Peer-reviewed version available at Urban Sci. 2018, 2, 25; doi:10.3390/urbansci2010025

Type of Paper: Article

Urban Chickens as a Pathway for Human Illness? An Examination of Knowledge, Behavior, and Risk

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Abstract: This research investigates the relationship among human knowledge, behavior, and risk as they relate to urban chicken husbandry in the United States. Concern over zoonotic diseases has been on the rise, and especially with increasing contact between birds and humans. In particular, avian influenza, or bird flu, *Salmonella enterica* (Salmonella), and *Escherichia coli* (E. coli), can all cross species lines between people and poultry. This study analyzed knowledge and practices in urban chicken husbandry to assess how they relate to risk of disease acquisition, hypothesizing that certain practices associated with a lower knowledge base may heighten the risk. This study used a survey distributed via social media to examine the self-reported knowledge base of individuals involved in chicken husbandry as they relate to beliefs and behaviors associated with the care of these animals. These results identify key factors that may heighten the risk of disease transmission, and demonstrate that an increased knowledge base could act to lessen this risk.

Keywords: keyword 1; urban chickens 2; poultry 3; disease transmission 4; food security 5; risk 6; exposure 7; locavore 8; urban agriculture

1. Introduction

Over the last few years, the chicken has increased in the public view in two prominent ways: as a vector of infectious disease, and as a prevalent member of local neighborhoods across the United States. Regarding the former, the spring of 2015 was marked by a near annihilation of egg-laying chickens and turkeys in response to what was called "the worst ever outbreak of the bird flu" [1] (p.1). An estimated 42 million birds across the nation were systematically killed in the name of human safety [1-2]. According to David Inall, vice-president of the United Egg Producers, "even farms with first class biosecurity still got hit" [1] (p. 1). But this was not the first time avian influenza, commonly known as the bird flu, was in the news in recent years. In the winter of 2011-12, a media storm erupted over the ethics of a publication associated with the H5N1 strain of avian flu [3]. The debate centered on whether peer-reviewed publications should be allowed to feature work relating to the transmission of the disease to mammals. The tension underscored the critical nature of a wide-spread pandemic and biosecurity risks with a sharp focus on birds as vector or

amplifier species [4-5]. Eventually, the research resumed, but not without weighty regulations aimed at improving biosafety [5].

Despite the publicity of these threats to human safety, the scientific community has largely ignored the media's second focus: urban chicken flocks as a growing agricultural movement throughout the United States. There is little research on how these small flocks contribute to human risk of, exposure to, and vulnerability for infection. The latest concerns around bird flu raise questions not only about the vulnerability of urban flocks to this specific infection, but also to the suite of infectious diseases that can be transmitted from poultry to people; including *Salmonella enterica* (Salmonella), *Escherichia coli* (E. coli), *Campylobacter jejuni*, West Nile virus, and histoplasmosis. The aims of this study were to examine the level of human engagement in maintaining small, backyard flocks, and the potential health-risk behaviors associated with this practice.

1.1 Rise of the urban chicken

Andrew Rowan characterized the rural-to-urban transition by discussing the separation that urbanites have from the natural world, and by default, their food production [6]. As is well-accepted, the human movement into high-density living spaces left knowledge of food production behind [7], not the least of which was animal husbandry [8]. As production animals reintegrate with human populations, a dearth of knowledge persists [8]. The novelty of and attachment to chickens translates into a risk factor for disease issues. Literature on subsistence and sustainable poultry flocks in underdeveloped and developing countries suggests disease transmission is a real and valid concern [see: 9-11], but otherwise there is minimal representation in the literature that addresses poultry diseases in small-scale flocks in developed countries like the US.

The rising popularity of urban poultry flocks means more American families have increasing physical contact with these birds, which are susceptible to avian diseases and have the potential to infect and sicken people. Commonly called backyard chickens, urban chickens, hobby flocks, and neighborhood chickens, these birds are a growing part of the locavore movement, aimed at decreasing one's carbon footprint and increasing food security on a community scale. Most commonly, these flocks consist of hens for egg production, without a rooster [12-13]. There is no formal definition or number of birds, rather, the characterization of these flocks is non-commercial and largely lies the local regulations and urban geography. Blogs and media suggest that raising chickens is believed to be a safe and wholesome way to provide organic, home-grown eggs and meat for their tables and no more difficult than caring for a pet cat or dog (see: www.mypetchicken.com). In fact, this situation presents real health threats that may not be remedied until some serious avian-borne zoonotic disease outbreak linked to these hobby flocks sickens significant numbers of people in a U.S. community. Currently, one of the most prominent diseases related to urban backyard poultry husbandry is Salmonella. In 2016, the CDC reported over 600 isolated incidents of people contracting Salmonella across states. These distinct cases include different strains of the

bacteria, but point to a rise in number of cases associated with people who keep urban chickens [14].

These birds represent a sweeping change in the local food movement [15] and challenge the social construction of how urban environments are defined juxtaposed to rural. In fact, a general assessment of news articles, blogs, and policy review indicates that the emergence of these birds occurred in the absence of government code, as the rural-to-urban transition left livestock in its wake so, by de facto, there were no animals to regulate. To date, municipalities are scrambling to catch up, which is spurring a swath of policy changes that legalize chickens even in large, densely populated areas such as Baltimore, Maryland, Los Angeles, California, Seattle, Washington, and Washington D.C. where regulations allow chickens as close as 25 feet from a neighboring property [16-18]. In places like Portland, Oregon chickens have been observed in fully contained hutch-style coops on apartment terraces and under stairwells.

Other prominent places urban chickens can be found are in news articles, websites, blogs and on Facebook groups, all focus on the bird's increasing neighborhood popularity and (see: www.efowl.com, www.mypetchicken.com) [19]. These sites provide everything from basic husbandry knowledge to chicken clothing and range in the quality of information. Rife with cute chicken pictures and trendy chicken names, many of these sites promote the human-animal relationship in a pet context, but may lack the expertise needed to address chicken health. And while the scientific literature is teeming with research on poultry health, husbandry, and production, little can be found in with regard to the bird's increasing presence in backyards in the US, especially with regard to related health risks.

The body of research addressing domestic poultry – specifically chickens – falls into four categories: 1) large-scale poultry management; 2) disease research; 3) sustainable poultry keeping in underdeveloped and developing countries; and 4) disease transmission. Large-scale poultry management research primarily addresses the chicken industry with regard to aspects of economic competition and chronic health management for issues that include treatment of chicken diseases and parasites [see: 20-22]. The second category, disease research, focuses on the infection, not poultry management. This work includes fields such as vaccines and genetics and has a heavy focus on industrial applications in national and international markets [see: 23-24]. The third category, sustainable husbandry, addresses chronic health management of poultry, but extends a focus to human health and welfare. While this aligns with the urban chicken movement in the United States, the vast majority of the literature addresses subsistence and sustainable flocks in low-income rural areas outside the US [see: 25- 27]. The health of backyard flocks in the US has received comparatively little scholarly attention, and includes single-diseases, such as Salmonella [see: 28] and policy aspects of specifically [see: 17, 13].

The fourth category of literature addressing poultry diseases focuses on transmission between wild birds and poultry [see: 29-31]. Within this body of work is a sub-set of studies that focus purposely on the transmission of the H5N1 avian influenza between passerines and chickens [32-33]. This research points to the fact that concern exists in and around

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aspects of zoonotic transmission of avian diseases. Specifically, this concern is at the intersection of domestic and wild bird diseases and bird-to-human transmission, which is far more likely in backyard flocks than commercial ones which adhere to staunch biosecurity regulations.

Collectively, all four categories converge around the critical nature of poultry diseases in relationship to preventing human illness, but highlight the gap in scientific knowledge of the urban chicken movement in the US and the associated possibility for disease exposure at a community level. As history and prehistory indicate, the increasing interaction between animals and people results in remarkable benefits, along with a number of downfalls that should not be ignored [see: 7].

While the dominant conviction is that the age of agriculture brought about a host of benefits that support our current society, the pitfalls should not be overlooked. A tremendous amount of bioarchaeological research has consistently shown that the health of people diminished to a great extent during the Neolithic revolution, in each of the six major geographic areas where agriculture was independently invented [34-37]. This is evidenced by dramatic changes in the skeletal and dental health of individuals during the early Neolithic period beginning around 10,000 years ago, when plant and animal domestication began to occur on a broad scale. This trend toward poorer health was associated with a changing diet and an initial decrease in the quantity and quality of agriculturally produced food, increased population density, and living in closer proximity to livestock as well as the greater probability of zoonotic transmission associated with it. Bioarchaeological research investigating the dental and skeletal health of individuals living before, during, and directly following this time, ubiquitously show indications of poor health in the form of malnutrition, undernutrition, and a heavy parasitic and pathogenic load, as a result of nutritional deficiency and infectious diseases such as leprosy, brucellosis, anthrax, cowpox, trepanematosis, and tuberculosis [38-39]. Poor knowledge of animal husbandry, specifically the close proximity between humans and non-human animals, as well as the low standard of hygiene are considered to be the largest contributors to this temporal [40].

The shift from hunting and gathering to agriculture prompted a variety of new stressors, as populations became sedentary and developed higher population densities. Most notably, because of greater exposure to animals, and both human and non-human animal waste, an increased risk of exposer to novel and existing pathogens arose. Many of these negative effects, such as the heavier pathogenic and parasitic load associated with living in close proximity to animals and their waste products, would be minimized by intensified agriculture and larger-scale farming operations, which are generally far removed from large population centers in the developed world. However, the emergent trend of backyard animal husbandry could potentially threaten this relative hiatus from the localized endemic disease burden of past groups, as we once again begin to live in closer proximity to livestock animals.

Today, the small-scale livestock husbandry that is practiced by a growing number of people living in urban centers increases the social exposer to chickens and occasionally ducks,

turkeys and novelty birds and by default, the potential for disease exposure as well. The domestic birds' exposure to wild birds in these backyard coops raises the likelihood of localized and pandemic disease outbreaks as a real threat to community health in urban centers and surrounding areas, as has already been shown to be a problem associated with poultry production elsewhere [41]. Additionally, because these birds are often treated as pets by those in the United States, a different and potentially more dangerous type of exposer and transmission may be associated with this new form of urban husbandry. Reviews of informational media indicate that people handle birds more as they would a dog or cat, with references to petting, cuddling, and even kissing them. In fact, the CDC conducted an investigation of urban poultry and Salmonella transmission, and of the 183 people surveyed who contracted Salmonella, an alarming 80% admitted to kissing and cuddling young ducklings and chicks [42]. Content analysis of on-line sources, discussion boards, and blogs further suggests that advice for sick birds counters the CDC's recommendations, and instead promotes interactive/in-home treatment and care[1][2]. Potential dangers in these scenarios include increased pathways of exposure, lack of reporting, and a medical professional's inability to diagnose a condition if the patient fails to make the connection.

1.2 The Current Study

The goal of this research was to understand the types of knowledge and practices that are common with urban chicken husbandry. As Barthel et al. point out, knowledge is key in the success of an urban food source [7]. Specifically, we assessed how people rank themselves as knowledgeable and classify specific behaviors around chickens – such as egg collection or coop-cleaning protocols– that may increase human risk. Our objective was to understand the types of knowledge and practices that are common in chicken husbandry and to assess how these relate to potential risk of disease acquisition that may be associated with them. We hypothesized that there were a number of practices that would heighten the risk of disease transmission and that these may not correspond with self-reported knowledge levels.

2. Materials and Methods

2.1 Participants

Participants in this study were recruited through Facebook social media groups associated with small-scale poultry and/or animal husbandry in the Rocky Mountain region[3] of the United States. Data collection was conducted through Qualtrics, a survey software program. In early January, 2016, two messages were posted with links to the online survey on the "Butte Animal Classifieds" (2,076 members) and the "Montana/Wyoming Poultry Buy Sell

[1] My pet chicken: https://www.mypetchicken.com/backyard-chickens/chicken-help/How-do-I-help-a-chick-that-isnt-eating-or-H243.aspx

[2] https://www.backyardchickens.com/threads/how-do-i-feed-a-sick-chick.40521/

[3] The region was selected solely because of proximity to the researchers and the possibility of doing in-person follow up.

Trade" (747 members) Facebook groups. The messages included a prompt to take the online survey "If you have or have recently had chickens." From these initial posts the messages were shared by group members more than six times in the subsequent two weeks. The survey was active for 6 weeks.

2.2 Questionnaire

Participants responded to forty-eight questions regarding their backyard chicken husbandry behaviors, and were asked to self-classify as urban if they lived on ½ an acre of land or less. Other target questions included demographic information such as participant gender and age. Family information was also solicited such as ages and number of children in household, as well as family participation in agricultural organizations (categories included "4-H, FFA, and Scouts" along with an open-ended "Other"). Several questions included information about the participants' flock: "What is the average number of birds that you keep?" (open ended), "For how long have you kept chickens?" (indicated in years), "From where do you get your chickens? (open ended), and "What do you feed your chickens?" (multiple selection from "Commercial food," "Scratch grains," "Table scraps," "Free-range forage," "Local spent grains," and "Other"). Lastly, participants were asked if they named their chickens by selecting all that apply from: "No," "Yes, in order to tell them apart," "Yes, but I'm candid about it, they get names like Perdue and Gravy," "Yes, each bird really is different: Lucy, Rainbow, Betsy," "Yes, I let the children name them," and "I used to, but not any more," as well as two "Other, please specify" selections.

Several questions assessed why participants kept flocks along with their meat and egg use. Participants were asked to indicate "What are the reasons you keep chickens?" and could select the following: "Eggs," "Meat," Enjoyment," and" Education for Children," as well as two open-ended "Other" selections. Participants were also asked "If you raise chickens for eggs, what do you do with the eggs?" and could select the following: "I only raise meat birds," "My family and I eat the eggs," "We give the eggs to neighbors and friends," "We sell the eggs to neighbors," and "We sell eggs to local stores," as well as two open-ended "Other" selections. Lastly, participants were asked if their birds were used for meat or not ("yes" or "no").

Participants were asked to categorize themselves into one of four husbandry knowledge groups with "On the following scale, please select how knowledgeable you consider yourself to be about chickens." The group selecting "I am a beginner: For example, I know different breeds and when birds start to lay" was scored as a one. A two was scored for "I know a little: For example, I know a lot of different breeds and a bit about common issues like broodiness and molting." A three was used for "I know a fair amount: For example, I'm learning about illnesses and diseases, I understand about the reproductive cycle and know where to go to find answers to most of my questions. I find I know a lot of the answers to questions other people ask me." And a four was assigned to "I am quite knowledgeable: Most of the things I read on chickens I find I already know. I don't have to look many things up any more and usually can answer all the questions that people ask me or I see in discussion forums."

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The questionnaire also attempted to establish participants' knowledge of avian diseases or health concerns and the appropriate way to address these. First, an open-ended question asked participants "What diseases do you think are a concern for chickens in the area?" Subsequent questions included "When, if ever, would you contact a veterinarian or health-care worker" and "Do you ever bring your chickens in the house?" The objective was to understand how knowledge of disease and one's ability to address the disease would align.

2.3 Composite risk score

In addition to these response variables, a composite risk score was calculated based on eight specific questions. These questions aimed at assessing the potential health risk associated with backyard human-chicken interaction. These items regarding individual and family behavior and practices included:

1. Do you keep other animals with the chickens? A "yes" response coded as risk.
2. Do you ever bring your chickens into your house? A "yes, please explain why" response coded as risk.
3. When you clean the coup do you remove and replace bedding (straw and droppings) inside the coop and nest boxes. A "no" response coded as risk.
4. When you clean the coup do you clean the water and food dispenser with soap or bleach? A "no" response coded as risk.
5. How often do you handle your birds? Handling birds more frequently than once a week was coded as risk.
6. If one of your birds seems unwell or sick, do you kill and eat them if they don't seem too sick? A "yes" coded as risk.
7. If one of your birds seems unwell do you take them to the veterinarian? A "no" coded as risk.
8. Do you vaccinate your chickens? A "no" coded as risk.

These eight risk variables were coded dichotomously, with 1 indicating that the behavior was risky, while 0 designated a non-risky behavior. These were summed for each individual in the dataset, which resulted in a composite risk score ($M = 2.68$, $SD = 1.19$). This composite score was used as a continuous variable to investigate how human risk behaviors correlate with other variables important to the research question, such as reported knowledge of chicken husbandry; reported and assessed knowledge of disease, in which the latter placed subjects into three categories (correct, lack of knowledge, no response) based on their answers to specific disease-related questions; relationship with chickens; size of flock; and others.

2.4 Analysis plan

The goal of this research was to understand knowledge and practices related to backyard chicken husbandry. In addition to descriptive statistics for target variables, knowledge group-level mean differences in composite risk scores and disease knowledge were examined through analysis of variance. Additionally, t-tests were used to examine mean differences in

risk score between those who name chickens and those who do not. Lastly, correlations were used to assess relationships between continuous variables.

3. Results

3.1 Descriptive statistics

In total, we received 169 responses, of which 88 were 100% complete. Facebook shares indicate that the geographic range included, but was not limited to, Arizona, Massachusetts, Montana, Oregon, Texas, Washington, and Wyoming. Eighty-one percent of respondents were female, 16% were male, and 2% reported as "other" or "prefer not to say." Participants selected one of five age categories; 13% indicated that they were between 18 and 30, 34% between 31 and 40, 13% between 41 and 50, and 39% over 51 years of age. Participants were asked if any family member living with them had experience with livestock or agriculture related organizations (4-H, Future Farmers of America, etc.). Twenty-two percent of participants indicated that at least one family member was involved in at least one such organization.

The average number of years that participants had kept non-commercial chickens was 6.06 years, with a range of less than a year up to 38 years (SD = 6.34). Additionally, twenty-seven per cent of participants indicated that they live on a property of .5 acre or less, and on average, participants had fifteen birds at any given time (M = 15.35, SD = 20.5), with seven people reporting they had over 40 birds, two of which had over 100. The maximum number of birds kept was 150.

Table 1: Primary and Secondary Rationales of Private Owners for Keeping Backyard Chicken Flocks.

Reason Text	Primary Reason	Secondary Reason
Eggs	80.77%	16.67%
Meat	5.13%	17.95%
Enjoyment	7.69%	55.13%
Education for Children	2.56%	5.13%
Other	3.84%	5.13%

N = 78

When asked for the primary reasons why they kept chickens, 81% of participants indicated that they kept them for eggs. Sixty-three per cent of participants indicated that they kept their flocks for enjoyment purposes, and 7% indicated that they kept chickens for the education of their children (Table 1). Ninety-two per cent of participants indicated that they fed eggs to their family, 62% indicated that they gave away their eggs locally, and 34% indicated that they sold some of their eggs to local families or businesses. No participants indicated that they kept birds solely for meat, but 52% of individuals surveyed indicated that their birds could be used for meat at some point.

3.2 Husbandry knowledge, disease knowledge, and risk

A significant relationship was observed between the composite risk score and two distinct variables, i.e. naming the birds and number of birds. More specifically, participants who named their chickens had a higher average composite risk score (M = 2.95, SD = 1.23) than those who did not (M = 2.08, SD = .90; $t(65) = 3.65$, $p < .001$). Participant's risk score was also moderately positively correlated with the average number of birds kept ($r(85) = .31$, $p < .01$). A third variable, length of time, measured in years, shows a non-significant but negative relationship with composite risk score ($r(82) = -.12$, p <.227).

Analysis of variance showed no significant difference among self-reported chicken husbandry knowledge groups ($F(4, 80) = 0.45$, *ns*) or disease-related knowledge groups ($F(2, 82) = 2.15$, *ns*) with regard to the composite risk score ($F(4, 80) = 0.45$, *ns*). Additionally, a chi-square test of independence indicated no significant relationship between self-reported chicken husbandry knowledge and assessed disease knowledge ($X^2(8, N = 91) = 13.89$, $p = .085$). Participants' ability to cite diseases that pose a risk to local populations was also unrelated to the self-reported chicken knowledge ($F(4, 86) = 1.74$, *ns*). However, there was an observable group difference in the composite risk score between individuals who could, or could not, correctly identify local chicken diseases, which approached statistical significance ($F(2, 82) = 2.98$, $p = .06$). Over half the respondents could not identify a formal disease, ten indicated it was not a problem in their area, and one noted brucellosis, a bovine disease.

3.4 Results summary

Collectively, these results indicate that individuals who name their chickens and kept more chickens actually increase their risk of exposure to disease. While length of time had only a slight negative correlation with no statistical significance, it could mean that individuals who are newer to the practice of chicken husbandry are less careful and put themselves at greater risk of disease transmission. This would be worthy of further examination with a larger participant base and/or more specific questions. Otherwise, these risk-based patterns of behavior may be from developing a close relationship with the birds, perhaps best-indicated by the inclination to name the birds. In fact, 39% of participants indicated that they brought sick birds into their home to care for them, an action that flags both nurturing and high-risk behaviors. With an increased number of birds one could consider the increased exposure, but the tests were designed around behavioral factors, not numerical.

4. Discussion

This study is among the first to combine the human-animal relationship of backyard chickens in the US with the vulnerability that persists in such scenarios. As a pioneer examination of the backyard chicken, we present our findings to demonstrate that there is a need to reduce risk and encourage healthy practices. The bottom line is that a risk for the transmission of diseases between chickens and people exists. These results demonstrate that backyard flock practices are diverse, husbandry knowledge is varied, and that risk factors are present in many the backyard flocks surveyed. Factors related to human behavior, risk and exposure of any sort are complex and often challenging to decipher against a backdrop of environmental

conditionality. For example, climate alone plays a large role in disease factors related to both prevalence and persistence. Initiating pilot studies that give way to subsequent research is an important first step in understanding such complexities.

Proponents of backyard chicken farming cite the benefits of such things as allowing families to experience human-animal bonds, feeling empowered over food selection choices and food security, potentially experiencing small-scale economic gains, and reducing their carbon footprint [13], sentiments echoed by many of the participants in the current study. In addition, backyard farming reduces direct dependence on imported foods, which has been endorsed as a means of creating sustainable communities [43]. Along with these and other benefits, there are also risks associated with urban poultry husbandry that have the potential to result in multiple disease-related exposure pathways [44]. However, these risks can be minimized by awareness and education of the urban farmer, public health professionals, as well as veterinary medicine practitioners [13]. Though to date, relatively little is known about the specific variables that contribute to exposure and the risk of disease transmission between chickens and humans in backyard flock scenarios.

The gender and age representation of participants in this study are 81% female and a slight majority, 52%, over 40. These trends resemble those of the animal care and locavore movements[4]. Both groups, animal care and locavore, are reported to have more women involved than men and both trend towards and mature population, though qualitative age is defined differently in different studies [see: 45-48]. Stranton et al. also characterize the locavore movement as higher income and more educated [47]. Though this study did not include income or education levels, it would be interesting to see the comparison given the knowledge acquisition related to poultry health. Further comparison of the urban chicken community to the animal-care and locavore communities will likely provide advanced insight into the relationship people have with their birds.

The main reason people cite for keeping chickens is in line with the locavore culture: local food, in this case in the form of eggs. As mentioned, nearly all (92%) of our respondents used the eggs for their families' consumption; though 62% said they also gave eggs away and sold them locally. The production of eggs as a local food source addresses the growing diversity in diets and ethical choices, including organic, subsistence and sustainable, paleo[5], and the local food economy. While each choice is rife with challenges, the baseline for consumers tends to focus on minimizing harm [49]. Scholars also cite Michael Pollan's *Omnivore's Dilemma,* stating that the local chicken answers the question of how to consume animal protein without the environmental impact of global food-miles and animal-welfare issues [16, 49-50]. Broadway goes onto to cite the social benefits of local food production, including

[4] Animal-care is inclusive of dog and cat rescue/foster and wildlife rehabilitation. The locavore movement is characterized as focusing on local or regional production of food, though specific area is not defined (see: Stanton et al. 2012).

[5] Defined as a fad diet that uses animal products as the main food choice with supplemental vegetables and minimal fruits and starches (http://thepaleodiet.com/)

connectivity with community, which could be a major component of the egg trading and even sales aspect of keeping chickens that our participants reported [16; see, also: 7].

The second most dominant reason for keeping birds, after egg production, was enjoyment, followed by family education. Numerous publications exist on the human enjoyment of animal watching. These include popular texts such as Desmond Morris's series that includes *Dogwatching* and *Horsewatching* as well as a cache of academic publications that include both wildlife and domestic animals. In fact, a large portion of the field of Animal Geography is dedicated to the human-animal relationship and how that unfolds geographically, with topics such as zoo spaces, cityscapes, the spectacle, and the ethics of animal spaces [51]. The chicken is emblematic of this discourse. Both Watts and Philo discuss how animals' extirpation from and return to the urban centers shape and defy a human-centered landscape, complete with new ethical and moral challenges [52-53]. Whether based on chicken watching or the fun of egg collection, human enjoyment of the chicken in urban spaces works to redefine our own compact living dynamics to include the year-round fixture of small-scale livestock, as well as a greater potential for disease transmission. However, despite their popularity, it is clear that a gap in knowledge exists.

For instance, this study revealed that a comparisons of self-assessed poultry knowledge and identification of poultry diseases was surprising, insofar as we expected to find an increase in correct answers about potential diseases for people who indicated that they possessed a higher level of poultry knowledge. Instead we got a wide dispersal of answer-types across the four knowledge levels. On one side, this could indicate that people have an inflated sense of their knowledge level. Conversely, this could also indicate that concern for disease is not a factor in familiarity people have poultry husbandry or perhaps access to the material is not prevent in their sources of information. This finding could be cause for concern, as it suggests that people's fear of potential disease transmission is low across all knowledge levels, which may contribute to diseases going unrecognized throughout a community.

The potential risk of exposure to and transmission of zoonotic diseases is further exacerbated with the number of birds in one flock. We use Ortiz and Resnick to define self-assessed risk: "the degree to which a user feels that their safety is in jeopardy" [54, p. 4-826]. Studies show that the more familiar the user becomes, the less vigilant they may be in taking precautionary measures [55-56]. The existing research supports our findings regarding number of chickens– and risky behaviors that could help mitigate disease transmission. Again, our results show a correlation between high bird numbers and riskier behaviors.

Despite the results on disease risk, urban chicken husbandry has merits. This study focuses on health risks related to disease transmission, discrete scenarios that can largely be mitigated with improved practices. When compared to large-scale industrial chicken production, it is possible to argue that urban flocks serve to negate conditions associated with disease transmission. Wallace adeptly points out that the connectivity created between individual birds in industrial warehouses, compounded with high stress, sets the stage for disease to sweep through a facility [57], so in a regional risk assessment, the disconnected coops and smaller flocks may have merit. In addition, a growing body of literature supports

the interaction between animals and humans, in particular, children, as a means to actually boost immunity and overall health. Several studies highlight links between growing up on an animal farm or having pets as young children and the reduced rate of conditions such as eczema and asthma, respectively (58-59). Charnetski, Riggers and Brennan illustrate that the simple act of petting a dog has positive effects on immunity [60], and research by Wells shows that watching animals can reduce stress and blood pressure [61]. While we did not focus our research on the ways our respondents enjoyed their chickens, the notion of enjoyment was a prominent sentiment throughout the data and included watching and interacting with the birds and enjoying the meat or eggs. The enjoyment factor is a driving force in the spread of backyard chickens and may have long-term benefits for human wellbeing which are harder to measure than the presence or absence of disease. Given these auxiliary findings, it would be prudent to further investigate the benefits of enjoyment and work to reduce the risks.

Thus far, the enjoyment of these animals in urban spaces prevails over the risks associated with it, but for enjoyment to continue, risks should not be dismissed. Disease emergence can be understood as an evolutionary response to changes in the environment, including anthropogenic factors such as new agricultural practices, urbanization, globalization, and climate change. Livestock pathogens are thought to intensify in situations of high production, processing, and retail environments, which, together, alter host contact rates, population size, and/or microbial traffic flows in the food chain [62]. Mounting evidence suggests that in the case of zoonotic diseases emerging in livestock, changes in agricultural practices have become a dominant factor that determines the conditions in which zoonotic pathogens evolve, spread, and eventually enter the human population [57, 62]. As such, our ability to assess risks has the potential to help improve urban agricultural practices, and make urban chickens more sustainable in the long-term. By contrast, our results highlight the fact that self-reported knowledge does not accurately reflect a knowledge base sufficient to reduce risks. Our data indicate relatively low-knowledge levels, combined with high-risk behavior, and a minimal understanding of health issues, could be a serious concern should an outbreak occur.

Further inquiry is required to elucidate what practices may be best in order to develop strategies that can aid in reducing public-health risks associated with backyard chicken husbandry. Simple strategies might include providing water and food systems that reduce cross-species contamination, identifying veterinarians that are familiar with poultry, keeping poultry vaccinated, and developing safe handling practices for birds and eggs. Like any preventive measure, knowledge of success can only be tested in practice, but efforts to minimize exposure and reduce potential negative outcomes can act to strengthen the urban chicken movement and promote it as a safe and healthy practice.

Acknowledgments: We would like to acknowledge the individuals who participated in this study and Jay Sellmer for taking the time to review this work.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Stella Capoccia originated the hypothesis. Stella Capoccia and Scott Risser conceived the designed the experiments; Scott Risser and Michael Masters analyzed the data. Stella Capoccia and Michael Masters developed the foundational literature review used in the introduction and discussion.

Conflicts of Interest: The authors declare no conflict of interest. There was no funding source and therefore no foundational conflict of interest.

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