flexural stiffness (55.4 ± 3.5 N/mm, 131.7 ± 3.5 N/mm, 113.3 ± 12.1 N/mm), force to cause plastic deformation (113.6 ± 11.0 N, 242.1 ± 13.0 N, 192.2 ± 17.9 N), and force to cause a 10° bend (140.0 ± 8.4 N, 299.4 ± 14.1 N, 265.5 ± 21.2 N).

<table>
<thead>
<tr>
<th>Construct</th>
<th>Flexural stiffness (N/mm)*</th>
<th>Force to cause plastic deformation (N)*</th>
<th>Force to cause 10° bend (N)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3 tubular plate</td>
<td>55.4 ± 3.5</td>
<td>113.6 ± 11.0</td>
<td>140.0 ± 8.4</td>
</tr>
<tr>
<td>Stacked 1/3 tubular plate</td>
<td>131.7 ± 3.5</td>
<td>242.1 ± 13.0</td>
<td>299.4 ± 14.1</td>
</tr>
<tr>
<td>2.7 mm LC-DCP plate</td>
<td>113.3 ± 12.1</td>
<td>192.2 ± 17.9</td>
<td>265.5 ± 21.2</td>
</tr>
</tbody>
</table>

*Tabulated values are mean ± standard deviation.

Statistical significance by t-test was performed for each of the three reported results (flexural stiffness, force to cause plastic deformation, and force to cause a 10° bend). When comparing 1/3 tubular plate against stacked 1/3 tubular plate and 1/3 tubular plate against 2.7-mm LC-DCP plate, all were significant at $p < 0.001$. When comparing stacked 1/3 tubular plate versus 2.7-mm LC-DCP plate, flexural stiffness was significant at $p = 0.0114$, force to cause plastic deformation was significant at $p = 0.0010$, and force to cause 10° bend was significant at $p = 0.0177$. Failure analysis of test specimens after bending also was performed, which showed that 2.7-mm LC-DCP plates failed at a single point of bending at the center screw hole overlying the fracture, whereas 1/3 tubular plates (stacked and single) failed by bending at the 2 screw holes adjacent to the fracture (Figure 5).
Figure 5. Failure analysis of (A) stacked 1/3 tubular plates and (B) 2.7-mm LC-DCP plate. Arrows show the site(s) of bending in each construct.

DISCUSSION

This study confirmed the hypothesis that stacked 1/3 tubular plates are biomechanically superior to a 2.7-mm LC-DCP plate. Further, it demonstrated that stacked plating provided a better than additive quantitative mechanical improvement in bending. This was true of the three metrics reported in this study of 4-point bending: flexural stiffness, force to cause plastic deformation, and force to cause a 10° bend.

Review of previously published works regarding stacked plating yielded only a few studies. Mudgal and Ring published a technique report about using stacked plating in adult distal radius fractures that had metadiaphyseal extension. They suggested using a combination of a T-plate plus a dynamic compression plate to allow longer extension of the construct to span from the metadiaphyseal fracture to the distal radius continuously. In their work, they presented the technique, as well as two case reports of its use with good outcomes; however, no biomechanical analysis was done. A recently published case report used a similar technique of stacking plates as a method of extending fixation across a metadiaphyseal segmental fracture in a pediatric patient with a good result. Uniquely, their construct combined titanium and stainless-steel plates. While the investigators reported successful fracture union without complication, they offered no biomechanical or construct analysis.

Another study completed in the field of veterinary surgery compared stacked plating for front leg fractures in canines. Biomechanical analysis was performed with axial load cyclic testing to compare single plate versus stacked plates. In their stacked plate constructs they tested 8-hole plate constructs stacked with another plate of either eight holes, four holes, or two holes. This study found that single plate constructs failed and most of the stacked plate constructs did not. However, due to the design of their mechanical testing, they were not able to provide any quantitative data as to the added strength of implementing stacked plating.

When designing our testing model, 4-point bending was chosen as it was judged to be more relevant to the authors' clinical question regarding its use in pediatric forearm fractures. The complexity of the two bones in the forearm and typical fracture mechanism make bending more applicable over torsion. To analyze the difference in the constructs fully, as well as to apply these results to other fractures (such as distal fibula), further work is necessary to test the plates in torsion. Fatigue testing also deserves consideration in future work. However, in fracture fixation of pediatric fractures, perhaps cyclic testing is less clinically relevant since fractures typically achieve bony union quickly and often are treated with supplemental immobilization.

While limited work has been published on stacked plating, numerous studies of other plate and screw constructs populate the literature. Since the advent and popularization of locking plates and screws, their biomechanics and performance have been presented and analyzed. Several studies have looked at how screw configuration, plate positioning, and bone quality impact biomechanical properties. Other studies have evaluated biomechanical properties of various plate and screw constructs in the setting of ankle fractures. While these works have drawn an array of conclusions with regards to their specific hypotheses, much can be learned and leveraged with regards to study design and methods. The testing design and parameters of the presented study were chosen with an aim to provide quantitative biomechanical data which would help to analyze the hypothesis objectively. Importantly, plastic deformation was achieved in all constructs which, unlike the only previously published biomechanical study on stacked plating, enabled the ability to compare the quantitative stiffness and performance between groups.

The results of this study supported the use of stacked 1/3 tubular plates as a biomechanically superior construct compared to 2.7 mm LC-DCP plating. This is a technique that the senior author has utilized to manage a wide variety of operatively-treated pediatric forearm fractures, including radial shaft fractures in the setting of both bone forearm fractures and ulna fractures in the setting of Monteggia fracture patterns (Figure 6). Benefits for use of stacked 1/3 tubular plates included: (1) tubular plate shape improves bone-plate fit in many patients, (2) availability of implants in a community hospital or surgery center, (3) tubular plates more easily contoured independently with improved strength by stacking, and (4) reduced cost.

Figure 6. Radiographs showing stacked 1/3 tubular plate constructs used in pediatric patients to treat: (A) distal 1/3 both bone forearm fracture with fixation of the radius and (B) Monteggia fracture with fixation of the ulna.
While the purpose of this work was not to define or explore the use of stacked plating fully, it helped to define the mechanical properties of the stacked plate construct, which could be used to guide clinical decision making, and supported the use of stacked plating in many fractures. The described and tested construct of stacked 1/3 tubular plates offers clinicians another option in fracture fixation.

REFERENCES

Keywords: biomechanics, fracture fixation, bone plates, materials testing, equipment design.
Disseminated Infection Due to Neocosmospora (Fusarium) falciformis in a Patient with Acute Myelogenous Leukemia

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INTRODUCTION

Fusarium species are ubiquitous in soil, plants, organic matter, and water; they are important plant pathogens associated with vascular wilt, rots, and damping-off diseases.1 Some species are animal and opportunist human pathogens. Fusarium solani species complex (FSSC), recently renamed Neocosmospora,2 accounts for half of human infections caused by Fusarium. Some of the species are associated with severe infections in transplant recipients and patients with hematological malignancies, persistent neutropenia, or immunosuppression caused by corticosteroid therapy.3 We present a case of disseminated Neocosmospora (Fusarium) infection in a 55-year-old male who developed febrile neutropenia on day four post induction chemotherapy for acute myelogenous leukemia. This case highlighted the clinical presentation and treatment for disseminated Neocosmospora (Fusarium) infection and the importance of clinical examination allogenic stem cell transplant recipients.

CASE REPORT

A 55-year-old male presented to his primary care provider with fatigue and diarrhea. Initial work-up showed a white blood cell count (WBC) of 103,600 cells/μL, prompting admission. Acute myelogenous leukemia (AML) with monocytic differentiation was diagnosed by bone marrow biopsy and he was started on induction chemotherapy on admission (day one), in addition to prophylactic acyclovir 400 mg twice daily, levofloxacin 500 mg daily, and micafungin 50 mg daily. He became neutropenic on day four. On day 16, he developed febrile neutropenia and a new painful grey lesion on his right fourth and fifth toes (Figure 1); otherwise, examination was unremarkable. WBCs were 200 cells/μL, hemoglobin 6.9 g/dL, and platelets 8,000/μL. Renal and liver function tests were within normal limits. Serum beta-D-glucan and Aspergillus galactomannan antigen tests were within normal range.

Figure 1. Skin lesion between the right fourth and fifth toes.

The patient was started on liposomal amphotericin B 5 mg/kg daily. Routine blood cultures were positive after four days of incubation. Hyphal elements were reported on the blood culture (Figure 2).

Figure 2. Gram stain of positive blood culture bottle showed septate hyphae (on BD BACTEC Aerobic medium; 20x).

Additionally, the dermatology consult team performed a shave biopsy, which was sent for aerobic, anaerobic, and fungal cultures. Routine culture grew Staphylococcus epidermidis. No tissue was sent for histopathology. After three days of incubation, the fungal culture of the tissue grew a mold identified as Neocosmospora falciformis by combined morphology and DNA sequencing of the TEF and RPB2 genes at the reference lab (Figure 3). The patient developed acute hypoxic respiratory failure requiring 4 L/min of oxygen by nasal cannula. Chest computed tomography (CT) showed innumerable nodular opacities throughout both lungs, which were greatest in the apices with surrounding ground-glass opacities suggestive of multifocal fungal pneumonia (Figure 4). Two weeks after broad spectrum antifungal therapy, a fungal Grocott’s methenamine silver (GMS) stain of bronchioalveolar lavage fluid demonstrated similar looking septate hyphae, but fungal culture remained negative. A transbronchial lung biopsy remained culture negative as well.

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The classification of fungi historically was based on morphology of the sexual forms. Many fungi are known to reproduce only asexually, and some have both asexual (anamorph) and sexual (teleomorph) states causing confusion in fungal taxonomy as several were inadvertently given two separate names. Since January 2013, each fungus can have only one name, as the system of permitting separate names to be used for anamorphs ended. However, confusion continues since many medically important fungi still are known by their established anamorph names (i.e., Candida). In this case study, the mold from both shave biopsy and blood culture was identified as Neocosmospora falciformis. The genus Neocosmospora, previously under Fusarium solani species complex (FSSC), contains at least 60 species. Taxonomy changes to Fusarium species have caused scientific opposition, due to the confusion it generated, and clinical laboratories are encouraged to continue to use the term Fusarium until conflicting viewpoints are resolved.

Infections with Fusarium species may result in a broad spectrum of clinical manifestations, including superficial keratitis and onychomycosis (second most common pathogen after dermatophytes), locally invasive or disseminated disease. Infection severity and location depends on the immune status of patients and the pathogen portal of entry. Invasive and disseminated infections occur almost exclusively in severely immunosuppressed patients, particularly among those with hematological malignancy with prolonged neutropenia. Allogeneic stem cell transplant recipients with graft-versus-host disease on steroid treatment are at particular risk for disseminated or invasive infection. Between 1986 and 1995 the incidence of Fusarium species infection was 1.2% among 750 allogeneic and 0.2% among 1,537 autologous marrow transplant recipients at M.D. Anderson Cancer Center in the U.S. Fusarium is reported to be the third most common mold infection in hematology patients and organ transplant recipients after Aspergillus and Zygomycetes.

The limited diagnostic tools available to diagnose invasive fungal infections lead to a delay in the diagnosis and treatment of these infections. Any clue to the early diagnosis of these infections may lead to changes in antifungal therapy and may be critical for an improved outcome. One of the most frequent, and frequently the only clinical sign, aspect of infections with Fusarium species is the development of skin lesions. Recognition of the skin manifestations will lead to early administration of antifungal therapy and obtaining biopsies for histopathology and fungal cultures.

Colonies of Neocosmospora (FSSC) grow rapidly within a few days and display aerial white to cream mycelium that turns bluish-brown when sporodochia develop. Curved, fusiform macroconidia with three to five septa (characteristic of Fusarium species) develop after four to seven days of incubation, while small, oval, one- or two-celled microconidia are usually abundant (Figure 3). Fusarium and Neocosmospora species are unique among other commonly identified clinical filamentous molds (e.g., Aspergillus and Zygomycetes species) in their ability to grow in routine blood cultures.

With unpredictable response to therapy, high virulence seen in case reports and animal models, Neocosmospora (FSSC) infections often are associated with poor prognosis in patients. Our patient’s specimen displayed significant resistance to antifungals with low MIC only reported to amphotericin B. Fusarium and Neocosmospora species are relatively resistant to most antifungals, therefore antifungal susceptibility testing is recommended while managing these infections, even though a correlation between MICs and clinical outcomes is not established. Treatment is typically a combination of surgical debridement, source control, and high dose liposomal amphotericin B, voriconazole with or without terbinafine. Novel antifungals like olorofim are being evaluated.
CONCLUSIONS

This case demonstrated the importance of a detailed physical examination for patients especially immunocompromised with fever. It also illustrated the changing fungal nomenclatures and the relatively high degree of antifungal resistance seen in Neocosmospora (Fusarium) infections.

REFERENCES


Keywords: Fusarium falciformis, Neocosmospora falciformis, soft tissue infection, acute myelogenous leukemia, febrile neutropenia
Diabetic Ketoacidosis in Undiagnosed Acromegaly: A Case Report and Literature Review

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INTRODUCTION

Diabetic ketoacidosis (DKA) is both a potentially deadly hyperglycemic crisis and one of the most common causes of diabetes-related hospitalization in the U.S.1,2 DKA currently is not established as a complication of acromegaly,3-5 even though many authors have described their association.6,7 This case reports a middle-aged male patient with a long history of untreated acromegaly who developed DKA.

Acromegaly is a rare endocrinologic disease first mentioned in 1886 by Perrier Marie, characterized by overproduction of growth hormone (GH), and in most cases from a pituitary adenoma.8,9 It often is diagnosed between 40 and 50 years old,10 and the common manifestations are acral growth, facial features deformities, soft tissue edema, hyperhidrosis, visual impairment, menstrual disturbances in women, and decreased libido in men.11,12

Diabetes mellitus (DM) is a common complication of acromegaly, with a prevalence ranging from 19 - 56%.13 The primary mechanism of DM in acromegaly is growth hormone (GH)-induced insulin resistance,14 thus hyperosmolar hyperglycemic state (HHS) would be expected as in Type 2 DM complications, instead of DKA.15

CASE REPORT

A 41-year-old male presented with a two-week history of polyuria, polydipsia, blurred vision, and dizziness, which progressed to nausea and vomiting for the prior two days. He had a medical history of hypertension, and a family history of Type 2 diabetes mellitus in his mother.

Physical examination was remarkable for a body mass index of 30 kg/m², blood pressure of 92/50 mmHg, heart rate of 105 beats/min, dry mucous membranes, a fruity odor to his breath, and physical findings suggestive of acromegaly: coarse facial features, enlarged mandible, enlarged-fleshy nose, increased space between the lower incisors, and bony overgrowth of the hands (Figure 1).

Visual field examination was unremarkable. Initial blood workup showed high anion gap metabolic acidosis (pH 7.27, bicarbonate 13.2mEq/L, and anion gap of 25mEq/L), serum glucose 472 mg/dl, glycosylated hemoglobin (HbA1c) 15.2%, ketones present in blood and urine, and serum osmolality 298 mOsm/kg.

Current 2021 British DKA guidelines for treatment,16 as well as ADA 2009 latest guidelines for hyperglycemic crisis in adults,17 recommended that the initial therapy starts with 0.9% sodium chloride solution and regular insulin infusion should be initiated at a rate of 0.1 units/kg/h. Efforts also should be made to maintain potassium in normal range. Hourly reassessments are needed to maintain blood glucose below 200 mg/dL until DKA resolves. This patient responded avidly to therapy and rapidly stabilized with expected ranges of blood glucose, pH, and bicarbonate.

Magnetic resonance imaging (MRI) of the head revealed a sella turcica mass (0.82 x 0.59 inches) with bilateral cavernous sinus invasion and likely mass effect on the optic chiasm (Figure 2).

An acromegaly laboratory panel confirmed the disease; random GH level was 98.2 ng/ml (normal 0-6 ng/ml) and insulin-like growth factor-1 (IGF-1) was 398 ng/ml (normal 101-267 ng/ml). Additional pituitary hormonal testing was unremarkable. A fasting C-peptide was 1.1 ng/dl (1.1-5 ng/dl), indicating some degree of insulin secretory reserve. Glutamic acid decarboxylase (GAD65) antibodies were negative, ruling out autoimmunity-related diabetes.

The patient underwent trans-nasal, trans-sphenoidal resection of the pituitary mass without complications, and biopsy confirmed pituitary adenoma (Figure 3).
DIABETIC KETOACIDOSIS IN ACROMEGALY
continued.

Figure 3. Pituitary adenoma composed of uniform, monomorphic polygonal cells arrayed in cords, with evidence of modest mitotic activity (400X).

Discharged treatment included subcutaneous insulin and metformin. At two-week follow-up, his coarse facial features slightly improved (Figure 4). At two months, the IGF-1 remained elevated at 837 ng/ml (98-261), indicating residual tumor. The patient was scheduled for a second MRI of the sella and consultation for stereotactic radiation therapy. Unfortunately, the patient was lost to follow-up.

Figure 4. Improvement of coarse facial features two weeks post-surgery.

DISCUSSION

The DKA episode was the initial presentation of the acromegaly in this patient. It was likely due to a combination of severe insulin resistance from acromegaly and impaired insulin secretion (or relative insulin deficiency) from chronic undiagnosed hyperglycemia. Although there are a few reports of DKA as a complication of acromegaly, the association was not well established.

Diabetes mellitus is a common complication of GH excess and caused by hepatic and peripheral insulin resistance. At the hepatic level, GH increases gluconeogenesis and glycogenolysis. Peripherally, GH inhibits glycogen synthesis and glucose oxidation. Growth hormone excess also causes increased lipolysis and, as a consequence, an increase in free fatty acid, which may contribute to insulin resistance.

Diabetic ketoacidosis occurs in the presence of insulin deficiency and excess of counterregulatory hormones like GH. The diabetogenic effect of GH initially is compensated by hyperinsulinemia; if GH excess remains, fasting hyperglycemia may develop, often corresponding with a fall in fasting insulin levels. Finally, the insulin response to carbohydrate exposure is decreased, which could result in DKA.

Islet cells may undergo progressive changes when exposed to prolonged high levels of GH, which could result in cell degeneration, a reduction in insulin production, and finally DKA. However, this mechanism has been borne out only in animal studies. An autopsy from an acromegalic woman who became diabetic and required insulin showed larger and more abundant islets with hypergranular beta cells, suggesting the initial hyperglycemic state with normal insulin secretion.

Another plausible explanation was that acromegalic patients who develop DKA might have DM independent of their acromegaly. Two important risk factors for DM secondary to acromegaly are hypertension and a positive family history of DM. Both were present in our patient. In these patients, chronic glucose toxicity leads to insulin resistance and contributes to impairment of insulin secretion.

Our patient had characteristics of ketosis prone, antibody-negative diabetes mellitus according to the Aβ classification system, in which it was hypothesized that chronic hyperglycemia increases susceptibility of the beta cell to desensitization and alters post-insulin receptor signaling.

Endocrine remission occurs in 50% of GH-secreting macroadenomas after surgery. Remission was not seen in this patient, owing to the presence of an unresected tumor in his cavernous sinuses. During follow-up, the IGF-1 level remained elevated, reflecting the presence of residual tumor. In previous case reports of DKA in acromegalic patients, complete discontinuation of insulin therapy was possible after GH level normalization. In our patient, the clinical scenario indicated that insulin discontinuation would not be possible, presumably due to persistent GH-induced insulin resistance that could yield another DKA episode.

If the patient was not lost to follow-up, further treatment or cure of his acromegaly would have revealed the extent to which his hyperglycemia and DKA were the result of acromegaly.

LIMITATIONS

Our patient had the phenotype for Type 2 DM, with obesity, age greater than 30 years, and a positive family history. This may have led to an atypical presentation of Type 2 DM rather than acromegaly-related DKA.

CONCLUSIONS

Growth hormone excess in acromegaly antagonizes insulin action both at the hepatic level and peripherally, making DKA an unlikely complication. It might be caused by B-cell failure due to chronic hyperglycemia. DKA can be managed with positive results, as well as hyperglycemic state after DKA control, until remission of the secreting-GH pituitary adenoma. This case report suggested that DKA was a possible complication of acromegaly and that it should be recognized as one.

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