



## Survey of small-enterprise chicken operations in the United States

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### ABSTRACT

The National Animal Health Monitoring System (NAHMS) Small-Enterprise Chicken study was conducted to better understand bird movement and biosecurity practices of commercial poultry operations having fewer than 20,000 chickens. A stratified random sample of 2511 operations having 1000–19,999 chickens was selected from a list maintained by the National Agricultural Statistics Service (NASS), based primarily upon data from the 2002 Census of Agriculture; 1789 (72.1%) operations participated in the study. Over one-half of operations were contract operations with breeding birds, and one-fourth were contract operations without breeding birds. Only 17% of operations were independent (noncontract) operations. Independent operations were primarily table-egg producers and to a lesser extent, growers. Independent operations were more likely to have birds other than chickens, to allow outdoor access to birds, and had less stringent biosecurity requirements compared to contract operations.

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### 1. Introduction

The fact that Highly Pathogenic Avian Influenza (HPAI) has quickly spread throughout the world, and has become endemic in some countries, highlights the need to understand potential ways foreign animal diseases (FAD) can spread in the U.S. poultry industry. In order to develop poultry disease spread models and plan resource allocation for a quick and effective response in the event of an outbreak, an understanding of the biosecurity and movement practices of all segments of the poultry industry is needed.

Information is available about the management practices of commercial poultry operations in the United States (Moreng and Avens, 1991; Tablante et al., 2002). A previous USDA study addressed layer operations with 30,000 or more layers (USDA, 1999, 2000). The USDA:APHIS also conducted a national study that addressed health, biosecurity, and bird movement practices of

backyard flocks with fewer than 1000 birds and gamefowl breeders (USDA, 2004a). However, little is known about small commercial operations in the United States. This study was conducted to gain a basic understanding of the types of operations with 1000–19,999 chickens and their biosecurity and bird movement practices. Comparison to the previously conducted USDA backyard flock study was a secondary objective.

### 2. Methods

The National Agricultural Statistics Service (NASS) list frame was used to randomly select operations with 1000–19,999 chickens (*Gallus gallus*). NASS conducts hundreds of producer-level surveys each year, and information from these surveys is used to build the list frame. Historically, producer association lists, tax assessor lists, and breed association lists were also used. The Census of Agriculture was first conducted by NASS in 2002, and it contributed heavily to increased list completeness for the NASS list frame. This study sample was based primarily on data from the 2002 Census of Agriculture, as no recent NASS survey program targeted the population explored during this

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study. The population total from which the sample was selected equaled 4265 producers having 1000–19,999 chickens. The list was sorted by type of operation (layer or broiler) and size (1000–9999 and 10,000–19,999 chickens) within each state. A systematic random sample was selected ( $n = 2511$ ), with the number of operations allocated to each state proportional to the number of operations in that state. All 50 states were included in the sample. Assuming a 70% response rate, and additionally assuming that 10–20% of respondents would no longer have chickens, we anticipated that between 1400 and 1600 respondents would complete the questionnaire. This sample size was adequate to estimate prevalences of 50% ( $\pm 2-3\%$ ) and 10% ( $\pm 1-2\%$ ) with 95% confidence (Centers for Disease Control and Prevention, 2005).

A questionnaire (English language, available upon request) was developed focusing on biosecurity practices and bird movements during the previous year. The questionnaire contained 37 questions that were primarily yes/no and multiple choice with an opportunity to write in explanations. The questionnaire was pretested at 5 small-enterprise chicken operations and revised based on input from respondents.

A total of 2511 questionnaires were mailed to eligible producers in August 2007, followed by a reminder survey to nonrespondents 2 weeks later. Nonrespondents to both mailings were contacted by telephone in September 2007 during which time the surveys were completed via telephone interview. Producers were asked if they had any chickens present on their operations from October 2006 to September 2007. Those operations with any chickens present completed the remainder of the questionnaire.

Estimates infer to the population of operations with 1000–19,999 chickens in the United States, based on inventory data available from NASS. All respondent data were statistically weighted to reflect the population from which they were selected. The inverse of the probability of selection for each operation was the initial analysis weight. This weight was adjusted by the sum of weights for all operations divided by the sum of weights for respondent operations (including those with no chickens from October 2006 to September 2007), within 2-type (layer or broiler), 2-size (fewer than 10,000 chickens or 10,000 or more chickens), and 7-region strata.

Data were entered into a SAS data set. Validation checks were performed to identify numeric extremes, improper categorical responses, skip patterns not followed, and relational checks. Weighted point estimates and odds ratios were calculated using SUDAAN software, which accounts for sampling methodology and clustering by use of the Taylor

linearization method (Shah et al., 1996). Each variable was modeled individually by logistic regression with contract status as the outcome variable. Region, flock size, and presence of breeding chickens were included as covariates to simultaneously adjust for the potential effect of these variables while evaluating the other variables of interest.

### 3. Results

#### 3.1. Response rate

A total of 964 operations responded by mail and 825 operations responded by telephone for a response rate of 71.2%. Additionally, 547 (21.8%) operations could not be contacted (inaccessible) and 175 (7.0%) declined to participate in the study.

#### 3.2. Population estimates (weighted results)

Overall, 67.5% (95% CI = 65.4–69.6%) of operations had chickens present between October 2006 and September 2007. Of operations with chickens present during the year, 5.8% (95% CI = 4.7–7.1%) of operations reported that the largest number of chickens they had on hand on any given day was 999 or fewer, while 21.3% (95% CI = 19.1–23.6%) reported they had 20,000 or more on any given day.

The majority of operations (55.2%) had breeder flocks operating under contract with a poultry company. Only 17.4% of operations were independents (not operating under contract with a poultry company) (Table 1). Nearly all operations with 10,000 or more chickens and over one-half of smaller operations (fewer than 10,000 chickens) operated under a contract with a poultry company (95.8 and 54.1%, respectively). Nearly all operations in the Southeast region operated under a contract with a poultry company (96.9%), compared to 59.8% of operations in the West region (Table 2).

#### 3.3. Odds ratios (weighted results)

Independent operations were more likely than contract operations to raise chickens for table-egg production (OR = 12.6) or for meat production (OR = 2.7) and were less likely to have breeding chickens (OR = 0.12) (Table 3). Independent operations were more likely to have birds other than chickens (OR = 10.8) and to keep multiple types of birds on the premises (which may have been multiple chicken types or multiple bird species) (OR = 13.4), while nearly all contract operations (97.0%) were limited to a single bird type.

**Table 1**

Survey of small-enterprise chicken operations in the United States (September 2007): weighted percentage of operations by contract status and presence of breeding chickens ( $n = 1191$  operations with chickens).

Contract status/breeding chickens	Percent operations	95% CI
Contract with breeding chickens	55.2	52.7–57.7
Contract without breeding chickens	27.4	25.0–29.9
Independent (noncontract) with breeding chickens	3.2	2.3–4.3
Independent (noncontract) without breeding chickens	14.2	12.6–16.0
Total	100.0	

**Table 2**

Survey of small-enterprise chicken operations in the United States (September 2007): weighted percentage of operations that operated under a contract with a poultry company, by flock size and region ( $n = 1191$  operations with chickens).

	Percent operations	95% CI
All operations	82.6	80.7–84.3
Flock size (chickens)		
1000–9999	54.1	49.6–58.6
10,000–19,999	95.8	94.2–96.9
Region		
West	59.8	52.6–66.7
Northeast	66.0	61.8–69.9
Southeast	96.9	95.4–97.9

Independent operations were more likely than contract operations to consider themselves to be natural, or free-range (OR = 1.6 and 11.6, respectively); to have outdoor access available to their birds (OR = 7.5); and for birds to be able to leave the property (OR = 9.0) (Table 4). Additionally, about two-thirds of operations with birds other than chickens allowed outdoor access, compared to less than 10% of operations with chickens only (66.4 and 7.7%, respectively; data not shown).

About one-half of both contract and independent operations that removed live birds did so directly to slaughter. Contract operations were 14 times more likely than independent operations to return birds to a contractor or poultry company, while independent operations were more likely to use other channels to remove live birds. Independent operations were more likely than contract operations to place day-old chicks or hatchlings, while contract operations were more likely to place birds older than hatchlings. The majority of operations that placed older birds (80.8%) got the birds directly from another premises with poultry. Independent operations were more

likely than contract operations to use other sources of older birds, which included feed stores, farmer's markets, fairs, shows, auctions, and other miscellaneous sources. Taking birds to another location where birds were present, such as a show or fair, and returning birds to the operation was a rare occurrence for both contract and independent operations (0.2 and 5.2%, respectively).

Rendering was not a common bird carcass disposal method for either contract (6.9%) or independent (5.2%) operations. About one-third of both contract and independent operations used composting of bird carcasses as their primary method of disposal. Contract operations were more likely to incinerate carcasses and independent operations were more likely to use burying on premises and other methods.

Independent operations were more likely than contract operations to see evidence of wild waterfowl, other wild birds, and wild animals other than rodents in the bird production area. Additionally, an association was found between exposure to these animals and outdoor access (data not shown). Exposure to neighboring poultry was rare for both contract and independent operations. Sharing equipment was less common for independent operations than for contract operations (OR = 0.43).

Although a more common occurrence on independent operations, workers rarely had exposure to birds on other operations or at their homes (Table 5). Contract operations required more biosecurity measures be taken by employees compared to independent operations.

Contract operations were more likely to have visits from feed delivery personnel, service persons, catch crews, and vaccination crews compared to independent operations, while independent operations were more likely to have customer and nonbusiness visitors (Table 5). A similar percentage of contract and independent operations required hand washing, parking away from the bird area, and no contact with other birds for at least 24 h before entering for visitors.

**Table 3**

Survey of small-enterprise chicken operations in the United States (September 2007): weighted percentage of contract and independent operations with the following types of birds on the premises on the day the questionnaire was completed, and odds of independent operations having the bird type compared to contract operations ( $n = 1191$  operations with chickens).

Bird type	Percent positive (all operations)	Percent positive (contract operations)	Percent positive (independent [noncontract] operations)	Odds ratio	95% CI
Breeding chickens for hatching egg production (including hens, roosters, etc.)	58.3	66.9	18.3	0.12	0.07–0.19
Chickens for table-egg production	19.2	8.6	68.6	12.6	7.8–20.2
Chickens for meat production	19.2	15.5	37.2	2.7	1.8–4.1
Chickens—other (show, exhibition, gamefowl)	2.1	0.7	8.8	9.7	3.3–28.2
Turkeys	3.9	0.9	17.2	11.8	4.7–29.7
Waterfowl	3.4	0.5	15.7	11.2	3.5–35.5
Guinea fowl	1.6	0.3	7.8	8.7	1.4–52.9
Pigeons, doves	1.0	0.3	4.5	9.6	2.1–44.5
Game birds (quail, pheasant)	1.0	0.4	4.1	3.6	0.42–31.9
Pet birds (e.g., parrots, parakeets)	0.5	0.2	1.9	11.5	1.6–82.8
Other	0.8	0.5	2.6	5.0	0.87–28.4
Any birds other than chickens	7.8	2.1	33.4	10.8	5.4–21.5
Multiple bird types on premises (multiple chicken types or birds other than chickens)	10.7	3.0	46.5	13.4	7.4–24.0

**Table 4**

Survey of small-enterprise chicken operations in the United States (September 2007): weighted percentage of contract and independent operations having the following characteristics and odds of independent operations having the characteristic compared to contract operations ( $n = 1191$  operations with chickens).

Characteristic	Percent positive (all operations)	Percent positive (contract operations)	Percent positive (independent [noncontract] operations)	Odds ratio	95% CI
Natural (no feed additives fed) <sup>a</sup>	24.0	18.7	48.2	1.6	1.01–2.6
Organic <sup>a</sup>	7.3	5.0	17.8	1.1	0.53–2.2
Free-range or pasture raised <sup>a</sup>	8.3	1.9	38.2	11.6	5.1–26.5
Outdoor access				7.5 <sup>b</sup>	4.1–14.0
Outdoor access—able to leave premises	3.3	0.6	15.1	9.0 <sup>c</sup>	2.9–27.7
Outdoor access—not able to leave premises	9.0	2.6	39.9		
No outdoor access	87.7	96.8	45.0		
Permanently removed live birds (previous 12 mo)	86.7	91.4	64.5	0.19	0.11–0.35
Channel birds removed <sup>d</sup>					
Directly to slaughter (slaughter facility or home slaughter)	50.8	50.1	57.0	1.3	0.77–2.2
Returned to contractor or poultry company	42.7	48.2	3.8	0.07	0.02–0.21
Another premises with poultry (including game birds)	9.6	7.2	28.4	5.4	2.4–12.1
Live-bird market	9.3	7.4	21.5	1.1	0.54–2.2
Feed store, farmers market, fair, show, auction, and others	4.7	1.9	23.2	13.0	3.8–44.6
Placed day-old chicks/hatchlings (previous 12 mo)	33.5	27.7	61.4	3.2	2.0–5.2
Placed older birds (previous 12 mo)	50.1	55.2	26.1	0.35	0.21–0.58
Source of older birds <sup>e</sup>					
Directly from another premises with poultry (including game birds)	80.8	81.9	71.9	1.0	0.38–2.8
Poultry wholesaler or dealer	19.1	17.5	32.3	1.0	0.43–2.5
Feed store, farmers market, fair, show, auction, and others	5.6	4.4	17.7	6.8	1.8–25.5
Took birds to another location where birds were present and returned birds to operation	0.2	0.2	5.2	10.7	0.77–149.5
Primary carcass disposal method					
Incinerate	33.3	37.3	14.0	0.57	0.33–0.99
Compost	32.0	31.4	34.5	0.55	0.34–0.89
Bury on premises	18.7	17.2	25.2	2.0	1.1–3.7
Landfill, put in trash, fed to other animals, added to manure pile, and others	9.5	7.2	21.1	2.6	1.3–5.3
Renderer	6.5	6.9	5.2	1.1	0.40–3.2
Contact with other animals (usually or sometimes)					
Rodents	73.9	76.1	64.9	0.84	0.54–1.3
Wild animals other than rodents (e.g., feral cats, raccoons, skunks, opossums)	26.1	23.0	41.0	1.7	1.04–2.6
Wild waterfowl	7.3	6.3	12.2	2.9	1.5–5.7
Wild birds other than waterfowl	22.7	19.7	37.3	1.8	1.2–3.0
Poultry from a neighbor	0.8	0.9	0.2	0.97	0.08–11.8
Shared equipment with other operations	13.3	15.0	4.8	0.43	0.22–0.85

<sup>a</sup> Based on producer's perception.

<sup>b</sup> Reference level = no outdoor access.

<sup>c</sup> Reference level = birds not able to leave premises.

<sup>d</sup> For operations that removed live birds.

<sup>e</sup> For operations that placed older birds.

#### 4. Discussion

Mail surveys present certain data quality challenges, as respondents may not complete the questionnaire properly. In particular, when a question included a list of yes/no sub-questions, some respondents only circled yes responses. In these instances, we imputed “no” responses so that “yes” responses would not be overestimated. However, it is possible that this imputation may overestimate “no” responses to some degree. In contrast, the phone interview “no” responses were confirmed and recorded by the data collector.

Because some surveys were completed by mail while others were completed via phone interview, differences between these types of respondents could potentially introduce bias. To address this issue, we examined mail versus phone respondents for geographic location, flock size, contract status, presence of chickens, and presence of breeding chickens specifically. Mail respondents were similar to phone respondents in these characteristics, allowing more confidence in the general representativeness of our sample.

Criteria for selection were dependent on chicken inventory only and therefore, inferences cannot be made

**Table 5**

Survey of small-enterprise chicken operations in the United States (September 2007): weighted percentage of contract and independent operations having the following worker and visitor practices and odds of independent operations using the practice compared to contract operations ( $n = 1191$  operations with chickens).

Worker and visitor biosecurity	Percent positive (all operations)	Percent positive (contract operations)	Percent positive (independent [noncontract] operations)	Odds ratio	95% CI
<b>Workers bird exposure</b>					
Work on other operations or for another business that handles live or dead birds	3.6	3.1	5.7	0.95	0.31–3.0
Have pet birds or poultry at home	1.9	0.9	7.0	7.4	1.6–33.8
<b>Worker requirements (always or sometimes)</b>					
Change into clean boots or use shoe covers	70.8	75.3	49.4	0.48	0.30–0.75
Use footbath before entry	69.5	77.6	31.0	0.30	0.19–0.48
Scrub shoes before entry	41.9	44.2	29.9	0.71	0.45–1.1
Scrub shoes after exit	42.8	45.0	31.8	0.78	0.49–1.2
Any footwear requirement	86.6	92.5	58.1	0.29	0.16–0.51
Wash hands before handling birds	63.8	65.3	57.2	1.0	0.65–1.6
Wash hands after handling birds	81.9	83.5	74.0	0.75	0.45–1.3
Change into clean clothes or coveralls	57.9	62.6	36.4	0.48	0.32–0.74
Shower	26.5	28.6	16.8	0.54	0.30–0.95
<b>Visitors</b>					
Feed delivery personnel	83.7	91.1	49.0	0.18	0.11–0.31
Service person employed by poultry company	79.8	93.6	14.6	0.03	0.02–0.06
Catch crew	77.3	90.2	16.5	0.06	0.04–0.11
Crew for vaccination or other medical procedures	40.4	47.8	6.1	0.11	0.05–0.21
Service person for facilities or equipment (e.g., meter reader, plumber, electrician, etc.)	42.8	47.2	22.0	0.54	0.34–0.86
Veterinarian (private or company)	34.5	35.9	28.3	0.91	0.56–1.5
State or federal veterinarian or animal-health worker	13.2	12.6	16.3	2.6	1.2–5.6
University veterinarian or cooperative extension agent	4.5	4.0	7.2	4.4	1.03–19.2
Inspector (e.g., county health inspector or official to certify birds as organic)	13.9	12.0	22.3	1.4	0.73–2.6
Nutritionist or feed company representative	9.0	7.1	18.0	2.2	1.2–4.2
Customer (private individual)	8.6	1.7	41.8	15.8	6.4–39.5
Bird wholesaler, buyer, or dealer (including live-bird market owner)	3.4	2.3	9.1	2.4	1.1–5.5
Other people visiting for business purposes	7.4	6.7	10.8	2.0	0.93–4.5
Nonbusiness visitors (e.g., school groups, friends, or neighbors just coming by to see the birds)	12.3	8.7	29.5	2.0	1.2–3.4
<b>Visitor requirements (usually or sometimes)</b>					
Change into clean boots or use shoe covers	62.4	63.3	54.4	0.93	0.57–1.5
Use footbath before entry	54.8	57.7	30.5	0.55	0.32–0.93
Scrub shoes before entry	36.7	37.4	30.2	1.1	0.60–1.9
Scrub shoes after exit	36.6	36.9	33.6	1.4	0.79–2.4
Any footwear requirement	69.2	70.7	57.5	0.82	0.50–1.3
Change into clean clothes or coveralls	54.7	56.3	41.4	0.81	0.50–1.3
Wash hands before handling birds	48.8	48.9	49.5	1.6	0.94–2.6
Wash hands after handling birds	55.3	55.0	56.4	1.5	0.92–2.5
Park away from bird area	55.7	55.2	58.0	1.1	0.70–1.9
No contact with other birds at least 24 h before entering	37.9	37.9	39.5	1.4	0.81–2.3

from this study to poultry operations without chickens. Although the operations were selected for this study from a list of farms that had between 1000 and 19,999 chickens at some point in time, only two-thirds of operations had any chickens present between October 2006 and September 2007. Also, for some operations, the maximum inventory for the year fell outside the size range targeted for this study (1000–19,999 chickens). Because the NASS list is based on inventory on a single day, it is not surprising that some operations would have a maximum inventory during the year greater than 20,000 chickens. The inference population must be considered to be operations with 1000–19,999 chickens on the day of reporting to NASS.

Additionally, although very few operations refused participation (7.0%), approximately 20% of selected operations were inaccessible (could not be contacted), indicating that the list for this population may need to be updated, as operations may go in and out of business frequently. An up-to-date list frame could facilitate contacting producers in an emergency situation.

This study was a first attempt to gain some knowledge about the characteristics and practices of small-enterprise chicken operations in the United States. The high percentage of contract farms (82.6%) in this population of small chicken enterprises was a surprising finding. Many poultry farms in the United States operate under a contract

with a poultry company (integrator), whereby the contract farm provides labor and housing, and the company provides birds, feed, and veterinary services (MacDonald, 2008). The high percentage of contract farms in our study population may reflect the high number of breeding farms that fall into the size group targeted for this study, particularly in the Southeast region. Contract broiler breeder farms are commonly about 8000–12,000 head, with 1–2 chicken houses (Jacob and Nesheim, 2003), which is a smaller flock size than most commercial growers and table-egg producers. Very few contract layer and broiler production farms would be expected to fall in the size range of this study. Based on NASS 2002 Census data, farms that sold 2000–59,999 chickens comprised only 3.3% of all broiler farms, while 34.0% of broiler farms sold less than 2000 and 62.7% sold 60,000 or more (USDA, 2004b). Likewise, many commercial table-egg flocks are becoming very large, some in excess of 2,000,000 birds (USDA, 2004b).

Although many poultry farms in the United States operate under a contract with an integrator, independent operations also exist. We hypothesized that the small-enterprise segment would contain many of these independent operations, but we did not find as many independent operations as expected in the study population. The NASS list frame may not capture all of the independent operations, as these operations may go in and out of business more frequently. Another possible explanation is that independents tend to be either very small flocks (fewer than 1000 birds) or larger operations with more than 20,000 birds. In fact, a 2004 study of backyard flocks found over 90% of backyard flocks had fewer than 100 birds (Garber et al., 2007). A 1999 study of operations with 30,000 or more layers found that 39% of farm sites were company owned farms (independent producers) (USDA, 1999).

Many areas in which the contract producers were different from independents may be due at least in part to the phenomenon of capturing a lot of contract breeders in the contract category. Regarding the more stringent biosecurity requirements of contract operations compared with independent operations, the contractors may have rules that the contract farms must follow. Also, breeder farms usually have good biosecurity due to the value of the birds and the difficulty of replacing the birds if they are lost to a disease outbreak (Leeson and Summers, 2000). Poor biosecurity practices have been identified as risk factors for the introduction of avian influenza (AI). Visitors from retail (live-bird) markets were a risk factor in the 2002 outbreak of HPAI in Hong Kong (Kung et al., 2007). Sharing of farm equipment among farms and incomplete visitor hygiene measures for shoes, clothes, and hands were identified as risk factors for the introduction of Low Pathogenicity Avian Influenza (LPAI) in an outbreak in Japan (Nishiguchi et al., 2007).

Both contract and independent small-enterprise operations had stricter visitor biosecurity such as footwear and hand-washing requirements, compared to backyard flock operations. In a previous study, about 1 in 10 backyard flock operations had any footwear requirement for visitors (11.4%) (Garber et al., 2007), compared with 69.2% of small-enterprise operations. In regard to footwear biose-

curity, the use of footbaths and scrubbing shoes before entry may be less effective footwear disinfection procedures compared to changing boots or wearing shoe covers, as footbaths may harbor bacteria (Langsrud et al., 2006). Contract operations were 2 times more likely to require change of boots or shoe covers compared to independent operations.

Although contract operations generally had more stringent biosecurity requirements compared to independents, sharing equipment was more likely on contract operations than on independent operations, perhaps because contract operations may share equipment with other farms that contract with the same company.

While independent operations had more introductions of day-old chicks and hatchlings, contract operations had more older-bird introductions, which may be due in part to introduction of spiking males (introduction of new male birds to stimulate breeding activity) on breeder farms. However, it should be noted that, other than introduction of spiking males, breeder farms tend to operate all-in/all-out. In retrospect, asking specifically about the practice of all-in/all-out would have been a useful addition to our questionnaire.

Independent operations were more likely to buy and sell birds via channels that bring birds together from multiple sources (e.g., auctions/shows/fairs) than contract operations. Without thorough cleaning and disinfection of vehicles, crates, shoes, etc., these practices introduce the risk of carrying disease agents back to the operation.

Outdoor access can potentially expose birds to disease transmission from wild birds or neighboring poultry. East et al. (2006) showed that the presence of wild birds on chicken farms in Australia was associated with an increased risk of seroprevalence for Newcastle-disease virus. Our study demonstrated that outdoor access was related to having birds other than chickens on the operation, perhaps because waterfowl, game birds, and pigeons/doves are often allowed outdoors. Our study showed that about two-thirds of operations with birds other than chickens allowed outdoor access, versus less than 10% of operations with chickens only. Since contract operations were less likely than independent operations to have birds other than chickens, this could explain the difference in outdoor access between contract and independent operations. In comparison, a previous study of backyard poultry flocks (USDA, 2004a) showed that 47.1% of backyard flocks had outdoor access with the ability of some birds to leave the property, which is considerably higher than either contract or independent small-enterprise operations.

Independent operations were more likely to see evidence of wild waterfowl, other wild birds, and wild mammals in the bird production area compared to contract operations, which was related in part to outdoor access. Presence of wild mammals such as raccoons, possums, etc., was associated with increased risk of LPAI during an outbreak in Virginia (McQuiston et al., 2005). These animals may serve as mechanical vectors, spreading disease from one farm to another.

Carcass disposal is another important biosecurity issue. The best methods for carcass disposal are burial, incinera-

tion, and composting (Moreng and Avens, 1991; Oviedo-Rondon, 2005). Composting may be useful for disposing of carcasses after catastrophic losses because when done properly, it is environmentally friendly and results in inactivation of many pathogens (Oviedo-Rondon, 2005; Wilkinson, 2007). Although a similar percentage of contract and independent operations used composting, contract operations were more likely to use composting after adjusting for covariates (OR = 0.55). Overall, 32.0% of small-enterprise operations used composting for carcass disposal; in contrast, very few backyard flocks compost carcasses (5.6%) (USDA, 2004a). Use of renderer was associated with the spread of LPAI in Virginia in 2002 (McQuiston et al., 2005). Very few contract or independent small-enterprise operations used rendering (6.9 and 5.2%, respectively), so this population of chicken producers poses little risk of disease spread via this route.

This study provides insight into which types of operations comprise the small-enterprise segment of the chicken industry, the frequency and nature of interaction among operations, and the vulnerabilities of farms to disease introduction. A basic understanding of all segments of the poultry industry and the mechanisms which contribute to disease spread enables researchers to better characterize the various means of disease introduction and transmission between poultry operations in the United States. The valuable information captured by this survey will be used to help develop disease spread models that can be used to study disease impacts, design cost-effective disease surveillance and control programs, and contribute to contingency planning for highly contagious poultry diseases. Doing so will assist disease managers in identifying and evaluating alternative approaches to poultry health management.

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