An Estimate of the Number of Dogs in US Shelters...
and the factors affecting their fate

Kimberly A. Woodruff, DVM, MS, DACVPM
David R. Smith, DVM, PhD, DACVPM (Epidemiology)
Currently….

- No governing body for shelter medicine
- No national list/registration of animal humane organizations
- No national registration/census of shelter animals
- Difficult to estimate total number of dogs in shelters
And yet....

- Their fate is important
- Shelters are an important source of dogs for adoption as pets
  - Health and well-being
  - Not a source of illness for other dogs in the home or community
- Little science
Objectives

• Estimate total number of shelters in the United States
  • Brick and mortar
  • Intake/adopt out dogs

• Estimate number of dogs entering US shelters annually and their outcome
  • Returned to owner
  • Adopted
  • Transferred
  • Euthanized

• Identify characteristics of US shelters that modify dog movement.
Materials and Methods

• Initial list of 10,890 animal shelters AND rescue organizations in the United States
  • Existing lists and Internet searches
• For inclusion
  • Must accept dogs
  • Must adopt dogs to the public
  • Brick and mortar
## Materials and Methods

<table>
<thead>
<tr>
<th>Contact List</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of cases provided by client</td>
<td>10,890</td>
</tr>
<tr>
<td>Not an animal shelter</td>
<td>(7,649)</td>
</tr>
<tr>
<td>Shelter not for dogs</td>
<td>(40)</td>
</tr>
<tr>
<td>Duplicate cases</td>
<td>(114)</td>
</tr>
<tr>
<td>No telephone number number available</td>
<td>(23)</td>
</tr>
</tbody>
</table>

**Total Number of Cases:** 3,064
Materials and Methods

• Additional shelters removed for:
  • not being an animal shelter
  • not a shelter for dogs
  • not adopting dogs to public
  • Duplicates

• Final survey frame: 2,862 shelters from 49 states
Materials and Methods

- Telephone survey
  - Attempt to contact each of 2,862
  - Calls made throughout July, 2016
  - 8 attempts per shelter before number was retired

- 413 completed surveys (14.4%)
Statistical Methods

• Significance defined at alpha = 0.05
• Model building with manual forward selection

Factors associated with number of dogs entering a shelter were tested using multivariable linear regression with “shelter” as the unit of investigation
  • Proc Mixed SAS
  • Tukey-Kramer adjustment for multiple comparisons

Multilevel, multivariable logistic regression, with shelter as a cluster effect, was used to test factors associated with the probability for shelters to:
  • Adopt
  • Transfer
  • Return to owner, or
  • Euthanize dogs

• Proc Genmod SAS (generalized estimating equations)
  • Tukey-Kramer adjustment for multiple comparisons
Number of dogs entering the shelter

Mean: 781.9
Median: 500
Max: 5500
Min: 10
LS means for a shelter’s annual dog intake

- Mixed: 900 (a)
- Municipal: 800 (a)
- Private: 400 (b)
LS means for a shelter’s annual dog intake
LS means for a shelter’s annual dog intake

Region

Dog Intake

<table>
<thead>
<tr>
<th>Region</th>
<th>MW</th>
<th>NE</th>
<th>SE</th>
<th>SW</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ab</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>ab</td>
</tr>
</tbody>
</table>

The Risk Project
# Number of Dogs Entering Shelters

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Standard error</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>472.48</td>
<td>118.95</td>
<td></td>
</tr>
<tr>
<td>Funding Source</td>
<td>Mixed</td>
<td>500.64</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Mixed</td>
<td></td>
<td>102.27</td>
<td></td>
</tr>
<tr>
<td>Municipal</td>
<td>424.29</td>
<td>88.42</td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Region</td>
<td>Midwest</td>
<td>-30.27</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Midwest</td>
<td></td>
<td>122.51</td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>-316.69</td>
<td>167.37</td>
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<tr>
<td>Southeast</td>
<td>115.02</td>
<td>129.8</td>
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<tr>
<td>Southwest</td>
<td>500.61</td>
<td>154.73</td>
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</tr>
<tr>
<td>West</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accepts Surrender</td>
<td>No</td>
<td>-415.14</td>
<td>0.0091</td>
</tr>
<tr>
<td>Yes</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Adoption  Transfer  Return to Owner  Euthanize
Factors affecting the probability that a shelter returns a dog to its owner.
Number of Dogs Returned to Owner

Number of dogs returned to owner

Relative Frequency

Number

0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000

1 201 401 601 801 1001 1201 1401 1601 1801 2001 2201 2401 2601 2801

The Risk Project
## Probability for dogs to be returned to owner

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>95% Confidence Limit</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-1.41</td>
<td>0.15</td>
<td>-1.70</td>
<td>-1.12</td>
</tr>
<tr>
<td>Funding Source</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>0.78</td>
<td>0.15</td>
<td>-1.09</td>
<td>1.09</td>
</tr>
<tr>
<td>Municipal</td>
<td>1.22</td>
<td>0.12</td>
<td>1.47</td>
<td>1.47</td>
</tr>
<tr>
<td>Private</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td>-0.53</td>
<td>0.12</td>
<td>-0.30</td>
<td>-0.30</td>
</tr>
<tr>
<td>Northeast</td>
<td>-0.98</td>
<td>0.27</td>
<td>-0.45</td>
<td>-0.45</td>
</tr>
<tr>
<td>Southeast</td>
<td>-1.44</td>
<td>0.16</td>
<td>-1.31</td>
<td>-1.13</td>
</tr>
<tr>
<td>Southwest</td>
<td>-0.93</td>
<td>0.15</td>
<td>-0.62</td>
<td>-0.62</td>
</tr>
<tr>
<td>West</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Admission Type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited Admission</td>
<td>-1.74</td>
<td>0.49</td>
<td>-0.78</td>
<td>-0.78</td>
</tr>
<tr>
<td>Open Admission</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Shelter Size</td>
<td>-0.0001</td>
<td>0</td>
<td>-0.0002</td>
<td>0</td>
</tr>
</tbody>
</table>
Shelter Size

- OR = 0.99 (0.98, 1)
  (OR = 0.90 per 1000 additional dogs)

- The larger the facility (greater number of dogs), the less likely that the facility will return a dog to owner.
Model-Adjusted Probability for a Shelter to Return a Dog to Owner

Funding Source

- Mixed: OR= 2.2 (1.7, 3.0)
- Municipal: OR= 3.4 (2.7, 4.3)
- Private: Referent
Model-Adjusted Probability for a Shelter to Return a Dog to Owner

Midwest: OR: 0.59 (0.47, 0.74)
Northeast: OR: 0.38 (0.22, 0.64)
Southeast: OR: 0.24 (0.18, 0.32)
Southwest: OR: 0.40 (0.29, 0.53)
West: Referent
Model-Adjusted Probability for a Shelter to Return a Dog to Owner

Admission Type

Limited admission: OR= 0.2 (0.1, 0.5)
Open Admission: Referent
Factors affecting the probability for a shelter to adopt a dog
Model Adjusted Probability for a Shelter to Adopt a Dog

Funding Source
- Municipal: OR= 0.6 (0.4-0.8)
- Mixed: OR= 0.3 (0.2-0.4)
- Private: Referent

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Model Adjusted Probability for a Shelter to Adopt a Dog

Admission Type

Limited admission: OR: 2.8
(1.5, 5.2)
Open admission: Referent

Probability

No
Stray Admission
Yes

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Factors affecting the probability that a shelter euthanizes a dog
Factors affecting the probability that a shelter euthanizes a dog

Shelter Size

OR = 1.0005 (1.0003, 1.0006)
(OR = 1.65 for every 1000 dogs)

The larger the shelter intake, the more likely they are to euthanize.
Model-Adjusted Probability for a Shelter to Euthanize a Dog

**Funding Source**

- Mixed: OR = 1.4 (0.6, 3.3)
- Municipal: OR = 2.1 (0.9, 5.1)
- Private: referent
Model-Adjusted Probability for a Shelter to Euthanize a Dog

- Midwest: OR = 1.6 (1.03, 2.6)
- Northeast: OR = 1.4 (0.5, 4.2)
- Southeast: OR = 5.1 (3.3, 7.9)
- Southwest: OR = 3.1 (1.8, 5.4)

West: Referent
Model-Adjusted Probability for a Shelter to Euthanize a Dog

**Admission Type**

- Limited Admission: OR = 0.14 (0.08, 0.6)
- Open Admission: referent

Probability

Stray Admittance

- No
- Yes
Factors affecting the probability that a shelter transfers a dog
Model-Adjusted Probability for a Shelter to Transfer a Dog

Funding Source

Mixed: OR = 1.6 (0.2, 2.6)
Municipal: OR = 2.1 (1.4, 3.1)
Private: Referent
Model-Adjusted Probability for a Shelter to Transfer a Dog

Midwest: OR= 1.3 (0.8, 2.2)
Northeast: OR= 0.2 (0.09, 0.5)
Southeast: OR= 1.5 (0.9, 2.6)
Southwest: OR= 1.2 (0.7, 2.3)
West: Referent
Model-Adjusted Probability for a Shelter to Transfer a Dog

Admission Type

Limited Admission: OR= 0.3 (0.09, 0.8)
Open Admission: referent

Stray Admission

Probability

0.12
0.1
0.08
0.06
0.04
0.02
0

No
Yes

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Factors affecting the probability that a shelter receives any dogs from transport.
Model-adjusted probability for a shelter to receive any dogs from transport

Region

MW: OR = 0.5 (0.3, 1.0)
NE: OR = 1.2 (0.4, 3.1)
SE: OR = 0.3 (0.1, 0.5)
SW: OR = 0.6 (0.2, 1.3)
W: referent
Model-adjusted probability for a shelter to receive any dogs from transport

- **Mixed**: OR = 0.7 (0.4, 1.1)
- **Municipal**: OR = 0.2 (0.1, 0.3)
- **Private**: referent
Model-adjusted probability for a shelter to receive any dogs from transport

No Surrender: OR = 0.3 (0.1, 0.9)
Surrender: referent
How many dog shelters are in the United States?

This sampling frame (like others) is likely a subset of the true number of dog shelters in the US.

If we knew the total number of shelters in the US, we could use the survey results to estimate the total number of dogs in shelters and then calculate the “fate” statistics.

A novel approach to this problem is capture-recapture methodology.
Capture-recapture methodology

• Used by wildlife researchers to estimate the number of animals in a population

• Compare shelters in our frame (Marked) to other shelters in other frames (Capture and Recaptured)

• e.g. the proportion of shelters from Mississippi in our frame and also found in an independent frame of Mississippi shelters
Capture-recapture methodology

The simplest method for estimating population size is the Lincoln-Petersen method. The basic method involves a single marking and a single recapture episode. If we mark a sample of animals, M and capture a sample of animals, C, containing R marked individuals, we estimate the size of the population at the time of the original marking, N, as:

\[
N/M = C/R \\
N = MC/R \\
N = M/(R/C)
\]
Capture-recapture methodology

- We know M (2,862). If we can estimate C/R, then we can calculate the total number of shelters.
- C = the total number of shelters in other lists
  - FL, MI, MS, ME, SC
- R = the number of repeats
- Clopper-Pearson 95% CI around R/C

\[ N = MC/R \]
\[ N = M/(R/C) \]
## Number of Dog Shelters

<table>
<thead>
<tr>
<th>State</th>
<th>Client Frame</th>
<th>Other Frames</th>
<th>Repeats</th>
<th>Simple</th>
<th>Unbiased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Florida</td>
<td>M</td>
<td>C</td>
<td>R</td>
<td>190</td>
<td>189</td>
</tr>
<tr>
<td>South Carolina</td>
<td>52</td>
<td>143</td>
<td>47</td>
<td>158</td>
<td>158</td>
</tr>
<tr>
<td>Maine</td>
<td>21</td>
<td>59</td>
<td>13</td>
<td>95</td>
<td>93</td>
</tr>
<tr>
<td>Michigan</td>
<td>101</td>
<td>140</td>
<td>66</td>
<td>214</td>
<td>214</td>
</tr>
<tr>
<td>Mississippi</td>
<td>35</td>
<td>66</td>
<td>25</td>
<td>92</td>
<td>92</td>
</tr>
<tr>
<td><strong>All</strong></td>
<td><strong>306</strong></td>
<td><strong>539</strong></td>
<td><strong>218</strong></td>
<td><strong>757</strong></td>
<td><strong>756</strong></td>
</tr>
</tbody>
</table>

\[ R/C = \frac{218}{539} = 0.40445 \text{ (95\% CI = 0.36-0.45)} \]
Estimated Number of Dog Shelters

\[ \frac{2,862}{0.40445} = 7,076 \]

(95% CI = 6,399-7,890)

\[ N = MC/R \]
\[ N = M/(R/C) \]
Number of Dogs...

- Entering shelters: 5,532,904  
  (95% CI: 5,003,528-6,169,579)
- Adopted: 2,628,112  
  (95% CI: 2,376,660-2,930,531)
- Returned to Owner: 969,443  
  (95% CI: 876,689-1,080,998)
- Transferred: 778,385  
  (95% CI: 703,911-867,955)
- Euthanized: 776,970  
  (95% CI: 702,631-866,377)
Number of Dogs...

- 379,994 (7%)
- 778,385 (14%)
- 969,443 (18%)
- 776,970 (14%)
- 2,628,112 (47%)

Key:
- Blue: adopted
- Red: euthanized
- Green: returned
- Purple: transferred
- Cyan: other
Conclusions

There are several variables that affect the numbers and fates of dogs entering shelters across the United States

• Region
• Funding source
• Admission Type
• Number of intakes
Conclusions

Compared to what is frequently reported, we estimate that there are:

• More dogs in shelters
• Greater percentage of dogs adopted
• Fewer dogs euthanized
Conclusions

Transport may be responsible for reducing the number of dogs euthanized

• Move from areas of surplus to areas of demand

• Concern about spread of disease (e.g. heartworms)
Applying risk-based strategies to solve everyday problems in animal populations

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Kimberly A. Woodruff, DVM, MS
Dipl. ACVPM (Epidemiology)
Director, Shelter Medicine
kimberly.woodruff@misstate.edu

David R. Smith, DVM, PhD
Dipl. ACVPM (Epidemiology)
Mikell and Mary Cheek Hall Davis Endowed Professor
david.smith@msstate.edu

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Dept. of Pathobiology and Population Medicine / Dept of Clinical Sciences
PO Box 6100, 240 Wise Center Drive
Mississippi State, MS 39762