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Small Poultry Flocks in Alberta: Demographics and Practices

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SUMMARY. The distribution, composition, and management characteristics of small "backyard" poultry flocks may have important implications in the spread of both avian diseases and zoonoses of public health concern. Although the prevalence of small poultry flocks has increased in Alberta, Canada, in recent years, there is minimal demographic information available for these populations. To gain initial epidemiologic insight into this growing population and potential areas of risk, a survey was conducted to characterize the sector. Information on flock demographics and bird health, as well as production and biosecurity practices, were gathered and analyzed from 206 surveys, representing respondents from 43 counties. These results revealed great diversity of both owners and flocks, characterized by wide variations in flock sizes and composition. Laying hens were the most commonly reported type of bird (93.4%), followed by ducks and geese (35.3%), turkeys, (33.8%), and broiler chickens (33.1%). Notably, 58.1% of owners reported having more than one type of bird in their flock, with many owners never, or only sometimes, separating flocks based on species or purpose. Personal consumption (81.8%) and sale of eggs (48.2%) were the most frequently cited purposes for owning a flock. Our findings suggest that owners in Alberta are predominantly new to production; most (73.1%) have kept birds for less than 5 yr and 25.6% for less than 1 yr. Flock health parameters revealed inconsistent use of medical interventions, such as vaccinations, treatments, and veterinary consultation. Data on the sourcing, housing, and movement of birds, as well as movement of people and visitors, reveal substantial potential for contact to occur directly and indirectly between flocks and humans. Additionally, basic husbandry and biosecurity practices were found to be inconsistent and often inadequate, highlighting important gaps and opportunities to improve the health of Alberta's small poultry flocks and mitigate risks to public health. These quantitative and qualitative results provide a baseline characterization of the sector and identify risks and challenges that may serve to inform the development and delivery of future study and interventions.

RESUMEN. Parvadas avícolas pequeñas en Alberta: Demografía y prácticas.

La distribución, composición y características de manejo de las parvadas pequeñas de traspatio pueden tener importantes implicaciones en la propagación de las enfermedades aviares y de zoonosis de interés para la salud pública. Aunque en los últimos años ha aumentado la prevalencia de pequeñas parvadas de aves de corral en Alberta, Canadá, existe poca información demográfica disponible sobre estas poblaciones. Para obtener una visión epidemiológica inicial de esta población creciente y áreas potenciales de riesgo, se realizó una encuesta para caracterizar el sector. Se recopiló y analizó la información sobre la demografía de las parvadas, así como la información sobre las prácticas de producción y de bioseguridad, mediante 206 encuestas, que representaron a encuestados de 43 condados. Estos resultados revelaron gran diversidad tanto con relación a los propietarios como de las parvadas, caracterizados por amplias variaciones en el tamaño de las parvadas y su composición. Las gallinas de postura fueron el tipo de aves que más se reportaron (93.4%), seguido por los patos y gansos (35.3%), pavos (33.8%) y pollos de engorde (33.1%). Cabe destacar que el 58.1% de los propietarios reportaron haber tenido más de un tipo de ave en su parvada, y muchos propietarios nunca separaron las aves acuerdo a su especie o propósito, o las separaron sólo algunas veces. El consumo personal (81.8%) y la venta de huevos (48.2%) fueron los propósitos más citados por los dueños de las parvadas. Estos hallazgos sugieren que los propietarios en Alberta son predominantemente nuevos en este tipo de producción. La mayoría (73.1%) han mantenido aves por no más de cinco años y 25.6% por menos de un año. Los parámetros de salud de las parvadas revelaron un uso inconsistente de intervenciones médicas, tales como vacunaciones, tratamientos y consultas veterinarias. Los datos sobre el abastecimiento, condiciones de alojamiento y el movimiento de las aves, así como del movimiento de personas y visitantes, revelan un potencial y sustancial contacto directo e indirecto entre las parvadas y los seres humanos. Además, se encontró que las prácticas básicas de producción y bioseguridad fueron inconsistentes y a menudo, inadecuadas, lo que destaca deficiencias y oportunidades importantes para mejorar la salud de estas parvadas pequeñas avícolas en Alberta y para mitigar los riesgos para la salud pública. Estos resultados cuantitativos y cualitativos proporcionan una caracterización básica del sector e identifican los riesgos y desafíos que pueden servir para definir el desarrollo de futuros estudios e intervenciones.

Key words: backyard chickens, small poultry flock, biosecurity, epidemiology, risk factors, zoonotic disease

Abbreviations: AI = avian influenza; HPAI = highly pathogenic avian influenza; NCD = Newcastle disease; NQ/NC = nonquota/noncommercial; PID = Premises Identification

The ambiguity of the colloquial term "backyard flock" and its lack of common definition may contribute to challenges in identifying, understanding, and characterizing the appropriate population. Through focus group consultation with relevant stakeholders, the term "small flock" was deemed most appropriate to represent the target population in Alberta. For the purpose of this study, it is understood to encompass a broad range of small-scale, nonquota/noncommercial (NQ/NC; NQ/NC refers to poultry production that exists outside of the supply management system; the term is generally and colloquially synonymous with "small flock" or "backyard flock." For the purposes of this study and discussion, the term NQ/NC includes flocks composed of less than quota controlled numbers [as per limits set in the regulations made under the Marketing of Agricultural Products Act: <300 layer hens or <2000 meat chickens)], regardless of whether eggs or meat will be

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direct marketed for consumption and regardless of route of sale). The term NQ/NC also encompasses other species or poultry types not subject to quota controls, such as pheasant and quail, and operations consisted of any combination of numerous species, including gallinaceous birds and waterfowl, for a variety of purposes, in urban or rural areas. Public interest in backyard poultry has been increasing in the United States (30); a trend reflected in Canada and evidenced by current policy attention to urban poultry regulations in various municipalities (24). There are many perceived benefits associated with small flock ownership, such as increased feelings of control over food sources and psychosocial benefits derived from the human-animal bond (3). However, there are also risks associated with these practices, most notably the spread of disease. Poultry and waterfowl are associated with numerous transmissible pathogens, including viral, bacterial, and fungal zoonoses, which may be spread through contact or through consumption of meat and eggs (15). The implication of small flocks in the transmission of both zoonotic diseases, such as avian influenza (AI) and *Salmonella* and other production-limiting diseases of economic concern such as Newcastle disease (NCD), has been studied in other regions and contexts (16,23). The impetus for this research has largely been to elucidate the potential risks to human health and threats to the commercial poultry industry, particularly in response to disease outbreaks. However, the conclusions of these studies have been somewhat mixed, and it has been argued that due to vast variation in practices, it is inappropriate to extend inferences about backyard flocks across contexts and regions (24). Although some have proposed that physical proximity of backyard operations to commercial poultry barns is not a significant risk factor for transmission of diseases, similar to what is known for AI (29), models developed by Smith and Dunipace (29) suggest that backyard flocks could have a modest impact on transmission dynamics during an epidemic. Even if this sector contributes only modestly to transmission of diseases, such as highly pathogenic AI (HPAI), within the industry at large (3), there remain known risks to bird health and welfare and human health. As diagnostics are often not performed on sick or dead birds, whether due to perceptions of need or issues of accessibility, causes of mortality in small poultry flocks in Alberta are largely unknown. A 5-yr study of backyard chicken mortality in California determined that most deaths were attributed to infectious diseases (60.4%), of which 5.9% were zoonotic pathogens (23). The absence of formal surveillance programs or reliable mortality data for Alberta flocks, in conjunction with reports that noncommercial poultry producers experience increased risk of zoonotic disease transmission due to close contact and variable adherence to biosecurity and hygiene practices (28), indicates an unacceptable knowledge gap for an at-risk population.

The provincial Premises Identification (PID) Program can be used to control the spread of infectious disease effectively through traceability and serves as a system to notify animal owners of events that could impact their animals or operations. This established program could serve to provide information on small flock owner demographics, but awareness of and participation by this population have not been previously evaluated. In addition, the prevalence and practices of small poultry flocks and producers in Alberta are largely unknown. Due to the heterogeneity of practices within this informal sector, generalizations drawn from previous studies in other regions (14) may be limited in their applicability, therefore justifying the collection of targeted regional data. The purpose of this study is to identify risks and challenges through analysis of data provided by small poultry flock owners to better characterize Alberta's unregulated poultry sector and inform decision making.

MATERIALS AND METHODS

Focus groups. Consultations were conducted with three focus groups (19 participants in total) consisting of small flock owners, relevant service providers (agriculture supply store and veterinarians), hatchery and industry representatives, and local interest groups in March 2014. Preliminary information on demographics, attitudes, and challenges of small poultry flock owners and their service providers was gathered and explored and used to develop the survey. In addition, an advisory working group (11 members in total), which consisted of small flock owners and representatives from their service providers (hatchery, Peavey Mart, Poultry Research Centre, processor, and private veterinarian) and members from the River City Hens, the Canadian Heritage Breeds, the North Central Alberta Poultry Association, and the Alberta Veterinary Medical Association, was created to provide guidance and feedback for the study. This advisory group helped direct the information-gathering phase and assist with development and distribution of surveys to the backyard poultry community and their service providers.

Another outcome of the consultations was a consensus that the term small flock is deemed most relevant for this study. Small flock is used to encompass the intended target population representing any NQ/NC flocks consisting of chickens, ducks, geese, pheasants, pigeons, turkeys, quail, or peafowl, or a combination of them in rural or urban settings. Explicit exclusion criteria for participants were not indicated or enforced, but expected interpretation was that nonquota producers would be self-selected, meaning production of less than 2000 birds per year for broiler chickens and 300 for layers and turkeys (14).

Survey. A questionnaire was designed, with input from the advisory working group, to investigate small flock demographics and practices in Alberta and to identify risk factors for disease transmission within and between flocks. Beta testing of the electronic survey was conducted with 20 participants, including the advisory working group and government staff.

The survey consisted of 56 questions, eliciting a combination of binary, categorical, and free-text responses, and delivered using the Opinio online survey platform (available upon request to corresponding author, Alberta Agriculture and Forestry). The survey was introduced at the North Central Alberta Poultry Association Show and Sale on February 14, 2015; hard copies were made available at this event and by request to any interested owners during the study period. The online survey was advertised through various avenues, such as Twitter, Kijiji, and Facebook, as well as local and regional small flock interest group Web sites. The survey was available to respondents between February 15, 2015, and July 15, 2015. Participation was voluntary, and responses kept confidential with no unique individual identifiers recorded. Survey is available as supplementary information. Data were cleaned, and preliminary analyses conducted in Microsoft Excel (Microsoft Corporation, Redmond, WA). Additional descriptive analyses were done through Stata Software (intercooled Stata 13, Stata Corporation, College Station, TX); ESRI ArcMap (Version 10) software was used to generate maps.

RESULTS

Respondents. A total of 206 (119 fully completed and 87 partially completed) surveys were obtained. Due to the variation in completion of the surveys, relative frequencies of responses were calculated on a per question basis, using total respondents for each question as the denominator. Many questions allowed for the selection of more than one response, thus the total number of responses may exceed total number of respondents (n) per question.

Demographics. The results represented owners in 43 counties in Alberta ($n = 128$; Fig. 1), and 27 (62.8%) of those counties had one

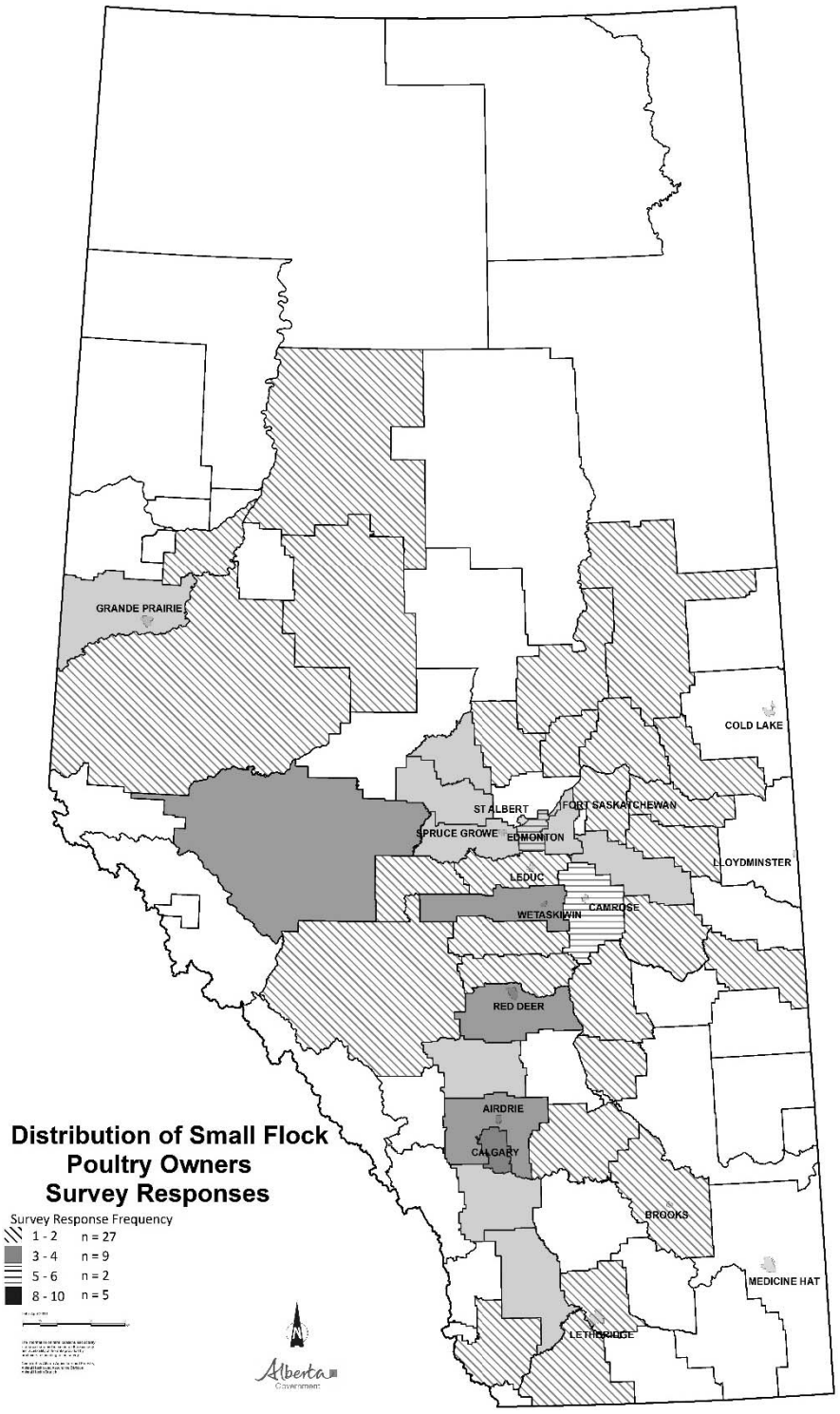

Fig. 1. Map of small poultry flock owner distribution in Alberta by survey response, represented at county level.

to two small poultry flock owners participate in the survey. Respondents to the survey were largely new to production: 25.6% had owned a flock for less than 1 yr, and the majority reported owning poultry for 5 yr or less (73.1%). No clear trend was noted between flock size and years in production within this sample.

As illustrated in Table 1, the majority of small flock owners reported having layer hens (93.4%). Flocks containing ducks and geese, turkeys, and broilers were also common, with other species less frequently reported. The sizes of flocks ranged considerably; overall, we found a mean of 136.4 birds per flock, with a median of 34 birds. Flocks containing layers tended to be smaller, with a mean of 34.7 birds and maximum recorded flock size of 299. Many (39.9%) of the respondents had layers only, of which 50.9% reported having 10 or fewer birds. Composite flocks were common: 58.1% of respondents had flocks with more than one bird type, and 30.9% had three or more bird types (Table 2). Of those reporting

Table 1. Flock size by bird type, as reported by small flock owners in Alberta.

Bird type	No. flocks reported, $n = 136$ (%)[A]	Mean flock size	Median flock size	Maximum flock size[B]
Layer	127 (93.4)	34.7	22.5	299
Broiler	45 (33.1)	186.1	65	1999
Duck/geese	48 (35.3)	21.2	10	500
Turkey	46 (33.8)	31.9	15	300
Pigeon	28 (20.6)	13	20	100
Quail/pheasant	27 (19.8)	93.7	10	2000
Other	28 (20.6)	13.9	12.5	120
Multiple	79 (58.1)	136.4	34	2597

[A]Number of flocks reported by bird type includes all flocks reported to include this type.
[B]No minimum flock size is provided, as there was reporting variation; many producers filled in 0 or left the field unpopulated.

two bird types, the most common combinations were layers with ducks or geese, layers and turkeys, and layers and broilers. Among owners with multiple species, 37.3% ($n = 118$) cited separating flocks, based on species or purpose, while 62.7% only sometimes or never separated flocks.

Table 2. Small flock characteristics as reported by owners (%).

Characteristic	%
No. bird types in flock ($n = 136$)	
1	42.6
2	26.5
3	16.9
4	9.6
5	4.4
Duration of ownership ($n = 156$)	
<1 yr	25.6
1–4 yr	36.5
5–9 yr	17.9
10–16 yr	9.6
>16 yr	10.3
Flock purpose ($n = 137$)[A]	
Own consumption	81.7
Hobby	56.2
Sale of eggs	48.2
Pet	45.9
Sale of live birds	32.1
Breeding	28.5
Sale of meat	17.5
Show/exhibition	16.8
Other	4.4
>1 reported purpose	79.6
>3 reported purposes	41.6
Bird source ($n = 136$)	
Breeder	59.6
Hatchery	44.1
Family/friends	26.5
Auction	25.7
Show/sale	22.1
Community contact	18.4
Store	5.9
Other[B]	5.9
Stage of bird purchased ($n = 137$)	
Chicks	72.9
Adults	45.9
Pullets	37.9
Fertilized eggs	27.7
None[C]	4.4

[A]Respondents were able to select more than one response.
[B]Most common response was www.kijiji.com.
[C]This represents owners who did not purchase any replacement stock.

Overall, own consumption was the most frequent purpose reported by flock owners across bird types (81.8%), followed by hobby, sale of eggs, and pet (Table 2). Most respondents (79.6%) cited more than one purpose for their flock, and 41.6% of respondents selected three or more purposes. Over half of those (52.8%) with layers sell eggs. Almost 56% ($n = 102$) of those raising birds for meat would process them at home rather than taking them to a slaughterhouse. As per Table 2, birds were obtained predominantly from breeders, hatcheries, or multiple sources (55.3%). They were sourced at various stages, with 73.0% purchasing chicks and 46.0% purchasing adults. In addition, 53% purchased birds of more than one age group. A large proportion (54.1%, $n = 135$) of owners sold or gave away birds, 30% of whom reported distributing birds of more than one life stage, and the majority (67.3%, $n = 113$) did so privately.

Flock health. The majority of owners (77.6%, $n = 125$) experienced bird mortalities in the previous year and were asked to report the number of birds that died, but no denominator was gathered. Raw reported mortality figures ranged from 2 to 250 birds, and an average annual crude mortality rate of approximately 15% was calculated by using figures of reported flock size and reported mortalities per owner that year. Table 3 lists predator, injury, and illness as the leading causes of mortality, followed by "other," particularly age and "unknown" as common causes of death.

Table 3. Relative frequency of flock characteristics and management practices reported by small flock owners.

Characteristic	%
Flock housing ($n = 118$)	
Indoors	5.1
Outdoors	3.4
Both	91.5
Cause of mortality in the past year ($n = 117$)	
Predator	42.7
Injury	35.9
Illness	29.1
Weather	22.2
Other[A]	17.1
Disposal of dead birds ($n = 117$)	
Burn	39.3
Garbage	34.2
Bury	28.2
Leave out for scavenging	16.2
Compost	13.7
Feed to other animals	7.7

[A]Common responses for "other" were age and unknown cause of death.

Treatments and veterinary care. Most owners sampled (82.0%, $n = 128$) reported always or sometimes treating sick birds in their flocks, and medicated water was the most frequently reported method of treatment (62.7%, $n = 118$). Fifty-five percent of respondents ($n = 127$) always or sometimes used medicated feed, typically for prevention (60.8%, $n = 102$), rather than treatment (5.9%). A range of other treatments, such as supportive care and culling, along with a variety of natural products, including probiotic yogurt, garlic, onion, apple cider vinegar, oregano oil, and cinnamon, were in use within this population. Regarding direct veterinary management of these flocks, 46.8% ($n = 126$) of owners stated there were veterinary services in their area, and others (35.7%) were unsure of the availability of these services. It was indicated that veterinary uptake was low: most owners (60.2%, $n = 128$) did not use veterinary services for their flock, and only few (7.0%) reported always using veterinarians. Reasons for this included the view that services were not economical (62.9%, $n = 89$) and veterinarians were not sufficiently experienced with poultry (44.9%). In addition, others offered the insight that veterinary attention was not required, as they did not perceive any health issues or felt comfortable treating flocks themselves.

Vaccination. Vaccination coverage of birds in small flocks was found to be inconsistent. Many (42.2%, $n = 128$) owners did not purchase any vaccinated chicks or birds, and only 37.2% ($n = 129$) reported vaccinating some, or all, birds in their flock. The most frequently used vaccine was for Marek's disease (35.3%, $n = 102$). Vaccines were most commonly administered by hatchery personnel (41.3%, $n = 63$) or owners (38.1%), which was consistent with responses of low veterinary services use. Interpretation of these results was complicated, as most (62.8%) reported that they vaccinated none of their birds, while 31.0% ($n = 128$) of these respondents purchased some or all of their birds vaccinated; information on vaccine boosters was not gathered.

Husbandry and management. Husbandry and management among small flock owners was characterized by great variation in practices. In Table 3, it was noted that a combination of indoor and outdoor housing was very common (91.5%), likely reflective of seasonal practices. Of owners who housed birds outdoors, most (75.2%, $n = 113$) used pens, but 54% reported combinations of penned, free range, and pastured. (Housing definitions were derived from focus group discussions and consultation with the advisory working group. Penned is understood to mean a fenced-in run out of doors; free range means that birds are not confined to cages, and pastured refers to birds kept out of doors in an unfenced area.) Among those using indoor housing, 90.4% ($n = 114$) of owners housed their flock in a dedicated barn or coop; most (83.1%, $n = 136$) did not report a period of downtime during which their coops were empty. For most owners, the results indicated 3-m perimeters were present around the facilities (68.6%, $n = 118$).

More than 50% (52.1%, $n = 117$) of owners stated that barns were always closed to wild birds and inaccessible by other animals (56.4%, $n = 117$). Only a small number of facilities (10.2%, $n = 118$) reported frequent evidence of mice, whereas 44.1% noticed no evidence of rodents where flocks were housed. Rodent control measures varied in frequency of use: 46.67% ($n = 105$) did not use mouse traps; 72.92% ($n = 96$) did not use bait; and 47.1% ($n = 70$) of owners who selected "other" cited using cats for mouse control.

A large variety of cleaning and disinfection practices were described. The majority (93.2%, $n = 117$) removed bedding and manure as part of their cleaning regimen. However, owners reported infrequent cleaning of coops (26.0% clean these coops two to three times per year) and equipment. A range of cleaning products and methods were reported, including use of "natural" disinfectants (27.8%, $n = 115$). Cleaning of feeders and waterers was typically done weekly (40.5%, $n = 116$), mostly with soap and water (65.5%, $n = 116$).

Shown in Table 3, the disposal methods for birds were diverse and included burning, garbage, burial, scavenging, and compost, with 34.0% of owners reporting a combination of methods. Most used open compost piles (74.4%) and spreading away from flock (29.1%) as means of disposing litter.

Feed and water. Most owners (74.14%, $n = 116$) purchased complete feed and always stored it indoors (75.21%, $n = 117$) within sealed bins (81.36%, $n = 118$). Most (80.0%, $n = 116$) offered more than one food source to their flocks, and common additional sources of feed included table scraps (61.2%) and access to pasture (56%). Water for flocks was mostly sourced from wells (72.7%, $n = 117$) and municipal water (25.6%).

Contact. Findings suggested there was the potential for direct and indirect contact between birds in the flocks surveyed. More than half (56.5%, $n = 124$) of the flocks had contact with visitors, and 33.6% ($n = 122$) of owners sometimes or often had contact with other flocks. Furthermore, a majority (55.3%, $n = 123$) of respondents attended farm or poultry shows. Although 60.2% ($n = 123$) stated that they always quarantined new birds, the duration of quarantine varied from 1 wk (14%, $n = 100$), 1 to 2 wk (28%), 2 to 3 wk (26%), and over 3 wk (32%). However, no separation protocol for new birds was specified. Most owners (71.2%, $n = 125$) reported always separating sick birds from the rest of the flock.

Biosecurity. Overall, many basic biosecurity practices were not used by the owners sampled (Fig. 2). Some practices, such as dedicated footwear, locks on doors, and screens on coop windows were used by greater than one third of respondents, but all other measures had considerably lower adherence. There was no clear trend between biosecurity practices and size of flock or years in production nor crude bird mortality.

Access to information. Information on poultry health was accessed predominantly through online sources (69.5%) particularly through forums (Table 4). Based on free-text responses throughout the survey, more information on natural or organic practices and products was of great interest to this population of owners. Awareness of the Alberta PID Program was determined to be 64.7% (Table 4). However, owners were not asked whether they were registered with the program.

DISCUSSION

The study aimed to gain insight into the number, distribution, and practices of small poultry flocks in Alberta. To the best of the authors' knowledge, this represents the first such detailed characterization of the sector in Canada. The authors recognize that these descriptive findings may be limited in representativeness and are intended to offer an initial understanding of small poultry flocks and their owners in Alberta, rather than yield inferences about the population.

Limitations and challenges. A major contextual limitation was the coincidence of a *Salmonella* outbreak of public health significance during the study period, involving the same population of small flock owners (25). This is expected to have decreased the response rate to the survey due to a shift in the focus of owners to the

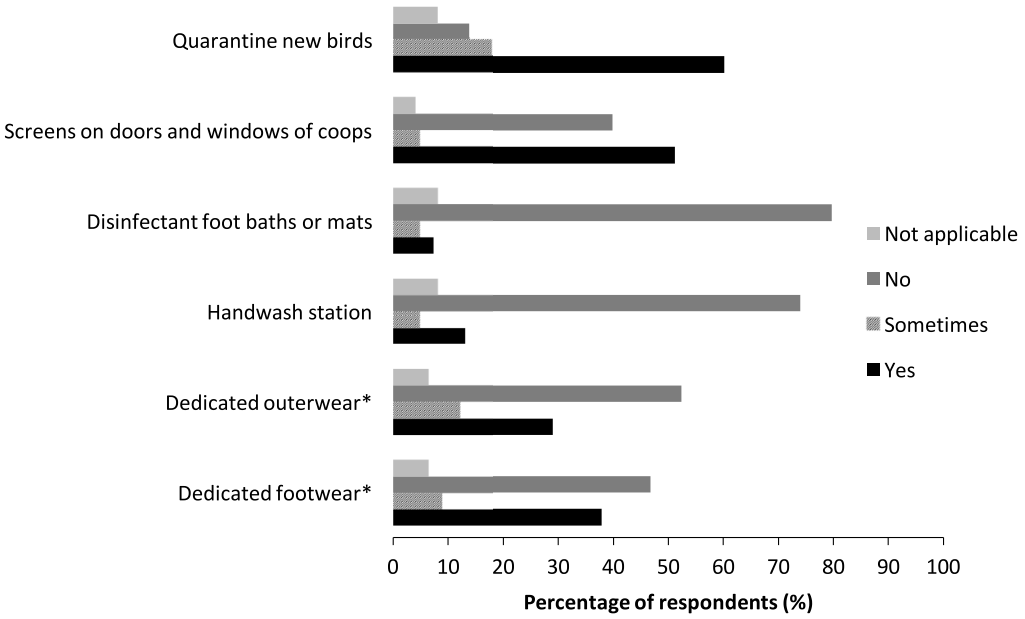

Fig. 2. Frequency of biosecurity practices reported ($n = 123$). *$n = 124$ respondents. Dedicated outerwear means any clothes, including coverall, jackets, or pants, which are only worn for the specific house, coop, or barn. Dedicated footwear means any footwear, including shoes, boots or booties, which are only worn for the specific house, coop or barn.

outbreak response. The total number of respondents likely represents a very small proportion of the true total small flock owner population in the province.

Generally, the incomplete questionnaires show an apparent loss of interest in recording responses, suggesting that some individuals completed the questions in order and stopped before completion.

Table 4. Characterization of small flock owners' access to information.

Characteristic	Relative frequency %
Information source ($n = 128$)	
Web site/forum[A]	69.5
Books	54.7
Veterinarian	40.6
Breeder	32.8
Government of Alberta	30.5
Club/association	28.1
Hatchery	21.9
Feed store	17.9
Supply store	17.2
More than one source	92.2
Topics of most interest to owners ($n = 107$)	
Flock diseases	85.0
Nutrition	81.3
Breeding and hatching	68.2
Infection control	67.3
Biosecurity	57.0
Pest management	53.3
Other[B]	9.35
Aware of Alberta PID Program ($n = 116$)	
Yes	64.7
No	35.3

[A]Most commonly cited Web sites include www.backyardchickens.com, www.the-chicken-chick.com, www.albertachickensetc.punbb-hosting.com, and Facebook groups.

[B]"Other" answers included predator control, information on flock testing and vaccinations, organic production, and information on husbandry tailored to small flock needs.

This may have been due to the length of the survey or discomfort in sharing all the information regarding their flock demographics and practices. Further, the data format of the responses to the matrix questions presented significant challenges for data manipulation and statistical analysis.

Conducting studies on small flock owners presents challenges, such as reaching members of a sector that are without an official representative association or directory list. Selection bias in recruitment of producers may have been introduced secondarily to the limitations of promotion and distribution of the survey. Only producers, who were both made aware of, and interested in, participated, which may have influenced the results gathered. In addition, as no exclusion criteria were employed, small flock owners were free to self-identify. The primary delivery of the survey online differs from the methods described in other studies that distributed questionnaires by mail or through feed and supply stores (30), although there exists precedent for online survey methodology as cost-effective and efficient (14). The online questionnaire format has some limitations: notably, being most readily accessible to those with Internet access and familiarity with technology; introducing more selection bias, including less incentive to complete the full survey; inability to clarify interpretations of questions; and variation in reporting by respondents.

Reporting bias by participants may have occurred, given the variability in completion rates for certain questions, including reporting location, as well as verbal statements that some producers were reluctant to accurately report on parameters, such as flock size. This is consistent with previously documented wariness of disclosing information to authorities (8). Conversely, there may be elements of "social desirability bias" in the results gathered, such as respondents inaccurately overreporting biosecurity measures or underreporting mortalities according to what they believed were the desired response.

Based on respondents sampled, we conclude that Alberta's small flocks are largely variable in composition and practices. Although some consistent trends were noted, such as the nearly ubiquitous

presence of layers in flocks, results must be interpreted with consideration of the relatively small number of respondents increasing the impact of potential outlier responses.

Other possible trends, such as birds used primarily for the owner's consumption, have to be weighed with the finding that most respondents selected other purposes for the birds as well. This variation is seen across other parameters, such as bird sourcing and distribution, and may be best interpreted as being in stark contrast to the practices of commercial poultry operations.

Our characterization of small flock owners, such as being new to production and demonstrating varying levels of experience and knowledge about poultry, are consistent with surveys of owners in the United States (21). Minimal measures for disease prevention were found in our sampled population: notably, inconsistent vaccination coverage; low veterinary oversight; and variable to insufficient cleaning and disinfection protocols. Overall, these findings are in line with those elucidated by other small flock surveys (30).

Biosecurity. Several biosecurity parameters varied from those found by other researchers. Practices, such as frequency of handwashing reported by this population (13.01%) was noted to be lower than that reported in similar studies conducted in Colorado (79.05% [28]) and Maryland (65.8% [21]). One possible explanation could be that our study, conducted by electronic means, may have provided increased perception of anonymity compared with the mail-out approach of previous studies; therefore, the Alberta owners may have been encouraged to report more accurately. It may also reflect challenges posed by the discomfort of frequent handwashing in cold conditions, characteristic of the region. However, the variable adherence to biosecurity practices found in this study is consistent with findings of other surveys, such as those conducted in the United States, United Kingdom, and New Zealand (13,18,32).

Although basic biosecurity measures alone may not be sufficient to produce measurable improvements in small flock poultry health in the short term (10), improving biosecurity practices should be a priority as a low-cost intervention to improve poultry health. In addition to public and poultry health benefits, biosecurity measures have been shown to increase egg production in backyard flocks in West Bengal (27), which may enhance owner compliance. Recommendations for government from a stakeholder analysis studying biosecurity in other commodities may be applicable to small flock owners. This includes raising awareness and a focus on the potential benefits of biosecurity to producers and collaborations with veterinarians and industry agents, such as in the hatcheries, to foster trust and communication between all parties, particularly between government and producers (17).

Inconsistent husbandry and flock management practices indicate gaps in knowledge and expertise among this population, some of which have further biosecurity, health, and welfare implications. The wide range of housing types reported makes it difficult to evaluate the true level of access by other animals, including wild birds, rodents, and other livestock. In addition, the widespread reported use of cats as rodent control suggests that felines have access to flock facilities. Widespread use of, and interest in, so-called natural products or alternative methods of flock management, particularly in cleaning and disinfection, should be addressed in educational materials.

Myriad resources on basic poultry husbandry and management, as well as biosecurity measures exist (1,6) and could be drawn upon to produce a useful resource for our target audience. Our findings echo those in other regions: the owner's main sources of information are online, with less reliance on veterinary input (8,12,18). Pollock *et al.* (24) recommend use of an online forum, where veterinary and public health professionals can provide guidance to owners.

Flock health. Mortality estimates rank predation and disease as leading causes of bird death, consistent with findings in Maryland (21). Many owners report losses due to unknown causes. The authors suggest that access to the outdoors in facilities and for flocks likely contributes to high levels of predation; thus, educating owners on proper housing may decrease these losses.

In the presence of limited data available for Alberta's small poultry flocks through the Alberta Agriculture and Forestry NQ/NC program, we look to results of other surveys for a preliminary understanding of disease etiologies in the population. A 5-yr retrospective study covering numerous regions of the United States noted that Marek's disease and *Escherichia coli* were the most commonly identified pathogens in small flock mortalities submitted for testing; no NCD or AI were found (11). This suggests that these diseases may not be frequent in backyard flocks in the United States, but further investigation is warranted to better understand causes of mortality in Alberta. In addition to risks of predation and disease transmission, the variable and potentially uncontrolled housing conditions reported by owners may lead to exposure to toxins such as lead, with bird health and food safety consequences (26).

Other surveys of backyard flocks have assessed owner's awareness of health and disease; Elkhoraibi *et al.* (12) found that the owner's self-rated level of poultry health knowledge served as a good indicator of assessed specific disease knowledge. Inclusion of this data in future surveys may enhance understanding of risks for flocks based on self-rated disease awareness scores. Transmissible poultry diseases of high concern, such as AI and NCD, were associated with lower levels of awareness among owners in the United States (12), which may have implications for outbreak preparedness. A study on awareness of diseases such as *Salmonella* by backyard flock owners showed varying levels of knowledge by region, but individuals selling or giving away eggs from their flocks had higher awareness of the link between contact with poultry and salmonellosis in humans (4).

Disease awareness was not evaluated in this survey, but in the wake of the *Salmonella* Enteritidis outbreak in this province (25), it could be a justifiable focus for future survey. Chicks may be an area of greater risk for public health, particularly the transmission of *Salmonella*, as children are more likely to have close contact with these birds, which can shed the pathogen in feces (9). Therefore, attention to health interventions, such as vaccinations, applied at the level of the hatchery may prove an effective measure in efforts to decrease disease transmission between birds and humans (5) to reduce risks for an individual owner receiving birds.

Veterinary involvement. In the absence of veterinary oversight, there is the potential for welfare issues due to improper management and husbandry; lack of proper diagnostics may result in inappropriate treatments, leading to poor poultry health and subsequent welfare issues, as well as risks to human and public health due to zoonotic diseases. Treatment of animals by the producers without veterinary guidance may lead to inappropriate doses or administration of prohibited substances, noncompliance of withdrawal times (31) posing risk to human health through poultry products contaminated with drug residues, or contribution to the spread of antimicrobial resistant organisms (16). In Canada, Health Canada Veterinary Drugs Directorate has proposed a policy change to move

all medically important antimicrobials to the prescription drug list. They estimate that this will come into effect in the fall of 2017 (S. Otto, pers. comm.).

Concerns regarding animal welfare in small poultry flocks, although not directly assessed in this study, have been raised (18) and may be mitigated by increased veterinary involvement in small flock management. Veterinarians are well placed to provide medical and diagnostic care for poultry, directly reduce disease burden through treatment, and provide information on biosecurity and husbandry. Furthermore, veterinarians can link to other experts, such as nutritionists, suited for an individual client's need. Veterinary involvement may also have a welfare benefit, and they may serve as an appropriate point of contact to provide information on pertinent government programs and regulations.

Potential courses of action to improve veterinary uptake would be to promote continuing education by government through the provincial regulatory body to increase veterinary competency in small poultry flock services. This will include a shift from practicing the traditional "flock health" management approach to poultry to providing care for individual birds, including diagnostics and treatment (20). It would be useful to provide veterinary services by trained private veterinarians that would be economical to the government, rather than engaging government veterinarians to provide day-to-day services to small poultry flock owners and to allocate resources to focus on reportable diseases, such as AI.

Establishing communication networks and further study. In light of the finding that the majority of owners obtain their birds from a hatchery or breeder, we can identify logical and feasible points for contact with owners. These contact points would then be used to gather further information, as well as provide a conduit for the distribution of educational materials and resources. Given the widespread use of commercial feed, suppliers have been recommended as another channel for rapidly contacting owners during an outbreak or emergency (19).

Burns *et al.* (7) recommend identification of movement patterns and connectivity between flocks in development of a risk-based approach to target education, surveillance, and, potentially, disease outbreak response measures. Participatory surveillance as an epidemiologic tool for risk assessment has effectively informed policy decisions in previous situations, such as surveillance of HPAI in small poultry flocks in some regions (22). If sufficient incentives for participation exist, such community-based techniques may capture data from otherwise underrepresented small poultry flock operations.

In future, the application of restrictions through regulation of this sector could have numerous implications. One outcome of requiring the registration of birds in urban environments would be construction of a conduit for dissemination of educational materials, as well as a means of contacting bird owners for surveillance or disease outbreak activities.

Small flock owners differ from commercial poultry production in many ways, including variation in levels of resources, knowledge, and different biosecurity gaps and requirements. Flock owners reported diversity in poultry experience, management, and biosecurity practices. The population sampled is characterized by traits, such as the wide range of species raised on the same premises, often sharing equipment and facilities. In addition, birds and poultry products were sourced from and distributed through several venues. These attributes present a set of risks that demand educational materials and programs tailored to the unique characteristics of small flock owners and their flocks.

Collaboration between small flock owners, industry representatives, such as hatcheries, veterinary professionals, and regulatory agents is essential, in the continuation of information gathering on Alberta's small poultry flocks and in moving forward in decision making regarding the implementation of educational or health improvement measures. Provision of education to flock owners is warranted and is expected to be a low-cost approach to improve bird and public health. Continued gathering of epidemiologic data will be necessary to measure changes in demographic or disease trends in Alberta, as well as track responses to any interventions implemented.

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