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Authors

Tobin, Molly R
Goldshear, Jesse L
Price, Lance B
et al.

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A Framework to Reduce Infectious Disease Risk from Urban Poultry in the United States

Molly R. Tobin[a]
Jesse L. Goldshear[b]
Lance B. Price, PhD[c,d]
Jay P. Graham, PhD, MBA, MPH[c]
Jessica H. Leibler, DrPH, MS[e]

ABSTRACT

Objectives. Backyard poultry ownership is increasingly common in U.S. cities and is regulated at the local level. Human contact with live poultry is a well-known risk for infection with zoonotic pathogens, notably *Salmonella*, yet the ability of local jurisdictions to reduce the risk of infectious disease transmission from poultry to humans is unstudied. We reviewed urban poultry ordinances in the United States and reported *Salmonella* outbreaks from backyard poultry to identify regulatory gaps in preventing zoonotic pathogen transmission. Based on this analysis, we propose regulatory guidelines for U.S. cities to reduce infectious disease risk from backyard poultry ownership.

Methods. We assessed local ordinances in the 150 most populous U.S. jurisdictions for content related to noncommercial poultry ownership using online resources and communications with government officials. We also performed a literature review using publicly available data sources to identify human infectious disease outbreaks caused by contact with backyard poultry.

Results. Of the cities reviewed, 93% (n=139) permit poultry in some capacity. Most urban poultry ordinances share common characteristics focused on reducing nuisance to neighbors. Ordinances do not address many pathways of transmission relevant to poultry-to-human transmission of pathogens, such as manure management.

Conclusions. To reduce the risk of pathogen exposure from backyard poultry, urban ordinances should incorporate the following seven components: limited flock size, composting of manure in sealed containers, prohibition of slaughter, required veterinary care to sick birds, appropriate disposal of dead birds, annual permits linked to consumer education, and a registry of poultry owners.

[a]Boston University, Sargent College, Boston, MA

[b]Boston University, College of Arts and Sciences, Boston, MA

[c]George Washington University, Milkin Institute School of Public Health, Department of Environmental and Occupational Health, Washington, DC

[d]Translational Genomics Research Institute, Center for Food Microbiology and Environmental Health, Flagstaff, AZ

[e]Boston University School of Public Health, Department of Environmental Health, Boston, MA

Address correspondence to: Jessica H. Leibler, DrPH, MS, Boston University School of Public Health, Department of Environmental Health, 715 Albany St., Talbot 430W, Boston, MA 02118; tel. 617-638-7674; fax 617-638-4857; e-mail <jleibler@bu.edu>.

Backyard poultry ownership in urban areas of the United States has increased dramatically in recent decades, and approximately 50 million chicks are sold annually in the United States.[1–3] Human contact with live poultry is a well-documented risk factor for infection with zoonotic pathogens, including *Salmonella* species (spp.), *Listeria* spp., *Campylobacter* spp., extraintestinal pathogenic *Escherichia coli*, *Enterococcus* spp., and avian influenza viruses.[4–6] Poultry ownership is regulated at the municipal level, typically in the context of an urban agriculture ordinance. Despite the growing popularity of urban poultry keeping, little research to date has systematically evaluated urban poultry ordinances for their ability to reduce infectious disease transmission from poultry to humans.

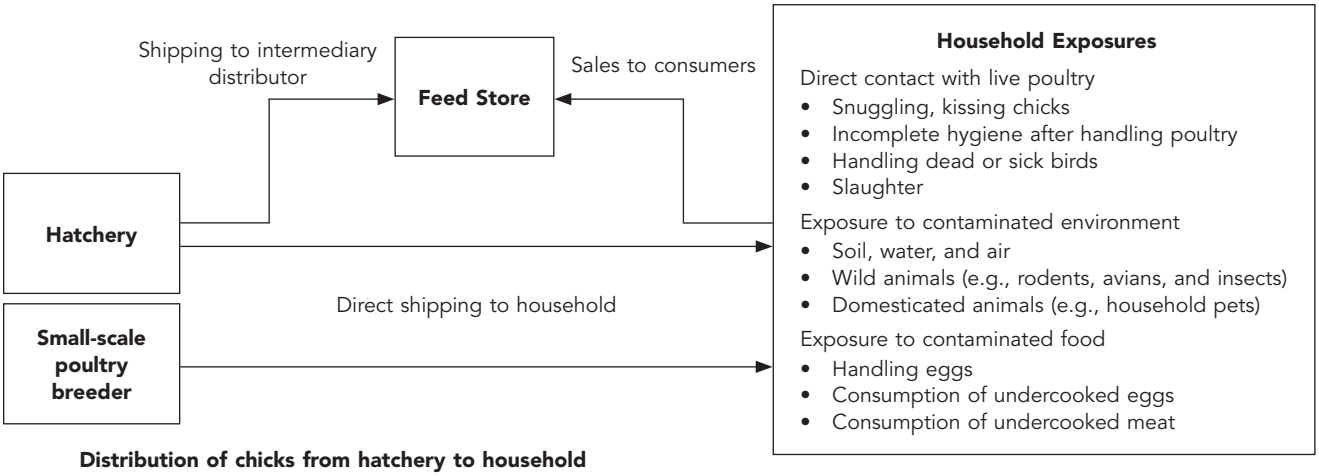
Across the country, urban ordinances excluding livestock from cities emerged in the early 1900s in response to sanitation problems, increasing awareness of disease risk, and noise and odor concerns.[7–9] Beginning in the 1950s, the intensification of animal agriculture in the United States increased production of meat products in rural areas and reduced the cost of meat at the market, eliminating the need for livestock ownership in the city.[10] In the early 2000s, Madison, Wisconsin, and Seattle, Washington, were among the first U.S. cities to reintroduce poultry ownership as a regulated activity within the city. This practice quickly spread, and as of 2014, approximately 700 U.S. jurisdictions allowed limited chicken ownership as a regulated activity, according to community postings on a popular website, backyardchickens.com.[11] Motivations behind urban poultry ownership include hobby, increased control of food choices, education for children, improved nutrition, and benefits for the environment and animal welfare.[12,13]

The poultry breeding industry that supplies noncommercial chicks for urban poultry holders is highly centralized, with fewer than 20 hatcheries supplying poultry to the backyard market nationwide.[14] These hatcheries supply chicks to local feed stores, which in turn sell them to consumers and also sell directly to consumers through online purchasing and shipment to the household (Figure 1). Some hatcheries breed and hatch chicks on site, while others serve as distributors of chicks bred at other facilities. Small-scale private sellers also offer chicks for sale and may advertise online, through flyers, or by word of mouth.

Annually, an estimated 1.4 million people in the United States are infected with nontyphoidal *Salmonella* serovars; roughly 12% of these infections result in visits to physicians, 1% result in hospitalizations, and nearly 0.03% result in death.[15] In the United States, exposure to noncommercial live poultry and eggs has been the source of 45 documented *Salmonella* outbreaks since 1991, with 1,581 documented illnesses, 221 hospitalizations, and five deaths.[4,16] Because the majority of gastrointestinal illnesses go unreported, the mortality and morbidity associated with *Salmonella* outbreaks from contact with noncommercial live poultry likely represent a small portion of the actual burden caused by this exposure.[17]

Despite these risks, many backyard poultry owners are unaware of infectious disease risks from poultry contact and do not engage in appropriate hygienic behaviors. A 2010 U.S. Department of Agriculture study suggested that more than 50% of urban poultry owners

Figure 1. Depiction of chick distribution network and pathways of pathogen transmission from poultry to humans in the context of backyard poultry ownership



were unaware that live poultry contact poses infectious disease risks for humans, and nearly 25% reported not washing hands after handling live poultry.[12] Furthermore, antibiotics are available directly to consumers for purchase at feed stores without a prescription, in therapeutic form or as a component of poultry feed. The use of antibiotics for nontherapeutic purposes in food animal production poses risks for increased antibiotic resistance in human clinical medicine.[18,19] The scale, frequency, and public health implications of antibiotics in backyard poultry flocks remain largely unstudied.

We evaluated the characteristics of municipal ordinances guiding urban backyard poultry production in the United States. We reviewed the existing literature on the documented infectious disease outbreaks resulting from human contact with backyard poultry to identify transmission pathways of concern in the U.S. urban context. We identified gaps in current regulatory structure and provide a regulatory framework to reduce the risk of infectious disease transmission associated with this emerging practice.

METHODS

We evaluated local ordinances in the 150 largest urban U.S. jurisdictions, as ranked by 2013 population according to the U.S. Census, for content regarding noncommercial poultry ownership.[20] We used online resources and in-person communications (e.g., phone, e-mail, and in-person interviews) with city officials to collect and confirm data. We initially identified Web links to the municipal ordinances for poultry ownership through the website backyardchickens.com, where data from more than 1,000 ordinances have been compiled by users. We then verified data through independent searches of these ordinances online and through communications with local government officials. We performed Google searches for cities not included in the database. Three researchers gathered data during a 12-month period from June 2013–June 2014 and entered the data into a Microsoft® Excel® spreadsheet for analysis. Individuals involved in data collection and organization were trained in the use of standardized data entry procedures.

We performed a literature search to identify reported human infectious disease outbreaks and infections caused by contact with noncommercial poultry in the United States. We used databases (e.g., PubMed, Google Scholar, PLoS One, Web of Science, and Science Direct) and relevant keywords (e.g., "live poultry," "zoonoses," "urban poultry," and "backyard poultry") to locate outbreak reports and appropriate articles. In addition, the Centers for Disease Prevention and Control (CDC) publishes reports on *Salmonella* outbreaks in the United States, some of which have been attributed to contact with live poultry. These reports were also reviewed and incorporated into the analysis.

RESULTS

Regulation of urban poultry ownership

Of the 150 largest U.S. cities, 11 banned poultry and other livestock (i.e., Detroit, Michigan; Miami, Florida; Yonkers, New York; Bismarck, North Dakota; and Worcester, Massachusetts). The remaining jurisdictions (n=139) had current livestock ownership ordinances that were included in this analysis.

The ordinances we reviewed share a set of common characteristics, including maximum flock size; lot, coop, and sanitation restrictions; bans on rooster keeping, excessive noise, and odors; stipulations regarding veterinary care, animal slaughter, and disposal; permitting requirements; and owner education (Table 1).

Flock size. Seventy-five percent (n=103) of reviewed urban poultry ordinances specified a limit on the number of chickens allowed (ranging from four in San Francisco, California, to 25 in Atlanta, Georgia). Twelve percent (n=17) of municipalities, including Charlotte, North Carolina, and San Jose, California, regulate flock size by allowing a certain number of birds per acre or square footage of land. Cities also may specify that flock size is contingent on zoning areas within the city limits, with a reduced number of animals allowed in denser areas. Fewer than 5% of cities required permitting beyond a specific flock size, including St. Louis, Missouri, which allowed four chickens without a permit and eight with a permit (data not shown).

Lot, coop size, and sanitation. Specifications regarding mandatory distances between an abutter's property and the coop or minimum required lot size were reported in nearly half (n=68) of reviewed ordinances. Distances between the coop and the street varied greatly by jurisdiction, from 5 to 350 feet. The median required distance between the coop and abutting residences was 50 feet. Sixty-three percent of ordinances (n=87) required design specifications for the coop itself. These restrictions included minimum square footage per bird, maximum height of the coop, and predator-proof structures. More than 50% of the ordinances (n=73) required adherence to basic sanitation requirements, such as ventilated coops, lime treatments, or designated bins for manure composting. Houston, Texas,

Table 1. Characteristics of selected U.S. urban poultry ordinances, 2014

City (2013 population)	*Maximum number of chickens allowed per household*	*Roosters allowed*	*Permit required (cost)*	*Permit renewal*	*Lot size or location restrictions*	*Coop restrictions*	*Education requirement of owners*	*Other restrictions*
Albuquerque, New Mexico (556,495)	15 hens >4 months of age; unspecified for chicks <4 months of age	Yes (one only)	No	No	No	No	No	Must be provided with adequate shelter and shade, food, and water
Atlanta, Georgia (447,841)	25	Yes	No	No	Coop must be at least 50 ft. from nearest neighbor and 5 ft. from owner's house	2 sq. ft per bird	No	Manure bin must be at furthest point from road and residence
Baltimore, Maryland (622,104)	Four on lots <2,000 sq. ft	No	Yes	No	Coop must be more than 15 ft. from nearest residence	Mobile, moved frequently, minimum 2 sq. ft per hen; animals provided space, air, light, and shade	No	Veterinary care is required for ill or diseased animals
Boston, Massachusetts (645,966)	Unspecified for central city; six for city neighborhoods outside the central city	No	Yes ($20)	Annual	Coops and runs must be set back at least 5 ft. in residential districts, 15 ft. minimum distance from main neighboring building/house	2 sq. ft./hen; 48 sq. ft. maximum footprint; washable and sanitary material	No	Additional fee of $10 for each 50 chickens; slaughter prohibited.
Charlotte, North Carolina (792,862)	20/acre	Yes	Yes ($40)	Annual ($40 fee)	25 ft. from property line	4 sq. ft. per bird, cleaned daily, more than 18 inches high, sanitary and free of odors	No	Inspection before permit is granted, permit application must list all neighbors
Chicago, Illinois (2.72 million)	Unspecified	No	No	No	No	Sanitary; "of humane size"	No	May not slaughter or use for food; disposal of dead animals through burial on property.

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Table 1 (continued). Characteristics of selected U.S. urban poultry ordinances, 2014

City (2013 population)	*Maximum number of chickens allowed per household*	*Roosters allowed*	*Permit required (cost)*	*Permit renewal*	*Lot size or location restrictions*	*Coop restrictions*	*Education requirement of owners*	*Other restrictions*
Cleveland, Ohio (390,113)	One animal per 800 sq. ft.	Yes (if at least 1 acre of land and coop is 100 ft. from all property lines)	No	No	No animals in front or side yard, must be within 5 ft. of property yard line	May not be more than 15 ft. high and must be predator-proof and ventilated, with 10 sq. ft. of space per bird	No	Fenced-in enclosure also required
Jackson, Mississippi (172,638)	Unspecified	Yes	Yes	No	No	No	No	No
Minneapolis, Minnesota (400,070)	Unspecified	No	Yes ($50)	Annual ($40 fee)	May not have ≥3 dwelling units, at least 20 ft. from another residence	Enclosed	No	Written consent of 80% of neighbors within 100 ft. of property, inspections as necessary, no slaughter on premises
New York, New York (8.41 million)	Unspecified	No	Yes	No	No	If selling poultry, coops/runway must be 25 ft. from next inhabited building and must be kept whitewashed/clean	Permit holders must complete refresher course in care and handling of poultry following violations of ordinance	Not specified
Portland, Oregon (609,456)	Three (without permit), no limit provided for permit holders	No	Yes (only for more than three birds)	No	More than 5 ft. from another residence	No	No	Not specified
Providence, Rhode Island (177,994)	One per 800 sq. ft., up to six birds	No	No	No	More than 20 ft. from another residence	Sanitary, weather- and predator-proof; may not be built onto shared fence	No	Birds must be confined between 9 p.m. and 8 a.m.

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Table 1 (continued). Characteristics of selected U.S. urban poultry ordinances, 2014

City (2013 population)	*Maximum number of chickens allowed per household*	*Roosters allowed*	*Permit required (cost)*	*Permit renewal*	*Lot size or location restrictions*	*Coop restrictions*	*Education requirement of owners*	*Other restrictions*
Richmond, Virginia (214,114)	4	No	Yes ($60)	Annual ($60 fee)	At least 15 ft. from adjacent property	At least 3 sq. ft. of space per bird	Educational materials provided at animal control department in conjunction with permitting	Permit requires visit to animal control department, animal cruelty background check, inspection of yard and coop, and coop plan
Salt Lake City, Utah (191,180)	15	No	Yes ($5 per animal, maximum $40 per year)	Annual	More than 25 ft. from any dwelling on adjacent property	Ventilated, predator-proof, covered, sanitary, 2 sq. ft. per bird	Birds must have 6 sq. ft. of space in coop	Poultry not allowed onto adjacent properties
San Francisco, California (837,442)	4	No	No	No	No	At least 20 ft. from nearest door or window of human dwelling	No	Inspected and approved by Director of Public Health, may not keep birds for commercial purposes

sq. = square

ft. = feet

and Charlotte, North Carolina, had stricter sanitation policies, requiring that coops be cleaned daily (data not shown).

Rooster keeping, noise, and odors. Most cities (65%) banned roosters, although jurisdictions in the South and Southwest, including New Orleans, Louisiana, and Albuquerque, New Mexico, permitted roosters pending noise complaints. The policies that determine acceptable rooster ownership varied greatly by location. For example, while roosters were allowed in Los Angeles, California, if they are at least 100 feet from any neighbors, Louisville, Kentucky, allowed one rooster per property regardless of distance from abutters. Specifications regarding noise or odor were included in approximately one-third of ordinances. Most commonly, ordinances specified that poultry owners must abide by existing noise ordinances and that the coop not produce objectionable odors. The ordinance in Honolulu, Hawaii, has notably specific language in regard to noise, indicating that poultry may not make noise for more than 10 minutes at a time. Neighbor approval prior to permitting was unusual and was required by fewer than 5% of the cities evaluated, including Las Vegas, Nevada, and Minneapolis, Minnesota. Objections by a neighbor in Durham, North Carolina, on the basis of noise or odor can warrant an inspection of the property under question (data not shown).

Veterinary care, slaughter, and disposal. Baltimore, Maryland, Austin, Texas, and Albuquerque, New Mexico, required poultry owners to provide veterinary care to sick birds, but such stipulations were unusual and only observed in these jurisdictions. With few exceptions, ordinances omitted specific language on animal slaughter, but restriction or prohibition was the norm when present.[13] Boston, Massachusetts, and Chicago, Illinois, specifically forbade slaughter. Los Angeles allowed slaughtering, while San Francisco only allowed it when performed at a distance from the coop. Rochester, New York, required a poulterer's license for slaughtering, and Cleveland, Ohio, allowed for slaughter if the chicken was consumed on the premises. Policies for the disposal of dead birds were specified in fewer than 10% of ordinances (n=12) and varied significantly by jurisdiction. Bagging in the weekly trash, burying, composting, incineration, and dropping off at designated sites were the most commonly recommended and utilized methods (data not shown).

Permit requirements and owner education. Permitting was required in 38% (n=52) of cities reviewed. Cities may charge a small fee to receive a permit, typically from $40–$60, with limited municipalities requiring permit renewal on an annual basis (Table 1). Inspections were occasionally required prior to approval; Charlotte, Richmond, Virginia, and Houston, Texas, required a property and coop inspection before a permit was granted. In Columbus, Ohio, and El Paso, Texas, veterinarians were responsible for inspecting properties and issuing permits, but such inspections were uncommon. In Jacksonville, Florida, permit applicants were required to attend an educational seminar hosted by the county's Agricultural Extension Office prior to receiving a permit. Richmond also had an educational component required alongside permitting. Such requirements were uncommon and not observed beyond these cities in our review (data not shown).

Zoonotic infections and backyard poultry

Salmonella is the only pathogen identified in reported human disease outbreaks associated with live, noncommercial poultry in the United States.[16] The first reported *Salmonella* outbreak in the United States due to exposure to live, noncommercial poultry occurred in 1955.[21] Since 1990, 45 reported *Salmonella* outbreaks have occurred in the United States from contact with live, noncommercial poultry.[4] Table 2 details these *Salmonella* outbreaks.

Recent outbreaks have been characterized by a diversity of *Salmonella* species, young age of cases (often <5 years of age), elevated severity of disease, and multistate distribution of cases. Since 2007, most reported outbreaks have been traced back to a hatchery that distributed infectious chicks to feed stores and/or directly to consumers.[22–30] Earlier outbreaks identified poultry contact as a risk factor, but did not specify hatcheries of origin.[31–33] While contact with poultry was an identified risk factor for infection for a majority of cases, data on specific behaviors related to poultry contact were typically missing.

In 2013, the largest reported *Salmonella* outbreak (*Salmonella* serotype Typhimurium) from live poultry occurred with 356 identified cases across 39 states, and 26% of the cases were hospitalized.[29] A single hatchery in New Mexico was identified as the supplier. Another notable recent outbreak (*S.* Montevideo) extended from 2004 through 2011, involving 316 cases in 43 states.[22] This strain primarily affected young children (median age = 4 years) and was linked to contact with live poultry from a single, unspecified mail-order hatchery in the western United States. The lengthy time

Table 2. Selected *Salmonella* outbreaks from contact with live, noncommercial poultry in the United States, 1990–2014

Year of outbreak	Location	Pathogen	Number of cases identified	Percent hospitalized (deaths)	Median age of cases (in years)	Transmission pathway
1991[a]	Multistate (Connecticut, Maryland, Pennsylvania)	*S.* Hadar	22	27	7.5	Pet ducklings from a single Pennsylvania hatchery
1995/1996[b]	Multistate (Idaho, Washington)	*S.* Montevideo	23	13	<2	77% reported exposure to chicks
1996[b]	Oregon	*S.* Montevideo	16	13	32	64% reported exposure to chicks
1999[c]	Michigan	*S.* Infantis	21	14	25	81% reported exposure to chicks from a single unspecified hatchery
	Missouri	*S.* Typhimurium	40	78	13	97% reported exposure to young poultry
2004–2011[d]	Multistate (43 states)	*S.* Montevideo	316	23	4	Chicks from a single mail-order hatchery
2006[e]	Michigan	*S.* Enterica	21	33	18	57% reported exposure to baby poultry
	Multistate (21 states)	*S.* Montevideo	56	17	2	88% reported exposure to baby poultry
	Oregon	*S.* Ohio	4	25	32	100% reported exposure to baby poultry, 75% from hatchery in Washington (previously implicated in five other outbreaks)
2007[f]	Multistate (22 states)	*S.* Montevideo	65	Not specified	25	Exposure to live poultry from a single hatchery
	Multistate (23 states)	*S.* Montevideo	64	21	5	Exposure to live poultry from a single hatchery
2009[g]	Multistate (23 states)	*S.* Montevideo	96	28	32	Exposure to live poultry; 38 cases exposed at three catered events where caterer had exposure to live poultry
	Multistate (seven states)	*S.* Thompson	26	10	17	Exposure to live poultry from feed store chain; one case exposed while working at agricultural feed store
	Multistate (New York, Pennsylvania)	*S.* Typhimurium	36	26	8	92% reported purchasing baby chicks from single feed store chain
	Multistate (Maine, New Hampshire, Kentucky, Virginia)	*S.* Johannesburg	7	28	1	Exposure to live baby poultry; two cases with exposure at day care
2011[h]	Multistate (24 states)	*S.* Altona; *S.* Johannesburg	96	Not specified	<5	74% (*S.* Altona) and 75% (*S.* Johannesburg) reported exposure to live poultry; all cases from a chain of feed stores supplied by a single hatchery
2012[i]	Multistate (11 states)	*S.* Hadar	46	36	33	Exposure to live poultry from Idaho hatchery
2012[j]	Multistate (23 states)	*S.* Montevideo	93	34	20	Exposure to live poultry from Estes Hatchery, Springfield, Missouri
	Multistate (27 states)	*S.* Infantis, *S.* Lille, *S.* Newport	195	34 (two deaths)	32	Exposure to live poultry from Mt. Healthy Hatchery, Ohio

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Table 2 (continued). Selected *Salmonella* outbreaks from contact with live, noncommercial poultry in the United States, 1990–2014

Year of outbreak	Location	Pathogen	Number of cases identified	Percent hospitalized (deaths)	Median age of cases (in years)	Transmission pathway
2013[k]	Multistate (39 states)	*S.* Typhimurium	356	26	7	Purchase of live poultry from feed stores; source identified as Privett Hatchery in Portales, New Mexico
	Multistate (30 states)	*S.* Infantis, *S.* Lille, *S.* Newport, *S.* Mbandaka	158	28	17	Exposure to live poultry from Mt. Healthy Hatchery, Ohio
2014[l]	Multistate (42 states)	*S.* Newport, *S.* Infantis, *S.* Hadar	300 (as of August 5, 2014)	31	28	80% exposure to live poultry from Mt. Healthy Hatchery, Ohio

[a]Svitlik C, Cartter M, McCarter Y, Hadler JL, Goeller D, Groves C, et al. *Salmonella* Hadar associated with pet ducklings—Connecticut, Maryland, and Pennsylvania, 1991. MMWR Morb Mortal Wkly Rep 1992;41(11):185-7.

[b]Blythe D, Goldoft M, Lewis J, Stehr-Green P, Chehey R, Greenblatt J, et al. *Salmonella* serotype Montevideo infections associated with chicks—Idaho, Washington, and Oregon, spring 1995 and 1996. MMWR Morb Mortal Wkly Rep 1997;46(11):237-9.

[c]Bidol S, Stobierski MG, Robinson-Dunn B, Massey J, Hall W, Boulton M, et al. Salmonellosis associated with chicks and ducklings—Michigan and Missouri, spring 1999. MMWR Morb Mortal Wkly Rep 2000;49(14):297-9.

[d]Gaffga NH, Behravesh CB, Ettestad PJ, Smelser CB, Rhorer AR, Cronquist AB, et al. Outbreak of salmonellosis linked to live poultry from a mail-order hatchery. N Engl J Med 2012;366:2065-73.

[e]Bidol S, Stobierski M, Leschinsky D, Ettestad P, Smelser C, Sena-Johnson D, et al. Three outbreaks of Salmonellosis associated with baby poultry from three hatcheries—United States, 2006. MMWR Morb Mortal Wkly Rep 2007;56(12):273-6.

[f]Hedican E, Smith K, Jawahir S, Scheftel J, Kruger K, Birk R, et al. Multistate outbreaks of *Salmonella* infections associated with live poultry—United States, 2007. MMWR Morb Mortal Wkly Rep 2009;58(2):25-9.

[g]Loharikar A, Briere E, Schwensohn C, Weninger S, Wagendorf J, Scheftel J, et al. Four multistate outbreaks of human *Salmonella* infections associated with live poultry contact, United States, 2009. Zoonoses Public Health 2012;59:347-54.

[h]Centers for Disease Control and Prevention (US). Multistate outbreak of human *Salmonella* Hadar infections linked to live poultry in backyard flocks (final update). 2011 [cited 2014 Aug 12]. Available from: URL: http://www.cdc.gov/salmonella/hadar-live-poultry-07-12/index.html

[i]Centers for Disease Control and Prevention (US). Multistate outbreak of human *Salmonella* Montevideo infections linked to live poultry in backyard flocks (final update). 2012 [cited 2014 Aug 12]. Available from: URL: http://www.cdc.gov/salmonella/montevideo-06-12/index.html

[j]Forshey TM, Nowicki S, Mohr M, Roney CS, Gomez TM, Mitchell JR, et al. Notes from the field: multistate outbreak of *Salmonella* Infantis, Newport, and Lille infections linked to live poultry from a single mail-order hatchery in Ohio—March–September 2012. MMWR Morb Mortal Wkly Rep 2013;62(11):213.

[k]Centers for Disease Control and Prevention (US). Multistate outbreak of human *Salmonella* Typhimurium infections linked to live poultry in backyard flocks (final update). 2013 [cited 2014 Aug 4]. Available from: URL: http://www.cdc.gov/salmonella/typhimurium-live-poultry-04-13/index.html

[l]Centers for Disease Control and Prevention (US). Multistate outbreak of human *Salmonella* infections linked to live poultry in backyard flocks, 2014 [cited 2014 Mar 3]. Available from: URL: http://www.cdc.gov/salmonella/live-poultry-05-14

S. = *Salmonella*

span of this outbreak reflected challenges in identifying the source, linking cases, and reducing risk.

DISCUSSION

Given the relevance of *Salmonella* in human disease from contact with live poultry, understanding transmission pathways for this pathogen from poultry to people is critical. Poultry shed *Salmonella* in feces, and direct or indirect contact with poultry fecal material can result in exposure.[3,4] Pathogenic fecal bacteria can be found on the beak, feathers, or feet of live poultry. Egg handling and consumption also poses opportunities for pathogen transmission, as eggs may be contaminated with fecal matter, and hand hygiene following collection of eggs from backyard chickens is often insufficient.[35,36]

Chicks are introduced into the household either directly from the hatchery, from a feed store, or from a local breeder. Once in the household environment, humans may be exposed to *Salmonella* from direct contact with live poultry (e.g., snuggling or kissing chicks, incomplete hand hygiene following poultry contact, or through slaughter).[4] Children may be at particular risk as they are more likely to touch, kiss, or snuggle live poultry (particularly chicks), put their hands in their mouth, and inconsistently practice hand washing.

Handling infected, ill, or dead poultry also poses a risk for pathogen transmission, as does animal slaughter.

Indirect exposure to poultry fecal pathogens can occur following fecal contamination of the environment.[37] Bacterial pathogens from poultry feces may remain infectious in environmental media from several days to months, and can contaminate soil, water, and air.[38,39] Transmission of pathogens into the home and outside the backyard may occur via shoes and clothing worn in the coop. Wild animals in the urban environment, including rodent and avian species, may have contact with poultry coops, resulting in interspecies transmission of pathogens. Likewise, domesticated animals may carry pathogens into the household from the backyard, or may become infected themselves.[40]

Shaping urban poultry ordinances to reduce infectious disease risk

To reduce infectious disease risk from contact with live poultry, urban poultry ordinances should include the following components: limited flock size, safe composting of poultry fecal waste, prohibition of slaughter at the home, required veterinary care in the event of bird illness, appropriate disposal of dead birds, annual permitting linked to consumer education, and a regularly updated registry of households with live poultry (Figure 2). These guidelines reflect an understanding of pathways of *Salmonella* transmission from backyard poultry to humans and have two central goals: (*1*) to reduce human contact with infectious animal material and (*2*) to provide information on the scope and location of poultry within the jurisdiction for planning purposes.

Limiting flock size. Controlling flock size reduces (*1*) opportunities for pathogen transmission from other animals to poultry, (*2*) the risk of human infection from contact with poultry, and (*3*) the infectious burden of manure that could contaminate the environment. The number of animals permitted may vary depending on a typical lot size, but should be appropriate for the region.

Compost poultry manure in sealed containers. Appropriate disposal of poultry fecal waste is imperative to reduce the risk of human infection. Owners should be required to compost poultry litter in a manner that allows for pathogen die-off, prevents animal contact with the waste, and prevents contamination of the environment with poultry manure. One such approach is to compost manure in an enclosed container (e.g., a 55-gallon barrel) along with soil and carbonaceous materials, such as leaves, for a minimum of 120 days before the manure is applied to soil as compost.[28]

Figure 2. Guidelines for urban backyard poultry regulations to reduce the risk of zoonotic pathogen exposure

1. Limit flock size.
   - Fewer birds per household reduces exposure risk with potentially infectious animal wastes, reduces environmental pathogen contamination, and may increase owner awareness of poultry illness.
2. Compost poultry manure in sealed containers.
   - Manure should be composted on site in appropriate containers so as to degrade pathogens and reduce environmental contamination.
   - Cities may consider providing waterproof and animal-proof composting containers for poultry owners.
3. Prohibit slaughter at the home.
   - Slaughter poses opportunities for exposure to potentially infectious animal material, including viscera, blood, and wastes.
4. Require veterinary care in the event of bird illness.
   - Owners should be informed as to the visible signs of illness in the flock and given a list of poultry veterinarians who can provide care.
   - Required reporting of rapid die-offs within the flock to city officials through a website or hotline will help officials stay informed of outbreaks.
5. Dispose of dead birds properly.
   - Dead birds can be mixed with compost or disposed of in municipal trash depending on local regulations.
6. Link permitting to consumer education on hygiene.
   - Owners should be required to participate in educational programs, such as online modules, about hygiene and sanitation in conjunction with the permitting and renewal process.
7. Register households with poultry.
   - Contact information and addresses of poultry owners will assist in communication in the event of outbreaks, education, or modeling efforts to understand disease transmission.

Prohibit slaughter at the home. Slaughtering animals on site in urban environments poses opportunities for pathogen transmission from infectious birds to the environment, humans, and other animals. The urban household environment is not well suited for containment of pathogens from the slaughtering of birds, including viscera, blood, and feces, and in particular may draw wild and domesticated animals to the premises, thereby increasing the risk of pathogen transmission.

Require veterinary care in the event of illness. Mandating veterinary care for sick animals increases the likelihood of identifying infectious agents in poultry and reduces opportunities for direct and indirect pathogen transmission to humans.

Disposal of dead birds. Dead birds must be disposed of in a way that minimizes human exposure and pathogen contamination of the environment. Dead birds could be composted in the same manner as fecal waste, such as by combining carcasses with a carbon-bulking agent in an appropriate composting container for 120 days. Dead birds could also be disposed of in the municipal trash, depending on local regulations for biohazard disposal. Double-bagging dead animals prior to disposal in the trash would reduce the potential risk of pathogen transmission and odors. Dead animals should not be transported to municipal facilities in private vehicles for disposal, as they may contaminate vehicles.

Link permitting to consumer education on hygiene. Issuing permits for poultry ownership and requiring permit renewal annually present important opportunities for ongoing education, communication regarding disease risk, and enforcement. Owners should be required to obtain a permit prior to poultry ownership and renew their permit on a regular basis. Education on hygiene, protective equipment, and zoonotic disease should be a requirement for receiving a permit or renewal. For example, permit applicants could be required to engage with an interactive module online and answer questions regarding disease transmission risks from poultry prior to receiving a permit. Such training could be required annually as part of the permit renewal process.

Maintain registry of households with poultry. The jurisdiction's ordinances should require the jurisdiction to maintain a registry of households with poultry. Such data could be gathered by permitting. Understanding the spatial distribution of poultry in the city may assist in modeling disease outbreaks or planning interventions.

CONCLUSIONS

The reintegration of live poultry into the urban environment poses risks to human health due to zoonotic disease transmission from poultry to humans. Noncommercial contact with poultry has been associated with numerous multistate *Salmonella* outbreaks in recent years and poses risks for transmission of other bacterial and viral pathogens. The local nature of poultry regulation poses challenges for systematically managing infectious disease risk from backyard poultry, and many U.S. urban ordinances do not fully address the infectious disease risks to humans associated with this practice. Urban poultry ordinances should incorporate specifications regarding maximum flock size, manure management, slaughter and disposal, veterinary care, permitting, and consumer education and develop and maintain a registry of households with poultry to aid with public health planning. The incorporation of this framework into urban poultry ordinances will help reduce the risk of infectious disease associated with backyard poultry ownership in U.S. cities.

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