



Economic and Social Impacts of Veterinary Medicine in Ohio

A Study Commissioned by a Partnership Between
The Ohio State University College of Veterinary Medicine
and the Ohio Veterinary Medical Association

Bill LaFayette, Ph.D.
Owner, Regionomics® LLC

Stephen A. Buser, Ph.D.
Professor Emeritus, Fisher College of Business
The Ohio State University¹

July 11, 2017

Regionomics®
From Trends to Insight to Action



THE OHIO STATE UNIVERSITY

FISHER COLLEGE OF BUSINESS

Table of Contents



I. Summary of Major Findings	1
II. Veterinary and Animal-Related Economic and Employment Trends	7
A. Industries	7
B. Occupations	14
C. Industries Employing Veterinary and Animal-Related Occupations	16
D. Age Distribution of Veterinarians	17
III. Spatial Characteristics of Veterinary Medicine and Animal Ownership	18
IV. Veterinary and Animal Care Education in Ohio	24
V. Economic Impact of Veterinary and Animal-Related Industries in Ohio	27
A. Theory and Derivation of Economic Impacts	27
B. Economic Impacts	29
VI. Social Impacts of Veterinary Medicine	30
VII. Impacts of Veterinary College Tuition on Students and Graduates	33
Appendix	36
Bibliography	50

Table of Tables

Table S-1: Summary Economic Impacts on the Ohio Economy of Veterinary and Animal-Related Industries and Ohio State Institutions, 2015	2
Table 1: Ohio Payroll Employment in Veterinary and Animal-Related Industries	8
Table 2: Wages in Veterinary and Animal-Related Industries	11
Table 3: Establishments in Veterinary and Animal-Related Industries	12
Table 4: Average Establishment Size in Veterinary and Animal-Related Industries	13
Table 5: Payroll Employment in Veterinary and Animal-Related Occupations	14
Table 6: Wages and Salaries in Veterinary and Animal-Related Occupations, May 2016	15
Table 7: Practice Discipline of Veterinarians in Ohio	15
Table 8: Veterinary Services Employment Growth and Establishment Counts by Region, 2007 and 2015	19
Table 9: Farm Animal Population, Ohio Totals, 2002-2012	21
Table 10: Regional Veterinary Services Employment per 10,000 Farm Animals, 2012	21
Table 11: Companion Animal Ownership and Population, U.S. and Ohio, 2012	22
Table 12: Estimated Annual Veterinary Visits for Companion Animals, Ohio	23
Table 13: Veterinary Services Employment per 10,000 Households, 2012	23
Table 14: Animal-Related Programs in Ohio High School Career Centers	24
Table 15: Animal-Related Programs in Ohio Two-Year and Four-Year Colleges and Universities	25
Table 16: Summary Economic Impacts on the Ohio Economy of Veterinary and Animal-Related Industries and Ohio State Institutions, 2015	29

¹The authors acknowledge the essential research assistance provided by Amy Buser, Ph.D. and the design and layout work provided by Tim Vojt.

Table of Tables - continued

Table A-1: Occupational Employment in Animal Production and Aquaculture	36
Table A-2: Occupational Employment in Animal Food Manufacturing	37-38
Table A-3: Occupational Employment in Veterinary Services	38
Table A-4: Industries Employing Veterinarians, United States, 2014	39
Table A-5: Industries Employing Veterinary Technologists and Technicians, United States, 2014	39
Table A-6: Industries Employing Veterinary Assistants and Laboratory Animal Caretakers, United States, 2014	40
Table A-7: Industries Employing Non-farm Animal Caretakers, United States, 2014	40
Table A-8: Veterinary Services Employment and Number of Establishments by County, 2007 and 2015	41
Table A-9: Farm Livestock by County, Selected Breeds, 2012	42-43
Table A-10: Output Impacts on the Ohio Economy of the Veterinary Services Industry by Sector, 2015	44
Table A-11: Earnings Impacts on the Ohio Economy of the Veterinary Services Industry by Sector, 2015	45
Table A-12: Employment Impacts on the Ohio Economy of the Veterinary Services Industry by Sector, 2015	46
Table A-13: Output Impacts on the Ohio Economy of Veterinary and Animal-Related Industries and Ohio State Institutions by Sector, 2015	47
Table A-14: Earnings Impacts on the Ohio Economy of Veterinary and Animal-Related Industries and Ohio State Institutions by Sector, 2015	48
Table A-15: Employment Impacts on the Ohio Economy of Veterinary and Animal-Related Industries and Ohio State Institutions by Sector, 2015	49

Table of Figures

Figure 1: Ohio Veterinary Services and Ohio Total Employment Growth, 2007-2015	9
Figure 2: Ohio and United States Veterinary Services Employment Growth, 2007-2015	9
Figure 3: Ohio Veterinary and Animal-Related Employment Growth and Ohio Total Employment Growth, 2007-2015	10
Figure 4: Ohio Dog and Cat Food Manufacturing, Other Animal Food Manufacturing, and Total Manufacturing Employment Growth, 2007-2015	10
Figure 5: Age Distribution of Employed Veterinarians, United States, 2016	17
Figure 6: Ohio Regions	18
Figure 7: Percentage of Urban Population in Ohio Counties, 2010	19
Figure 8: Percentage of Ohio Counties' Land Area in Farms, 2012	20
Figure 9: Initial Debt Burden of Graduates of the Ohio State Veterinary Medical Program and All Veterinary Medical Programs Nationwide, 2016	34

I. Summary of Major Findings

The purpose of this report is to assess the scope and impact of veterinary medicine in Ohio. Evaluations are based on findings for firms that operate in related industries, as well as findings from surveys of the veterinary and animal-related programs in Ohio educational institutions. We consider both economic impacts and the social impacts of veterinary medicine on Ohio residents. We also consider the impact of the cost of a veterinary degree and debt burden that it imposes on graduates.

Even if a narrow definition is applied, Veterinary Services account for more than 23,000 Ohio jobs, and those jobs generate more than \$800 million in wages for Ohio workers. In addition, the total contribution of Veterinary Services to the Ohio economy exceeds \$2.4 billion. If the industry definition is expanded to include supporting businesses and animal related businesses, the number of Ohio jobs grows to more than 93,000, total wages grow to nearly \$3.7 billion, and the total contribution to the Ohio economy grows to nearly \$13 billion.

These broader animal-related industries include animal production (farming) and related industries, animal food manufacturing, farm and pet supplies wholesalers and retailers, biotechnology research, racetracks, zoos, and non-veterinary pet care. The impacts also include those of The Ohio State University College of Veterinary Medicine, including the Veterinary Medical Center (VMC). The contributions include the direct output and employment of the industries themselves, as well as the necessary contributions of suppliers, which are referred to as indirect impacts. It also includes the impact of the household spending of direct and indirect workers. These workers earn wages and salaries from their employment, and as a result purchase household goods and services of all kinds.

Veterinary medicine contributes significantly to Ohio agriculture by ensuring the health and marketability of farm animals. Agriculture is the heart of a \$110 billion industry that is Ohio's largest. The state ranks 10th in the nation for the value of farm products. The impact of veterinary medicine on Ohio agriculture enters to some degree in the measured impacts. While this impact cannot be fully quantified, veterinary medicine makes a vital contribution to the overall Ohio economy.

Impacts of veterinary services, the College of Veterinary Medicine and the VMC, and the auxiliary animal care industries are shown in Table S-1 (page 2). These also include earnings impacts: the wages, salaries, and self-employment income earned through direct, indirect and induced activity.

93,000

Ohio Jobs Supported in 2015

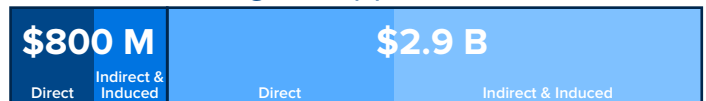


Veterinary Services

Supporting & Animal-related Industries

\$3.7 billion

Ohio Wages Supported in 2015

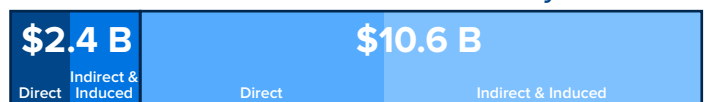


Veterinary Services

Supporting & Animal-related Industries

\$13 billion

Contribution to the Ohio Economy in 2015



Veterinary Services

Supporting & Animal-related Industries



Veterinary Medicine Helps Protect & Support Ohio's Agriculture Industry

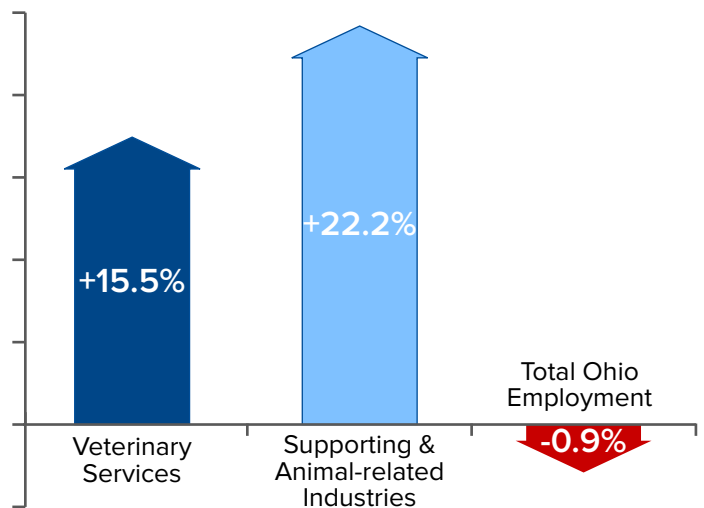
Table S-1: Summary Economic Impacts on the Ohio Economy of Veterinary and Animal-Related Industries and Ohio State Institutions, 2015

	Direct	Indirect	Induced	Total
Employment (jobs)				
Veterinary services	12,877	3,766	6,520	23,163
Ohio State (college and VMC)	673	92	403	1,167
Other industries	28,422	18,954	21,863	69,238
Total	41,972	22,812	28,785	93,569
Earnings (\$)				
Veterinary services	438,097,000	161,485,000	228,328,000	827,910,000
Ohio State (college and VMC)	33,118,000	3,900,000	14,067,000	51,084,000
Other industries	1,171,098,000	839,431,000	768,966,000	2,779,495,000
Total	1,642,313,000	1,004,816,000	1,011,361,000	3,658,489,000
Output (\$)				
Veterinary services	1,110,543,000	559,047,000	769,495,000	2,439,085,000
Ohio State (college and VMC)	71,008,000	11,739,000	47,511,000	130,258,000
Other industries	4,483,200,000	3,320,848,000	2,580,747,000	10,384,795,000
Total	5,664,751,000	3,891,634,000	3,397,753,000	12,954,138,000

Ohio veterinary services employment in 2015 was 15.5 percent higher than 2007 (immediately before the recession) and the veterinary auxiliary industries' employment was 22.2 percent higher. Total Ohio employment across all sectors as of 2015 was 0.9 percent lower than in 2007.

In contrast to total Ohio employment, which during the recession suffered a three-year decline totaling 7.5 percent, veterinary services and the auxiliary industries experienced small declines in only one year (2009). In neither case was this decline large enough to reduce employment below its pre-recession level. In the years following the end of the recession in 2010, employment in veterinary services gained 14 percent and the auxiliary industries gained 20.9 percent, but total Ohio employment gained only 7.1 percent. Thus, in a small way, these animal-related industries reduced the impact of the recession on Ohio employment and increased its growth in the expansion.

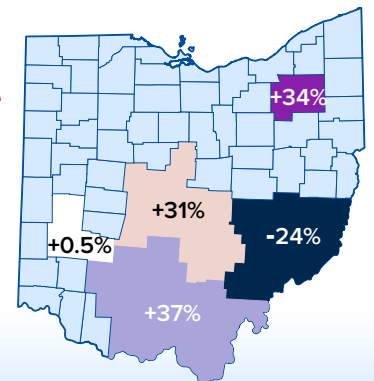
Change in Employment from 2007 to 2015



There are considerable differences in veterinary services employment growth among Ohio regions.

Southern Ohio enjoyed the strongest net growth between 2007 and 2015 with a gain of 37 percent, while the Akron Metropolitan Statistical Area (MSA) gained 34 percent and the Columbus MSA gained 31 percent. However, employment in the Dayton MSA increased only 0.5 percent and employment in Southeastern Ohio declined almost 24 percent.

Veterinary Service Job Growth in Ohio 2007-2015



There are approximately 3,300 veterinarians practicing in Ohio. While this number is relatively small, the corresponding economic impact of the veterinary industry in Ohio is remarkably strong.

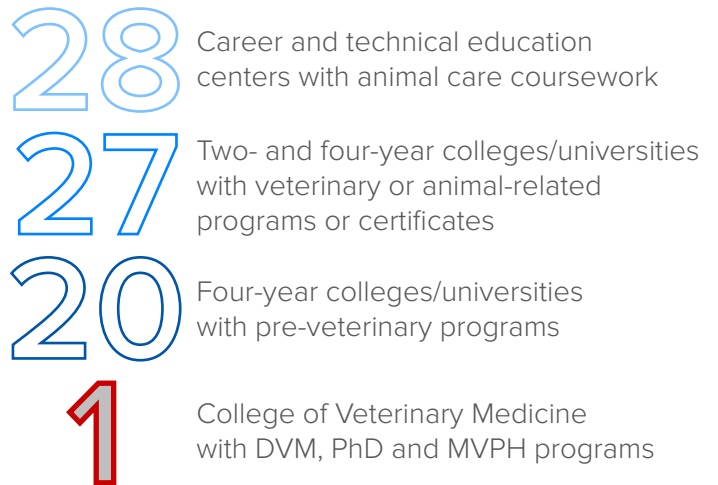
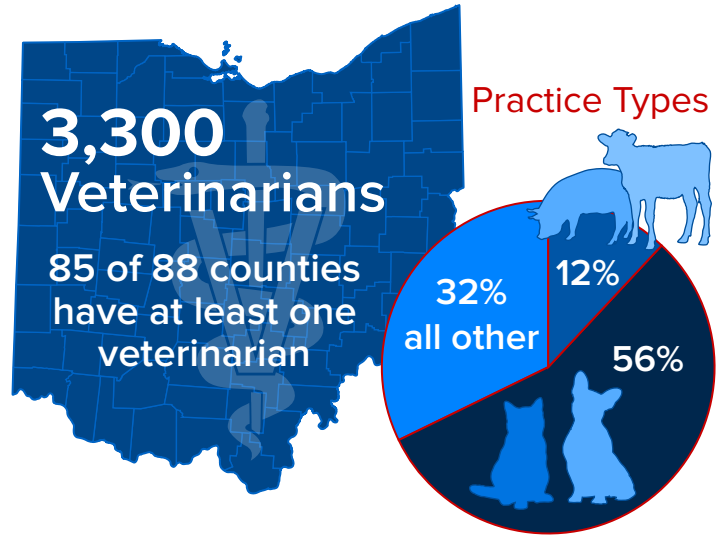
This total is an estimate by the Ohio Veterinary Medical Association, and includes both payroll employment and self-employed individuals. Many of these self-employed veterinarians are owners of their own practice. There is at least one veterinary office in 85 of Ohio's 88 counties. The majority of veterinarians in Ohio (56 percent) are in private practices focusing on companion animals and another 12 percent treat both pets and farm animals. Smaller numbers treat horses and farm animals exclusively, work in academics and research, or are employed by corporations or government.

Ohio educational institutions offer an array of veterinary and animal care programs beginning as early as high school and continuing through Ohio State's doctoral programs.

Of the 86 high school career and technical education centers throughout the state, 28 offer coursework in animal science or animal care, including five offering a specific program in equine science. At least 27 two-year and four-year colleges and universities in Ohio offer veterinary and animal-related programs and/or certificates, including 20 four-year pre-veterinary programs. Ohio State offers the state's only doctoral program in veterinary medicine, master's and doctoral degrees in comparative and veterinary medicine, and a master's program in veterinary public health.

Ohio State also accommodates a robust veterinary research program, some discoveries of which are commercializable, and one of the largest veterinary medical centers in the U.S.

Researchers in the college developed the first feline leukemia vaccine and have developed technology used in tick-borne disease diagnostics. Faculty are leaders in the development of advanced animal orthopedic procedures, infectious diseases, food safety, and cancer. The VMC is one of the largest veterinary medical centers in the U.S. and is the only comprehensive referral veterinary medical center for companion animals, farm animals, and horses in Ohio, Kentucky and West Virginia. The VMC admits more than 35,000 patients annually. Additionally, the college's Large Animal Services in Marysville, Ohio provides farm-based service to livestock operations across 17 counties.



The Ohio State University
College of Veterinary Medicine

- Robust Research
- Translational Medicine



Veterinary Medical Center

- One of the largest in the U.S.
- 42,000 patients annually
- Comprehensive referral for three states

Animals convey a wide variety of physical, behavioral, mental, psychological and social benefits. Among these are the therapeutic value of owning and caring for pets. Veterinarians play an important role in the study, prevention and containment of zoonotic diseases — infectious diseases that animals can transmit to humans and that humans and animals share.

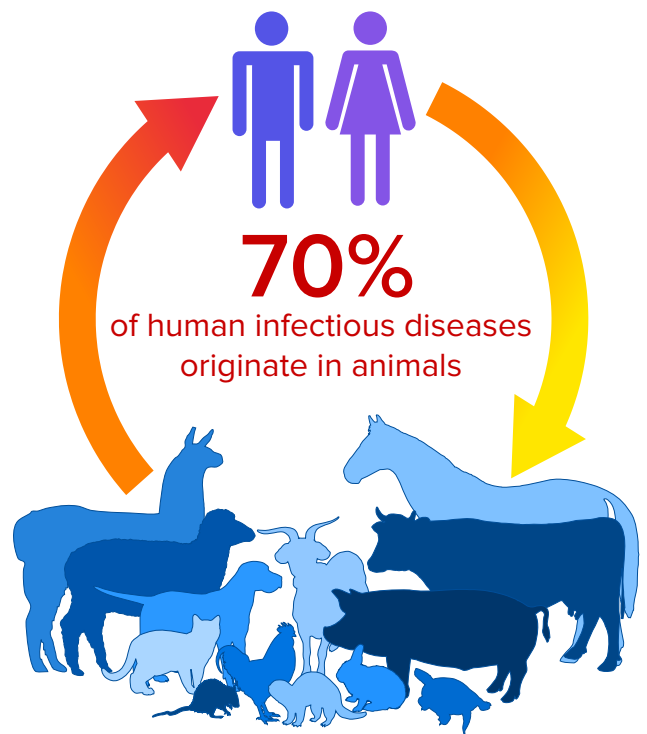
Pets make substantial contributions to the health and well-being of pet owners. Owning or interacting with pets or other animals has been found to lower blood pressure, alleviate depression, and improve many other health conditions. Interacting with animals has resulted in significant improvement in patients suffering from severe mental and emotional conditions, including schizophrenia, psychosis, autism, and post-traumatic stress syndrome (PTSD). These benefits reduce healthcare costs, lengthen life spans, and likely improve workforce participation and economic productivity. Companies that allow employees to bring their pets to work enjoy greater productivity perhaps because of the effect on decreasing stress and increasing workplace satisfaction among employees.

A number of diseases that can be transmitted from animals to humans have attracted worldwide attention because of the disruption, suffering, and death they have caused. This also has an immense economic impact because of the effect on travel, international trade, and healthcare costs. These include Ebola, avian influenza (bird flu), rabies, Lyme disease, West Nile disease, and Zika virus among others. Studying transmission and patterns of infection can help the medical profession understand, anticipate, and mitigate outbreaks of these diseases. Research has shown that approximately 70 percent of all human infectious diseases share this animal-to-human link and first originate in animals.

A wide variety of ailments are common to animals and humans. Veterinarians routinely observe and treat these conditions for a broad array of species. They have often developed methods for diagnosing and treating certain conditions applicable to animals and people. The ability to apply insights from veterinary studies and treatment protocols to treatment of humans can leverage the effectiveness and reduce the cost of medical research.



Pets make substantial contributions to the health and well-being of pet owners.



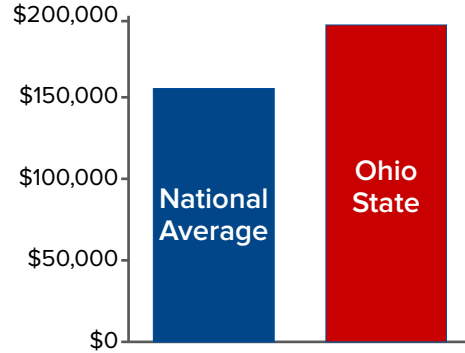
The high cost of a veterinary degree and the substantial debt burden that obtaining a degree entails is likely deterring some individuals from entering this field. The Ohio State veterinary students generally graduate with higher debt than do graduates of other veterinary programs. This is a result of the comparatively low level of state support for the veterinary medical program at Ohio State.

The total in-state tuition for a four-year veterinary degree at Ohio State is currently \$140,017, not including books, supplies, lab fees, room, and board. An annual survey by the American Veterinary Medical Association (AVMA) of veterinary program graduates found that students graduating in 2016 had an average debt burden of \$155,291, more than double the inflation-adjusted 2001 level. The average debt burden of Ohio State graduates was \$194,363, which is 25 percent greater than the national average. There is a risk that the high cost of a veterinary education and the need to assume a significant amount of debt will discourage interested students from entering the field.

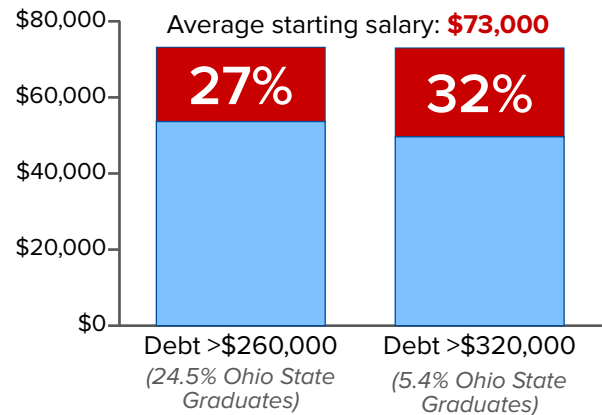
The AVMA finds that the prospects of future earnings are generally sufficient to cover the tuition costs for advanced degrees in veterinary medicine, but the extent of such coverage appears to have narrowed substantially in recent years. If public financial support continues to decline and tuition continues to increase, the relationship of future earnings to initial debt levels could turn negative. Regardless of the positive long-term prospects, however, debt service payments can impose a significant burden on individuals beginning their career. The American Veterinary Medical Association reports a \$73,000 average starting salary for recent graduates going into practice. The 24.5 percent of Ohio State students graduating with at least \$260,000 in debt can face annual payments of \$19,530 or more – at least 27 percent of their before-tax income if income based loan repayment programs are not employed or discontinued at a federal level. The 5.4 percent of graduates with \$320,000 or more in debt would make payments amounting to 32 percent or more of their income.

The high tuition of the Ohio State veterinary program and the high debt levels of its graduates are a direct result of low levels of state support. Ohio’s support amounts to ~\$19,500 per student, less than half the \$44,000 average for the top 10 veterinary programs nationwide. Increases in state support is needed to attenuate increases in tuition and maintain a supply of qualified program candidates.

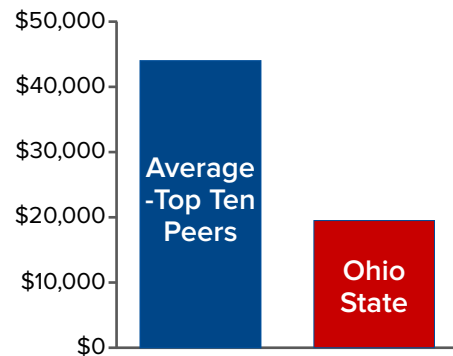
Ohio State 2016 graduates average debt is **25% higher** than the national average.



Percent of average starting salary represented by loan repayment liability.



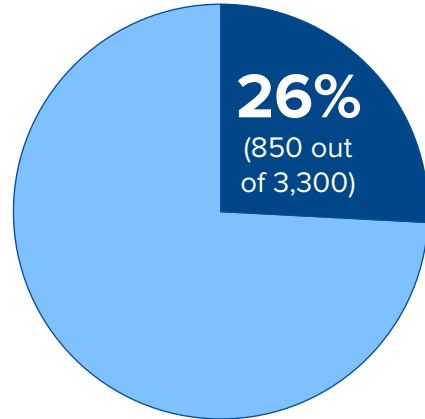
State support per student at Ohio State is **less than half** the average of its top ten peer institutions.



Nationwide, 26 percent of veterinarians are 55 years or older and 7 percent are 65 or older.

If the same percentages apply to Ohio veterinarians, 850 of the 3,300 veterinarians are at least 55 years of age. Virtually all of these are likely to retire within the next 15 to 20 years. If the Ohio distribution were available, however, it might show an even larger share in older age groups because the Ohio population is older than the U.S. average. The Ohio State College of Veterinary Medicine has an important role in ensuring that the supply of new veterinarians is sufficient to fill this emerging gap, and to supply future needs.

850 Ohio veterinarians are expected to retire in the next 15 to 20 years



II. Veterinary and Animal-Related Economic and Employment Trends

This section explores the level and trend of veterinary services and animal-related employment in Ohio and its regions. Employment can be measured in either of two ways: by industry (where people work regardless of what they do) or by occupation (what people do regardless of where they work). Both are relevant in assessments of veterinary services and other animal-related employment. As is discussed later in this section, a veterinary office includes the veterinarians but also technicians and other office and administrative staff. These support positions are included in the veterinary service industry and rightly so. If not for these support workers, office operations would be less efficient – if the office were able to function at all. On the other hand, the veterinarian occupation includes veterinarians in these offices as well as those in other industries such as research organizations, higher education, food inspection, and elsewhere in a broad array of employment opportunities. Industry employment, growth, and concentration is discussed first, followed by a discussion of occupational employment.

This study in part updates a 2010 analysis of the economic impact of Ohio veterinary medicine by Thomas Sporleder². Both that study and this one take the view that industries beyond veterinary services impact farm and companion animals and have a complementary relation to veterinary services. Consequently, Sporleder defined 13 auxiliary industries in addition to veterinary services that have some relationship to animal care. The industries included in this analysis are to the extent possible and desirable the same as those defined by Sporleder; differences are discussed below.

A. Industries

Table 1 on page 8 reports the 2015 Ohio employment in veterinary services and auxiliary animal-related industries. Total Ohio payroll employment is shown on the last line for comparison. These industries are defined by the North American Industry Classification System (NAICS); the industry's NAICS code is shown with the industry's name. Along with industry employment is provided the state and national percentage change in employment since 2007, immediately prior to the recession. The final column of Table 1 reports the location quotient, a measure of relative employment concentration. The location quotient is calculated as the percentage of total Ohio employment in a specific industry divided by the percentage of total nationwide employment in that industry. Thus, a location quotient greater than 1.0 implies an industry that is more concentrated in Ohio than average. Specifically, a location quotient of 1.2 would imply that the industry's employment is 20 percent greater than average, or 20 percent greater than would be expected in an economy Ohio's size. (Total payroll employment has a location quotient of 1.0 by definition.)

With two exceptions, the veterinary services and auxiliary industries are those analyzed by Sporleder. The first difference is animal production and aquaculture (NAICS code 112), which the Sporleder report did not include. The second difference is research and development in biotechnology (NAICS code 541711). This industry was defined after the earlier study was completed. At that point, the only industry available was the broader industry, research and development in the physical, engineering, and life sciences. Another difference between Sporleder's study and the current one is the database used in the analysis. Sporleder used the U.S. Census Bureau's County Business Patterns (CBP); this study uses the Quarterly Census of Employment and Wages (QCEW) of the U.S. Bureau of Labor Statistics. While CBP does have some analytical benefits, its employment totals are only available for mid-March. The QCEW totals are available as annual averages, providing a more complete picture of employment trends. CBP generally excludes farming employment, so it was not available to be analyzed by Sporleder. Further, there can be differences in the classification of individual businesses, creating differences between the two sources in reported employment totals apart from the timing differences.

² Thomas Sporleder (2010). Economic impacts of veterinary medicine in Ohio: Special research report to the College of Veterinary Medicine, The Ohio State University

Table 1: Ohio Payroll Employment in Veterinary and Animal-Related Industries

NAICS code and industry	Ohio employment, 2015	Change, 2007-2015		Location quotient
		Ohio	U.S.	
541940 Veterinary services	12,877	15.5%	17.7%	0.997
Auxiliary industries				
112 Animal production and aquaculture	5,808	43.8%	14.3%	0.606
115210 Support activities for animal production (including equine boarding)	960	27.8%	3.3%	0.877
311111 Dog and cat food manufacturing	1,106	-10.1%	25.3%	1.252
311119 Other animal food manufacturing	1,745	9.7%	3.7%	1.418
325412 Pharmaceutical preparation manufacturing (including veterinary medical preparations mfg.)	4,349	-2.9%	-11.6%	0.572
339112 Surgical and medical instrument manufacturing (including veterinarians' instruments)	2,128	7.9%	7.4%	0.475
423490 Other professional equipment merchant wholesalers (including veterinarians' equipment)	687	-45.9%	4.7%	0.658
424210 Druggists' goods merchant wholesalers (including veterinary medicines)	7,076	-25.8%	-5.7%	0.932
424910 Farm supplies merchant wholesalers	3,460	7.5%	5.3%	0.797
453910 Pet and pet supplies stores	4,404	-4.3%	16.0%	1.024
541711 Research and development in biotechnology	3,617	34.2%	16.9%	0.606
711212 Racetracks	1,063	-34.2%	-26.8%	0.859
712130 Zoos and botanical gardens	2,674	70.9%	25.1%	1.850
812910 Pet care, except veterinary services	3,585	84.4%	78.7%	0.993
Total auxiliary industries	42,662	5.3%	6.8%	0.784
Veterinary services plus auxiliary industries	55,539	7.5%	8.7%	0.825
Excluding 325412, 339112, 423490, and 424210				
Auxiliary industries	28,422	22.2%	15.6%	0.844
Veterinary services plus auxiliary industries	41,299	20.1%	16.2%	0.886
Total Ohio payroll employment	5,258,288	-0.9%	3.0%	1.000

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics

Using CBP for March 2008, Sporleder reported total veterinary services employment of 11,780, an auxiliary industry total of 47,308, and an all-industry total of 59,088. The comparable totals from that year's QCEW (excluding from auxiliary industries animal production and aquaculture and substituting the broader research and development industry for biotechnology research) are 11,388 in veterinary services, 47,984 in auxiliary industries, and a total of 59,372 – a difference of less than 300. **By 2015, the Sporleder-equivalent total employment had grown to 63,398, a 7.3 percent increase.**

However, it can be argued that some of these auxiliary industries are overly broad and should be excluded. Four industries in particular, pharmaceutical preparation manufacturing (NAICS 325412), surgical and medical instrument manufacturing (NAICS 339112), other professional equipment merchant wholesalers (NAICS 423490), and druggists' goods merchant wholesalers (NAICS 424210) are

significantly broader than their animal-related component. The first three include pharmaceuticals, medical instruments, and druggists' goods for both animals and humans. The other professional equipment wholesalers industry is even broader, including wholesalers of veterinarians' equipment, but also wholesalers of non-medical laboratory equipment, engineers' supplies, and religious supplies. Consequently, these four industries are not considered in the analysis to follow. The relevant industry totals are highlighted in dark blue in Table 1.

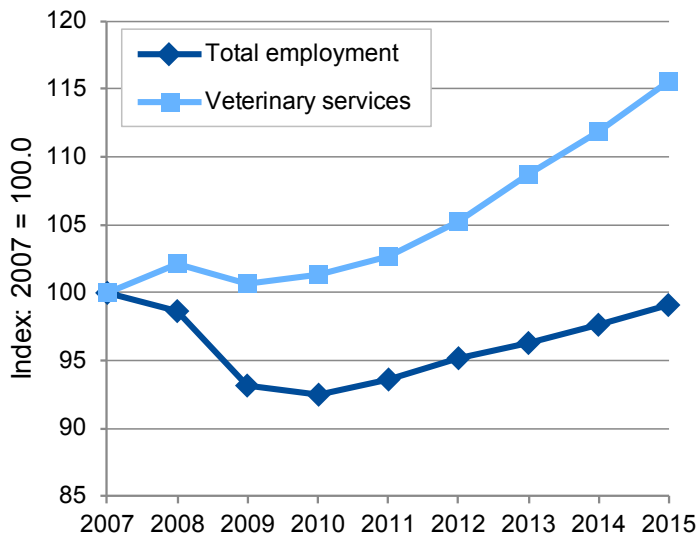
Table 1 reveals that as of 2015, **total Ohio employment across all sectors was still 0.9 percent less than its pre-recession peak although U.S. employment exceeded its pre-recession level by 3.0 percent. This contrasts sharply with the performance of all veterinary services and animal-related industries. Veterinary services employment was 15.5 percent higher than its pre-recession level.** Although the industry-level comparisons with the national averages

are mixed for the remaining industries, **Ohio employment in all veterinary and auxiliary industries was 20 percent higher in 2015 than it was in 2007, a net gain nearly one-quarter greater than the national average.**

Also notable in Table 1 is the outstanding growth of several other industries. **The growth in animal production and aquaculture was triple the national average, and growth in support activities for animal production (including breeding services, horse training and boarding, milk testing for butterfat, and sheep shearing) was even stronger.** As is true of the other employment counts, the 5,808 workers counted in animal production include only payroll employees covered by unemployment insurance so farm owners are not included, regardless of their involvement in the day-to-day operation of the farm.

The high location quotients of the two animal food manufacturing industries are consistent with the overall above-average concentration of manufacturing in Ohio's economy. Manufacturing's total location quotient in 2015 was a very high 1.48. Ohio manufacturing has enjoyed employment growth greater than the national average since the recovery began. This has been the first sustained manufacturing employment growth since the early 1990s, and is the primary reason why total Ohio employment growth was on par with the national average in the early years of the expansion.

Figure 1: Ohio Veterinary Services and Ohio Total Employment Growth, 2007-2015

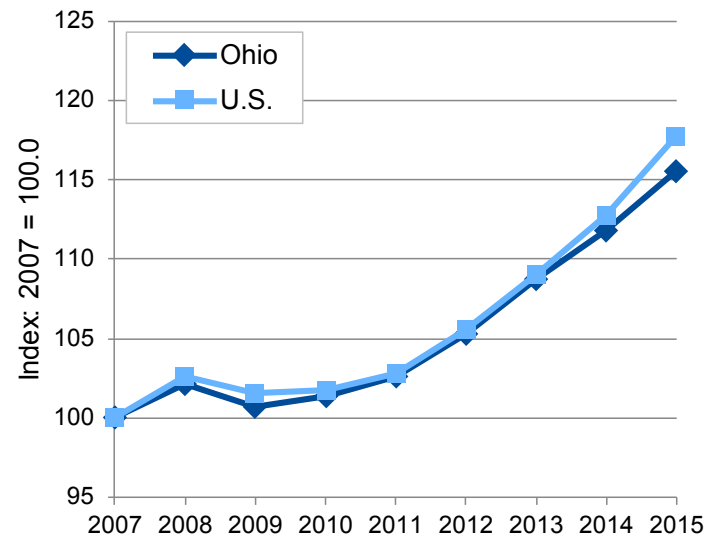


Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics

Although veterinary services employment has significantly outperformed total payroll employment growth with a 15.5 percent net gain, it has slightly underperformed the national average gain for veterinary services (15.5 percent versus 17.7 percent). These comparisons are charted in Figures 1 and 2. This and the following charts show employment on an index basis, thus comparing cumulative percentage growth between 2007 and 2015. As Figure 1 shows, total Ohio employment sustained a three-year recession decline between 2008 and 2010 totaling 7.5 percent. In contrast, veterinary services employment declined in only one year (2009) and by only 1.4 percent (165 jobs). Even with this decline, employment remained above its pre-recession 2007 level. **Thus, in a small way, the veterinary services industry mitigated the severe impact of the recession on total Ohio employment.**

Figure 2 compares eight-year growth in Ohio veterinary services employment to that industry's growth nationwide. As this chart demonstrates, the shortfall in Ohio employment growth was caused mostly by lagging growth in 2014 and 2015. However, because a significant percentage of veterinary services establishments focus partly or exclusively on companion animals and most function in a primarily local market, one might expect the industry's growth to mirror the very slow growth of Ohio population and households. **It could be argued that the fact that the veterinary services industry's employment growth is only slightly less than the national average is a sign of strength.**

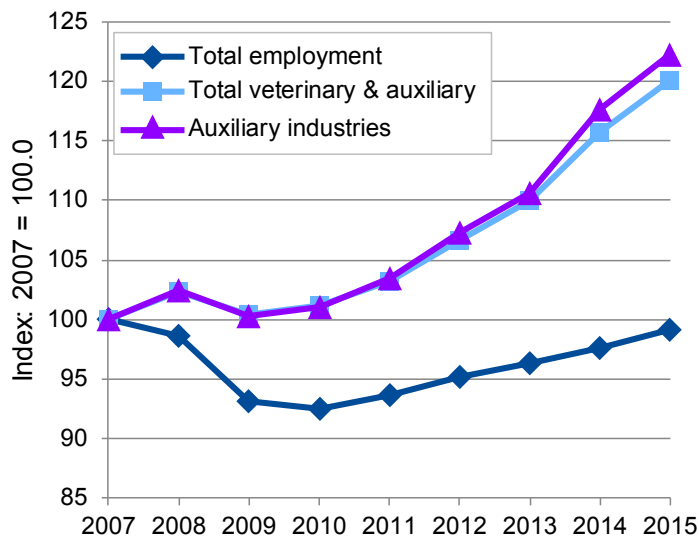
Figure 2: Ohio and United States Veterinary Services Employment Growth, 2007-2015



Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics

Figure 3 contrasts payroll employment growth of veterinary and auxiliary animal-related industries with the growth of total Ohio employment. As the chart shows, the overall animal-related sector (purple line) performed even better than veterinary services, gaining 22.2 percent (5,170 net new jobs). The overall animal-related sector industries along with veterinary services increased by 20.1 percent (6,900 jobs). The auxiliary industries' recession performance mirrored that of veterinary services: a small one-year decline in 2007 that kept employment above its pre-recession level. The auxiliary industries' growth also exceeded the corresponding national average. As shown in Table 1, national average growth in these industries amounted to 15.6 percent over the eight-year period. **The key message of these three charts is that in a small way, veterinary services and other animal-related industries helped to cushion the blow of the recession and improved the below-average growth of Ohio employment during the expansion.**

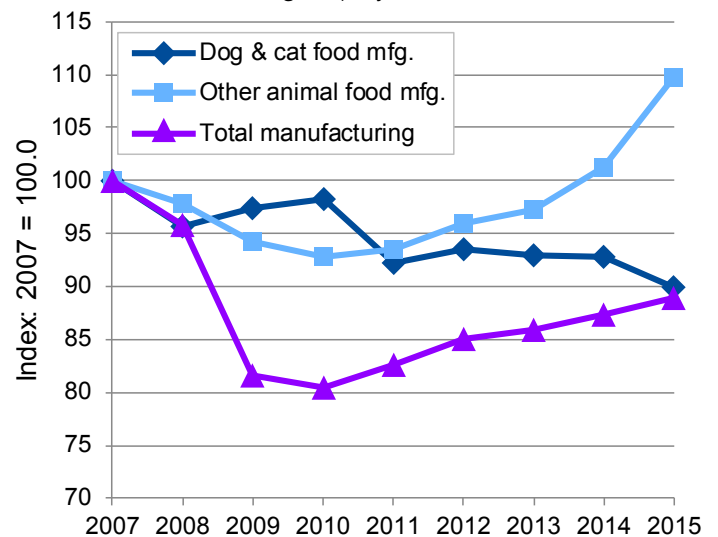
Figure 3: Ohio Veterinary and Animal-Related Employment Growth and Ohio Total Employment Growth 2007-2015



Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics

Figure 4 compares employment growth of dog and cat food and other animal food manufacturing with total Ohio manufacturing growth. Employment in other animal food manufacturing declined only modestly during the recession and increased rapidly during the recovery. Employment change in dog and cat food manufacturers has been far more erratic, with a net increase during the recession years of 2008 and 2009 and stagnation and decline during the recovery. However, an important point is that this employment decline does not necessarily indicate a decline in activity of these firms. More than many other sectors, manufacturers are able to substitute machinery and robotics for labor and increase their output while reducing their workforce. Employment of all manufacturing firms declined throughout the expansion of 2001 through 2007, and then more rapidly through the recession. But the 16 percent pre-recession employment decline was accompanied by a 28 percent output increase. The increase in employment during the expansion was probably the result of the decade of employment declines that left manufacturers with inadequate workforce to accommodate the increase in activity as the recovery took hold. However, the lack of significant employment decline in dog and cat food manufacturing during the recession may have left the industry without a workforce shortage and able to respond to any increase in demand with its current workforce. Thus, the decline in dog and cat food manufacturing employment may be because the industry contracted, or it may be because new technologies allowed the same or greater levels of production with fewer workers. Statistics that would establish conclusively which of these alternative explanations is correct are not yet available.

Figure 4: Ohio Dog and Cat Food Manufacturing, Other Animal Food Manufacturing, and Total Manufacturing Employment Growth, 2007-2015



Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics

Table 2 reveals payroll earnings of the workers in these industries. The average (mean) wages must be interpreted with caution. For statistical reasons, average wages usually overstate the earnings of the typical worker, and do so by differing degrees. A different measure of the average wage, the median, is a far better reflection of workers' wages. This is the wage that is at the midpoint of the wage distribution, so that 50 percent of workers in the industry earn less and 50 percent earn more. The median wage is unavailable in this data set, however. The \$35,157 average wage of veterinary services and the \$40,408 average wage

of the combined veterinary and auxiliary industries are both less than the average Ohio wage and less than the corresponding national average wage of these industries. The inflation-adjusted total wage growth of veterinary services between 2007 and 2015 is seven times total Ohio wage growth, and the combined average of veterinary and auxiliary industries is more than eight times the all-industry average. **Thus, in a small way, the veterinary services and auxiliary industries are improving Ohio wage growth just as they are improving Ohio employment growth.**

Table 2: Wages in Veterinary and Animal-Related Industries

NAICS code and industry	Ohio total wage, 2015 (\$)	Average wage, 2015		Total wage change 2007-2015*	
		Ohio	U.S.	Ohio	U.S.
541940 Veterinary services	\$438,097,000	\$35,157	\$36,434	25.7%	26.7%
Auxiliary industries					
112 Animal production and aquaculture	196,821,000	35,482	35,509	61.9%	27.8%
115210 Support activities for animal production (incl. equine boarding)	34,615,000	39,651	34,774	36.2%	6.5%
311111 Dog and cat food manufacturing	91,199,000	79,859	66,332	-1.7%	34.1%
311119 Other animal food manufacturing	94,938,000	58,895	56,899	27.2%	22.9%
325412 Pharmaceutical preparation manufacturing (including veterinary medical preparations mfg.)	360,735,000	79,615	131,314	12.1%	4.4%
339112 Surgical and medical instrument manufacturing (including veterinarians' instruments)	125,480,000	58,066	83,767	8.3%	19.8%
423490 Other professional equipment merchant wholesalers (including veterinarians' equipment)	34,994,000	38,455	75,959	-63.6%	0.0%
424210 Druggists' goods merchant wholesalers (including veterinary medicines)	619,605,000	91,658	111,954	-28.6%	6.0%
424910 Farm supplies merchant wholesalers	179,485,000	52,313	57,579	21.9%	21.9%
453910 Pet and pet supplies stores	83,793,000	18,767	22,405	-0.3%	18.5%
541711 Research and development in biotechnology	334,894,000	99,909	160,720	52.2%	63.0%
711212 Racetracks	22,996,000	18,772	31,353	-25.4%	-18.2%
712130 Zoos and botanical gardens	67,836,000	27,059	31,483	39.5%	25.7%
812910 Pet care, except veterinary services	64,521,000	20,106	20,204	109.5%	84.5%
Total auxiliary industries	\$2,311,912,000	\$55,408	\$78,509	1.5%	20.3%
Veterinary services plus auxiliary industries	\$2,750,009,000	\$50,751	\$70,438	4.7%	20.9%
Excluding 325412, 339112, 423490, and 424210					
Auxiliary industries	\$1,171,098,000	\$42,799	\$58,447	33.7%	40.6%
Veterinary services plus auxiliary industries	\$1,609,195,000	\$40,408	\$52,348	31.4%	37.7%
Total Ohio payroll	\$247,893,602,000	\$47,824	\$52,943	3.7%	8.8%

*Adjusted for inflation

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics

Table 3 displays the number and percentage growth of establishments in veterinary services and animal-related industries. According to the Bureau of Labor Statistics (BLS): “An establishment is an economic unit, such as a factory, mine, store, or office that produces goods or services. It generally is at a single location and is engaged predominantly in one type of economic activity.” A firm with three locations is a single “enterprise” but three establishments. The establishment is the unit by which BLS measures activity; the industry in which the establishment’s employment is classified is based on the primary activity

within the establishment. Thus, a pet food manufacturer with a factory and a separate research laboratory would be classified both in dog and cat food manufacturing and in research and development in biotechnology. If, however, the lab is inside of the factory, all employment in the facility is classified in manufacturing.

³ United States Bureau of Labor Statistics. Chapter 2: Employment, Hours, and Earnings from the Establishment Survey, in Handbook of Methods, p. 1.

Retrieved from <https://www.bls.gov/opub/hom/pdf/homch2.pdf>

Table 3: Establishments in Veterinary and Animal-Related Industries

NAICS code and industry	Ohio establishments, 2015	Change, 2007-2015	
		Ohio	U.S.
541940 Veterinary services	1,073	4.6%	11.0%
Auxiliary industries			
112 Animal production and aquaculture	478	28.5%	11.6%
115210 Support activities for animal production (including equine boarding)	126	27.3%	8.5%
311111 Dog and cat food manufacturing	12	0.0%	49.5%
311119 Other animal food manufacturing	70	4.5%	-0.7%
325412 Pharmaceutical preparation manufacturing (including veterinary medical preparations mfg.)	39	44.4%	38.5%
339112 Surgical and medical instrument manufacturing (including veterinarians’ instruments)	33	-13.2%	47.5%
423490 Other professional equipment merchant wholesalers (including veterinarians’ equipment)	67	-40.7%	1.1%
424210 Druggists’ goods merchant wholesalers (including veterinary medicines)	375	-7.9%	15.0%
424910 Farm supplies merchant wholesalers	360	-2.7%	-2.1%
453910 Pet and pet supplies stores	336	-2.6%	7.1%
541711 Research and development in biotechnology	199	15.0%	57.2%
711212 Racetracks	35	-25.5%	-17.5%
712130 Zoos and botanical gardens	24	14.3%	13.1%
812910 Pet care, except veterinary services	561	30.2%	47.3%
Total auxiliary industries	2,715	7.7%	17.1%
Veterinary services plus auxiliary industries	3,788	6.8%	15.6%
Excluding 325412, 339112, 423490, and 424210			
Auxiliary industries	2,201	13.6%	17.0%
Veterinary services plus auxiliary industries	3,274	10.5%	15.3%
Total Ohio payroll employment	290,876	-0.8%	6.1%

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics

As is true of employment and wages, net establishment growth in veterinary services and animal-related industries is greater than average, both in Ohio and nationwide.

Employment growth exceeded establishment growth, meaning that establishments were generally larger in 2015 than in 2007. Table 4 documents these differences for the state and the U.S. by showing average (mean) establishment

sizes in 2007 and 2015. The earlier caution applies: the mean likely overstates the size of the typical establishment. **Note, however, that the average size of Ohio veterinary services establishments increased from 10.9 to 12, larger than the national average.** Noteworthy increases in size were also seen in animal-producing farms, research and development in biotechnology, and zoos.

Table 4: Average Establishment Size in Veterinary and Animal-Related Industries

NAICS code and industry	Ohio		United States	
	2007	2015	2007	2015
541940 Veterinary services	10.9	12.0	10.7	11.3
Auxiliary industries				
112 Animal production and aquaculture	10.9	12.2	10.1	10.3
115210 Support activities for animal production (including equine boarding)	7.6	7.6	5.6	5.3
311111 Dog and cat food manufacturing	102.5	92.2	57.9	48.5
311119 Other animal food manufacturing	23.7	24.9	18.9	19.8
325412 Pharmaceutical preparation manufacturing (including veterinary medical preparations mfg.)	165.9	111.5	143.2	91.4
339112 Surgical and medical instrument manufacturing (including veterinarians' instruments)	51.9	64.5	80.6	58.7
423490 Other professional equipment merchant wholesalers (including veterinarians' equipment)	11.2	10.3	8.9	9.2
424210 Druggists' goods merchant wholesalers (including veterinary medicines)	23.4	18.9	19.3	15.8
424910 Farm supplies merchant wholesalers	8.7	9.6	9.6	10.4
453910 Pet and pet supplies stores	13.3	13.1	11.4	12.4
541711 Research and development in biotechnology	15.6	18.2	28.0	20.8
711212 Racetracks	34.4	30.4	43.8	38.8
712130 Zoos and botanical gardens	74.5	111.4	49.7	55.0
812910 Pet care, except veterinary services	4.5	6.4	5.0	6.0
Total auxiliary industries	16.1	15.7	16.2	14.8
Veterinary services plus auxiliary industries	14.6	14.7	14.9	14.0
Excluding 325412, 339112, 423490, and 424210				
Auxiliary industries	12.0	12.9	11.7	11.5
Veterinary services plus auxiliary industries	11.6	12.6	11.4	11.5
All establishments	18.1	18.1	15.1	14.6

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics

II. Veterinary and Animal-Related Economic and Employment Trends

B. Occupations

As discussed earlier, Ohio employment is measured by occupation as well as by industry, allowing the same analysis of employment and wage changes as presented above for industries. Unlike the industry statistics, however, these occupational statistics are based on a limited sample and include nearly 800 individual occupations. For this reason, employment levels and wages are reported with a margin of error, which in some cases is considerable. Occupations are defined and classified by the Standard Occupational Classification (SOC) system, a scheme analogous to NAICS.

Newly-released statistics for May 2016 allow a fairly current analysis of employment, wages, and salaries by occupation. Table 5 shows 2016 payroll employment of the relevant veterinary and animal care occupations. These are grouped into two categories: primary occupations, which are directly associated with veterinary services and animal science activities, and secondary occupations, which provide less-direct animal care and support. The table also shows the range within which the true employment level is likely to fall (with a 90 percent likelihood) and changes from May 2007, before the recession.

Table 5: Payroll Employment in Veterinary and Animal-Related Occupations

Occupation	Employment, 5/2016		Change, 5/2007-5/2016	
	Est.	Range*	Ohio	U.S.
Primary occupations				
29-1131 Veterinarians	2,910	2,470-3,350	75.3%	25.0%
29-2056 Veterinary technologists and technicians	3,370	2,710-4,030	32.7%	25.5%
31-9096 Veterinary assistants and laboratory animal caretakers	2,750	2,180-3,320	23.3%	12.1%
25-1071 Health specialties teachers, postsecondary (incl. Veterinary medicine teachers, postsecondary)	8,640	4,400-12,890	33.5%	40.3%
19-1011 Animal scientists	70	50-90	n/a	12.8%
19-1023 Zoologists and wildlife biologists	160	130-190	n/a	1.5%
Secondary occupations				
39-2011 Animal trainers	350	310-390	218.2%	34.8%
39-2021 Non-farm animal caretakers	6,660	6,350-6,970	52.4%	41.0%
45-2093 Farmworkers, farm, ranch, and aquacultural animals	990	920-1,060	n/a	1.9%
45-2021 Animal breeders**	50	40-60	-93.2%	-25.3%

*90 percent confidence level. **2016 data not reported; levels and changes use 2015 data.

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics

It is important to note that these estimates, like the industry estimates, refer to payroll employment only and do not include business owners. **This is especially important when considering the number of veterinarians because, as discussed later in this section, 16.2 percent of veterinarians nationally are self-employed. This is a much higher self-employment percentage than that of the typical occupation.** The 2,910 estimate for veterinarians does not include these self-employed individuals. According to Jack Advent, executive director of the Ohio Veterinary Medical Association, the Ohio Veterinary Medical Licensing Board reported 4,135 veterinarians and 3,782 registered veterinary technicians with an Ohio license in testimony this spring. However, some veterinarians holding Ohio licenses are located outside of Ohio – mostly in adjacent states

– but occasionally treat animals in Ohio. Advent believes that these non-Ohio veterinarians licensed by the state are around 20 percent of the total. **Thus, the total number of Ohio veterinarians is around 3,300.**⁴ It is much less common for veterinary technicians to be licensed outside their home state, so the actual total is much closer to the 3,782 who are registered.⁵ (Note that 3,782 is within the margin of error in Table 5.)

⁴ Assuming that the 16.2 percent national proportion of self-employed veterinarians also applies in Ohio, adding these to the payroll total gives a point estimate of approximately 3,470 with an approximate range between 2,950 and 4,000. This is consistent with the 3,300 estimate in the text.

⁵ Email from Jack Advent, executive director, Ohio Veterinary Medical Association, June 26, 2017.

Median annual Ohio and U.S. wages and salaries for these occupations are reported in Table 6. As discussed above, the median is the preferable statistic because it represents the wage of the typical worker. As in the case of employment, wages are reported with error so 90-percent ranges are also reported. In cases in which the ranges overlap, we cannot be confident that the Ohio wage is actually different from the national average. Ohio wages of veterinary assistants, zoologists, animal trainers, and non-farm animal caretakers are significantly less than the national average; those of animal breeders are significantly greater. Again, however, these estimates refer to payroll earnings

(wages and salaries) and do not include self-employment income. Jack Advent believes that the veterinarian salary figure is understated even for payroll employment: "...most recent graduates who enter practice are making around \$73,000. Associates with five or more years' experience are around \$85,000. A number of practices are going to a base salary plus a percentage of production. The overall average figure that is reported for veterinarians across the US, though it is now five-year-old data, is just over \$91,000. Practice owners should be making well above that when sources of business income are included outside the base salary they pay themselves."

Table 6: Wages and Salaries in Veterinary and Animal-Related Occupations, May 2016

Occupation	Ohio		United States	
	Est.	Range*	Est.	Range*
Primary occupations				
29-1131 Veterinarians	86,430	72,680-90,720	88,770	87,210-90,330
29-2056 Veterinary technologists and technicians	31,630	28,580-33,880	32,490	32,180-32,800
31-9096 Veterinary assistants and laboratory animal caretakers	23,650	21,850-23,520	25,250	24,970-25,530
25-1071 Health specialties teachers, postsecondary (including Veterinary medicine teachers, postsecondary)	77,960	66,490-95,210	99,360	96,180-102,540
19-1011 Animal scientists	59,590	58,030-67,030	60,330	56,760-63,900
19-1023 Zoologists and wildlife biologists	57,690	55,610-58,350	60,520	59,840-61,200
Secondary occupations				
39-2011 Animal trainers	22,230	17,990-24,430	27,690	26,670-28,710
39-2021 Non-farm animal caretakers	19,770	18,750-19,930	21,990	21,810-22,170
45-2093 Farmworkers, farm, ranch, and aquacultural animals	25,130	21,860-23,980	24,520	24,290-24,760
45-2021 Animal breeders**	50,534	44,470-55,510	35,690	32,270-39,120

*90 percent confidence level. **2016 data not reported; levels and changes use 2015 data (inflated to 2016 dollars).

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics

The Ohio Veterinary Medical Association periodically collects data from its members regarding the focus of their practice. Table 7 applies the percentages reported by the survey to the estimate of 3,300 Ohio veterinarians derived from state registrations. As shown, the majority of veterinarians concentrate on pets or companion animals (dogs/cats). Some veterinarians treat a variety of species (mixed) and others practice predominately on horses or food/farm animals.

Table 7: Practice Discipline of Veterinarians in Ohio

Practice discipline	Survey percentage	Inferred number of veterinarians
Pet animal	56%	1,848
Mixed animal	12%	396
Equine	2%	66
Food animal	2%	66
Academic	2%	66
Animal shelter	1%	33
Government/military	1%	33
Corporate	1%	33
Research	1%	33
Not reported	22%	726
Total	100%	3,300

Source: Ohio Veterinary Medical Association member survey; totals calculated from Occupational Employment Statistics, U.S. Bureau of Labor Statistics.

C. Industries Employing Veterinary and Animal-Related Occupations

National-level statistics from the BLS provide estimates of the number of individuals in each occupation employed within individual industries, as well as the industries employing those in specific occupations, and the number employed. These can be used to estimate the number of workers for three of the veterinary and animal-related industries in Ohio in 2015 by localizing them based on the total state employment in the industry from Table 1.

This requires the assumption that the employment patterns of these industries within Ohio are equivalent to those elsewhere. This assumption is not entirely correct. Differences in the size distribution of Ohio businesses versus those nationally could give rise to differences in the occupational distribution of industry employment in Ohio, as could differences in the makeup of customers – the share of large-animal veterinarians in Ohio, for example. Differences in the distribution of workers among individual industries will certainly vary based on differences in the industry makeup of the Ohio economy. Still, the relationship between industry employment and occupational employment is useful in suggesting the range of occupations needed by the animal-related industries and the industries within which veterinary and animal-related workers can find employment.

The industry-occupation database provides occupational employment estimates for four of the industries in Table 1: veterinary services, animal production and aquaculture, dog and cat food manufacturing, and other animal food manufacturing. (These last two are combined into a single industry, animal food manufacturing.) The estimates of the number of Ohio workers in these industries are presented in Tables A-1 through A-3 in the Appendix. As Table A-1 reveals, nearly half of the payroll employment in animal production consists of farmworkers. However, the total estimate of 2,700 farmworkers is far greater than the estimated total of 1,110 farmworkers in Ohio in 2015. The 1,110 workers also include those working in crop production, so the implication is that the employment of other occupations in this industry is likely underestimated. In any event, animal breeders, animal trainers, and veterinarians are also represented among the industries employed by these farming operations.

Employment in animal food manufacturing is focused on production-oriented occupations, with food scientists and technologists and agricultural and food science technicians – presumably with training in animal nutrition – accounting for approximately 40 positions, or 1.3 percent of the total industry employment. This may not include all the animal science-related support required by this industry, however. Some work may be performed by outside academic and non-academic research facilities on a contract basis. For example, researchers at The Ohio State University’s College of Veterinary Medicine developed the first feline leukemia vaccine. The vaccine was licensed to Zoetis (formally Pfizer) and is now used worldwide. Battelle in Columbus has a practice area dedicated to the study of animal metabolism and other animal-related research activities. The use of these services by private industry mitigates the need to employ scientists directly.

Table A-3 dramatizes the importance of support positions in veterinary offices: veterinarians comprise less than 20 percent of the employment in these offices, while veterinary technologists and assistants and non-farm animal caretakers account for more than half. The remaining 30 percent of employment is composed primarily of administrative and clerical support occupations.

Appendix Tables A-4 through A-7 provide national-level estimates of employment by industry for four veterinary and animal-related occupations: veterinarians, veterinary technologists and technicians, veterinary assistants and laboratory animal caretakers, and non-farm animal caretakers. These estimates cannot be as easily localized to Ohio as those for occupations within industries. In addition to the potential problem of industries in which the employment distribution differs from the national average, there is a much greater problem of industries with greater or less concentration in Ohio than average. If an industry has greater-than-average employment in Ohio, such as animal food manufacturing or zoos and botanical gardens, that industry should also account for a greater-than-average share of total employment within the relevant industries. Still, the national-level employment shares provide a general sense of the industries within which Ohio workers are employed.

Table A-4 shows that **90 percent of veterinarians are either employed in veterinary offices or are self-employed.** While some of these self-employed individuals may be consultants, the vast majority are likely owners of their own practice. **The 16.2 percent of veterinarians who are self-employed is a far greater share than the 6.2 percent of all workers who are self-employed.** This implies that a veterinary career offers a significant opportunity for business development and entrepreneurship. Those pursuing this career would therefore be well-served to develop the skills needed to start and operate a business. Recognizing this need, the College of Veterinary Medicine recently launched a graduate business minor in cooperation with the Fisher College of Business. Other veterinarians are employed primarily by federal and state governments, social advocacy organizations (such as animal welfare organizations), and public and private colleges and universities.

According to Table A-5, more than 90 percent of veterinary technologists and technicians nationwide are employed in veterinary offices. Colleges and universities employ 3.3 percent, social advocacy organizations employ 1.6 percent and research and development enterprises employ 1.0 percent. The employment pattern of veterinary assistants, shown in Table A-6, is roughly similar, with a somewhat larger percentage of workers employed by postsecondary institutions and research organizations.

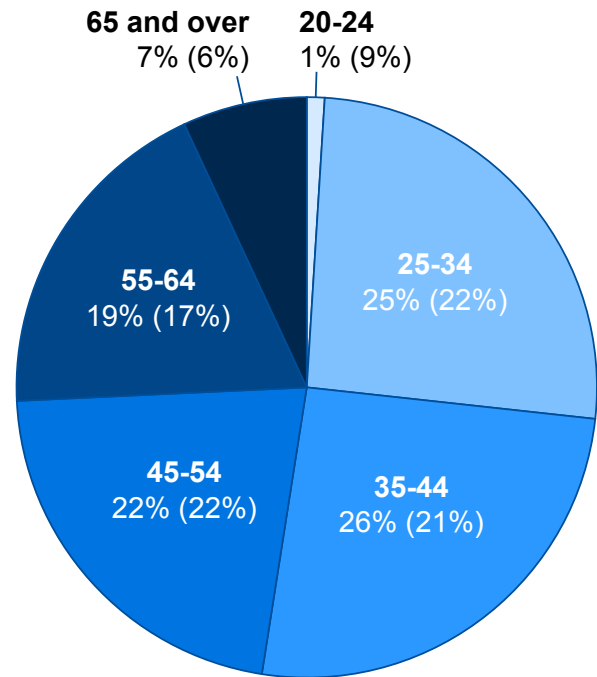
The employment of non-farm animal caretakers is more dispersed among industries than the other occupations, with the share of self-employed workers (19.1 percent) even higher than among veterinarians. One-third of these workers nationwide are employed in the other personal services industry, which includes the non-veterinary pet care services included in Table 1 – services such as animal grooming, animal shelters, and pet boarding. Other miscellaneous store retailers (pet stores) account for 13.9 percent of these jobs, with veterinary services employing 12.8 percent.

D. Age Distribution of Veterinarians

The increasing age of the workforce is a growing concern among employers and workforce professionals. The aging Baby Boomers are retiring in large numbers and younger workers are not entering the workforce in sufficient numbers to replace them. Not reflected in the statistics is the talent and experience that these retiring workers are taking with them.

The age distribution of veterinarians in Ohio is not available, but it is at the national level. This distribution is shown in Figure 5. The share of all workers in the specific age group is shown in parentheses. The Ohio distribution, if it were available, might show an even larger share in older age groups: the median age of the Ohio population is 39.3 versus the 37.8 U.S. average. Primarily because veterinarians start their careers later than those in many professions, veterinarians are typically older than average: the median age of veterinarians is 44.2, compared to 42.2 for the entire workforce. However, the share of veterinarians in the prime working years of 25 through 54 is 73 percent versus 65 percent for all workers. Applying the percentages to the 3,300 employed veterinarians in Ohio, around 860 of these are 55 years or older and 230 are 65 or older. Many of these are likely to retire within the next 15 to 20 years.

Figure 5: Age Distribution of Employed Veterinarians, United States, 2016



Percentage of all workers by age in parentheses. Chart omits the 16-19 age group (0% of veterinarians, 3% of all workers).

Source: Labor Force Statistics from the Current Population Survey, U.S. Bureau of Labor Statistics.

III. Spatial Characteristics of Veterinary Medicine and Animal Ownership

The number and growth of veterinary services practices and their employment varies widely across the state. However, there is at least one veterinary office in 85 of Ohio’s 88 counties. Appendix Table A-8 provides county-level employment totals in these practices (i.e., veterinarians and staff) in 2007 and 2015, the net change in employment, and the number of establishments in each of the two years.

These totals are obtained from a source different from that used in Tables 2 and 3: County Business Patterns (CBP) from the U.S. Census Bureau. As discussed earlier, unlike the annual totals in Tables 2 and 3, CBP statistics are available only for mid-March. There can be differences in the classification of individual businesses as well, creating differences between the two sources in reported employment totals apart from the timing differences. But CBP has a significant advantage in county-level analysis: it permits unreported values to be estimated. In order to maintain confidentiality of the employment and wages of individual businesses, all government data sources suppress industry totals when there are few establishments in the industry or one particularly large firm – in either the industry in question or a related industry. This is rarely a problem in statistics for a state the size of Ohio, but county-level totals are regularly suppressed, particularly for smaller counties.

However, CBP also includes counts of establishments by size, even when the employment total is suppressed. If an industry consists of three establishments with between five and nine employees, it can be assumed that each establishment has seven employees (the midpoint of the employment range). Estimated employment for the industry is thus 21.

While county-level analyses can be worthwhile, it is often preferable to examine trends in a broader regional context. This is especially important in the analysis of the availability of veterinary services considered later in this section. While there may be no veterinary offices in a specific county, those in adjoining counties may (or may not) adequately meet the needs of both the county without offices and their home county. Figure 6 proposes a regional grouping of Ohio’s counties. These 13 regions consist of the state’s six largest MSAs – Akron, Cincinnati, Cleveland, Columbus, Dayton, and Toledo – and seven other regions including smaller MSAs and rural counties. These counties were grouped together based on economic commonality, primarily in agriculture and manufacturing. These regions are regularly used in the bimonthly *On the Money* articles on the Ohio economy for Hannah News Service.

Figure 6: Ohio Regions

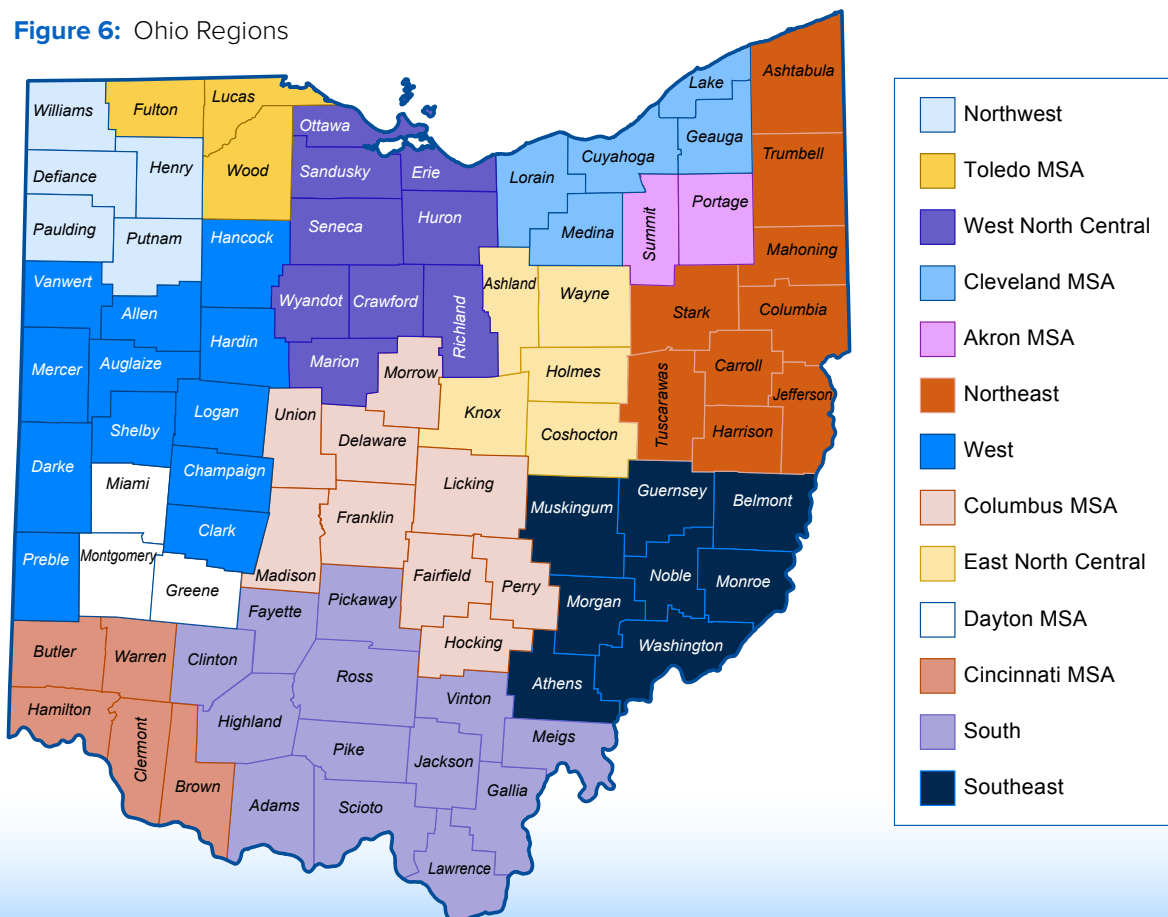


Table 8 shows the veterinary services employment and establishment data for these 13 regions. As is true of the state, employment in most regions was higher in 2015 than in 2007. The South region enjoyed the strongest net growth with a gain of 37 percent; the Akron MSA gained 34 percent and the Columbus MSA gained 31 percent. However, employment in the Dayton MSA increased only marginally, while veterinary services employment in the Southeast declined by nearly 24 percent.

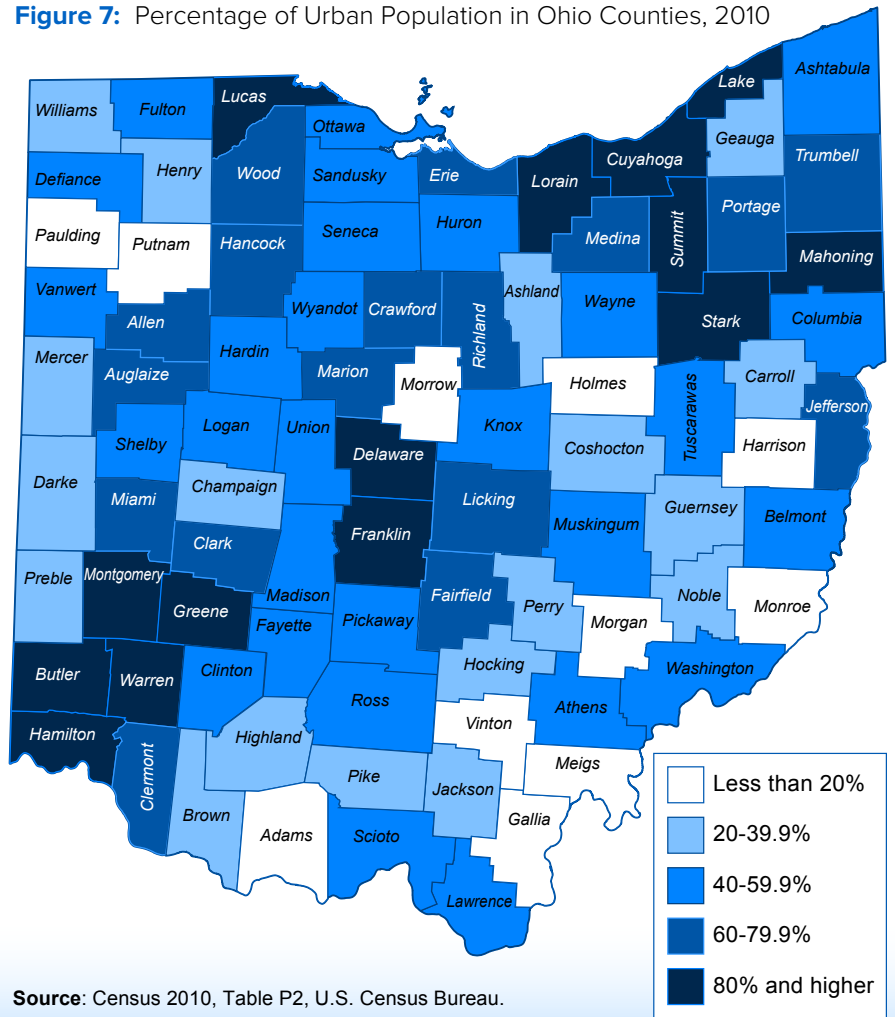
Population density also varies widely across Ohio. This is an important issue for veterinary service demand because higher concentrations of population lead to more pets and higher demand for companion animal veterinary services. The Census Bureau classifies areas as urban or rural based on the density of development, both residential and non-residential. These areas are built up from census blocks (which in an urban area correspond to city blocks) and do not correspond to corporation limits. A developed area with a population of at least 50,000 is called an “urbanized area,” and one with a population between 2,500 and 50,000 is called an “urban cluster.” Population, housing, and territory outside of urbanized areas and urban clusters are classified as rural. Figure 7 maps the percentage of each county’s population in urbanized areas and urban clusters. Ohio is a fairly urbanized state, with urban population accounting for at least half the total in 45 of the 88 counties.

Table 8: Veterinary Services Employment Growth and Establishment Counts by Region, 2007 and 2015

County	Employment			# of establishments	
	2007	2015	Net change	2007	2015
Akron	773	1,036	34.0%	71	77
Cincinnati	1,775	2,028	14.3%	156	172
Cleveland	2,000	2,087	4.4%	185	177
Columbus	2,606	3,411	30.9%	195	200
Dayton	796	800	0.5%	58	63
Toledo	545	675	23.9%	47	49
Northeast	954	1,068	11.9%	113	117
Southeast	397	303	-23.7%	34	30
South	271	372	37.3%	36	37
West	539	657	21.9%	73	74
Northwest	113	138	22.1%	15	16
W North Central	415	438	5.5%	59	58
E North Central	338	413	22.2%	41	40

Source: County Business Patterns, U.S. Census Bureau

Figure 7: Percentage of Urban Population in Ohio Counties, 2010



Source: Census 2010, Table P2, U.S. Census Bureau.

Statewide farm animal totals from the past three agricultural censuses are shown in Table 9. The number of cattle has declined slightly over the past decade as the number of hogs and broiler chickens has increased. Summarized livestock counts by county are shown in Appendix Table A-9. Confidentiality requirements apply to livestock counts as they do to employment totals, so some county counts are suppressed. Particularly worth noting is the high concentration of chickens in very few counties. Holmes, Stark, and Wayne Counties account for 73 percent of all broiler chickens statewide, while 59 percent of all layers are in Darke and Mercer Counties. It is noteworthy that Ohio ranks second among all states in egg production.

With these county data in hand, it is possible to compare the number of livestock to the employment in veterinary services. As discussed above, veterinarians can and do treat patients outside of their home county, so it is more meaningful to make this comparison on the basis of the regions specified above than at the county level. This is shown in Table 10. The total livestock counts omit poultry because of the large number of suppressed counts. One-quarter of the statewide total is unreported at the county level, and including the poultry counts that are reported would distort the comparisons. Aside from this omission, there are weaknesses in this analysis. First, the regions specified in Figure 6 may not fairly represent the service area of veterinary practices. The ratios for the MSAs are high because of the relatively small number of farm animals and the large number of veterinary employees. Conversely, the veterinary coverage in the heavily-farmed West and Northwest is quite low. But it is likely that many of the veterinary practices in MSAs are focused on companion animals, while those in the West and Northwest regions may include a focus on farm animals. If this distinction could be incorporated in the analysis, the contrast would likely be less stark. That said, the analysis here can provide guidance to those wishing to focus their practice on one type of animal or the other.

Table 9: Farm Animal Population, Ohio Totals, 2002-2012

Breed	Total			Change	
	2002	2007	2012	2002-2012	2007-2012
Cattle excluding cows	718,151	706,707	696,487	-3.0%	-1.4%
Cows	522,461	565,695	545,806	4.5%	-3.5%
Goats	45,061	69,505	51,558	14.4%	-25.8%
Hogs	1,422,966	1,831,084	2,058,503	44.7%	12.4%
Sheep and lambs	149,936	123,161	111,972	-25.3%	-9.1%
Chickens: broilers	5,878,909	10,021,948	12,194,024	107.4%	21.7%
Chickens: layers	30,759,965	27,070,109	28,312,692	-8.0%	4.6%
Geese	4,409	4,215	2,757	-37.5%	-34.6%
Roosters	n/a	n/a	43,609	n/a	n/a
Turkeys	1,873,917	2,074,750	2,096,395	11.9%	1.0%
Equine	134,368	119,198	114,127	-15.1%	-4.3%

n/a = Not available.

Source: Agricultural Census, U.S. Department of Agriculture.

Table 10: Regional Veterinary Services Employment per 10,000 Farm Animals, 2012

Region	Farm animals*	Veterinary services employment	Employees per 10,000 farm animals
Akron	11,057	856	774.2
Cincinnati	60,283	1,936	321.2
Cleveland	56,523	2,029	359.0
Columbus	329,292	2,549	77.4
Dayton	54,865	850	154.9
Toledo	83,804	572	68.3
Northeast	183,554	1,032	56.2
Southeast	163,378	263	16.1
South	191,427	333	17.4
West	1,224,924	652	5.3
Northwest	291,125	133	4.6
W North Central	392,536	439	11.2
E North Central	413,609	396	9.6

*Excluding poultry; see text.

Source: 2012 Agricultural Census, U.S. Department of Agriculture; County Business Patterns, 2012, U.S. Census Bureau.

It is not possible to undertake this same depth of analysis on companion animals because counts of these animals and the number of owning households are only available at the national level. The number of pets in Ohio can be roughly inferred based on these national statistics and the total number of households nationwide and in Ohio. However, pet ownership rates are likely to vary based on demographics, income, and the rate of homeownership (many landlords prohibit pets). Demographic characteristics vary significantly across Ohio, and so may the rate of pet ownership.

Consequently, these state-level estimates are themselves rough and should not be brought down to the regional or county level. Pet ownership and population estimates are presented in Table 11 on the next page. These estimates suggest that there may be nearly 10 million companion animals in Ohio. (Household counts are not totaled because some households own more than one type of pet.) Note that the horse and livestock ownership statistics here are not double-counting those in Table 9 because these animals are owned by households rather than farms.

Table 11: Companion Animal Ownership and Population, U.S. and Ohio, 2012 (Totals in Thousands)

Animal	United States			Ohio	
	Total/owning households	Average number per household	Animal population	Total/owning households	Animal population
Total households	115,970			4,555	
Pet ownership					
Dogs	43,346	1.61	69,926	1,702	2,746
Cats	36,117	2.05	74,059	1,418	2,909
Birds	3,671	2.26	8,300	144	326
Horses	1,780	2.73	4,856	70	191
Fish	7,738	7.46	57,750	304	2,268
Ferrets	334	2.24	748	13	29
Rabbits	1,408	2.28	3,210	55	126
Hamsters	877	1.31	1,146	34	45
Guinea pigs	847	1.61	1,362	33	53
Gerbils	234	2.00	468	9	18
Other rodents	391	2.22	868	15	34
Turtles	1,320	1.74	2,297	52	90
Snakes	555	2.07	1,150	22	45
Lizards	726	1.54	1,119	29	44
Other reptiles	365	2.01	732	14	29
Poultry	1,020	12.34	12,591	40	495
Livestock	661	7.63	5,045	26	198
All others	246	3.65	898	10	35
Totals	---	---	246,525	---	9,682

Source: U.S. Pet Ownership Statistics, American Veterinary Medical Association; American Community Survey, One-Year Estimates, 2012, U.S. Census Bureau.

The national pet ownership statistics also provide the average number of veterinary visits per year for dogs, cats, birds, and horses. Again assuming that Ohio is comparable to the U.S., the total number of visits to treat these animals can be estimated. As shown in Table 12, owners of these pets generate about 7 million veterinary visits per year.

Although the pet population is unavailable at the county level, the number of households can be used to approximate the market for veterinary services. Table 13 relates the number of households to veterinary services employment for the 13 regions. The small MSA and rural regions are generally less well-served by veterinarians than are the large MSAs, although the employee-household ratios in Cleveland and Dayton are lower than those in the other MSAs. The West region's ratio is highest among the rural regions, but recall that this region's population of farm animals is particularly large. The two best-served regions are the Columbus MSA and East North Central Ohio.

Table 12: Estimated Annual Veterinary Visits for Companion Animals, Ohio

	Dogs	Cats	Birds	Horses	Total
Visits per household per year, U.S.	2.6	1.6	0.3	1.9	
Inferred total visits, Ohio (thousands)	4,426	2,270	43	362	7,101

Source: Calculated from U.S. Pet Ownership Statistics, American Veterinary Medical Association.

Table 13: Veterinary Services Employment per 10,000 Households

Region	Households	Veterinary services employment	Employees per 10,000 households
Akron	281,957	1,036	36.7
Cincinnati	636,201	2,028	31.9
Cleveland	847,608	2,087	24.6
Columbus	756,520	3,411	45.1
Dayton	328,004	800	24.4
Toledo	243,939	675	27.7
Northeast	497,894	1,068	21.5
Southeast	142,366	303	21.3
South	186,558	372	19.9
West	260,933	657	25.2
Northwest	73,490	138	18.8
W North Central	216,498	438	20.2
E North Central	113,116	413	36.5

*Excluding poultry; see text.

Source: 2012 Agricultural Census, U.S. Department of Agriculture; County Business Patterns, 2012, U.S. Census Bureau.

IV. Veterinary and Animal Care Education in Ohio

High-quality educational offerings are required to keep the veterinary and animal care workforce pipeline well stocked and prepared for continuing growth needs. A student's path to a veterinary career in Ohio often begins in elementary school. Surveys have shown that many veterinary students first considered becoming a veterinarian when they were six to eight years of age. This interest can be satisfied more formally when the student reaches high school. There are

86 career and technical education centers throughout the state, serving primarily high school students. Of these, 28 offer coursework in animal science or animal care, including five offering a specific program in equine science. Two other centers offer at least one animal science course as part of a larger agricultural career program. These programs are listed in Table 14.

Table 14: Animal-Related Programs in Ohio High School Career Centers

School	County	Course(s), no program	Program		
			Animal/vet. sci.	Equine science	Animal Care
Ashland County-West Holmes Career Center	Ashland		X		
Ashtabula County Technical and Career Center	Ashtabula				X
Butler Technology & Career Development Schools	Butler		X	X	
Springfield-Clark Career Technology Center	Clark		X		
Grant Career Center	Clermont		X	X	
Columbiana County Career and Technical Center	Columbiana		X		
Academies of Cleveland	Cuyahoga		X		
Delaware Area Career Center	Delaware		X	X	
Four County Career Center	Fulton				
Greene County Career Center	Greene		X		
Great Oaks Career Campuses	Hamilton		X		
Millstream Career Center (Findlay City Schools)	Hancock		X	X	
Collins Career Technical Center	Lawrence	X			
Ohio Hi-Point Career Center	Logan		X		
Toledo Public Schools	Lucas		X		
Tolles Career and Technical Center	Madison		X		
Tri-Rivers Career Center	Marion		X		
Medina County Career Center	Medina		X		
Tri Star Career Compact	Mercer		X		
Mid-East Career and Technology Centers	Muskingum				X
Maplewood Career Center	Portage		X		
Pioneer Career and Technology Center	Richland		X		
Vanguard-Sentinel Career and Technical Centers	Sandusky	X			
South Stark Career Academy	Stark				X
R.G. Drage Career Center	Stark		X		
Akron Public Schools	Summit				X
Trumbull Career & Technical Center	Trumbull		X	X	
Warren County Career Center	Warren		X		
Wayne County Schools Career Center	Wayne				X

Source: Individual school websites.

At least 27 two-year and four-year colleges and universities in Ohio offer veterinary and animal-related programs and/or certificates, including 20 four-year pre-veterinary programs. These are listed in Table 15.

Table 15: Animal-Related Programs in Ohio Two-Year and Four-Year Colleges and Universities

Institution	Pre-vet track/ program	Animal science	Vet assistant	Vet technology	Equine vet tech
Ashland University	X				
Belmont College	X				
Bowling Green State University	X				
Capital University	X				
Clark State Community College			X		
Cleveland State University	X		X		
Columbus State Community College				X	
Cuyahoga Community College				X	
Hocking College					X
Kent State University				X	
Malone University	X				
Miami University	X				
Muskingum University	X				
The Ohio State University	X	X		X	
Ohio University	X				
Otterbein University	X				X
Rio Grande Community College	X				
Shawnee State University	X				
Sinclair Community College				X	
University of Akron	X				
University of Cincinnati				X	
University of Findlay	X	X			
University of Mount Union	X				
University of Toledo	X				
Walsh University	X				
Wright State University	X				
Xavier University	X				

Source: Individual institution websites.

The Ohio State University (Ohio State), through the College of Veterinary Medicine, offers the state's only Doctor of Veterinary Medicine (DVM) degree program. In addition, the College of Veterinary Medicine offers master's and doctoral degrees in comparative and veterinary medicine, and a master's program in veterinary public health in collaboration with the College of Public Health. These graduate degree programs can be completed as dual degree programs with the DVM degree. Ohio State also offers a pre-professional track in veterinary medicine and bachelor's and master's programs in animal sciences. Additionally, veterinary students at the Ohio State College of Veterinary Medicine can earn a combined business minor degree in association with the Fisher College of Business, which is designed to help these individuals gain knowledge, experience and skills to be successful practice owners and small business owners.

The Ohio State College of Veterinary Medicine, founded in 1885, is one of only 30 veterinary colleges in the U.S., and one of the oldest and largest. It is the only college of veterinary medicine in Ohio. Its doctoral program has graduated more than 9,100 veterinarians, who practice in all 50 states and 40 countries and account for almost 80 percent of the practicing veterinarians in Ohio. **The veterinary medicine program is ranked fifth among all North American veterinary schools by U.S. News and World Report, the highest-ranked college at Ohio State.**

The Doctor of Veterinary Medicine (DVM) program admits 162 students per year and takes four years to complete.

The College has a robust and respected research program. As noted previously, College researchers developed the first feline leukemia vaccine and developed research-

based technology used in commercial tick-borne disease diagnostics. The College is the lead institution in the interdisciplinary Center for Retrovirus Research. The College is also a leader in the university's Global One Health Initiative and the newly-formed Infectious Disease Institute, including zoonotic diseases (those transmitted from animals to people), antimicrobial resistance, the host response to infectious disease including immunology and microbiome, and much more. The College also plays an integral role through its Comparative and Translational Oncology Program by collaborating with the Ohio State Comprehensive Cancer Center, The James Cancer Hospital, and Nationwide Children's Hospital. Other faculty are leaders in the development of advanced animal orthopedic procedures, regenerative medicine and related areas.

The Veterinary Medical Center (VMC) is one of the largest academic veterinary medical centers in the country, comprised of the Hummel & Trueman Hospital for Companion Animals, the Hospital for Farm Animals, and the Daniel M. Galbreath Equine Trauma, Intensive Care and Research Center, and is the only comprehensive referral veterinary hospital for companion animals, farm animals, and horses in Ohio, Kentucky and West Virginia. The VMC admits more than 35,000 patients annually. Other animal treatment and research facilities include the Large Animal Services Ambulatory Clinic in Marysville (which provides veterinary services to individual and large livestock facilities, including dairies, beef cattle cow-calf operations, feedlots, and much more across 17 counties), and the Alice Lloyd Finley Memorial Veterinary Research Farm in Madison County, which serves as a teaching and research facility.

V. Economic Impact of Veterinary and Animal-Related Industries in Ohio

A. Theory and Derivation of Economic Impacts

It is possible to quantify the impacts on the Ohio economy of the animal-related industries discussed in Section II and at least some of the educational activities in Section IV. Economic impact studies measure the increase in **output** (production and spending) in a specific geographical area (in this case, Ohio) that results from specific economic activities. The specific economic activities of interest are those of veterinary services and auxiliary animal-related industries discussed in Section II and the Ohio State College of Veterinary Medicine, including the VMC. Output is the value of goods and services produced annually in the state. The production of output generates wages, salaries, and self-employment income (earnings) for workers and business owners. The economic impact assessment estimates these earnings as well as the number of jobs that are created or sustained as a result of these activities. The activities of the other veterinary educational programs summarized in Tables 13 and 14 are part of these activities as well, but despite repeated attempts, we were unable to obtain financial information sufficient to derive estimates. In some cases, these programs may be part of larger accounting units and isolating their financial information would be difficult.

The output, earnings, and employment generated by the industries themselves is referred to as **direct** impacts. However, direct impacts are only part of the total economic impact. The suppliers of goods and services to the firms in animal-related industries generate output and increase their own purchases of supplies to accommodate the direct activities, pay wages, and may hire additional workers. These supplier activities are referred to as **indirect** impacts. In addition, direct and indirect business owners earn profits and their employees earn salaries, wages, and tips. These owners and workers use their earnings to purchase household goods of all kinds. To the extent that these payments for purchases and wages and salaries are made to suppliers and employees within Ohio, the region's economic activity and output is increased further. The impact of this household spending is referred to as an **induced** impact. It is important to emphasize that the direct activities cause the indirect and induced activities, which would never have occurred had the direct activities not generated economic activity in the first place. For this reason, the indirect and induced impacts are as much a part of the total economic impact as are the direct impacts. This is the point that makes economic impact analysis legitimate.

The veterinary services industry contributes \$2.4 billion annually to the Ohio economy, including \$1.1 billion from the industry itself and \$1.3 billion from industry suppliers

and employee households. These activities together sustain more than 23,000 Ohio jobs. When considering the veterinary services industry together with the Ohio State College of Veterinary Medicine and other supporting and animal-related industries, there is nearly a \$13 billion annual contribution to the Ohio economy, including \$5.7 billion from the industries themselves and \$7.3 billion from industry suppliers and employee households. These activities together sustain 93,600 Ohio jobs.

Output, earnings, and employment impacts can be estimated by applying an economic impact model to the direct spending increase. Several generally-accepted models are available for this purpose; this analysis uses the Regional Input-Output Modeling System (RIMS II) of the United States Bureau of Economic Analysis. As is the case for the other impact models, RIMS II is based on a framework called an input-output table. For a given industry in a given geographic area, the input-output table shows the increase in purchases from other local firms by industry and the sales to other local firms by industry resulting from a one-dollar increase in the given industry's output. Thus, the input-output table can be used to derive the impact on other local firms of an increase in production within a specific industry.

These impacts are specific both to a given industry and to a given region. The array of suppliers benefiting from the spending of a specific group of industries is generally the same regardless of where the spending occurs. But if the structure of the local economy is such that most purchases must be made from vendors outside the state, then most of the impact will leak from the local economy. In cases where purchases are made from suppliers outside Ohio, the indirect and induced impacts are zero. Conversely, a broad economy with many in-state suppliers keeps more of the impact of the output increase circulating within the economy, and the indirect and induced impacts are greater. Thus, the values within the input-output table are unique both to the specific industries and to Ohio. RIMS II summarizes the information in the regional input-output table by calculating a set of unique impact factors (multipliers) for each of 369 detailed industries within the MSA. Because of their origin in the input-output table, the factors implicitly reflect the structure of the Ohio economy and the presence or absence of suppliers. The RIMS II factors are used in a set of economic impact equations developed by Regionomics.

Employment and earnings for the industries are those shown in Tables 1 and 2. Output is derived by the economic impact model based on the given level of payroll.⁶ Direct

⁶ Because self-employment income is not available, the output estimates are somewhat understated.

output, earnings, and employment are all provided for the College and VMC. Industry indirect and induced impacts were derived by applying the multipliers for the appropriate industry to the direct impacts as given. Rather than using this approach for the College and the VMC – which would have entailed multiplying output by the multipliers for junior colleges, colleges, and universities and veterinary services, respectively – detailed financial information was obtained for both the College and the VMC. Indirect and induced impacts were derived by applying to each expenditure item the multiplier for the industry affected by the expenditure. These line-item impacts are summed to calculate a total. This “bill-of-goods” approach generates more reliable results that are specific to the operations of the College and the VMC. This approach is particularly important for the College of Veterinary Medicine, whose operations and purchase patterns are likely to be significantly different from those of a typical university department.

Employment estimates in an economic impact analysis must be interpreted particularly carefully. First, these are not all full-time jobs. Instead, a RIMS II analysis provides a mix of full-time jobs and part-time jobs (i.e., headcount) that is typical for the industry in question. While it is legitimate to refer to the direct jobs in a new activity as “created,” the same cannot be said for indirect and induced jobs. The implication of an indirect or induced employment impact is that additional activity exists to increase the headcount to the specified extent, but the model cannot determine whether this need is filled by new hiring or by existing workers increasing their hours and/or effort. Therefore, it is more appropriate to refer to these jobs not as created but as sustained. Note, however, that even if no new workers are hired, the income of existing workers should increase. This would give rise to additional induced activity. A final point is that the results of a RIMS II analysis, as is true of any economic impact study, represent only the order of magnitude of the actual impacts and cannot be regarded as precise.

Although the economic impacts presented below are reasonably comprehensive, they are more likely to be understated than overstated. As mentioned above, the impacts do not include those of the veterinary services and animal-related educational programs other than Ohio State. But because these are single programs, often within a larger department, their scale and impacts are far smaller than those of the College of Veterinary Medicine. The impacts also omit broad industries that have a veterinary component. Four of these were discussed earlier: pharmaceutical preparation manufacturing (including veterinary pharmaceuticals); surgical and medical instrument manufacturing (including veterinary instruments); other

professional equipment merchant wholesalers (including veterinary equipment); and druggists’ goods merchant wholesalers (including veterinary medicines). Examples of other omitted activities and industries include:

- Transportation of livestock, which is part of general freight trucking;
- Pet food and supplies sold in supermarkets and discount stores;
- The Ohio Agricultural Council, the Ohio Veterinary Medical Association (OVMA), and meat and livestock development and marketing associations, which are part of an industry including all professional organizations;
- The animal-related work of the Ohio Department of Agriculture and state boards and commissions.

Another impact that is not considered is the visitor spending of out-of-state professionals and scholars who come into the state for conferences, seminars, and meetings with researchers in Ohio. One key example is the Midwest Veterinary Conference hosted by the OVMA. This is the fifth largest veterinary conference in the U.S.

The 2016 conference attracted 6,406 animal care professionals, students, exhibitors and guests. The Greater Columbus Convention Center, five hotels, and the services of various vendors accommodated attendees. Conference revenue totaled \$1,255,000, including \$391,000 from exhibits, \$94,000 in sponsorships and \$770,000 from registration fees. Experience Columbus estimates that the conference brought \$3,102,000 into the central Ohio economy. However, because this analysis is at the state level, relevant expenditures are only those that come in from out of state. In-state versus out-of-state attendance is only tracked for veterinarians. However, there were attendees from 28 states, Canada and the Netherlands. The OVMA estimates that total non-Ohio attendance is approximately 35-40 percent. OVMA’s direct expenditures associated with producing this event were \$562,334 in 2016, not including the indirect costs of allocated payroll or other OVMA operational expenses; the share of these applying to out-of-state attendees would constitute indirect impacts.⁷

The Midwest Veterinary Conference is only a portion of a much larger animal-related visitor impact, however. An even larger animal-focused event is the All-American Quarter Horse Congress has been held annually at the Ohio State Fairgrounds since 1967. The 27-day event, the world’s largest single-breed horse show, also includes lectures, demonstrations, and exhibits. It attracts more than 650,000 people and 6,500 horses to Columbus, and generates \$275 million annually for the central Ohio economy.⁸

⁷ Emails from Jack Advent, Ohio Veterinary Medical Association, March 3, 2017.

⁸ The All-American Quarter Horse Congress, www.quarterhorsecongress.com.

Another equine event, the Equine Affaire, has been hosted annually at the Ohio State Fairgrounds since 1997. This four-day event also attracts enthusiasts from a wide area, and features educational programs, exhibitions, competitions, and a trade show.

The Ohio State Fair and the state's 88 county fairs also allow people to experience and learn about farm animals. The State Fair draws more than 900,000 visitors annually during

its 17-day run. The county fairs, held annually from mid-June through mid-October, are major summertime community events. Many visitors to these fairs are likely in-state residents, so their spending primarily relocates economic impacts rather than creating them. The key value of these fairs is deepening understanding of the importance of animals and Ohio agriculture among people who may never otherwise have such close encounters with these animals.

B. Economic Impacts

Table 16 summarizes the results of the economic impact calculations. This table shows the output, earnings, and employment of the veterinary services industry, the College of Veterinary Medicine (including the VMC) and the remaining animal-related industries discussed in Section II. Even though the VMC is in the veterinary services industry, adding its impacts to those of the industry does not lead to double-counting because the industry totals only count earnings and employment in the private sector. Because the VMC is a component of the Ohio State College of Veterinary

Medicine, its employment is in the public sector. According to the results, firms in the veterinary services industry, along with their suppliers and employees of the firms and their suppliers, created in 2015 \$2.4 billion in output in Ohio, \$828 million in wages, salaries and self-employment income, and sustained more than 23,000 jobs in Ohio. The VMC and College of Veterinary Medicine together contributed an additional \$130 million in output and more than \$62 million in earnings, and sustained nearly 1,200 jobs.

Table 16: Summary Economic Impacts on the Ohio Economy of Veterinary and Animal-Related Industries and Ohio State Institutions, 2015

	Direct	Indirect	Induced	Total
Output				
Veterinary services	1,110,543,000	559,047,000	769,495,000	2,439,085,000
Ohio State (College and VMC)	71,008,000	11,739,000	47,511,000	130,258,000
Other industries	4,483,200,000	3,320,848,000	2,580,747,000	10,384,795,000
Total	5,664,751,000	3,891,634,000	3,397,753,000	12,954,138,000
Earnings				
Veterinary services	438,097,000	161,485,000	228,328,000	827,910,000
Ohio State (College and VMC)	33,118,000	3,900,000	14,067,000	51,084,000
Other industries	1,171,098,000	839,431,000	768,966,000	2,779,495,000
Total	1,642,313,000	1,004,816,000	1,011,361,000	3,658,489,000
Employment				
Veterinary services	12,877	3,766	6,520	23,163
Ohio State (College and VMC)	673	92	403	1,167
Other industries	28,422	18,954	21,863	69,238
Total	41,972	22,812	28,785	93,569

The economic impact model also generates component impacts for primary industry sectors. Tables in the Appendix detail these impacts for the veterinary services industry and for all industries including the College of Veterinary Medicine. The output impacts of veterinary medicine are in Table A-10, earnings impacts are in Table A-11, and

employment impacts are in Table A-12. Output, earnings, and employment impacts for this industry plus the other auxiliary animal-related industries and the College of Veterinary Medicine are in Tables A-13, A-14, and A-15, respectively. The key message of these tables is that the impact of these industries extends to all sectors of the Ohio economy.

VI. Social Impacts of Veterinary Medicine

Additional benefits of veterinary medicine, animal care, and the human-animal bond are much more difficult to quantify than the output, earnings, and employment benefits discussed above, but are no less important. Views on the positive nature of psychological benefits from owning pets were expressed as early as 1881 in a book by Walter Gregor entitled *Notes on the Folk-Lore of the North-East of Scotland*. The first modern approach to pet-oriented psychotherapy is generally attributed to a paper published by Boris M. Levinson in the 1962 issue of the *Mental Hygiene Journal*. The title of this innovative paper was “The dog as a co-therapist.”

An increasing number of authors have subsequently confirmed the general finding of Levinson that pets do indeed have a significant positive effect on the general health of humans as well as on the rate of recovery of humans who suffer from conditions that are seemingly unrelated to the ownership of pets. This phenomenon is commonly referred to as “zoeyia.”

One early anecdotal finding for zoeyia came from two therapists treating human patients in Ohio. These therapists acknowledged that they initially stumbled upon the therapy value of pets totally by accident. When a local hospital was found to have excess capacity, a dog ward was created within that hospital for the purpose of studying animal behavior. When human patients who were being treated in an adjacent area within the same hospital happened to hear the dogs barking, several patients, including some who had been uncommunicative throughout their hospital stay, broke their self-imposed silence and asked if they could play with and/or help care for the animals.

In response to this early finding, psychotherapists at The Ohio State University College of Medicine decided to provide a dog for a male patient who had been found to be psychotic and was spending nearly all of his time lying in a hospital bed and provided very limited responses to questions he was asked. After receiving a therapy dog, the patient smiled broadly and showed immediate interest in the pet. The patient quickly reversed course and began to respond favorably to therapy. That in turn led to a surprisingly quick discharge.

The same Ohio State psychotherapists employed a similar treatment strategy for a female patient who had been hospitalized due to a condition of catatonic schizophrenia. After traditional treatment methods had failed, including drug therapy and even electrical shock therapy, the patient became withdrawn, frozen and was nearly mute. However, when a dog was brought to this patient, she too responded quickly, and following rapid improvement in her condition, this patient was also discharged.

As a follow up to the Ohio findings, researchers at Pennsylvania State University provided pets to 65 elderly people living in rural areas. Nearly one-half of these subjects were the sole members of their households. The Pennsylvania State study found the introduction of pets produced “dramatic transformations” in people who were severely disabled and yet were able to function substantially better when they were provided with pets. The same study found that people who had been reclusive were able to become more socially interactive, and people who suffered from depression exhibited substantially reduced levels of depression when pets were provided to them.

Subsequent studies established a scientific basis for the Ohio and Pennsylvania cases. In particular, it has been shown that the human brain typically releases endorphins when a person sees a dog. As a result, a person suffering from depression will typically experience less loneliness and higher self-esteem if he or she simply acquires a dog.

Additional research has established that dog owners who routinely take their dogs on walks are likely to improve their cardiovascular health and experience lower blood pressure. As a result, they are likely to increase their life expectancy. In addition, individuals at risk for social isolation can increase their extent of social connected if they routinely walk dogs and engage in daily conversations with others.

The National Institutes of Health (NIH) has reported that a growing number of hospitals routinely use dogs as a form of therapy for patients undergoing treatment for a wide variety of procedures and ailments including mental illness and physical handicaps. NIH has also reported that treatment by “dog therapy” is effective for elderly persons who are in need of energy as well as for individuals who are overly aggressive and in need of a calming influence.

Additional research has established an impressive and growing list of additional health benefits from pets including decreased blood pressure and improvements in patients with cancer, PTSD, depression, anxiety, autism, Alzheimer’s disease, dementia, and many other conditions. When considered as a whole, the potential savings on health care costs appear to be substantial for individuals or families with pets. In support of this view, Heady and Grabka (2007) report that surveys conducted in Germany and Australia show the number of required physician office visits is significantly lower for individuals and household with pets compared to individuals and households without pets. Heady and Grabka estimate that the total savings the reduced physician office visits is nearly \$5.6 billion per year for Germany and nearly \$3.9 billion per year for Australia. Based on similar survey findings for pet owners in the U.S. Clower and Neaves (2015) estimate that pet owners in the

U.S. save nearly \$11.4 billion per year due to the reduced number of required physician office visits. Clower and Neaves also find that the rate of obesity is substantially lower for dog owners who walk their dogs at least five times per week. Estimates of the additional health care savings for these dog owners total nearly \$420 million per year.

The zooeconomy phenomenon does have positive economic consequences, although these would be difficult to quantify. To the extent that health outcomes are improved with pet ownership, medical spending is reduced, personal independence is enhanced, and workforce participation is improved through fewer sick days and possibly higher workforce participation. To the extent that the latter point is correct, productivity of these individuals – and thus that of their employers – is enhanced. The fact that the veterinary services industry is concerned with improving the health and longevity of pets implies that at least some of the economic impacts of these benefits can be attributed to that industry.

An additional positive impact on productivity occurs in companies that allow pets in the workplace. It has been shown that these companies have greater employee satisfaction and productivity. Thus, pets play an even greater role in the economic impact through interactions that support the human-animal bond.

A second benefit of veterinary research is in human disease prevention and treatment. It is widely acknowledged that animals are capable of transmitting various diseases to humans, and that humans and animals are at risk for many common diseases. Understanding these diseases can both reduce their risk to humans and can provide insights for human medical research.

Animal-to-human disease transmission is referred to as “zoonosis.” Estimates of the share of emerging and re-emerging infectious diseases that adhere to the zoonosis pattern are as high as 70 percent of all diseases. A number of these have attracted worldwide attention because of the disruption, suffering, and death they have caused. The most catastrophic of these has been Ebola, which travels to humans from animals including fruit bats and is usually fatal. The most recent outbreak, discussed by Rupp (2017), began in December 2013 in Guinea and spread during the following months to several other nations in western Africa. By the time that the outbreak was declared concluded in June 2016, it had infected more than 28,000 individuals, 11,000 of whom had died. Other examples include avian and porcine (pig) influenza, West Nile Virus, rabies, Zika virus, and many others.

Avian influenza (bird flu) is an ongoing problem. According to the World Health Organization, while the virus does not spread easily among humans, it transmits easily among birds and can transmit from animals to humans. Avian influenza in farm settings can cause the death of large numbers

of birds, seriously affecting agricultural livelihoods. This created a major economic issue in surrounding states and led to banning of poultry at Ohio county and state fairs in 2015. The outcome of avian influenza in humans can range from a mild illness to death. A 1997 outbreak in Hong Kong subsequently spread to other parts of Asia, Africa, Europe, and (rarely) North America.

Rabies is a virus transmitted from animals to humans, producing inflammation in the brain, and is almost always fatal without prompt treatment. The availability of rabies vaccines for pets has significantly altered the disease. According to the Centers for Disease Control (2016a), more than 90 percent of animal cases reported are in wild animals, including bats, raccoons, skunks, and foxes. Before 1960, the majority of cases were in companion animals. The CDC reported 6,033 animal cases of rabies in the U.S. in 2014, and only one human case. The number of human deaths from rabies declined from more than 100 in the early years of the 20th Century to only one or two in the 1990s. The current treatment for rabies is nearly always successful.

An array of viruses carried by ticks and mosquitoes can spread to humans through bites. Lyme disease is carried by the blacklegged tick. According to the CDC (2017), initial symptoms include fever, headache, fatigue, and skin rash. If left untreated, the infection can spread to joints, the nervous system, and the heart. Although more prevalent on the East Coast, the number of Lyme disease cases in Ohio reported to the CDC steadily increased from 21 in 2010 to 112 confirmed and 42 probable cases in 2015. Veterinarians play an important role in the education and prevention of Lyme disease in animals and people.

Two notable viruses transmitted by mosquito bite include the West Nile virus and the Zika virus. According to the CDC (2016b), up to 80 percent of people infected with the West Nile virus develop no symptoms; however, in some individuals the virus can cause headaches, body aches, fever, and joint pain. In the worst cases, severe neurological problems and death can occur. There were 72 Ohio cases of West Nile in Ohio in 2015, including two deaths. Zika attracted broad attention in 2016, primarily because of the severe birth defects it can cause if pregnant women are infected. The CDC (2017b) reports that most people who contract the disease suffer at worst mild symptoms lasting up to a week; however, the potential for microcephaly or other brain abnormalities in infants is a serious concern. Mosquito-borne Zika in the U.S. is still rare, occurring thus far only in specific areas of Texas and Florida, but the specific mosquito species carrying the disease can be found as far north as Ohio during the summer months. There is an obvious concern for pregnant women traveling to at-risk areas. Zika transmission has also occurred through sexual contact.

The discussion above highlighted a number of infectious diseases that begin in animals and then move to humans, but there are many more. Studies of zoonoses (those infectious diseases that start in animals and are transmitted to people) can lead to important breakthroughs in the surveillance, detection, containment, and even prevention of the potential transmission of infectious diseases to humans.

Beyond animal-to-human disease transmission, a variety of ailments are common to animals and humans. Examples include the following:

- Some older dogs get osteosarcoma, a bone cancer. This disease also strikes teenagers and young adults. This can be a catastrophic condition for these individuals, often requiring amputation of limbs.
- Some dogs and cats get mammary cancer, as do some jaguars, kangaroos and beluga whales.
- Dogs and cats develop some of the same cancers as people – not surprising considering that pets and people live in the same environment.
- Some koalas catch chlamydia.
- Some rabbits get syphilis.
- Some canaries, fish, and even Yorkie dogs faint when they are overly stressed.
- Some gorillas experience clinical depression and eating disorders.
- Some reindeer seek out narcotic escape in hallucinogenic mushrooms.
- Some Siamese cats and Doberman pinscher dogs appear to be subject to obsessive-compulsive disorder (OCD). Some animals diagnosed as suffering from OCD are even treated with Prozac.

Based on tests of dinosaur remains, researchers have determined that even some dinosaurs likely suffered from diseases commonly found in humans, including brain cancer, gout, and arthritis.

Veterinarians routinely observe and treat these conditions in a wide range of species including cats and dogs as well as birds, fish, snakes, and wild animals. As a result, it is often the case that veterinarians will have developed methods for diagnosing and treating certain conditions that are common to animal and human patients. In some situations, physicians are not yet aware of these methods.

Zoobiquity is the common name of a formal discipline that explores how common features of animal and human health and disease can be used to diagnose, treat, and heal patients of all species. The ability to apply insights from veterinary medical studies and treatment protocols to the treatment of humans can leverage the effectiveness and reduce the cost of medical research. By combining the findings from medical and veterinary science, as well as from evolutionary and molecular biology, zoobiquity proposes an integrated, interdisciplinary approach to physical and behavioral health. Applications are possible to cardiology, gastroenterology, pediatrics, psychiatry, and many other sub-specialties. Early research indicates that animal responses to potential treatments can lay the foundation for new research as well as enhance findings for current studies of treatments for humans. This social benefit is generally referred to as “improving health and well-being through comparative biomedical research.”

A partial list of related research studies and resources highlighting the topics discussed in this section is provided in the bibliography at the end of the report.

VII. Impacts of Veterinary College Tuition on Students and Graduates

A veterinary doctoral degree is an expensive prospect. The Ohio State program takes four years to complete. The in-state tuition for each of the first three years is \$31,148, but increases by 50 percent to \$46,573 for the final year due to an extended term for that year. Total tuition is thus \$140,017, not including books, supplies, lab fees, room, and board. Tuition for out-of-state residents exceeds \$71,000 per year.

The AVMA conducts surveys of veterinary school graduates annually regarding their post-graduation plans and the amount of debt that they are carrying upon graduation. The national results are discussed and analyzed through 2015,⁹ and the AVMA has released data summaries of the 2016 survey both for the national sample and for Ohio State. In the survey's initial year, 2001, the average (mean) amount of debt of veterinary medicine graduates was roughly \$55,000, or \$75,000 adjusted for inflation. Considering only graduating students with debt, the average was approximately \$59,000, or an inflation-adjusted \$79,000. However, due in part to the severe recession of 2007-2009, many veterinary schools suffered substantial reductions in government support and private contributions, including Ohio State. Although they did not experience substantial reductions, the longstanding history of the state's insufficient investment in veterinary medical education at Ohio State has had an immense and detrimental impact. As a result of the loss of support, most if not all veterinary schools were required to offset these revenue losses by increasing tuition rates significantly. Higher tuition and fees in turn led to increased student debt. The 2016 survey results report an average debt burden among all students of \$155,291, more than double the inflation-adjusted 2001 level. Among only those students with debt, the average was \$181,740, 2.3 times the 2001 level, adjusted for inflation. Debt burdens of Ohio State graduates are substantially greater than the national average. Among all Ohio State graduates, the average debt burden was \$194,363; the average of those with debt was \$216,450. **These averages are 25 percent and 19 percent greater than the national average, respectively.**¹⁰

Figure 9 compares the distribution of debt burdens of veterinary medical graduates of the Ohio State program to the distribution for graduates of all such programs. The chart also shows the annual debt service confronting those within each range of the distribution. Debt service is computed at the midpoint of the range assuming current loan terms (discussed below). As the figure reveals, fewer 2016

graduates of the Ohio State program emerged with no debt than graduates of all programs: 10.2 percent of Ohio State graduates were debt-free versus 14.6 percent of graduates nationwide. Of graduates nationwide, 34 percent had debt of at least \$200,000, but 58.5 percent of Ohio State graduates had debt of at least this amount. This level of debt gives rise to annual debt payments of at least \$15,000 for 25 years. **Higher debt burdens are more common for Ohio State graduates than for those graduating from other programs.** Again, this is a direct result of the comparatively very low level of financial support provided in the state budget of a profession that has a much greater impact than most people realize on the health and well-being of animals, people and the environment.

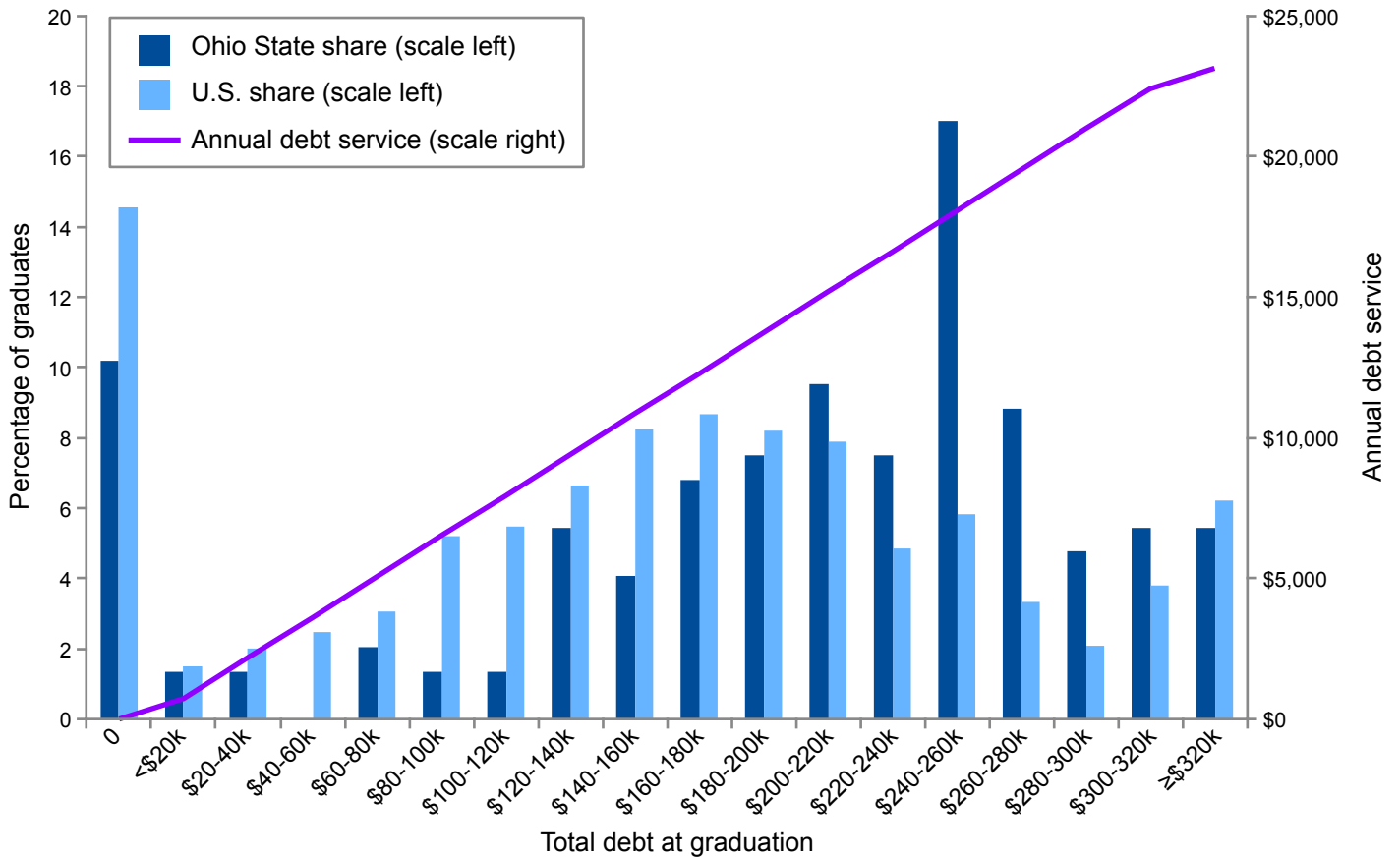
By virtue of the higher debt levels illustrated in Figure 9, the ratio of average debt to average starting salary is likely higher for graduating Ohio State students than for graduating students in the broader sample. The authors of this study do not have access to individual response data required for a precise calculation. However, if the average level of debt reported in the 2016 survey is comparable for students who accept salaried positions and those who accept internships and residency positions, then the corresponding estimate for debt to income is roughly 2.6 for Ohio State students who graduated in 2016 versus roughly 2.1 for students in the broader sample who graduated in 2016.

The AVMA study findings suggest that for most areas of specialization, the prospects of future earnings are currently sufficient to cover the tuition costs for advanced degrees in veterinary medicine. However, the extent of such coverage appears to have narrowed substantially in recent years. If public (legislative) financial support continues to decline and tuition rates continue to increase at or near recent rates, then the evaluation of future earnings in relation to initial debt levels could very well turn negative for growing numbers of students in a variety of specializations. This will discourage potential prospective students from entering lower-wage specializations such as those in the public sector where their talents are needed, and will push them toward higher-paying career tracks. The increased supply of candidates vying for the higher-wage positions will in turn reduce wage rates and the coverage ratio in even these specializations as the supply of applicants increases relative to the demand.

⁹ Veterinary Economics Division, American Veterinary Medical Association. *AVMA 2015 Report on Veterinary Debt and Income*, April 2015, p. 19.

¹⁰ The median (50th percentile) represents the debt burden of the typical graduate. In 2016, this was \$160,000 for all graduates and \$176,000 for those graduating with at least some debt. The Ohio State medians were \$213,000 for all students and \$227,500 for those with debt.

Figure 9: Initial Debt Burden of Graduates of the Ohio State Veterinary Medical Program and All Veterinary Medical Programs Nationwide, 2016



Note: The upper bound of each of the intermediate ranges is one dollar less than that shown; e.g., the \$20k-\$40k range is actually \$20,000-\$39,999.

Source: “2016 AVMA Survey of Graduating Veterinary Students: National Report – 28 US Accredited Veterinary Medical Schools,” and “2016 AVMA Survey of Graduating Veterinary Students: The Ohio State University.” American Veterinary Medical Association

Regardless of the positive long-term prospects, required debt service payments can impose a significant burden on individuals beginning their career. Loan rates for federal student loans for graduate study are currently 5.31 percent for direct unsubsidized loans and 6.31 percent for direct PLUS loans. Perkins loans with a rate of 5 percent are available to students with exceptional financial need, but there is a lifetime borrowing limit of \$60,000 for these loans, including amounts borrowed as an undergraduate. Direct unsubsidized loans have a maximum borrowing limit of \$20,500 per year, and a lifetime limit of \$138,500. The only annual limit for PLUS loans is the cost of attendance as determined by the school less any other financial assistance received. The loan term is at least 10 years and may be as long as 25 years for loans greater than \$30,000. Assuming the average loan principal of \$160,000 and a 25-year term, debt service totals \$964 per month or \$11,574 per year. This can place a substantial burden on a young veterinarian starting his or her career. Another AVMA study

on the market for veterinary education reported that in 2015, Ohio State graduates on average paid 22 percent of their income in debt service, higher than the 19 percent average for all veterinary schools.¹¹ However, this calculation was based on the higher 7.21 percent interest rate and a shorter 20-year term. Based on the more favorable terms of the loans specified above, the payment burden for Ohio State graduates would be 17 percent rather than 22 percent. However, the burden would still be greater than average because students at all schools would enjoy these more favorable terms.

An important point is that evaluations such as these that are carried out at average debt levels do not represent the situation facing substantial numbers of graduates of the Ohio State veterinary program. As stated in Section II, the American Veterinary Medical Association reports a \$73,000 salary for recent graduates going into practice. The 24.5 percent of Ohio State students graduating with at least \$260,000 in debt would face annual payments of \$19,530 or

¹¹ Veterinary Economics Division, American Veterinary Medical Association. *2015 AVMA Report on the Market for Veterinary Education*, October 2015, p. 49.

more – at least 27 percent of this before-tax income. The 5.4 percent of graduates with \$320,000 or more in debt would make payments amounting to 32 percent or more of their income.

A separate point is that these are loans made by the U.S. government, and debt service payments are thus sent ultimately to Washington, DC. The earlier discussion of economic impact makes clear that expenditures made to entities outside the state provide no indirect or induced benefits to the Ohio economy. Consequently, as debt obligations increase, the favorable impacts of veterinary medicine on the Ohio economy – and the state tax revenues resulting from these activities – decline.

Again, the debt burden resulting from a veterinary education is likely to deter some individuals who would otherwise pursue a career as a veterinarian, and those who worry about taking on the required debt without graduating. As a result, the supply of veterinarians entering the field is reduced, making it more difficult to accommodate the demand resulting from growth of the field and the need to fill existing positions coming open because of retirement, relocation, or other reasons. Thus, government and individual support for veterinary education is essential.

As outlined in recent testimony by Dean Rustin Moore, the Ohio State College of Veterinary Medicine receives support from the State of Ohio through the Medical-1 set-aside within the State Share of Instruction as well as a separate line item, the Ohio State Clinic Support. This line item supports clinical experiences for students within the College of Veterinary Medicine and the College of Dentistry. However, this line item was reduced by 3.5 percent in a bill recently passed by the Ohio House, and will be combined with other line items to be distributed by the Chancellor of Higher Education. This will place this funding stream in competition with a variety of other needs, increasing the uncertainty of its level from year to year.¹² The tuition of the Ohio State veterinary program and the high debt levels of graduates are a direct result of low levels of state support. Ohio's support for this program is \$19,500 per student, less than half the \$44,000 average for the top 10 veterinary programs nationwide. Increases in state support would help to limit further rates of increase in tuition and help to ensure that the quality of the Ohio State veterinary program is maintained and further enhanced and that the most qualified students are attracted.

Conclusion

Veterinary medicine is a vital industry in Ohio, contributing billions of dollars to the state's economy and supporting thousands of jobs. Its impact is widespread, ranging from companion animal clinical practice to animal agriculture, research, biotechnology and much more.

From the veterinary students and faculty at the College of Veterinary Medicine at The Ohio State University to the practitioners taking care of Ohio's pets, horses and farm animals, to veterinarians employed in industry, research and government, the fabric of veterinary medicine supports and serves communities throughout Ohio. The veterinary profession and the college contribute broadly across many disciplines to create a healthier world for animals and people.

This study reaffirms what intuitively has been known by many – that veterinary medicine protects the health of Ohio animals, supports the health of people and contributes significantly to a healthy Ohio economy.

¹² "Testimony of Rustin M. Moore, DVM, PhD, Diplomate ACVS, Dean of the College of Veterinary Medicine at The Ohio State University, Senate Finance Higher Education Subcommittee," May 18, 2017.

Appendix

Table A-1: Occupational Employment in Animal Production and Aquaculture

Occupation	SOC	Employment	Percentage
Total, all occupations	00-0000	5,808	100.0%
Farmworkers, farm, ranch, and aquacultural animals	45-2093	2,681	46.2%
Farmers, ranchers, and other agricultural managers	11-9013	1,493	25.7%
Farmworkers and laborers, crop, nursery, and greenhouse	45-2092	192	3.3%
First-line supervisors of farming, fishing, and forestry workers	45-1011	144	2.5%
Heavy and tractor-trailer truck drivers	53-3032	109	1.9%
Agricultural equipment operators	45-2091	93	1.6%
Animal breeders	45-2021	92	1.6%
Animal trainers	39-2011	88	1.5%
Bookkeeping, accounting, and auditing clerks	43-3031	86	1.5%
Agricultural and food science technicians	19-4011	57	1.0%
Office clerks, general	43-9061	49	0.9%
Maintenance and repair workers, general	49-9071	48	0.8%
Agricultural workers, all other	45-2099	42	0.7%
Bus and truck mechanics and diesel engine specialists	49-3031	42	0.7%
Secretaries and administrative assistants, except legal, medical, and executive	43-6014	35	0.6%
Production workers, all other	51-9199	35	0.6%
Laborers and freight, stock, and material movers, hand	53-7062	35	0.6%
General and operations managers	11-1021	34	0.6%
Janitors and cleaners, except maids and housekeeping cleaners	37-2011	33	0.6%
Veterinarians	29-1131	30	0.5%
Light truck or delivery services drivers	53-3033	28	0.5%
Graders and sorters, agricultural products	45-2041	24	0.4%
Industrial production managers	11-3051	23	0.4%
Tour guides and escorts	39-7011	20	0.3%
Weighers, measurers, checkers, and samplers, record keeping	43-5111	16	0.3%
Packers and packagers, hand	53-7064	16	0.3%
Dietitians and nutritionists	29-1031	14	0.2%
Operating engineers and other construction equipment operators	47-2073	13	0.2%
First-line supervisors of mechanics, installers, and repairers	49-1011	13	0.2%
Transportation, storage, and distribution managers	11-3071	11	0.2%
Landscaping and grounds-keeping workers	37-3011	11	0.2%
File clerks	43-4071	11	0.2%
Conveyor operators and tenders	53-7011	11	0.2%
Industrial truck and tractor operators	53-7051	11	0.2%
First-line supervisors of non-retail sales workers	41-1012	10	0.2%
Installation, maintenance, and repair workers, all other	49-9099	10	0.2%
Other		147	2.6%

Source: Industry-Occupation Employment Matrix, Employment Projections, U.S. Bureau of Labor Statistics.

Table A-2: Occupational Employment in Animal Food Manufacturing-part 1

Occupation	SOC	Employment	Percentage
Total, all occupations	00-0000	2,851	100.0%
Packaging and filling machine operators & tenders	51-9111	291	10.2%
Mixing and blending machine setters, operators, & tenders	51-9023	279	9.8%
Heavy and tractor-trailer truck drivers	53-3032	177	6.2%
Laborers and freight, stock, and material movers, hand	53-7062	148	5.2%
Industrial truck and tractor operators	53-7051	117	4.1%
First-line supervisors of production & operating workers	51-1011	111	3.9%
Food batchmakers	51-3092	94	3.3%
Sales representatives, wholesale & manufacturing, except technical & scientific products	41-4012	86	3.0%
Maintenance and repair workers, general	49-9071	77	2.7%
General and operations managers	11-1021	74	2.6%
Extruding, forming, pressing, and compacting machine setters, operators, & tenders	51-9041	63	2.2%
Helpers--production workers	51-9198	63	2.2%
Office clerks, general	43-9061	57	2.0%
Industrial machinery mechanics	49-9041	51	1.8%
Crushing, grinding, and polishing machine setters, operators, & tenders	51-9021	51	1.8%
Bookkeeping, accounting, & auditing clerks	43-3031	46	1.6%
Customer service representatives	43-4051	46	1.6%
Industrial production managers	11-3051	34	1.2%
Secretaries and administrative assistants, except legal, medical, & executive	43-6014	37	1.3%
Inspectors, testers, sorters, samplers, & weighers	51-9061	37	1.3%
Light truck or delivery services drivers	53-3033	37	1.3%
Packers and packagers, hand	53-7064	37	1.3%
Shipping, receiving, and traffic clerks	43-5071	31	1.1%
Maintenance workers, machinery	49-9043	31	1.1%
Production workers, all other	51-9199	31	1.1%
Retail salespersons	41-2031	26	0.9%
Production, planning, & expediting clerks	43-5061	23	0.8%
Team assemblers	51-2092	26	0.9%
Food scientists and technologists	19-1012	20	0.7%
First-line supervisors of office & administrative support workers	43-1011	20	0.7%
Stock clerks and order fillers	43-5081	20	0.7%
Food and tobacco roasting, baking, and drying machine operators & tenders	51-3091	20	0.7%
Conveyor operators & tenders	53-7011	17	0.6%
Accountants and auditors	13-2011	17	0.6%
Agricultural & food science technicians	19-4011	17	0.6%
Billing and posting clerks	43-3021	14	0.5%
First-line supervisors of mechanics, installers, & repairers	49-1011	14	0.5%
Bus and truck mechanics & diesel engine specialists	49-3031	14	0.5%
Food processing workers, all other	51-3099	17	0.6%
First-line supervisors of helpers, laborers, & material movers, hand	53-1021	14	0.5%

Table A-2: Occupational Employment in Animal Food Manufacturing-continued

Occupation	SOC	Employment	Percentage
Machine feeders & offbearers	53-7063	14	0.5%
Sales managers	11-2022	11	0.4%
Market research analysts & marketing specialists	13-1161	11	0.4%
Industrial engineers	17-2112	11	0.4%
Cashiers	41-2011	11	0.4%
Chief executives	11-1011	9	0.3%
Financial managers	11-3031	9	0.3%
Buyers and purchasing agents, farm products	13-1021	9	0.3%
Purchasing agents, except wholesale, retail, & farm products	13-1023	9	0.3%
Logisticians	13-1081	9	0.3%
Other		362	12.7%

Source: Industry-Occupation Employment Matrix, Employment Projections, U.S. Bureau of Labor Statistics.

Table A-3: Occupational Employment in Veterinary Services

Occupation	SOC	Employment	Percentage
Total, all occupations	00-0000	12,877	100.0%
Veterinary technologists and technicians	29-2056	3,414	26.5%
Veterinary assistants and laboratory animal caretakers	31-9096	2,450	19.0%
Veterinarians	29-1131	2,281	17.7%
Receptionists and information clerks	43-4171	1,831	14.2%
Non-farm animal caretakers	39-2021	1,027	8.0%
Office clerks, general	43-9061	368	2.9%
First-line supervisors of office and administrative support workers	43-1011	270	2.1%
Customer service representatives	43-4051	220	1.7%
Secretaries and administrative assistants, except legal, medical, and executive	43-6014	220	1.7%
Bookkeeping, accounting, and auditing clerks	43-3031	176	1.4%
Medical secretaries	43-6013	172	1.3%
Janitors and cleaners, except maids and housekeeping cleaners	37-2011	94	0.7%
General and operations managers	11-1021	86	0.7%
Maintenance and repair workers, general	49-9071	31	0.2%
Executive secretaries and executive administrative assistants	43-6011	27	0.2%
Business operations specialists, all other	13-1199	20	0.2%
Medical and health services managers	11-9111	12	0.1%
Accountants and auditors	13-2011	12	0.1%
Other		165	1.3%

Source: Industry-Occupation Employment Matrix, Employment Projections, U.S. Bureau of Labor Statistics.

Table A-4: Industries Employing Veterinarians, United States, 2014

Occupation	NAICS	Employment (000)	Percentage
Total employment		78.3	100.0%
Veterinary services	541940	58.2	74.3%
Self-employed workers	TE1110	12.7	16.2%
Animal production and aquaculture	112000	2.1	2.7%
Federal government, excluding postal service	999100	1.3	1.7%
Social advocacy organizations	813300	0.7	0.9%
State government, excluding education and hospitals	999200	0.7	0.9%
Colleges, universities, and professional schools; state	611302	0.6	0.8%
Research and development in the physical, engineering, and life sciences	541710	0.3	0.3%
Colleges, universities, and professional schools; private	611305	0.3	0.4%
Museums, historical sites, and similar institutions	712000	0.2	0.3%
Other personal services	812900	0.2	0.3%
Local government, excluding education and hospitals	999300	0.2	0.3%
Drugs and druggists' sundries merchant wholesalers	424200	0.1	0.1%
Management of companies and enterprises	551000	0.1	0.1%
General medical and surgical hospitals; private	622105	0.1	0.1%
Spectator sports	711200	0.1	0.1%
Other		0.4	0.5%

Source: Industry-Occupation Employment Matrix, Employment Projections, U.S. Bureau of Labor Statistics.

Table A-5: Industries Employing Veterinary Technologists and Technicians, United States, 2014

Occupation	NAICS	Employment (000)	Percentage
Total employment		95.6	100.0%
Veterinary services	541940	87.1	91.0%
Colleges, universities, and professional schools; state	611302	2.0	2.1%
Social advocacy organizations	813300	1.5	1.6%
Colleges, universities, and professional schools; private	611305	1.1	1.2%
Research and development in the physical, engineering, and life sciences	541710	1.0	1.0%
Federal government, excluding postal service	999100	0.6	0.6%
Other personal services	812900	0.4	0.4%
Self-employed workers	TE1110	0.4	0.4%
Local government, excluding education and hospitals	999300	0.3	0.4%
Pharmaceutical and medicine manufacturing	325400	0.2	0.2%
General medical and surgical hospitals; private	622105	0.2	0.2%
Support activities for agriculture and forestry	115000	0.1	0.1%
Museums, historical sites, and similar institutions	712000	0.1	0.1%
State government, excluding education and hospitals	999200	0.1	0.1%
Other		0.5	0.6%

Source: Industry-Occupation Employment Matrix, Employment Projections, U.S. Bureau of Labor Statistics.

Table A-6: Industries Employing Veterinary Assistants and Laboratory Animal Caretakers, United States, 2014

Occupation	NAICS	Employment (000)	Percentage
Total employment		73.4	100.0%
Veterinary services	541940	62.5	85.2%
Colleges, universities, and professional schools; private	611305	2.7	3.7%
Colleges, universities, and professional schools; state	611302	2.4	3.3%
Research and development in the physical, engineering, and life sciences	541710	1.8	2.5%
Social advocacy organizations	813300	1.1	1.5%
Local government, excluding education and hospitals	999300	0.5	0.7%
Animal production and aquaculture	112000	0.3	0.4%
General medical and surgical hospitals; private	622105	0.3	0.4%
Other personal services	812900	0.3	0.5%
Pharmaceutical and medicine manufacturing	325400	0.2	0.2%
Specialty (except psychiatric and substance abuse) hospitals; private	622305	0.1	0.2%
Museums, historical sites, and similar institutions	712000	0.1	0.1%
State government, excluding education and hospitals	999200	0.1	0.2%
Other		1.0	1.1%

Source: Industry-Occupation Employment Matrix, Employment Projections, U.S. Bureau of Labor Statistics.

Table A-7: Industries Employing Non-farm Animal Caretakers, United States, 2014

Occupation	NAICS	Employment (000)	Percentage
Total employment		204.8	100.0%
Other personal services	812900	67.9	33.1%
Self-employed workers	TE1110	39.2	19.1%
Other miscellaneous store retailers	453900	28.4	13.9%
Veterinary services	541940	26.2	12.8%
Social advocacy organizations	813300	11.0	5.4%
Spectator sports	711200	8.7	4.2%
Museums, historical sites, and similar institutions	712000	6.0	2.9%
Local government, excluding education and hospitals	999300	4.0	2.0%
Support activities for agriculture and forestry	115000	2.2	1.1%
Colleges, universities, and professional schools; state	611302	1.2	0.6%
Animal production and aquaculture	112000	1.1	0.5%
Private households	814000	1.1	0.5%
Colleges, universities, and professional schools; private	611305	0.6	0.3%
Federal government, excluding postal service	999100	0.5	0.3%
Farm product raw material merchant wholesalers	424500	0.2	0.1%
Temporary help services	561320	0.2	0.1%
Other schools and instruction; private	611605	0.2	0.1%
Services for the elderly and persons with disabilities	624120	0.2	0.1%
State government, excluding education and hospitals	999200	0.2	0.1%
Other		5.7	2.8%

Source: Industry-Occupation Employment Matrix, Employment Projections, U.S. Bureau of Labor Statistics.

Table A-8: Veterinary Services Employment and Number of Establishments by County, 2007 and 2015

County	Employment			# of establishments	
	2007	2015	Net change	2007	2015
Ohio	11,511	13,395	16.4%	1,083	1,110
Adams	0	0	0.0%	0	0
Allen	55	77	40.0%	10	10
Ashland	62	63	1.6%	7	9
Ashtabula	75	90	20.0%	11	12
Athens	55	57	3.6%	6	5
Auglaize	<i>24</i>	29	20.8%	6	7
Belmont	<i>55</i>	89	61.8%	9	8
Brown	36	32	-11.1%	4	4
Butler	300	361	20.3%	29	33
Carroll	17	26	52.9%	3	3
Champaign	14	21	50.0%	3	3
Clark	103	152	47.6%	14	14
Clermont	265	261	-1.5%	29	31
Clinton	26	47	80.8%	6	5
Columbiana	98	106	8.2%	16	17
Coshocton	37	37	0.0%	5	5
Crawford	30	30	0.0%	4	4
Cuyahoga	989	977	-1.2%	101	92
Darke	42	47	11.9%	6	7
Defiance	25	23	-8.0%	4	5
Delaware	192	291	51.6%	21	24
Erie	<i>40</i>	42	5.0%	8	6
Fairfield	184	200	8.7%	16	16
Fayette	30	<i>1</i>	-96.7%	3	1
Franklin	1,828	2,529	38.3%	116	118
Fulton	53	37	-30.2%	6	3
Gallia	<i>15</i>	19	26.7%	3	3
Geauga	148	151	2.0%	18	18
Greene	172	142	-17.4%	15	15
Guernsey	<i>22</i>	<i>50</i>	127.3%	2	2
Hamilton	899	1,051	16.9%	71	77
Hancock	83	85	2.4%	9	6
Hardin	26	31	19.2%	3	3
Harrison	<i>7</i>	<i>7</i>	0.0%	1	1
Henry	<i>15</i>	<i>30</i>	100.0%	1	2
Highland	<i>24</i>	37	54.2%	6	8
Hocking	<i>15</i>	19	26.7%	3	3
Holmes	<i>23</i>	<i>43</i>	87.0%	3	3
Huron	64	69	7.8%	10	11
Jackson	19	21	10.5%	3	4
Jefferson	<i>31</i>	32	3.2%	7	6
Knox	55	81	47.3%	8	7
Lake	272	290	6.6%	23	23
Lawrence	<i>37</i>	<i>51</i>	37.8%	3	3

County	Employment			# of establishments	
	2007	2015	Net change	2007	2015
Licking	188	181	-3.7%	22	20
Logan	31	27	-12.9%	4	3
Lorain	387	445	15.0%	20	22
Lucas	379	534	40.9%	32	37
Madison	67	60	-10.4%	5	6
Mahoning	118	129	9.3%	12	12
Marion	53	43	-18.9%	6	6
Medina	204	224	9.8%	23	22
Meigs	<i>7</i>	<i>22</i>	214.3%	1	2
Mercer	79	103	30.4%	8	9
Miami	121	130	7.4%	10	10
Monroe	0	0	0.0%	0	0
Montgomery	503	528	5.0%	33	38
Morgan	<i>9</i>	<i>7</i>	-22.2%	3	1
Morrow	20	18	-10.0%	3	3
Muskingum	32	40	25.0%	5	7
Noble	<i>1</i>	<i>1</i>	0.0%	1	1
Ottawa	28	38	35.7%	4	5
Paulding	<i>1</i>	<i>1</i>	0.0%	1	1
Perry	<i>35</i>	<i>35</i>	0.0%	1	1
Pickaway	<i>45</i>	47	4.4%	5	5
Pike	<i>1</i>	<i>1</i>	0.0%	1	1
Portage	123	154	25.2%	12	14
Preble	40	44	10.0%	5	7
Putnam	<i>22</i>	<i>36</i>	63.6%	2	2
Richland	80	93	16.3%	10	11
Ross	62	90	45.2%	7	7
Sandusky	66	55	-16.7%	7	6
Scioto	50	83	66.0%	3	3
Seneca	46	54	17.4%	7	7
Shelby	42	41	-2.4%	5	5
Stark	304	323	6.3%	37	35
Summit	650	882	35.7%	59	63
Trumbull	190	243	27.9%	17	19
Tuscarawas	114	112	-1.8%	9	12
Union	32	31	-3.1%	3	4
Van Wert	24	18	-25.0%	3	3
Vinton	0	0	0.0%	0	0
Warren	275	323	17.5%	23	27
Washington	223	59	-73.5%	8	6
Wayne	161	189	17.4%	18	16
Williams	26	30	15.4%	4	3
Wood	113	104	-8.0%	9	9
Wyandot	8	<i>14</i>	75.0%	3	2

Note: Totals in red italics are estimates; see text. Because of inexact employment estimates, county employments do not add to the state total.

Source: County Business Patterns, U.S. Census Bureau.

Table A-9: Farm Livestock by County, Selected Breeds, 2012-part 1

County	Cattle	Goats	Hogs	Sheep	Chickens*	Turkeys	Equine
Ohio	1,242,293	51,558	2,058,503	111,972	40,506,716	2,096,395	114,127
Adams	22,927	1,155	3,584	824	3,940	85	1,779
Allen	5,210	254	80,372	704	n/r	122	930
Ashland	23,106	704	19,210	3,654	136,252	737	1,759
Ashtabula	14,113	678	636	783	6,570	140	2,104
Athens	7,458	570	168	721	2,664	24	923
Auglaize	21,132	524	104,701	1,335	n/r	n/r	421
Belmont	18,261	1,284	122	1,166	2,283	12	848
Brown	15,896	616	4,473	383	3,412	287	1,292
Butler	13,352	849	10,502	746	3,479	80	1,825
Carroll	14,982	504	931	1,332	n/r	147	1,198
Champaign	7,830	847	24,030	994	5,231	37	1,155
Clark	16,235	624	11,526	300	2,174	139	1,591
Clermont	4,402	1,057	49	165	4,868	155	1,976
Clinton	6,163	510	28,381	997	1,763	86	762
Columbiana	27,910	907	5,225	1,753	418,349	243	1,633
Coshocton	21,771	1,193	33,609	3,302	n/r	88	2,125
Crawford	8,468	522	66,481	468	75,767	120	141
Cuyahoga	n/r	9	n/r	30	927	n/r	502
Darke	42,000	972	237,185	1,536	8,811,973	364,021	1,052
Defiance	10,605	813	5,675	597	n/r	0	363
Delaware	2,478	548	23,089	1,025	1,755	122	1,904
Erie	2,236	98	155	226	1,192	n/r	862
Fairfield	12,083	552	31,418	1,097	6,195	163	2,193
Fayette	5,696	630	489	1,366	1,136	0	645
Franklin	773	179	642	684	1,510	n/r	1,049
Fulton	37,033	370	22,785	1,059	1,389	74	429
Gallia	16,180	1,302	359	2,554	3,081	36	1,097
Geauga	13,905	801	589	1,305	6,675	335	4,315
Greene	4,543	555	11,882	1,171	3,213	42	1,394
Guernsey	18,379	685	n/r	1,532	3,157	14	1,590
Hamilton	1,516	247	51	200	n/r	n/r	834
Hancock	3,175	372	14,165	1,466	n/r	11	642
Hardin	11,929	333	80,781	1,161	n/r	424	836
Harrison	10,600	362	1,178	3,031	n/r	n/r	760
Henry	5,870	176	5,212	103	n/r	0	172
Highland	19,890	1,170	12,271	3,498	6,162	81	1,405
Hocking	2,144	441	112	363	2,009	14	555
Holmes	68,072	807	10,678	7,140	2,432,940	617	9,898
Huron	15,877	535	19,665	1,272	312,623	86	711
Jackson	10,036	502	303	632	2,106	n/r	1,037
Jefferson	7,373	362	435	680	1,361	42	573
Knox	16,464	1,274	26,419	6,063	330,024	n/r	2,828
Lake	478	77	60	130	n/r	n/r	400
Lawrence	5,240	637	221	336	1,987	n/r	1,052

Table A-9: Farm Livestock by County, Selected Breeds, 2012-continued

County	Cattle	Goats	Hogs	Sheep	Chickens*	Turkeys	Equine
Ohio	1,242,293	51,558	2,058,503	111,972	40,506,716	2,096,395	114,127
Licking	21,613	924	20,003	2,618	n/r	101	2,509
Logan	9,763	496	11,214	1,888	3,926	73	1,191
Lorain	8,418	345	18,863	678	2,884	124	1,095
Lucas	n/r	51	11,659	133	1,261	35	242
Madison	15,776	213	26,663	630	2,466	91	955
Mahoning	15,345	229	658	422	371,465	n/r	1,480
Marion	5,862	514	72,656	1,757	987	76	374
Medina	8,481	621	500	1,233	5,486	153	3,798
Meigs	7,725	577	232	402	5,224	n/r	726
Mercer	66,024	618	261,390	1,229	n/r	1,408,779	390
Miami	5,194	482	13,185	1,302	3,917	n/r	794
Monroe	14,676	666	294	2,758	2,162	140	907
Montgomery	8,568	474	7,112	397	5,980	165	1,605
Morgan	12,523	439	264	847	3,039	n/r	778
Morrow	9,669	1,065	37,622	2,759	8,237	244	1,356
Muskingum	30,710	1,075	9,015	2,998	n/r	95	1,889
Noble	12,184	562	264	2,033	2,119	0	758
Ottawa	988	167	997	155	2,708	n/r	489
Paulding	12,730	397	28,937	63	499	n/r	253
Perry	8,481	1,218	n/r	826	2,359	51	751
Pickaway	8,665	401	50,517	367	1,075	24	806
Pike	6,543	427	327	256	1,561	73	703
Portage	7,465	616	521	867	4,157	127	2,111
Preble	17,735	1,206	51,185	1,205	5,511	n/r	1,259
Putnam	13,304	676	81,249	782	n/r	n/r	90
Richland	24,966	613	27,258	1,305	530,863	135	1,603
Ross	11,827	445	1,385	1,039	2,357	32	1,055
Sandusky	4,871	367	6,475	947	1,292	56	531
Scioto	7,997	877	211	360	n/r	68	1,299
Seneca	9,157	251	48,960	2,235	3,204	16	307
Shelby	26,094	302	101,760	1,122	n/r	105	330
Stark	20,838	914	4,217	1,213	1,341,585	306	2,332
Summit	978	288	113	209	3,704	201	730
Trumbull	11,029	410	448	423	n/r	613	2,018
Tuscarawas	27,434	1,093	2,913	2,193	540,255	n/r	2,161
Union	8,877	914	30,513	1,330	n/r	47	1,196
Van Wert	13,814	95	79,807	428	n/r	n/r	188
Vinton	2,523	69	175	177	n/r	10	416
Warren	3,957	358	911	553	4,834	185	2,748
Washington	18,635	486	1,375	1,228	3,242	20	1,163
Wayne	99,948	1,023	62,924	6,248	5,735,976	2,239	5,401
Williams	18,413	362	10,315	702	1,163	n/r	720
Wood	5,875	458	3,609	772	n/r	129	882
Wyandot	2,368	167	62,498	999	n/r	0	178

n/r = Not reported.

Source: 2012 Agricultural Census, U.S. Department of Agriculture.

Table A-10: Output Impacts on the Ohio Economy of the Veterinary Services Industry by Sector, 2015 (in thousands of dollars)

	Direct	Indirect	Induced	Total
Agriculture, forestry, fishing, and hunting	0	3,998	7,219	11,216
Mining	0	1,333	1,999	3,332
Utilities	0	7,330	19,768	27,097
Construction	0	5,775	6,996	12,771
Durable goods manufacturing	0	26,653	33,761	60,414
Nondurable goods manufacturing	0	102,836	77,849	180,685
Wholesale trade	0	62,079	42,423	104,502
Retail trade	0	4,886	80,181	85,068
Transportation and warehousing	0	38,536	29,540	68,076
Information	0	30,540	25,987	56,527
Finance and insurance	0	36,537	76,961	113,497
Real estate and rental and leasing	0	70,075	102,059	172,134
Professional, scientific, and technical services	1,110,543	48,864	24,987	1,184,394
Management of companies and enterprises	0	31,539	14,104	45,643
Administrative and waste management services	0	28,208	20,545	48,753
Educational services	0	666	12,882	13,549
Health care and social assistance	0	7,552	107,612	115,163
Arts, entertainment, and recreation	0	4,664	11,328	15,992
Accommodation	0	3,776	4,442	8,218
Food services and drinking places	0	22,766	31,095	53,861
Other services and government	0	20,434	37,758	58,192
Total	1,110,543	559,047	769,495	2,439,085

Table A-11: Earnings Impacts on the Ohio Economy of the Veterinary Services Industry by Sector, 2015 (in thousands of dollars)

	Direct	Indirect	Induced	Total
Agriculture, forestry, fishing, and hunting	0	666	1,555	2,221
Mining	0	222	333	555
Utilities	0	1,111	2,887	3,998
Construction	0	1,888	2,221	4,109
Durable goods manufacturing	0	5,553	6,330	11,883
Nondurable goods manufacturing	0	18,102	12,549	30,651
Wholesale trade	0	19,212	13,215	32,428
Retail trade	0	1,777	28,430	30,207
Transportation and warehousing	0	11,772	9,440	21,211
Information	0	6,330	5,108	11,439
Finance and insurance	0	9,551	19,212	28,763
Real estate and rental and leasing	0	10,883	15,992	26,875
Professional, scientific, and technical services	438,097	25,555	11,216	474,868
Management of companies and enterprises	0	12,660	5,664	18,324
Administrative and waste management services	0	11,883	8,995	20,878
Educational services	0	333	5,997	6,330
Health care and social assistance	0	3,332	48,309	51,640
Arts, entertainment, and recreation	0	1,777	3,554	5,331
Accommodation	0	999	1,333	2,332
Food services and drinking places	0	7,774	10,217	17,991
Other services and government	0	10,106	14,659	24,765
Households	0	0	1,111	1,111
Total	438,097	161,485	228,328	827,910

Table A-12: Employment Impacts on the Ohio Economy of the Veterinary Services Industry by Sector, 2015

	Direct	Indirect	Induced	Total
Agriculture, forestry, fishing, and hunting	0	32	67	99
Mining	0	3	5	8
Utilities	0	10	27	37
Construction	0	35	44	79
Durable goods manufacturing	0	91	109	200
Nondurable goods manufacturing	0	255	212	467
Wholesale trade	0	284	194	479
Retail trade	0	61	1,081	1,142
Transportation and warehousing	0	259	201	460
Information	0	102	85	187
Finance and insurance	0	171	361	532
Real estate and rental and leasing	0	642	985	1,628
Professional, scientific, and technical services	12,877	409	199	13,485
Management of companies and enterprises	0	123	55	179
Administrative and waste management services	0	362	287	649
Educational services	0	11	244	255
Health care and social assistance	0	59	1,057	1,117
Arts, entertainment, and recreation	0	78	160	238
Accommodation	0	39	46	85
Food services and drinking places	0	422	569	991
Other services and government	0	316	431	747
Households	0	0	101	101
Total	12,877	3,766	6,520	23,163

Table A-13: Output Impacts on the Ohio Economy of Veterinary and Animal-Related Industries and Ohio State Institutions by Sector, 2015 (in thousands of dollars)

	Direct	Indirect	Induced	Total
Agriculture, forestry, fishing, and hunting	769,870	484,248	31,891	1,286,009
Mining	0	26,543	8,953	35,496
Utilities	0	80,612	87,227	167,839
Construction	0	37,338	31,073	68,412
Durable goods manufacturing	0	245,613	149,029	394,642
Nondurable goods manufacturing	1,179,412	876,301	343,887	2,399,600
Wholesale trade	755,150	403,983	187,248	1,346,381
Retail trade	324,131	24,894	354,247	703,272
Transportation and warehousing	0	303,396	130,656	434,052
Information	0	114,031	114,802	228,833
Finance and insurance	0	247,843	339,916	587,760
Real estate and rental and leasing	0	270,536	450,570	721,106
Professional, scientific, and technical services	2,093,934	299,360	110,358	2,503,652
Management of companies and enterprises	0	143,544	62,005	205,549
Administrative and waste management services	0	173,363	90,675	264,038
Educational services	46,912	8,996	56,721	112,629
Health care and social assistance	0	9,452	474,991	484,443
Arts, entertainment, and recreation	297,577	20,151	49,904	367,632
Accommodation	0	7,374	19,758	27,131
Food services and drinking places	0	42,719	137,158	179,877
Other services and government	197,765	71,336	166,684	435,785
Total	5,664,751	3,891,634	3,397,753	12,954,138

Table A-14: Earnings Impacts on the Ohio Economy of Veterinary and Animal-Related Industries and Ohio State Institutions by Sector, 2015 (in thousands of dollars)

	Direct	Indirect	Induced	Total
Agriculture, forestry, fishing, and hunting	231,436	7,147	6,914	245,497
Mining	0	4,304	1,501	5,805
Utilities	0	11,724	12,797	24,521
Construction	0	12,012	9,989	22,001
Durable goods manufacturing	0	44,678	27,828	72,506
Nondurable goods manufacturing	186,137	127,530	55,807	369,474
Wholesale trade	179,485	179,738	58,683	417,906
Retail trade	83,793	34,928	125,792	244,514
Transportation and warehousing	0	94,289	41,748	136,037
Information	0	26,427	22,673	49,100
Finance and insurance	0	63,443	84,883	148,326
Real estate and rental and leasing	0	42,911	70,597	113,508
Professional, scientific, and technical services	783,124	113,144	50,773	947,041
Management of companies and enterprises	0	57,631	25,037	82,668
Administrative and waste management services	0	78,870	39,721	118,591
Educational services	22,985	4,067	26,580	53,632
Health care and social assistance	0	4,191	213,442	217,632
Arts, entertainment, and recreation	90,832	33,203	16,078	140,113
Accommodation	0	2,025	5,616	7,641
Food services and drinking places	0	14,382	45,013	59,395
Other services and government	64,521	48,172	64,957	177,650
Households	0	0	4,932	4,932
Total	1,642,313	1,004,816	1,011,361	3,658,489

Table A-15: Employment Impacts on the Ohio Economy of Veterinary and Animal-Related Industries and Ohio State Institutions by Sector, 2015

	Direct	Indirect	Induced	Total
Agriculture, forestry, fishing, and hunting	6,768	3,843	295	10,905
Mining	0	56	21	77
Utilities	0	110	119	229
Construction	0	230	192	422
Durable goods manufacturing	0	741	479	1,220
Nondurable goods manufacturing	2,851	2,318	938	6,107
Wholesale trade	3,460	1,851	858	6,169
Retail trade	4,404	309	4,773	9,486
Transportation and warehousing	0	1,879	888	2,767
Information	0	421	374	795
Finance and insurance	0	1,083	1,594	2,678
Real estate and rental and leasing	0	2,392	4,351	6,743
Professional, scientific, and technical services	16,717	2,328	880	19,926
Management of companies and enterprises	0	562	243	805
Administrative and waste management services	0	2,380	1,269	3,649
Educational services	450	163	1,076	1,690
Health care and social assistance	0	75	4,668	4,743
Arts, entertainment, and recreation	3,737	337	706	4,780
Accommodation	0	76	205	281
Food services and drinking places	0	788	2,511	3,299
Other services and government	3,585	867	1,901	6,353
Households	0	0	444	444
Total	41,972	22,812	28,785	93,569

Bibliography

- Ascione, F., & Weber, C. (1996). Children's attitudes about the humane treatment of animals and empathy: One year follow up of a school-based intervention. *Anthrozoos*, 9 (4), 188-195.
- Brody, J. E. Owning a pet can have therapeutic value. *New York Times*, August 11, 1982.
- Carlsen, K., et al. (2012). Does pet ownership in infancy lead to asthma or allergy at school age? Pooled Analysis of Individual Participant Data from 11 European Birth Cohorts. *PLOS One*, 7(8): 1-12
- Centers for Disease Control (2016a). Rabies. <https://www.cdc.gov/rabies/index.html>.
- Centers for Disease Control (2016b). West Nile virus. <https://www.cdc.gov/westnile/>
- Centers for Disease Control (2017). Lyme disease. <https://www.cdc.gov/lyme/index.html>.
- Charnetski C. J., Riggers S. (2004). Effect of petting a dog on immune system function. *Psychological Reports* 95:1087- 1091. 19
- Church J., Williams H. (2001). Another sniffer dog for the clinic?. *Lancet* 358 (9285): 930–930. doi:10.1016/S0140-6736(01)06065-2.PMID 11575380.
- Clower, T. L., Neaves, T. T. (2015). *The health care cost savings of pet ownership*. Report prepared for the Human Animal Bond Research Initiative Foundation.
- Dharmage, S., et al. (2012). Exposure to cats: Update on risks for sensitization and allergic diseases. *Current Allergy and Asthma Report*, 12(5): 413-423 .
- Ehmann R., Boedeker E., Friedrich U, et al. (August 2011). Canine scent detection in the diagnosis of lung cancer: Revisiting a puzzling phenomenon. *European Respiratory Journal*, 39 (3): 669–76. doi:10.1183/09031936.00051711. PMID 21852337.
- Fine, A. H. (2000). *Animal-assisted therapy: Theoretical foundations and guidelines for practice*. San Diego, CA: Academic Press.
- Freidman, E., Katcher, A., Lynch, J. and Thomas, S.(1980). "Animal companions and one-year survival of patients after discharge from a coronary care unit." *Public Health Report*, 95(4): 307-312.
- Gammonley, J., Howie, A. R., Jackson, B., et al., (2000). *Animal-assisted therapy: Therapeutic interventions*. Renton, WA: Delta Society.
- Heady, B. and Grabka, M. (2007). Pets and human health in Germany and Australia: National longitudinal results. *Social Indicators Research*, 80(2): 297-311.
- Irani, S., Mahler C., GoetGern, J., et al. (2004). Effects of dog ownership and genotype on immune development and atopy in infancy. *Journal of Clinical Immunology*. 113(2):307-314.
- Johnson CC, Peterson EL (2002) Exposure to dogs and cats in the first year of life and risk of allergic sensitization at 6 to 7 years of age. *Journal of the American Medical Association*, 2002; 288: 96372.
- Lakdawalla, P. (2003). Sea-ing results: An Aquarium can Help Boost Alzheimer's Patients' Appetites. *Contemporary Long Term Care*, 26(7): 28.

- Levine G. N., Allen K., Braun L. T., et al., (2013). Pet Ownership and cardiovascular risk: A scientific statement from the American Heart Association. *Circulation*, 127(23): 2353-2363.
- Levinson, B. M. (1962). The dog as a co-therapist. *Mental Hygiene*, 46, 59-65.
- Levinson, B. M. (1969). *Pet oriented child psychotherapy*. Springfield, IL: Charles C. Thomas.
- Lodge, C. J., Allen, K. J., Lowe, A. J., et al. (2012). Perinatal cat and dog exposure and the risk of asthma and allergy in the urban environment: a systematic review of longitudinal studies. *Clinical and Developmental Immunology*, 2012(2012): 1-10.
- McCulloch M., Jezierski T., Broffman M, et al. (2006). Diagnostic accuracy of canine scent detection in early- and late-stage lung and breast cancers. *Integrative Cancer Therapies* 5 (1): 30-39
- Michel J. B., Shen Y. K., Aiden A. P., et al. (2011). Quantitative analysis of culture using millions of digitized books. *Science*, 331(6014):176-182
- Nafsted P., Magnus P., Gaader P. I., Jaakola J. J. K. (2002). Exposure to pets and atopy-related diseases in the first 4 years of life. *Allergy*, 56: 30712.
- Rupp, J. A. (2017). Ebola virus. *World Book Advanced*.
- Siegel, J. (1990). Stressful life events and the use of physician services among the elderly: "The Moderating Effects of Pet Ownership." *Journal of Personality and Social Psychology*, 58(6): 1081–1086.
- Verrier L (March 1970). Dog licks man. *Lancet* 1 (7647): 615. doi:10.1016/S0140-6736(70)91650-8.PMID 4190562.
- Wegienka, G., Johnson, C. C., Havstad, S., et al. (2011). Lifetime dog and cat exposure and dog- and cat-specific sensitization at age 18 years. *Clinical and Experimental Allergy*, 41(7): 979-986.
- Williams H., Pembroke A. (1989). Sniffer dogs in the melanoma clinic?. *Lancet* 1 (8640): 734. doi:10.1016/S0140-6736(89)92257-5.PMID 2564551.
- Willis C. M., Church S.M., Guest C. M., et al. (2004). Olfactory detection of human bladder cancer by dogs: proof of principle study. *BMJ* 329(7468)
- World Health Organization (2016). Avian and other zoonotic influenza fact sheet. www.who.int/mediacentre/factsheets/avian_influenza/en/