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The Influence of Veterinary Schools on the Veterinary Labor Market

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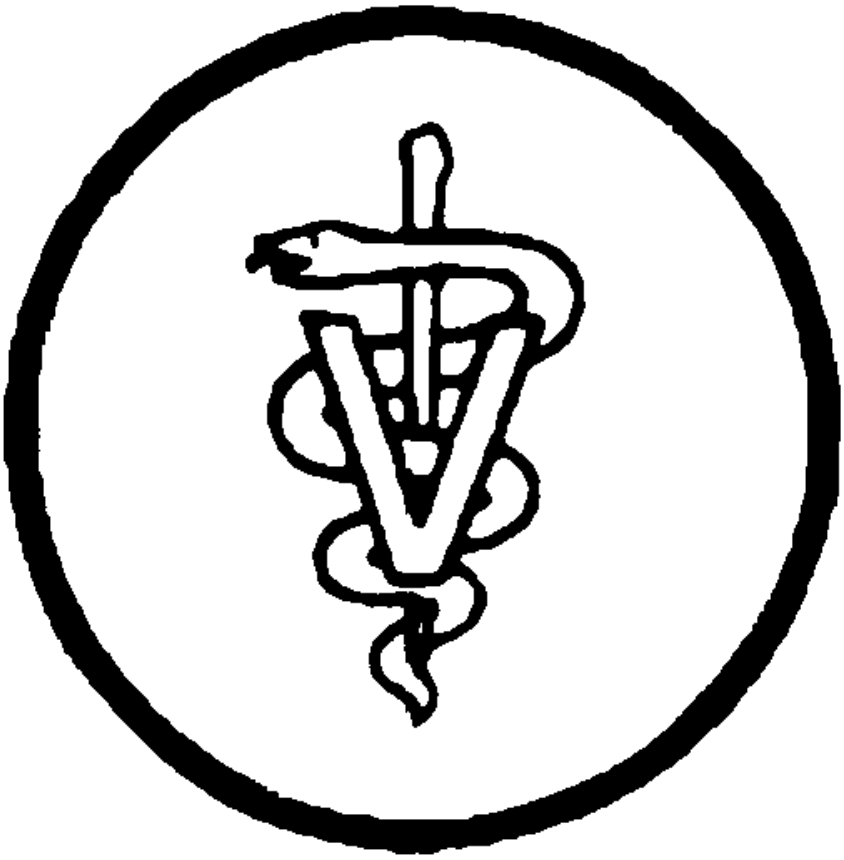

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Executive Summary

Problem Statement:
Does the presence of a veterinary school in a state influence the supply of veterinarians practicing in that state? Citizens and animals in states without a veterinary school are at a disadvantage if the presence of a veterinary school significantly improves public health and access to medical services in those states that have a veterinary school.

Research Strategy:
The unit of analysis in this study is 50 states and the District of Columbia. The study is designed as a cross-sectional analysis of 2006 pet, 2002 livestock, 2006 human, labor, and economic data. The study uses simultaneous equations to measure supply and demand functions. Supply and demand functions were estimated using the two stage least squares model to see if a relationship exists between the presence of a veterinary school and the number of practicing veterinarians. This study examines the ratios pets and livestock to veterinarians to see if variation exists between states with and without veterinary schools to determine which states are at a higher risk for public health and bioterrorism related issues.

Major Findings:
When assessing the supply function, the presence of a veterinary school significantly influences the number of veterinarians in a state. Veterinary salary was significant in determining the number of veterinarians in a state. This suggests if a state wants more veterinarians they should either increase salaries or open a new veterinary school. While specific shortages and oversupplies are not known across states, we do know one of two things is occurring: Either states without veterinary schools are undersupplied with veterinarians or states with veterinary schools are oversupplied with veterinarians. When assessing the demand function, pets are highly significant in determining the number of veterinarians as well as per capita income and veterinary salary. As the number of pets and per capita income increase the demand for vets increases, and as veterinary salary increases the demand for vets decreases. Great variation exists in terms of the ratios of pet and livestock to veterinarian among states. Differences in the ratios among states are not related to the presence of a veterinary school in a state. However, states with higher animal to vet ratios are at a greater risk for public health and bioterrorism related issues.

Recommendations:
Direct federal funding, if available, to states with the highest animal to veterinarian ratios as they are at the greatest risk for public health and bioterrorism issues. Further assess specialization areas such as food supply veterinary medicine, as shortages or oversupply cannot be ruled out in specific areas. Alternate methods of providing veterinary education are recommended for states wanting to expand veterinary services including building a vet school, adding contract seats, or forming partnerships with other states. Further research is necessary over a longer period of time for a better understanding of the relationship between veterinary schools and the supply of veterinarians. Additional research is needed to determine whether a shortage, oversupply, a distribution problem, or none of the above exists.

Problem Statement

Is veterinary medicine at a crossroads in America? Veterinary medicine is an integral part of the U.S. economy, food supply, and public health. When most people think of a veterinarian they think of the person who takes care of the family dog, cat, or horse, but in reality veterinarians do much more. Veterinarians work in many areas including private practice, government, wildlife programs, zoos, academia, military, and private industry. However, the majority serve in private practice (Prince et al. 2006). Veterinarians play a vital role in preserving our country's public health by protecting people from diseases spread from animals to humans, known as zoonotic diseases. Examples of zoonotic diseases include E-Coli, Listeria, Tuberculosis, West Nile Virus, Rabies, Salmonella, Ebola, Monkeypox, and Lyme disease. Veterinarians are unique as they are the only profession trained in comparative medicine across species, creating a link between animals, humans, bioterrorism, food safety, and security (AAVMC 2006).

With this background it is easy to understand the importance of supplying an adequate labor force to address public health related concerns regarding zoonotic diseases and basic medical care in companion and livestock animals. Since veterinary schools are the primary method for entry into a career in veterinary medicine, it is prudent to assess the current method of entry into the veterinary labor market**.** Are current federal and state government policies related to public health and veterinary education adequate for the demands individuals and animals place on them?

Senate Bill 746 was passed in the United States Senate by a vote of 95-0 in July of 2007. It is known as the Veterinary Public Health Workforce Expansion Act introduced by Senator Wayne Allard (R-CO) and Congresswoman Tammy Baldwin (D-WI-2). After passage in the

Senate the bill was attached to HR 1642, the Higher Education Reauthorization Bill, and at this time is still waiting passage in the House of Representatives. Some of the reasons listed as background and facts for passage of the bill are listed below (AAVMC 2008).

1. Increase the veterinary workforce to meet a growing population of humans and animals, meet bioterrorism risks, and growing public health issues.
2. The existing veterinary colleges lack the capacity to produce more food supply and public health veterinarians.
3. Only 27 states bear the cost not covered by tuition of producing the veterinarians who protect the entire nation's food supply and public health.
4. The CDC estimates that 80% of potential bioterror agents are infectious diseases that spread to humans from animals.
5. Homeland Security Presidential Directive-9 calls for the establishment of a competitive grants program designed to produce more veterinarians working in public health and enhance our capacity for research on zoonotic diseases (HSPD-9, 2004).

The primary question for this research study is to determine whether the presence of a veterinary school in a state influences the supply of veterinarians practicing in that state. Veterinary schools are the method in which governments use policy to influence supply. States can support veterinary education by building and operating a school of veterinary medicine, subsidizing out of state tuition at existing veterinary schools in the form of a contract, or they can do nothing. Each has significant policy implications for residents of each state and those who seek admission into the schools. Citizens in states without a vet school are at a disadvantage if the presence of a vet school significantly improves public health and access to medical services in those states that have a vet school.

Secondly, the study will examine the influences of pet, livestock, and human populations and per capita income on the demand for veterinarians in a state. The results of the analysis will be used as a baseline for future research in federal and state policy on the direction of veterinary education and veterinary care. Future questions include: (1) Should the federal government invest in states that do not have veterinary schools or increase capacity at existing veterinary schools? (2) Should states allocate resources to expand contract spaces at existing schools, support a new veterinary facility at an existing university within its borders, or should they make no changes?

Background and Literature Review

There are 28 schools of veterinary medicine located in 27 states. California and Alabama have two schools of veterinary medicine. Maryland and Virginia share one school of veterinary medicine (AAVMC 2007). On average, 2,600 veterinary students graduate each year from all United States veterinary schools combined (AAVMC 2007). Veterinarians must attend professional medical school in a manner similar to human medical doctors. While in veterinary school, students learn about multiple animal species. A Doctorate of Veterinary Medicine (DVM) generally takes four to five years to complete depending on the program and student initiative. Total expenses can vary across schools, and vary depending on resident status and whether the institution is public versus private. Total expenses are defined in different ways by different institutions, but generally include tuition, fees, room and board, books and equipment, personal expenses, transportation, health insurance, and other expenses. The first year total expenses for in-state students for the Class of 2009 ranged from $20,588 at North Carolina State University to $53,475 at Western University of Health Sciences in California. Non-resident total expenses ranged from $27,124 at Tuskegee University in Alabama to $60,015 at Ohio State

University. The national average for veterinary school expenses per year is $29,759 for resident students and $45,508 for non-resident students (AAVMC 2007). See Appendix 1 for expenses at various veterinary schools.

Veterinary medical school is preceded by four years of pre-veterinary work in an undergraduate program and internships at vet clinics. After graduating from veterinary school, students are eligible to apply for a veterinary license, which is required to practice. Licensing requirements vary by state. After graduating from veterinary school, students generally complete two years of residency or internships at a vet clinic, animal hospital, or research institution. Veterinarians can apply to become board certified in an area of their choosing. Certifications exist in twenty different specialty areas including anesthesiology, animal behavior, clinical pharmacology, dentistry, dermatology, emergency and critical care, internal medicine, laboratory animal medicine, microbiology, nutrition, ophthalmology, pathology, poultry medicine, private practice, preventive medicine, radiology, surgery, reproduction, toxicology, and zoological medicine.

Currently only 27 states maintain veterinary schools, while 18 states have no veterinary school but do have a contract for a limited number of seats in another state for students to attend at in-state tuition rates. See Appendix 2 for a list of universities that offer contract seats to out of state residents. At this time 5 states including Alaska, Nebraska, Connecticut, Vermont, Rhode Island, and the District of Columbia do not have a veterinary school and do not have contracts in place for students to attend out-of-state veterinary schools at in-state tuition rates (AAVMC 2007). Approximately 10,000 potential veterinarians are in training in schools across the country in any given year (Swope 2001).

Acceptance rates to veterinary schools are generally low, with substantial preference given to students with residency in the school's state location. In-state residents applying for admission had an acceptance rate of 33.5% across all schools. Overall, the acceptance rate for all schools regardless of residency in 2005/2006 was 12.0%. The acceptance rate for non-residents and contact applicants was 4.6% and 17.3% respectively (AAVMC 2007).

There are differences in the distribution of entrants among resident, non-resident, and contract students. Some states included contract entrants as either residents or non-resident entrants in their report to AAVMC. Therefore, looking only at the 12 schools that reported to the AAVMC having contract entrants into veterinary school, approximately 17% of entrants were from contract states, 60% were residents, and 23% were non-residents. See Appendix 3 for more information on veterinary school admissions.

Malcolm Getz conducted a major study in 1997 called "Veterinary Medicine in Economic Transition." Getz looked at factors influencing the probability of entering a school of veterinary medicine across states. Factors examined included states with and without veterinary schools, the number of veterinarians in each state, per capita income, and research funds awarded to the school. Getz concluded that, having a veterinary school increased the probability of a high school graduate entering veterinary school. In contrast, as the number of veterinarian's increased and per capita income increased the probability of a high school graduate entering veterinary school decreased.

Policy makers clearly show preferential treatment to in-state residents for veterinary school admission. In order to receive the political support needed to access the state resources to finance and operate a veterinary school, preference to residents is generally considered favorable

to constituents and legislators. Policy makers believe veterinary schools bring value to a state and they desire to keep the majority of these benefits within the state's borders (Getz 1997).

Supply and demand are the fundamental structure of any labor market. In economics the supply curve can be defined as the quantity of a good or service firms are willing and able to supply at a given price. Demand curves show the quantity of a good or service potential buyers are willing and able to purchase at given price (Gruber 2005).

What factors influence supply in the veterinary labor market? The single largest factor determining the number of veterinarians is the number of graduates from veterinary schools (Getz 1997). Rarely does a person enter the U.S. labor market for veterinarians from abroad (Getz 1997). The supply of veterinarians can be described as persons who are trained and licensed for practice. The veterinary labor market can change in several ways: (1) entry of new graduates into the field; (2) retirement or death of existing veterinarians; (3) exit from the market because the costs are too great relative to the benefits to continue in practice; people exiting the market is rare in the field of veterinary medicine because of the high psychological returns often associated with careers in veterinary medicine and the limited alternative career opportunities for people with a DVM (Getz 1997).

The quantity of animals is the single largest factor in determining the demand for veterinary services (Getz 1997). People use veterinarians to service the healthcare needs of companion animals and livestock. Humane Societies use veterinarians for intakes of stray animals to provide basic care, vaccinations, and reproductive control services. Veterinarians play an integral role in monitoring the food supply on dairy, beef, hog, sheep, and poultry farms.

The demand for veterinary services varies by animal species. Age is also a significant factor in determining when medical services are needed most. Older animals generally require

more medical care then younger animals. With livestock owners, profit is a significant factor in the amount of veterinary services demanded. If the cost of providing care for a cow is greater than the value of the cow in the market farmers may choose to dispose of the animal themselves rather then seek medical attention.

In studying the veterinary labor market it is important to understand the emotional differences for most humans between their considerations of companion and livestock animals. Animal owners vary in the depth of attachment they have to a pet, but many consider pets to be family members. In the 2007 American Veterinary Medical Association (AVMA) survey of pet ownership and demographics, 53.5% of respondents reported that they considered their dog a family member, while 45.1% considered them a companion/pet. Cats scored similar high marks with 49.2% of owners reporting they considered their cat a family member, and 49.4% considered their cat a companion/pet (AVMA 2007).

Getz (1997) looked at veterinarians in private practice across states. The independent variables included the number of livestock for cows, sheep, hogs, turkeys, chickens, and horses in each state, the number of pets, such as dogs and cats, per capita income of state residents, and whether the state had a veterinary school. Getz examined differences in the number of veterinarians in the states for each of these independent variables. Sheep, turkeys, chickens, and non-dairy cattle were not statistically significant in predicting demand which means they were relatively unimportant in determining the aggregate demand for veterinarians. Income was statistically significant which suggests higher income households are able and willing to purchase more in veterinary services than lower income households. The numbers of dogs, cats, horses, dairy cattle, and hogs significantly influenced the number of veterinarians in a state. According to Getz, “A state with a veterinary school has no more veterinarians than a state

without a veterinary school, given the count of animals and income. The investments the 27 states with veterinary schools make in the schools appear to have no statistically significant effect on the number of veterinarians in private practice in the states" (Getz 1997). Getz believes this can be attributed to a high degree of mobility across state lines among new graduates.

Veterinary schools are not immune to the politics of federal and state governments as the majority of veterinary schools are public institutions and the private institutions still face government regulation. Public funds are used to support the development of new veterinary schools and contract seats at existing schools. Operating costs are allocated in the university budget, as provided by the state legislature, if it is a public institution.

In the past, agriculture interests have been the strongest supporters of veterinary schools and veterinary education. Agriculture interests lobby for veterinary schools because farmers with livestock benefit from having veterinarians in the area, and rural people historically have been the ones to attend veterinary school. Farmers desire relatively close access to medical facilities where treatment can occur for significant medical problems of their livestock. Finally zoonotic diseases generally affect livestock crops before they would endanger companion animals so having a veterinary school nearby is a benefit for control of disease outbreaks.

It should be noted that this study is focusing on factors related to the veterinary labor market as a whole, so research on the factors influencing supply and demand of food supply veterinary medicine are included in the literature review since it is part of the overall veterinary labor market. Limited research is available on the economics of the veterinary labor market. However, a study titled "Academic Food-Supply Veterinarians: Future Demand & Likely Shortages" indicates several factors affecting the decreasing supply of food supply veterinarians (Prince et al. 2006). Some of these variables included less emphasis on food animal practice in

veterinary colleges, selection processes that favor non-food supply veterinary medicine students, little exposure in undergraduate programs to food animals, and a perceived lack of demand for food supply veterinary medicine skills.

Prince et al (2006) indicates that limited positive role-models exist in food supply veterinary medicine because few veteran veterinarians are practicing with food animals. In general few spousal career options exist in rural areas where most food supply veterinary medicine positions are located since animal farms are mostly in rural areas. The study indicates more women are entering the field of veterinary medicine and suggested this was a reason for the decrease in supply of food animal veterinarians. Women are less likely to choose food animal veterinary medicine as compared to men (Elmore 2003). In addition Prince et al (2006) cites indebtedness as a factor influencing the supply of food animal veterinarians.

Vet school is a costly endeavor, with 67% of the veterinarians graduating with $80,000 plus in student loan debt in 2006 (AAVMC 2007). See Appendix 4 for more information on distribution of indebtedness for 2006 veterinary student graduates. Indebtedness matters if high costs prevent entry into the field causing those with fewer resources to forgo entry to the field. Indebtedness becomes an even bigger factor when the mean annual wages for similar medical type professions are compared. The DVM degree is consistently the lowest paid medical profession of all healthcare and public health providers even though the time, energy, and costs are similar to those in other medical professions. Continued interest in the veterinary field in spite of high costs and minimum return in comparison with other professions could suggest other factors besides the economic reward influence why individuals pursue a career in veterinary medicine. If people are happy working in a career they are much more likely to retain that

position even if costs become greater than costs in similar fields of study (JAVMA 2006). See Appendix 5 for more information on mean annual wages for medical positions.

Methods

The unit of analysis in this study is 50 states and the District of Columbia. The study is designed as a cross-sectional analysis of 2006 data to see if a relationship exists between the presence of a veterinary school and the number of practicing veterinarians. The study differs from Getz (1997) as it uses more recent data. The study uses simultaneous equations to measure supply and demand functions, whereas Getz uses multiple linear regression. Getz's study looked at the influence of individual animal species on the supply of veterinarians whereas this study looked at total livestock and total pet population as two distinct variables rather then by species.

Data used in this study comes from multiple public documents. Estimates for 2006 human population data were obtained from the U.S. Census Bureau website. The U.S. Bureau of Labor Statistics was used to obtain information on the number of veterinarians by state and the mean salary of veterinarians by state in 2006. Veterinary school information was obtained from the Association of American Veterinary Medical Colleges (AAVMC) 2007 edition of the *Veterinary Medical School Admission Requirements Handbook*. Livestock data was found on the U.S. Department of Agriculture (USDA) website. The 2002 census of agriculture was used to collect total livestock data and is defined as cattle, horses, pigs, poultry, and sheep. Agriculture census data was not available for 2006 as the census is only taken every five years with the 2007 results to be released by the end of 2008. Pet population estimates are defined as dog and cat populations. Data on pets came from the *U.S. Pet Ownership & Demographics Sourcebook* published by the American Veterinary Medical Association. The sourcebook is a compilation of data from an annual survey done by the AVMA. A questionnaire was mailed to

80,000 U.S. households selected to be representative of U.S. Census data for family versus non-family households and by state. The AVMA response rate for the survey was approximately 60%. Per Capita income was obtained from the U.S. Department of Commerce Bureau of Economic Analysis for 2006.

Data from all 50 states and the District of Columbia was used in the analysis. It should be noted that missing data is present in the study for Alaska and Hawaii. Alaska and Hawaii are missing pet population data because they were not included in the AVMA survey used for this study. This leaves 48 states and the District of Columbia in the analysis.

To estimate supply and demand for veterinarians a simultaneous equation system was used. This is usually done by estimating them in a two stage least squares equation, which is an application of instrumental variables. Instrumental variables influence supply or demand but not both. Simultaneous equations are used when two or more jointly determined variables affect each other simultaneously. In this case price and quantity for veterinarians are simultaneously determined by the equilibrium point for supply and demand. We know wages drive the quantity of veterinarians but the quantity of veterinarians also drives wages. By estimating a simultaneous equation we are able to isolate the supply and demand curves respectively using exogenous variables, some of which influence directly the price and the quantity in the supply or demand functions but not both (Gujarati 1995).

Supply and demand functions were estimated using the IVREG procedure in STATA, which is equivalent to the two stage least squares model. The supply function variables used to predict the endogenous variables are states with veterinary schools, states with a contract but no vet school within the state, and states that have no contract and no vet school. The endogenous variables are price and quantity; in this study these are the number of veterinarians and vet

salary. The demand function endogenous variables are also price and quantity or the number of vets and vet salary. The exogenous variables used to predict the demand are total pet population, human population, livestock population, and per capita income.

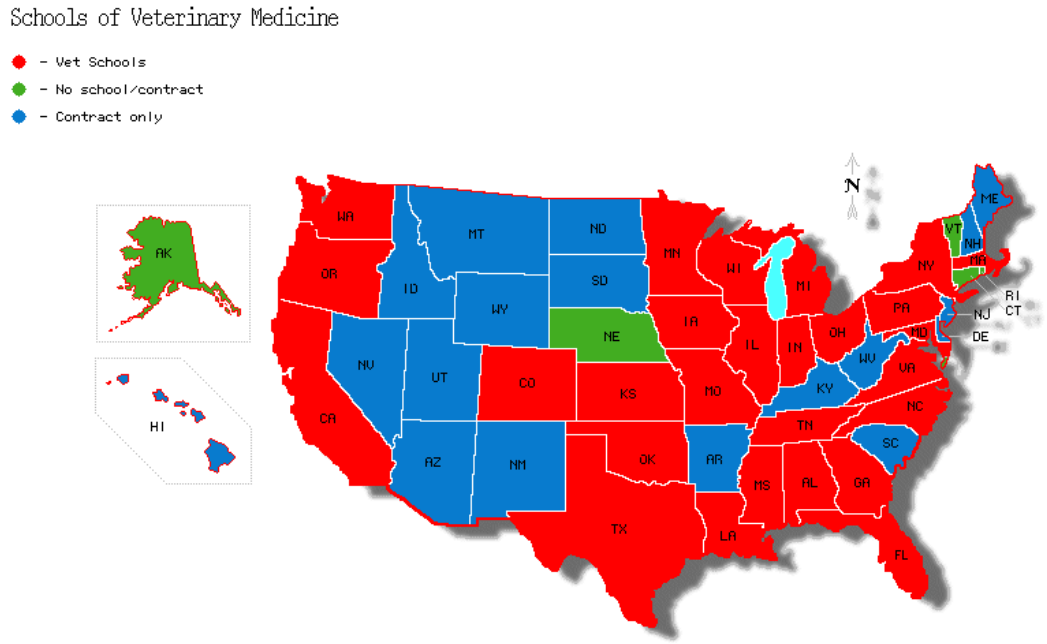
Results

States are represented in one of three categories: (1) no vet school or contract present, (2) no vet school, but have a contract for seats in a vet school located in another state, and (3) vet school located within the state. The states in each category can be seen in Figure 1. Figure 2 illustrates the ratio of livestock to human population across the United States. Among states ranked within the lowest third, the ratio of livestock to humans ranged from 0.03 in Alaska to 1.90 in the state of Florida. States ranking in the middle third had ratios ranging from 1.93 in Washington to 8.62 in Minnesota. Among states ranking in the top one third, the ratio of livestock to humans ranged from 9.01 in West Virginia to 75.34 in Arkansas. This means more than seventy-five livestock exist in the state of Arkansas for every one person in the state. It is interesting to illustrate the similarities and differences between Figures 1 and 2. Among the 16 states with the largest ratio of livestock to humans, seven do not have a school of veterinary medicine. They include West Virginia, South Carolina, South Dakota, Kentucky, Delaware, Arkansas, and Nebraska.

Figure 3 illustrates the ratio of pet to human population by state. Among states ranked within the lowest third, the ratio of pets to humans ranges from 0.16 in Washington D.C. to 0.500 in Rhode Island. States ranking in the middle third had ratios from 0.501 in Florida to 0.618 in the state of Washington. Among states ranking in the top third, the ratio of pets to humans ranged from 0.625 in Nebraska to 0.892 in the state of Montana. There is almost one pet for every person in Montana. It is interesting to note that of the 16 states with the highest pet to

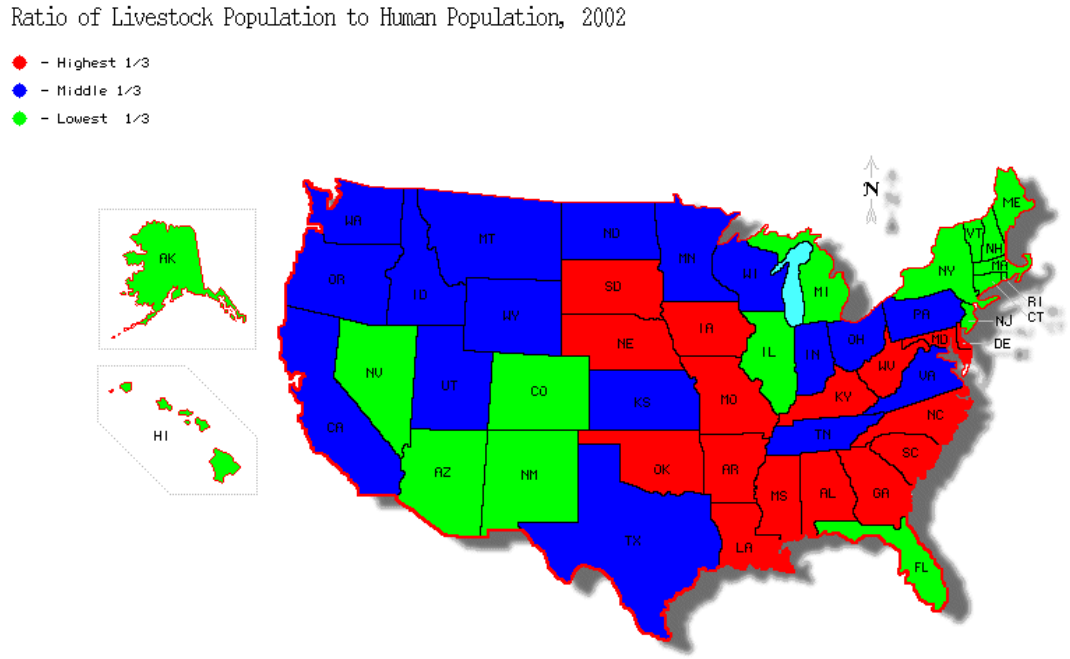
human ratio, 10 do not support a school of veterinary medicine. Those ten states are spread fairly evenly throughout the country and include Nebraska, Kentucky, Idaho, Maine, West Virginia, Vermont, New Mexico, Arkansas, Wyoming, and Montana.

Figure 1.



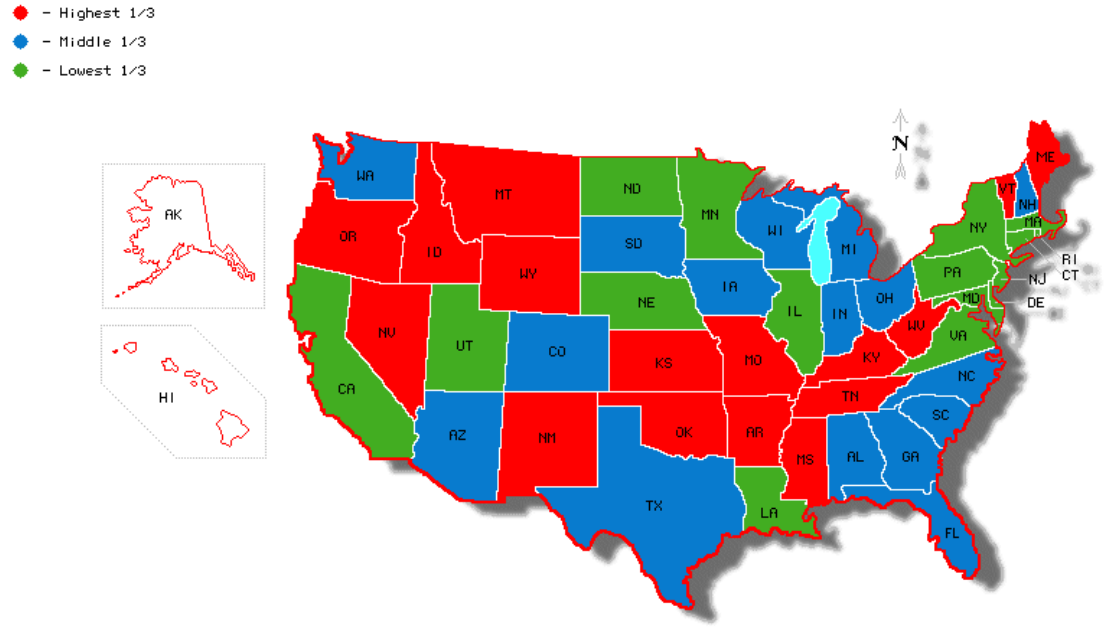
Source: AAVMC

Figure 2.



Source: U.S. Department of Agriculture and U.S. Census Bureau

Figure 3



Source: AVMA and U.S. Census Bureau

Table 1 includes descriptive statistics for the number of veterinarians, human population, total pet population, total livestock population and veterinary wages by veterinary school category. On average, the human and pet populations and the number of veterinarians were greatest in states with schools of veterinary medicine and smallest in states with no vet school and no contract. On average livestock population is also greatest in states with schools of veterinary medicine.

The overall model examining the factors influencing the supply of veterinarians was significant ($p<0.001$). The adjusted R squared for this model was 0.39. As compared to the states with vet schools, states that had no contract with other states and no vet school present in the state had significantly fewer veterinarians working within the state controlling for differences in human and animal population sizes ($p<0.001$). States that had a contract established with another state for student placement in veterinary degrees programs, but had no vet school within the state, had more vets than the no contract and no vet school states. However these states still had significantly fewer veterinarians than states with a vet school. ($p<0.001$) As the salary of veterinarians increased, the number of veterinarians increased significantly ($p<0.001$). See Table 2.

Table 1. Descriptive Statistics of Population and Wage Data by Veterinary School Category

Veterinary School in State	Variable	N	Mean	Std Dev	Minimum	Maximum
No Vet School, No Contract	Number of Veterinarians, 2006	6	266.67	199.77	60.00	540.00
	Human Population per million, 2006	6	1.37	1.13	0.59	3.50
	Total Dog and Cat Population per million, 2006	5	0.74	0.55	0.09	1.49
	Total Livestock Population per million, 2002	6	3.74	8.78	0.00	21.66
	Veterinary Wage, 2006	6	87,668.33	20,684.10	63,090.00	113,390.00
No Vet School, Contract	Number of Veterinarians, 2006	18	410.56	329.11	100.00	1,350.00
	Human Population per million, 2006	18	2.45	2.16	0.51	8.67
	Total Dog and Cat Population per million, 2006	17	1.40	0.97	0.30	3.27
	Total Livestock Population per million, 2002	18	22.71	50.24	0.34	211.63
	Veterinary Wage, 2006	18	74,863.33	14,730.65	54,750.00	108,330.00
Vet School	Number of Veterinarians, 2006	27	1,510.74	884.28	380.00	4,100.00
	Human Population per million, 2006	27	9.13	7.54	2.76	36.25
	Total Dog and Cat Population per million, 2006	27	4.66	3.40	1.66	15.77
	Total Livestock Population per million, 2002	27	60.14	61.05	0.48	233.79
	Veterinary Wage, 2006	27	78,078.89	9,892.70	60,090.00	100,590.00

Table 2 Supply Function Predicting the Number of Veterinarians

Variables	Coefficient	Standard Error	p Value	95% Confidence Interval	
Vet Salary, 2006	0.04	0.01	<0.001	0.02	0.06
No Vet School /No Contract	-1619.34	349.83	<0.001	-2323.94	-914.74
Contract / No Vet School	-942.55	216.11	<0.001	-1377.82	-507.28

Note: Per Capita Income, Human Population per million, Pet Population per million, Livestock Population per million were used to shift demand in order to get more accurate estimate of the supply curve.

The overall model examining the factors influencing the demand for veterinarians was significant ($p<0.001$). The adjusted R squared for this model was 0.74. The demand function showed the following trends, but none of the variables listed in Table 3 were significant at the 0.05 level. As the veterinarian salary increased the demand for veterinarians decreased, but was statistically insignificant. ($p=0.108$). As human population increased the demand for veterinarians increased, but was statistically insignificant ($p=0.276$). Total pet population had a greater effect on the demand for veterinarians compared to human and livestock populations. As the number of pets increased, the demand for veterinarians trended upward ($p=0.194$). As livestock population increased the demand for veterinarians increased, but was statistically insignificant ($p=0.478$). Finally as per capita income increased the demand for veterinarians trended upward ($p = 0.079$). See Table 3.

Table 3. Demand Function Predicting the Number of Veterinarians

Variables	Coefficient	Standard Error	p Value	95% Confidence Interval	
Vet Salary, 2006	-0.05	0.03	0.108	-0.12	0.01
Human Population (per million), 2006	73.10	66.20	0.276	-56.65	202.86
Total Pet Population (per million), 2006	174.45	132.17	0.194	-84.60	433.50
Total Livestock (per million), 2002	1.19	1.66	0.478	-2.06	4.44
Per Capita Income, 2006	0.10	0.05	0.079	-0.01	0.20

Note: No Vet School No Contract and Contract No Vet School were used to shift supply in order to get a more accurate estimate of the demand curve.

It appears that nothing affects demand, but that is not true. The presence of multicollinearity was detected among the human population, total pet population, and total livestock population; a joint test of all three effects is highly statistically significant ($p<0.001$). There is a strong correlation between human and pet population ($r=0.976$). Weaker correlations existed between human and livestock populations ($r=0.246$) and pet and livestock populations ($r=0.311$). The sizes of human and pet population matter. Assuming that the relevant population is pet population, and to address the issues of multicollinearity, a revised regression is estimated removing the human population variable. Pet population was chosen to remain in the model over human population because it had the largest effect on the number of veterinarians.

The overall revised model examining the factors influencing the demand for veterinarians was significant ($p<0.001$). The adjusted R squared for this model was 0.72. This high R square is another confirmation that collinearity is the difficulty in the original specification. After making this change pet population was significant in determining the number of veterinarians in a state. See table 4. In this model, as pet population increased, there was a significant increase in

the number of veterinarians (p<0.001). As per capita income increased the demand for veterinarians increased (p=0.060). A larger sample over more years, perhaps just two years, would find statistical significance if the effect sizes here stay the same. As the veterinarian salary increased the demand for veterinarians decreased (p=0.099). Changes in the livestock population did not have a significant effect on the demand for veterinarians (p=0.621)

Table 4. Revised Demand Function Predicting the Number of Veterinarians

Variables	Coefficient	Standard Error	p Value	95% Confidence Interval	
Vet Salary, 2006	-0.05	0.03	0.099	-0.11	0.01
Total Pet Population (per million), 2006	324.75	37.77	<0.001	248.80	400.70
Total Livestock Population (per million), 2006	0.71	1.43	0.621	-2.18	3.60
Per Capita Income, 2006	0.09	0.05	0.060	-0.01	0.19

Note: No Vet School No Contract and Contract No Vet School were used to shift supply in order to get a more accurate estimate of the demand curve.

Table 5 illustrates the ratio of pets per vet. There was not a significant difference in the ratio of pets per vet among states with vet schools and without. In addition the ratio of pets per vet was highly variable between states suggesting other factors are influencing the pet to vet ratio. Table 5 examines the ratio of pets per veterinarian by state. The ratio of pets per vet was highly variable among the states and ranged from 1557.7 – 6676.2. No correlation was present between the number of pets per veterinarian and the number of veterinarians in a state (r = -0.0403). There were no significant differences in the ratio of pets per vet among states with vet schools, contracts, and no contracts no vet school. From an estimation standpoint, the independence of the pet to vet ratio from vet school status makes endogeneity of pet ownership unlikely, which is good for statistical analysis. From a policy viewpoint, the conclusion is more puzzling. This one measure suggests there is not an oversupply of veterinarians in states with vet

schools. The great variability in the ratios suggests states must examine their veterinary capacity policies individually.

Table 6 illustrates the ratio of livestock per vet. This measure was also highly variable among the states and ranged from 166.5 – 503,876.2 livestock per vet. The District of Columbia did not have any livestock reported. Five of the top ten states in terms of livestock to vet ratio did not have a veterinary school. Again, endogeneity of the ratio to vet school status is unlikely.

Table 5. Ranking of Ratio of Pets Per Vet by State

Rank	State	Total Pet Population	Vet School	Pets Per Vet
1	West Virginia	1,402,000	Contract	6,676.2
2	Arkansas	2,289,000	Contract	5,450.0
3	Mississippi	1,863,000	Vet School	4,902.6
4	Oklahoma	2,792,000	Vet School	4,362.5
5	Tennessee	4,016,000	Vet School	4,098.0
6	Alabama	2,700,000	Vet School	4,090.9
7	Kentucky	2,757,000	Contract	4,054.4
8	Utah	999,000	Contract	3,996.0
9	New Mexico	1,571,000	Contract	3,927.5
10	Ohio	6,332,000	Vet School	3,908.6
11	California	15,765,000	Vet School	3,845.1
12	South Carolina	2,411,000	Contract	3,827.0
13	Texas	13,409,000	Vet School	3,683.8
14	Montana	845,000	Contract	3,673.9
15	Nevada	1,195,000	Contract	3,414.3
16	Georgia	5,062,000	Vet School	3,374.7
17	Kansas	2,126,000	Vet School	3,321.9
18	Rhode Island	531,000	Neither	3,318.8
19	Washington	3,940,000	Vet School	3,310.9
20	Wyoming	421,000	Contract	3,238.5
21	Indiana	3,412,000	Vet School	3,218.9
22	New York	7,393,000	Vet School	3,214.3
23	Louisiana	1,879,000	Vet School	3,184.7
24	Florida	9,056,000	Vet School	3,177.5
25	Arizona	3,268,000	Contract	3,112.4
26	North Dakota	302,000	Contract	3,020.0
27	Pennsylvania	6,074,000	Vet School	3,006.9
28	Oregon	2,769,000	Vet School	2,977.4
29	Maine	914,000	Contract	2,948.4
30	North Carolina	5,103,000	Vet School	2,916.0
31	Missouri	3,789,000	Vet School	2,914.6
32	Michigan	5,163,000	Vet School	2,852.5
33	Idaho	996,000	Contract	2,845.7
34	Connecticut	1,494,000	Neither	2,766.7
35	New Hampshire	761,000	Contract	2,624.1
36	Illinois	4,964,000	Vet School	2,519.8
37	Virginia	3,745,000	Vet School	2,340.6
38	Maryland	2,305,000	Vet School	2,259.8
39	Nebraska	1,104,000	Neither	2,253.1
40	Vermont	486,000	Neither	2,209.1
41	Minnesota	2,509,000	Vet School	2,181.7
42	New Jersey	2,937,000	Contract	2,175.6
43	Colorado	2,885,000	Vet School	2,031.7
44	Wisconsin	2,848,000	Vet School	2,005.6
45	Massachusetts	2,383,000	Vet School	1,953.3
46	South Dakota	401,000	Contract	1,743.5
47	Iowa	1,661,000	Vet School	1,612.6
48	District of Columbia	94,000	Neither	1,566.7
49	Delaware	405,000	Contract	1,557.7
N/A	Alaska		Neither	
N/A	Hawaii		Contract	

Source: AVMA Sourcebook 2007 and Bureau of Labor Statistics 2006

Table 6. Ranking of Ratio of Livestock Per Vet By State

Rank	State	Total Livestock Population	Vet School	Livestock Per Vet
1	Arkansas	211,628,021	Contract	503,876.2
2	Mississippi	144,054,045	Vet School	379,089.6
3	Alabama	174,585,956	Vet School	264,524.2
4	Delaware	45,688,493	Contract	175,725.0
5	Georgia	233,791,849	Vet School	155,861.2
6	North Carolina	190,671,570	Vet School	108,955.2
7	Louisiana	48,382,209	Vet School	82,003.7
8	Oklahoma	51,931,149	Vet School	81,142.4
9	Kentucky	53,603,428	Contract	78,828.6
10	West Virginia	16,294,695	Contract	77,593.8
11	South Carolina	44,693,020	Contract	70,941.3
12	Iowa	70,815,659	Vet School	68,753.1
13	Maryland	55,531,244	Vet School	54,442.4
14	Missouri	57,620,760	Vet School	44,323.7
15	Nebraska	21,663,535	Neither	44,211.3
16	South Dakota	9,816,277	Contract	42,679.5
17	Minnesota	44,409,925	Vet School	38,617.3
18	Indiana	39,889,601	Vet School	37,631.7
19	Virginia	59,387,303	Vet School	37,117.1
20	Texas	121,730,602	Vet School	33,442.5
21	Tennessee	30,187,878	Vet School	30,804.0
22	Ohio	48,332,631	Vet School	29,835.0
23	North Dakota	2,876,225	Contract	28,762.3
24	Pennsylvania	56,818,304	Vet School	28,127.9
25	Utah	5,917,242	Contract	23,669.0
26	California	72,390,866	Vet School	17,656.3
27	Montana	3,563,361	Contract	15,492.9
28	Kansas	9,703,753	Vet School	15,162.1
29	Wyoming	1,953,741	Contract	15,028.8
30	Wisconsin	17,803,472	Vet School	12,537.7
31	Florida	34,379,031	Vet School	12,062.8
32	Idaho	3,653,145	Contract	10,437.6
33	Washington	12,296,451	Vet School	10,333.2
34	Oregon	9,103,315	Vet School	9,788.5
35	Michigan	13,093,974	Vet School	7,234.2
36	Hawaii	1,010,947	Contract	6,739.6
37	Colorado	8,643,048	Vet School	6,086.7
38	Maine	1,730,672	Contract	5,582.8
39	Illinois	10,336,922	Vet School	5,247.2
40	New Mexico	2,095,438	Contract	5,238.6
41	New York	7,431,653	Vet School	3,231.2
42	Vermont	577,210	Neither	2,623.7
43	New Jersey	2,295,827	Contract	1,700.6
44	Nevada	561,214	Contract	1,603.5
45	New Hampshire	340,420	Contract	1,173.9
46	Arizona	1,012,816	Contract	964.6
47	Massachusetts	483,249	Vet School	396.1
48	Rhode Island	50,702	Neither	316.9
49	Connecticut	115,234	Neither	213.4
50	Alaska	21,641	Neither	166.5
51	District of Columbia	0	Neither	0.0

Source: U.S. Department of Agriculture 2002 census and Bureau of Labor Statistics 2006

Limitations

The study is not conclusive on whether a shortage or oversupply of veterinarians is present in any state throughout the country. Since the study is a cross-section of data over one year we don't know whether the results hold true over a longer period of time. It is possible a time lag is present in the relationship between changes in the animal population and changes in the veterinary workforce. Having data over a longer period of time would allow growth trends to be established across populations and veterinarian entries and exits and to remove the problems of collinearity encountered in the demand curve estimation.

This study does not examine what factors influence the type of practice a veterinarian may choose to enter. The study does not look at the individual factors influencing the type of practice. In the real world vets may learn medical care for multiple species but they generally have a specialized area they work in. Some veterinarians are large animal exclusive; others are small animal exclusive, while still others work in a medical practice that is mixed. Do demographics and geography influence the practice specialization a veterinarian might pursue? This study is not able to answer this question. The livestock to human ratio as seen in Figure 2 illustrates regions of the country do in fact matter in the type of veterinary services required. The variability in livestock populations is quite significant among states, in some cases exceeding the human population quite significantly. Pet populations remained varied throughout the country but no state has more pets than people living in it.

Finally, we know wages for DVM's are lower compared to other professionals in the human medical field. This could suggest an oversupply in the market, but it may also suggest veterinarians enter the career of veterinary medicine due to large external benefits that are not measurable in terms of wages. The lower wages in the veterinary medical profession compared

to human medicine maybe related to the fact that people are more willing to pay a higher price for human healthcare compared to healthcare for animals. Certainly happiness is a factor in why many people choose to take the time and spend the resources to obtain a DVM degree when similar degrees that require the same amount of time and expense yield higher monetary rewards. This study is not able to assess the degree of happiness people might feel towards the field of veterinary medicine and choosing it as a career.

Recommendations:

This study isolated the effect of a veterinary school on the veterinary labor market using simultaneous equations regression techniques. Pet population and human population are highly correlated. Increases in these populations are related to increases in the number of veterinarians. Veterinary wages and vet schools matter in determining the supply of veterinarians in a state. Veterinarians tend to be located where animals and people are located, other things equal. The largest states in terms of human population such as California, New York, Florida, Texas, Ohio, and Illinois tended to have vet schools. However smaller states such as Kansas, Arkansas, Mississippi, and Iowa do have veterinary schools as well. Smaller states such as Wyoming, Montana, Utah, Vermont, Hawaii, and others tended to be without a veterinary school. However, larger states such as New Jersey and Arizona are also without a veterinary school.

Pets are naturally associated with people, hence the collinearity problem observed when modeling factors influencing the demand for veterinarians. Although it is humans that pay for the veterinary services supplied, the demand for veterinary services would not exist if not for the presence of animals. In addition, veterinarians do intervene and provide services for animals that are not owned or have been abandoned by owners, for example, the rescue of abused and neglected animals, humane societies, and injured wildlife. If the population of people was

dramatically reduced in some fashion but the number of animals remained the same it is likely veterinarians would still find work even though their wages may be significantly reduced.

The results of this study are different than the study done by Getz (1997). Although similar data from the AVMA and USDA in 1992 were used in the study by Getz, he did not observe a relationship between the number veterinarians and a vet school being present in the state. This current study employed simultaneous regression techniques to account for the endogeneity between the number of veterinarians and veterinary wage, while Getz explored the relationship using linear regression techniques. It is entirely possible trends could be changing over time in the veterinary labor market.

Although there were differences in the number of veterinarians among the states by vet school category, there were not differences in the number of pets served by veterinarians or livestock served by veterinarians by vet school category. However, the variability in these ratios was great among the states. Given the fact that the number of veterinarians in states with veterinary schools was found to be higher than in states without vet schools, after controlling for population sizes, it was surprising that the ratio of animals to veterinarians was not lower in the states with vet schools compared to those without schools. Although not important economically, the ratio measures the potential veterinarian caseload. This suggests other factors are influencing the ratio of pets per vet by state, so states may want to examine individual veterinary education policies on a state level rather then looking at the situation from a national level.

From a policy perspective veterinary schools are subsidized by governments because of the public health benefits veterinarians provide in terms of zoonotic and bioterrorism disease control. Public health and food safety is the greatest reason a market failure may be present and

government intervention is needed within veterinary education. Even though livestock are not significant in determining the demand for veterinarians, they do pose a great public health risk in the face of a zoonotic disease outbreak or bioterrorism threat. Larger pet and livestock to vet ratios by state indicate these states are at a higher risk for public health and bioterrorism related issues. Existing policies address public health and bioterrorism such as Homeland Security Presidential Directive-9, and Senate Bill 746. Each provide directives on these public health issues which indicates the federal government believes public health and bioterrorism are a very real threat to the United States. Since federal money may be available through these policies it is prudent to direct these funds, if available, to states with the highest animal to vet ratios.

Further studies examining the veterinary labor market within specialized areas of the veterinary field, such as food animal veterinary medicine, are needed. In turn this would allow us to gain a better understanding of where over or under supplies may exist in the field of veterinary medicine, if at all. Since this study examines the veterinary labor market overall, shortages or over supply in specific areas of veterinary specialization cannot be determined by the current study.

The higher costs and greater space requirements compared to other professional schools are barriers to establishing a veterinary school. These may be reasons states do not fund and operate a veterinary school even when they have a large animal population. At the University of Missouri the costs of replacing the veterinary school facilities is estimated to be $229.74 per square foot compared to $136.00 per square foot for replacement costs of the law school facilities. (Getz 1997). In terms of space requirements at the University of Missouri the veterinary school reported an average of 1,617 square feet of academic space per student. In contrast the law school averaged 313 square feet per student (Getz 1997). Although there are

significant costs to establishing a veterinary school we know the presence of veterinary schools are related to the number of veterinarians in a state.

In general most states have professional schools for human medicine, law, dentistry, engineering, and other professional programs. However this is not the case in veterinary medicine. As a comparison, the United States has 129 human medical schools in 44 states. See Appendix 6 for a map of states with medical schools. In 2005, approximately 17,000 students matriculated from medical school compared to around 2,600 graduating from vet school. In 2005 there were 21,283 veterinary school applicants versus 37,373 applicants for human medical school. The national acceptance rate in 2005 for medical schools was 48.1% versus 12.0% for veterinary schools in the same year (AAMC 2008, AAVMC 2007).

Some alternatives for states with no veterinary school to consider are supporting expanded veterinary education by establishing a vet school in their state, increasing contract seats at existing schools, or developing a partnership for a vet school if they believe additional veterinary capacity is needed. The Maryland/Virginia model illustrates a unique approach to providing veterinary education and care. The main campus itself is located at Virginia Tech University, but it also has two regional campuses in Leesburg, VA., and College Park, MD on the University of Maryland campus. The Leesburg campus focuses specifically on horses. Fifty spaces each year are reserved for Virginia residents and 30 seats are reserved for Maryland residents with the costs spilt between the two states. For smaller states this might be an alternative with the high financial barriers that are in place for starting and maintaining a veterinary school. Costs can be distributed over states potentially making building and operating a veterinary school more reasonable. A regional veterinary school among states currently without a school is a viable alternative to states building on their own.

In conclusion this study clearly shows veterinary schools matter in determining the supply of veterinarians in a state. Further research is necessary, examining a longer period of time to better understand the relationship between veterinary schools and the supply of veterinarians over time. Further study is needed to address the distribution of veterinarians in the United States, to determine whether a shortage, oversupply, a distribution problem, or none of the above exists. Veterinary schools are clearly important to the United States in providing a supply of veterinarians that meets the demand for companion animals, livestock, and public health.

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Appendix 1

DVM Student Total Expenses[a] – First Year (Class of 2009)

School	Resident	Non-Resident
Auburn	$24,609	$44,489
UC Davis	$36,816	$49,061
Colorado State	$23,276	$48,176
Cornell	$36,550	$46,050
Florida	$27,948	$48,312
Georgia	$20,752	$39,352
Illinois	$29,057	$49,851
Iowa State	$26,074	$44,659
Kansas State	$28,807	$49,007
LSU	$29,736	$48,336
Michigan State	$31,152	$48,752
Minnesota	$35,308	$52,096
Mississippi St.	$27,799	$46,789
Missouri	$30,405	$44,095
NC State	$20,588	$43,351
Ohio State	$33,279	$60,015
Oklahoma St.	$23,240	$40,520
Oregon State	$25,443	$38,916
Penn	$48,348	$53,820
Purdue	$24,392	$43,558
Tennessee	$27,912	$48,878
Texas A&M	$26,195	$36,995
Tufts	$29,235	$34,327
Tuskegee	$24,124	$27,124
Virginia/Maryland	$30,997	$48,197
Washington St.	$29,032	$49,260
Western	$53,475	$53,475
Wisconsin	$28,716	$36,750
United States Average	$29,759	$45,508

[a] Total expenses include tuition, room and board, fees, books and equipment, transportation, personal, health, and other.

Source: Association of American Veterinary Medical Colleges. 2007. Veterinary Medical School Admission Requirements, Purdue University Press, West Lafayette, IN Ed. 2007.

Appendix 2

	Veterinary Schools Accepting Contract Students
1	UC Davis
2	Colorado State
3	Oregon State
4	Washington State
5	LSU
6	Missouri
7	Oklahoma
8	Georgia
9	Tuskegee
10	Auburn
11	Tufts
12	Iowa
13	Cornell
14	Illinois
15	Penn
16	Kansas
17	Minnesota
18	Michigan State
19	Ohio State

Appendix 3

Veterinary Schools 2005-2006 Admissions Summary

School	Applicants Res.	Applicants Contract	Applicants Non	Total Applicants	Entrants Res.	Entrants Contract	Entrants Non.	Total Entrants
Auburn	88	102	613	803	46	34	13	93
UC Davis	514	75	377	966	125	1	5	131
Colorado State	243	181	1016	1440	75	36	23	134
Cornell	255	58	540	853	49	6	31	86
Florida	285	N/A	514	799	77	N/A	11	88
Georgia	171	93	260	524	70	25	1	96
Illinois	227	N/A	582	809	83	N/A	31	114
Iowa State	103	96	310	509	57	35	28	120
Kansas State	132	16	820	968	45	2	61	108
LSU	125	47	486	658	59	11	16	86
Michigan State	238	N/A	770	1008	72	N/A	36	108
Minnesota	204	N/A	711	915	55	N/A	35	90
Mississippi St.	52	N/A	349	401	36	N/A	36	72
Missouri	131	N/A	531	662	60	N/A	16	76
NC State	200	N/A	293	493	62	N/A	18	80
Ohio State	273	15	585	873	100	5	35	140
Oklahoma St.	132	N/A	268	400	56	N/A	24	80
Oregon State	91	181	477	749	36	1	12	49
Penn	228	N/A	1069	1297	59	N/A	54	113
Purdue	104	N/A	471	575	44	N/A	25	69
Tennessee	137	N/A	626	763	51	N/A	19	70
Texas A&M	329	N/A	117	446	124	N/A	8	132
Tufts	N/A	N/A	N/A	696	N/A	N/A	N/A	80
Tuskegee	39	80	139	258	4	15	41	60
Virginia/Maryland	283	N/A	593	876	80	N/A	10	90
Washington St.	115	223	446	784	59	31	7	97
Western	234	N/A	380	614	63	N/A	38	101
Wisconsin	166	N/A	978	1144	60	N/A	20	80
Total	5099	1167	14321	21283*	1707	202	654	2643*
Acceptance Rates					33.5%	17.3%	4.6%	12.0%

Note: Total Entrants is minus those who declined admission

Some Veterinary Schools include contract students in Resident or Non-Resident Applicants

* Tufts does not distinguish between resident, non-resident, and contract for applicant and entrant data. Therefore the sum of total resident, total contract, and total non-resident does not sum to the total applicants or entrants.

Source: AAVMC 2007

Appendix 4

Total Educational Debt for 2006 U.S. Vet School Graduates

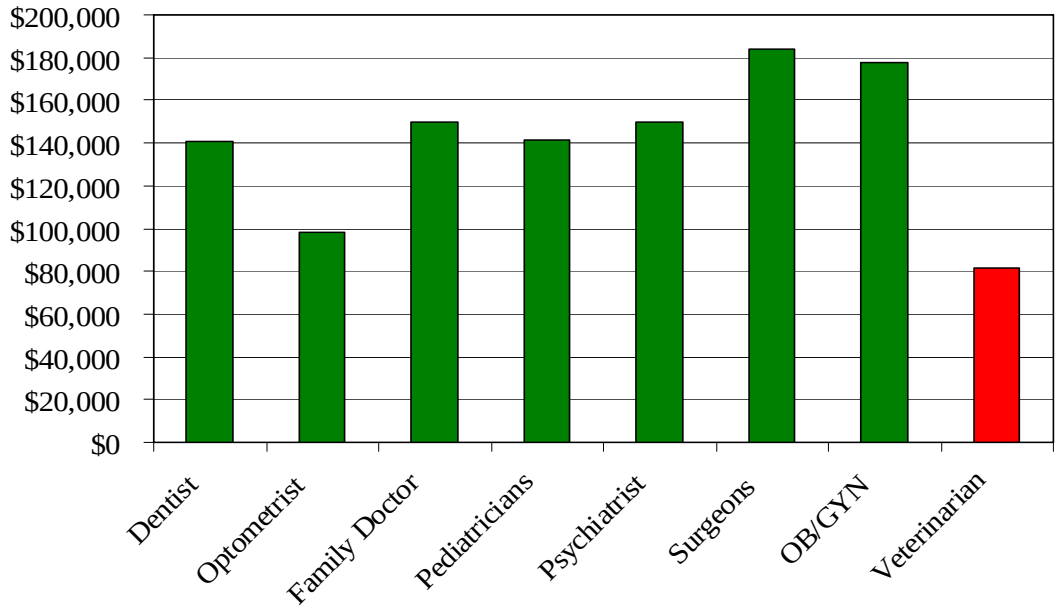
Educational Debt $	% of Respondents	Cumulative %
> $150,000	11.6	11.6
$140,000 - $149,999	3.2	14.8
$130,000 - $139,999	4.8	19.6
$120,000 - $129,999	9.1	28.7
$110,000 - $119,999	5.8	34.5
$100,000 - $109,999	11.0	45.5
$90,000 - $99,999	8.9	54.4
$80,000 - $89,999	11.3	65.7
$70,000 - $79,999	5.0	70.7
$60,000 - $69,999	5.2	75.9
$50,000 - $59,999	3.4	79.3
$40,000 - $49,999	3.1	82.4
$30,000 - $39,999	2.6	85.0
$20,000 - $29,999	1.3	86.3
$10,000 - $19,999	1.4	87.7
< $10,000	0.9	88.6
No Debt	11.4	100.0

Total Number of Respondents = 1,750. Total Respondents who had debt greater than or equal to $80,000 was 65.7%

Source: Employment, starting salaries, and educational indebtedness of year 2006 graduates of US veterinary medical colleges. JAVMA 229(7): 1087-1089)

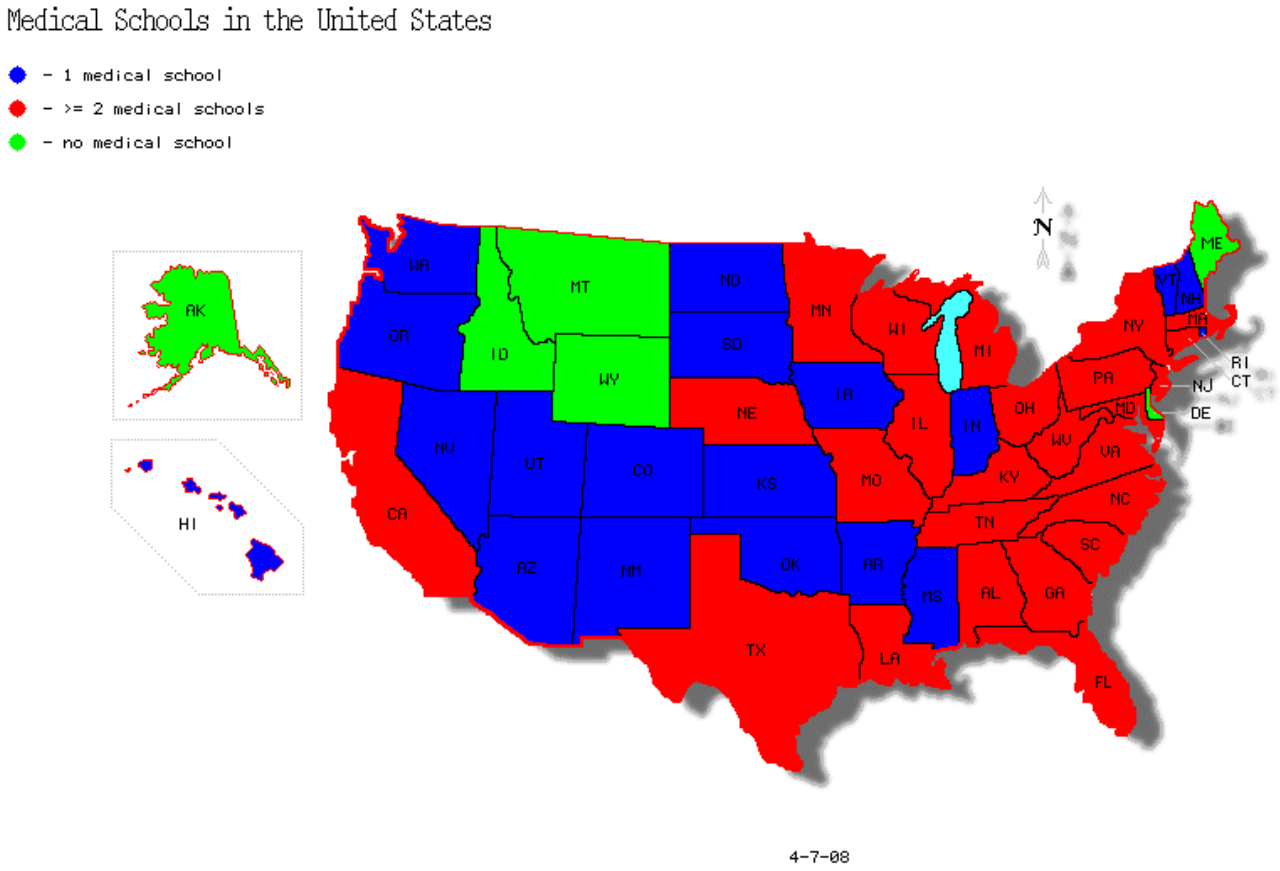
Appendix 5

Mean Annual Wages for Selected Medical Positions



Source**:** U.S. Department of Labor Bureau of Labor Statistics, 2006

Appendix 6



Source: Association of American Medical Colleges (AAMC)