There are 47 states experiencing a “veterinarian shortage situation” according to the USDA National Institute of Food and Agriculture (NIFA). There are 3 types of shortages, with type II shortages being those that exist in private practices focused on rural area food animal medicine. Shortage areas are regions that lack sufficient veterinary resources to meet the needs of an area’s farm animal population, based on the recommendation of a review panel, which evaluates nominations from state animal health officials. Factors for consideration include the ratio of livestock (labeled cattle, hogs, sheep, and horses) to veterinarians, the demographics of the food animal veterinarians in each area, and the number of veterinarians in individual food animal practices. These shortage areas are designated as a component of the Veterinary Medicine Loan Repayment Program, which pays up to $25,000 each year toward qualified educational loans of eligible veterinarians who agree to serve in a designated shortage area for 3 years.  

Rural food animal veterinarians are needed to ensure the health and safety of the nation’s food supply. Veterinarians in rural areas are imperative to protecting against foreign animal diseases, and they possess the knowledge and skills to improve, protect, and sustain the agricultural economy of the United States Food animal veterinarians comprise only 5% of the veterinary profession. An increasing number of companion animals needing care and higher salaries in the small animal sector make food animal medicine less appealing than other areas of veterinary employment. Additionally, the physical demands of food animal work, quality of life concerns, lack of mentorship, and difficulty finding employment for spouses in rural areas contribute to the rural veterinary shortage.
Increasing the number of rural food animal practitioners in the workforce will require the effort of many, including animal owners, producers, government officials, and industry leaders. Colleges of veterinary medicine can help by making efforts to admit students with a high probability of returning to underserved areas and cultivating their interests while they are students. However, predictive factors have been speculated, rather than demonstrated, due to a lack of evidence-based models for determining the likelihood for practicing in a rural area upon graduation.

To predict factors contributing to an individual’s choice to practice in a rural, food animal setting, admissions and outcome data from the Auburn University College of Veterinary Medicine DVM Classes of 2019 to 2022 were evaluated using logistic regression and latent class analysis to develop 2 models for predicting an individual’s likelihood of entering rural food animal practice upon graduation from veterinary school. This project was done through the Auburn University Insight Lab as a component of the Bright Idea seed grant program, Auburn Achieve, to allow units to be more strategic in preparing students for post-Auburn careers.

**Methods**

First destination outcomes were examined for professional veterinary (DVM) students across the classes of 2019 to 2022. Four different data sources were evaluated including Banner (the University’s Enterprise Resource Planning system), the CVM senior debriefing survey, Veterinary Medical College Application Service (VMCAS) applications, and the AVMA senior survey. All data were merged and cleaned, resulting in a final file with data from 478 graduates. Data were utilized with approval from the Auburn University Institutional Research Board, under the direction of the Office of Research Compliance.

Data was categorized by 6 standard demographic variables: gender, race, Pell-eligibility, marital status at graduation, age at graduation, and state of permanent residence. Additionally, the data was sorted by employment type by species and employment sector. Data was further disaggregated by location within the USDA NIFA shortage areas, as determined by matching zip codes corresponding to the employment data from AVMA exit surveys with counties on the USDA Veterinary Services Shortage Situation Map. AVMA exit survey data examined community of origin and preferred community (rural, suburban, urban), along with salary data. Individual states of origin and amount of food animal veterinary experiences reported in VMCAS were also included in the analyses, along with parents’ highest education level.

Employment in the food animal sector versus the non–food animal sector was compared, and statistical models were created based on the most salient variables according to their ability to predict employment in a food animal setting. Low numbers of students who indicated enrolling in advanced training were removed. A logistic regression was conducted to assess the predictive power of a set of variables on a graduate’s choice of employment setting (food animal position versus non–food animal position). Logistic regression is an appropriate analysis for a categorical dependent variable having 2 levels. Due to a smaller sample size for graduates entering food animal positions within shortage areas, this group was not examined in the analyses. The analysis consisted of 303 graduates who reported any employment type. Employment types were assigned to 1 of 2 categories: food animal employment (n = 52 [mixed practice = 45; food animal exclusive = 3; food animal predominant = 2; federal/state/local government = 2]), and non–food animal (n = 251 [companion animal exclusive = 181; companion animal predominant = 55; uniformed services = 7; equine practice = 6; not-for-profit = 1; other = 1]). The sample was split randomly into a 70% group used for analysis and a 30% group used to validate the model.

To further understand relationships among the data, latent class analysis was used to explore profiles of DVM graduates (n = 303) based on gender, state of origin, community of origin, preferred community, and amount of previous food animal experience. Latent class analysis is a statistical method that uncovers hidden groupings in data. Individuals are classified into mutually exclusive groups based on their patterns in selected characteristics. Latent refers to a variable that is hidden, unseen, or not able to be measured directly with a goal of identifying separate classes of students based on their employment choice (food animal or non–food animal), so that predictions can be made about future students with similar characteristics. The above-mentioned variables were included with consideration of a graduate’s employment in a food animal position or a non–food animal position (ie, covariate).

**Results**

Graphical representations of all data sets are provided (Supplementary Material S1). Across all cohorts, DVM graduates are mostly female (81%), white (93%), non-Pell eligible (71%), and single (73%) at graduation. By age at graduation, 93% of graduates fall within a student age range of 24 to 29, with 7% of graduates between ages 30 and 41 at graduation.

**Permanent state**

By state, 67% of graduates list either Alabama or Kentucky as their permanent state at the time of graduation. This is consistent with admissions practices at Auburn University, where 41 members of each class are Alabama residents at the time of matriculation and 38 members of each class are from the Commonwealth of Kentucky, under contract through the Regional Contract Program managed by the Southern Regional Education Board.
Employment type by shortage type

Most students took employment outside of a USDA shortage area. Of those employed within a shortage area, most were in a type II shortage area (Private Practice—Rural Food Animal Medicine). Companion animal practice positions comprise most jobs, both outside of and within shortage areas, while food animal positions (including mixed practice) are the second largest practice type for type II, type III (public practice), and non-shortage areas.1

Gender

Of graduates who reported food animal positions (n = 52), 67% were female and 33% were male. Of those graduates who reported non–food animal positions (n = 251), 83% were female and 17% were male. A higher percentage of males reported non–food animal positions in shortage areas (48%) compared to the 21% of male students who reported non–food animal positions in shortage areas.

State of origin

Of graduates who reported food animal positions (n = 52), 50% were from Kentucky and 27% were from Alabama. Of those graduates who reported non–food animal positions (n = 251), 27% were from Kentucky and 37% were from Alabama. Of graduates who reported food animal positions and who were employed in a shortage area (n = 31), 55% were from Kentucky and 27% were from Alabama. Of those graduates who reported non–food animal positions within shortage areas (n = 108), 41% were from Kentucky and 48% were from Alabama.

Community of origin

Of graduates who reported food animal positions, 69% were from rural communities. Of graduates who reported non–food animal positions, 34% were from rural communities. Of graduates who reported food animal positions within shortage areas, 71% were from rural communities. Of graduates who reported non–food animal positions within shortage areas, 44% were from rural communities.

Preferred community

Of graduates who reported food animal positions, 79% preferred to work and live in rural communities. Of those graduates who reported non–food animal positions, 15% preferred to work and live in rural communities. Of graduates who reported food animal positions in shortage areas, 74% preferred to work and live in rural communities. Of those who reported non–food animal positions within shortage areas, 26% preferred to work and live in rural communities.

Community of origin and preferred community alignment

A total of 36 graduates who accepted food animal positions were from rural communities. Of these, 31 indicated that they preferred to live and work in a rural community and 5 indicated that they preferred to work and live in a suburban community.

Marital status at graduation

By marital status at graduation, approximately the same percentages of graduates were married in both food animal (33%) and non–food animal (32%) position types. A total of 9 graduates reported having an average of 1.3 children in the non–food animal position group, and not enough data was available to report an average for the food animal position group. Within shortage areas, 39% of graduates were married in the food animal position group and 32% of students were married in the non–food animal position group. A total of 5 students had an average of 1 child in the non–food animal position group and no students in the food animal group reported having children.

Parents' highest education level

Of graduates in food animal positions, 74% reported a highest parent/guardian education level of a 4-year college degree or higher. In the non–food animal position group, this was 80%. Within shortage areas, 73% of graduates entering food animal positions reported a parent/guardian education level of a 4-year college degree or higher. In the non–food animal group, this was 74%.

Previous food animal experience

Of graduates who reported food animal positions, 73% reported previous experience in a food animal setting with an average of 1.31 food animal experiences per graduate reported in VMCAS at the time of application to veterinary school. Of those who reported non–food animal positions, 49% reported previous experience in a food animal setting with an average of 0.75 experiences per graduate. Of graduates who reported food animal positions within shortage areas, 7% reported previous experience in a food animal setting with an average of 1.35 food animal experiences per graduate. Of graduates who reported non–food animal position within shortage areas, 56% reported previous experience in a food animal setting with an average of 0.85 food animal experiences per graduate.

Average salary

Students reporting non–food animal positions reported an average salary of $84,541, which is roughly $10,000 higher in salary than their peers who reported food animal positions with an average salary of $74,316. Within shortage areas, graduates reporting non–food animal positions reported an average salary of $81,393, which is roughly $8,000 higher in salary than their peers who reported food animal positions with an average salary of $74,200.

Logistic regression

The parameter estimates from the first model are presented (Table 1), which include a graduate’s self-reported community of origin and gender. The Nagelkerke $R^2$ indicated that 16% of the variance in position type (food animal versus non–food animal) was explained by a graduate’s community of origin and gender.3 When this model was applied to the
holdout sample of 82 graduates, it accurately predicted employment settings for 83% of cases, with male students from rural communities having the highest probability of reporting a food animal position. However, by subgroup, the model accurately predicted 92% of the graduates who reported non–food animal positions and only 11% of the graduates who reported food animal positions.

The parameter estimates from the second model are also shown (Table 1), which include a graduate’s preferred community type and gender. The Nagelkerke $R^2$ indicated that 39.5% of the variance in choice of employment setting was explained by a graduate’s preferred community and gender.

The parameter estimates from the first model include a graduate’s self-reported community of origin and gender. The Nagelkerke $R^2$ indicated that 16% of the variance in position type (food animal vs non–food animal) was explained by a graduate’s community of origin and gender. Community of origin was coded as 1 = urban, 2 = suburban, and 3 = rural. Gender was coded as 1 = female and 2 = male. The parameter estimates from the second model include a graduate’s preferred community type and gender. The Nagelkerke $R^2$ indicated that 39.5% of the variance in choice of employment setting was explained by a graduate’s preferred community and gender.

Other variables considered in this analysis were a graduate’s state of origin and amount of food animal veterinary experience the graduate reported in their VMCA application. Neither of the variables made significant contributions to the model. Even though community of origin has smaller predictive power than preferred community, this variable remains constant, whereas the student’s preferred community may change during their time in the program. When both community of origin and preferred community are included in the model, community of origin’s contribution is no longer significant.

**Table 1**—Parameter estimates included in logistical regression analysis.

<table>
<thead>
<tr>
<th>Model 1—Parameter Estimates</th>
<th>$B$</th>
<th>SE</th>
<th>z value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-5.8732</td>
<td>1.07</td>
<td>-5.489</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Community of origin</td>
<td>1.2324</td>
<td>.337</td>
<td>3.653</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Gender</td>
<td>1.1354</td>
<td>.396</td>
<td>2.870</td>
<td>&lt; .01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model 2—Parameter Estimates</th>
<th>$B$</th>
<th>SE</th>
<th>z value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-8.6727</td>
<td>1.26</td>
<td>-6.884</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Preferred community</td>
<td>2.4958</td>
<td>.400</td>
<td>6.237</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Gender</td>
<td>1.0272</td>
<td>.453</td>
<td>2.268</td>
<td>&lt; .05</td>
</tr>
</tbody>
</table>

The parameter estimates from the first model include a graduate’s self-reported community of origin and gender. The Nagelkerke $R^2$ indicated that 16% of the variance in position type (food animal vs non–food animal) was explained by a graduate’s community of origin and gender. Community of origin was coded as 1 = urban, 2 = suburban, and 3 = rural. Gender was coded as 1 = female and 2 = male. The parameter estimates from the second model include a graduate’s preferred community type and gender. The Nagelkerke $R^2$ indicated that 39.5% of the variance in choice of employment setting was explained by a graduate’s preferred community and gender.

Other variables considered in this analysis were a graduate’s state of origin and amount of food animal veterinary experience the graduate reported in their VMCA application. Neither of the variables made significant contributions to the model. Even though community of origin has smaller predictive power than preferred community, this variable remains constant, whereas the student’s preferred community may change during their time in the program. When both community of origin and preferred community are included in the model, community of origin’s contribution is no longer significant.

**Latent class analysis**

The most meaningful and best fitting model for the dataset involved 2 distinct student profiles. These profiles represented the following sample ratios: Class 1, 74.2% (graduates who reported non–food animal positions) and Class 2, 25.8% (graduates who reported food animal positions).

Detailed percentages about the characteristics of the 2 classes are presented (Table 2). Two variables that provide the most meaningful distinction between the 2 classes and the position type are community of origin and preferred community. Specifically, the graduates who accepted food animal positions were from rural communities and preferred

**Table 2**—Sample ratios derived from latent class analysis.

<table>
<thead>
<tr>
<th>Class (sample ratio)</th>
<th>Class 1 = Non–food animal (74.18%)</th>
<th>Class 2 = Food animal (25.82%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>84% Female*</td>
<td>71% Female</td>
</tr>
<tr>
<td></td>
<td>16% Male*</td>
<td>29% Male</td>
</tr>
<tr>
<td>VMCAS State</td>
<td>37% Alabama</td>
<td>32% Alabama</td>
</tr>
<tr>
<td></td>
<td>14% Kentucky</td>
<td>51% Kentucky</td>
</tr>
<tr>
<td></td>
<td>40% Other</td>
<td>1% Other</td>
</tr>
<tr>
<td>Community of origin</td>
<td>9% Urban*</td>
<td>0% Urban*</td>
</tr>
<tr>
<td></td>
<td>64% Suburban*</td>
<td>31% Suburban*</td>
</tr>
<tr>
<td></td>
<td>27% Rural*</td>
<td>79% Urban*</td>
</tr>
<tr>
<td>Preferred community</td>
<td>23% Urban*</td>
<td>0% Urban*</td>
</tr>
<tr>
<td></td>
<td>72% Suburban*</td>
<td>13% Suburban*</td>
</tr>
<tr>
<td></td>
<td>5% Rural*</td>
<td>87% Rural*</td>
</tr>
<tr>
<td>Prior food animal experience</td>
<td>55% No*</td>
<td>22% No*</td>
</tr>
<tr>
<td></td>
<td>45% Yes*</td>
<td>78% Yes*</td>
</tr>
</tbody>
</table>

The most meaningful and best fitting model for the dataset involved 2 distinct student profiles. These profiles represented the following sample ratios: Class 1, 74.2% (graduates who reported non–food animal positions) and Class 2, 25.8% (graduates who reported food animal positions).

*Detailed percentages regarding characteristics of the 2 classes represent notable differences for each characteristic (eg, Class 1 is mostly female, which is distinct from Class 2, which is slightly more male than female).
to live in rural communities. Conversely, graduates who accepted non-food animal positions were from suburban communities and preferred to live in suburban communities. Prior food animal veterinary experience shows that graduates who reported food animal positions more frequently had prior food animal experience than those who reported non-food animal positions. For those who reported non-food animal positions, approximately half reported prior food animal experience while the other half did not.

Graduates with the characteristics required for Class 1 membership (female, not from Kentucky, suburban community of origin, preferred suburban community, may or may not have food animal experience) have an approximately 85% probability of accepting a non-food animal position and an 18% probability of accepting a food animal position. Conversely, students who meet the requirements for Class 2 memberships (rural community of origin, prefers rural community, has previous food animal experience) have an 85% probability of accepting a food animal position and a 15% probability of accepting a non-food animal position.

Discussion

The cause of the rural veterinary shortage is complex, and the solution to this problem will be multifactorial and will require the sustained efforts of many across the profession.9-11 Colleges of veterinary medicine play a critical role in the selection of candidates for entry into their highly competitive programs and in sparking and cultivating an interest in food animal practice in both pre-veterinary and professional students. Through dynamic instruction, species-specific rounds, support of food animal specific organizations, and funding internship, externship, and preceptorship experiences in rural practices, colleges can encourage exploration of rural food animal practice as a career.

A graduate’s community of origin and preferred community are related to their selection of employment type. If this information were examined during the admissions process, in keeping with institutional goals, it could be used to identify applicants who have a strong likelihood of accepting food animal positions. County of birth is a component of the VMCAS application and could be cross-referenced with population demographic data and the USDA NIFA veterinary shortage area map to determine whether an applicant is from a rural, suburban, or urban background. Preferred community is reported on the AVMA’s graduating senior survey. If this question were incorporated into the questions asked through VMCAS during the admissions process, the information could be utilized to make informed admissions decisions, acknowledging that a graduate’s preferred community could change over time, particularly if it is associated with an employment opportunity.

While gender is not as strong as a predictor compared to community of origin or preferred community, male graduates have a higher probability of entering a food animal practice than female graduates. This fact substantiates the arguments of those who link the shortage of food animal practitioners to the fact that the percentage of women in veterinary medicine has increased 12% in the last decade, with women comprising approximately 63% of the active veterinary workforce.12 At present, “sex” is a category of biographic information collected through VMCAS during the application process, although there has been some impetus to remove collection of such data from the process to prevent gender bias in admissions decisions.13 Perhaps knowledge that gender has the potential to impact the profession broadly by shifting the number of graduates entering different employment sectors is an argument to gather this information during the application process for those institutions who wish to utilize it in strategic admissions decisions.

While approximately half of the graduates who accepted non-food animal positions reported previous food animal experience, 73% of those who accepted food animal positions reported previous food animal experience on their VMCAS applications. Thus, if a student reports a food animal position, he or she likely had food animal experience before veterinary school. It is probable that those applicants who grew up in a rural environment surrounded by food animals are more likely to have had these experiences, making it difficult to determine if the rural environment as a predictor can be evaluated separately from prior food animal experience.

More data, particularly from graduates who accepted a food animal predominant or exclusive position would enable a more accurate analysis. Including mixed animal practices with the food animal predominant and food animal exclusive groups created a larger sample size for the targeted group of graduates accepting food animal employment and may have skewed the results. Inclusion of data from more years and more veterinary colleges would make the data more robust.

Based on analysis of the examined data from 1 large College of Veterinary Medicine in the United States, a graduate’s community of origin and preferred community, and to a lesser degree gender, are related to their selection of rural, food animal versus other employment type. Examination of these factors during the admissions process may assist veterinary colleges in making strategic admissions decisions with strong impacts on the food animal sector of veterinary practice.

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References


Supplementary Materials

Supplementary materials are posted online at the journal website: avmajournals.avma.org