One Health 13 (2021) 100296

Contents lists available at ScienceDirect

One Health

journal homepage: www.elsevier.com/locate/onehlt

"Chicken dumping": Motivations and perceptions in shifting poultry production practices

Hayden D. Hedman [a,b], Lixin Zhang [c,d], Bilal Butt [b], Priscila Papias [b], James A. Trostle [e], Joseph N.S. Eisenberg [f,*]

[a] Summit County Local Public Health Agency, Summit County, Frisco, CO 80443, USA
[b] School for Environment and Sustainability, University of Michigan, Ann Arbor, MI, USA
[c] Department of Microbiology and Molecular Genetics, Michigan State University, East Lansing, MI 48824, USA
[d] Department of Epidemiology and Biostatistics, Michigan State University, East Lansing, MI 48824, USA
[e] Department of Anthropology, Trinity College, Hartford, CT, USA
[f] Department of Epidemiology, School of Public Health, University of Michigan, Ann Arbor, MI 48109, USA

ARTICLE INFO

Keywords:
Mixed-methods
Poultry
Agricultural development
Global health

ABSTRACT

Non-governmental organizations (NGOs) often implement overseas development aid through intensive small-scale animal agriculture to alleviate food insecurity in low- and middle-income countries. Intensive animal farming can pose unclear outcomes to households engaged in the practice because of the reliance on industrial animal breeds that are reared with antibiotics and raised in higher densities compared to traditional scavenging husbandry systems. As a result, intensive small-scale farming operations that lack proper infrastructure, training, and financial resources could facilitate the spread of antimicrobial resistance and infectious diseases. We applied a mixed-methods framework towards analyzing the effectiveness of small-scale broiler chicken farming in northern Ecuador. First, from May 2016 – May 2017, our observational surveys indicated that intensive small-scale poultry farming follows a boom-and-bust cycle that is extremely vulnerable to environmental stressors. Second, in May 2016, we followed a cohort of households enrolled in a poultry development project led by an NGO. We observed a substantial decline in chicken survivorship from Survey period 1 to 2 (mean chicken count decrease from 50 to 35 corresponding to a 70% survivorship) and from Survey period 2 to 3 (mean chicken count decrease from 35 to 20.3 corresponding to a 58% survivorship). Heads of households were self-reporting broiler chicken survivorship substantially higher than our recorded observations during survey period two (46 compared to 35 respectively) and three (44.3 compared to 20.3 respectively). We speculate that if households continue to inaccurately report poultry demographics, then it could perpetuate a negative feedback loop where NGOs continue to conduct the same intervention practices without receiving accurate outcome metrics. Third, we used semi-structured questionnaires to determine that access to financial resources was the major motivation for determining when to farm broiler chickens. Intensive small-scale poultry farming can be unreliable and disease-enhancing, yet also associated with dubious self-reports of success.

1. Introduction

Small-scale poultry production systems have been essential for human livelihoods among rural agricultural communities for millennia, improving diet, finances, and food security of impoverished rural populations [1,2]. Small-scale chicken farming remains a rapidly growing micro industry because of the low initial investment compared to other livestock [3]. In resource-limited settings, administering antibiotics for both growth promotion and prophylactic purposes remains common in industrial broiler chicken farming [5,6]. Intensive poultry farming serves as an implementation strategy to enhance food and nutrition security, gender equity, and economic stability among impoverished communities [7].

Family-operated poultry farming systems comprise the majority of global poultry production [1]. The Food and Agriculture Organization (FAO) of the UN defines 'family poultry' as small-scale operations that can vary from scavenging to intensive farming systems, managed by up to several households living in rural, peri-urban, or urban environments

* Corresponding author.
E-mail address: jnse@umich.edu (J.N.S. Eisenberg).

https://doi.org/10.1016/j.onehlt.2021.100296
Received 2 May 2021; Received in revised form 20 July 2021; Accepted 21 July 2021
Available online 24 July 2021

[8]. The range of types of poultry farms allows families to select animal husbandry practices that best accommodate their specific farming capacity, objectives, and overall livelihoods [1,8].

Traditional scavenging farming systems consist of native breeds of extensively-raised, or village chickens poultry. Scavenging poultry systems are characterized by diets that primarily consist of open foraging on insects, plant matter, especially green leafy plants, and table scraps, with flock sizes ranging from 1 to 50 birds, and an absence of antibiotic usage [2,7,8]. Extensively-raised chickens can provide multiple roles including food security, marginal income, and bartering for critical items such as medical supplies or food [2]. In the last few decades, there has been a shift from small-scale extensively-raised chicken systems to intensive poultry systems [9,10]. As populations continue to rise, many countries have expanded intensive poultry production as an outlet to meet the demand for protein-rich animal-source food products (ASFs) [11,12]. Despite this shift in poultry productive practices, it remains questionable if intensive small-scale poultry farming is a more sustainable practice compared to extensively-raised poultry.

In contrast to scavenging, intensive small-scale poultry systems provide more efficient productivity of ASFs [1,13–15]. Expansion of intensive farming coupled with high use of growth promotion antibiotics is estimated to increase the global use of antimicrobials by 70%, with this increase driven by developing countries [16]. This increased level of production is made possible through use of industrial breeds (e.g. broilers for meat or layers for eggs), antibiotics, and housing facilities that can support 50 to 200 birds [6,17,18].

Non-governmental organizations (NGOs) often promote small-scale intensive poultry farming as a means to improve food security, economic development, and gender equity [19–21]. The United Nation's Sustainability Development Goals aim to eliminate poverty and malnutrition by 2030, accelerating small-scale poultry interventions [15,22,23]. Despite the many benefits of development programs linked to animal husbandry [24,25], studies have documented how livestock introductions are often un successful largely due to disease outbreaks, limited access to veterinary services, and limited educational resources [26–28]. In many cases small-scale poultry projects are constrained by limited access to quality veterinarian staff and husbandry equipment [29].

Our previous work has reported small-scale broiler chickens as sources of high AMR in rural communities in coastal Ecuador [30–33]. At the community scale, we have detected that *E. coli* sampled from extensively-raised chickens and humans exhibit overall greater AMR from communities engaged in small-scale broiler chicken farming compared to inactive broiler farming communities [30,34]. At the household level, we have found *E. coli* from broiler chickens with resistance to clinically relevant cefotaxime can potentially be spread to children and extensively-raised chickens [31]. In the same context, we also detected overall greater richness of antibiotic resistant genes (ARGs) and lower microbial community diversity within broiler chickens compared to extensively-raised chickens [35]. Our previous work outlines the trend of increasing broiler farming and a strong association of AMR associated with intensive small-scale broiler farming.

Given this evidence, questions remain about the efficacy of poultry interventions for development outcomes given that the environmental, social, and health outcomes of small-scale poultry projects are less clear [28]. This calls for a need to better assess the effects and the motivations of small holders partnering with these kinds of development projects.

While great attention [18,36] has been paid to the motivations of NGOs, little work has been concerned with household farmer motivations and the reliability of self-reporting from household farmers. Behavioral measures through self-reports are often limited due to various forms of biases [37]. Understanding the behavioral motivations behind the practices of broiler chicken farming could better inform the decision-making process leading to development goals. Our research encompasses a 'One Health' approach by evaluating risk perceptions, attitudes, and motivations towards small-scale poultry farming at the intersection of human micro-industries, the environment, and health This study relies on a mixed method approach to understand: (1) the survivorship of small-scale poultry reared in community development programs, and (2) the behavioral motivations behind small holders' decisions to engage in small-scale poultry farming.

2. Methods

2.1. Study area

This research is centered in northwestern Ecuador because (1) of the social and development changes that are occurring; (2) we have a history of good relationships at the local level and supplementary data obtained through a long-term monitoring program within the region.

In 1996, an international road development project was initiated to connect passageway to Columbia from Ecuador, and in 2001, a two-lane paved highway was completed in the Esmeraldas region [38]. Palm and timber industries constructed secondary and tertiary roads to expedite the transport and processing of natural resources [39,40]; resulting in increasing connectivity for rural communities [38]. All the study communities reside alongside the highway, making them primary target populations for micro-industry development projects facilitated by international NGOs. Earlier work has reported that communities residing closer to the highway exhibit greater human *E. coli* resistant to ampicillin and sulfamethoxazole [41], burden of enteric diseases [38], and childhood stunting [42] compared to more remote communities in the region.

2.2. Small-scale broiler demographic surveys

Surveys of small-scale poultry farming were conducted among three villages located near the highway and all had experience with development organizations (Fig. 1). Monthly household surveys were administered to every household farming broiler ($n = 32$) or extensively-raised chickens ($n = 51$) regarding flock demographics including number of infected, dead, and alive from May 2016 to May 2017.

2.3. Small-scale poultry developmental project cohort

In May 2016, a non-governmental organization introduced 50, one-day-old broiler poults to 10 households in a village under the agreement that the partnering households would pay for all other chicken farming expenses. All households partnered with the NGO volunteered to be enrolled in our observational study to monitor the demography of broiler chickens during a small-scale development project. From May

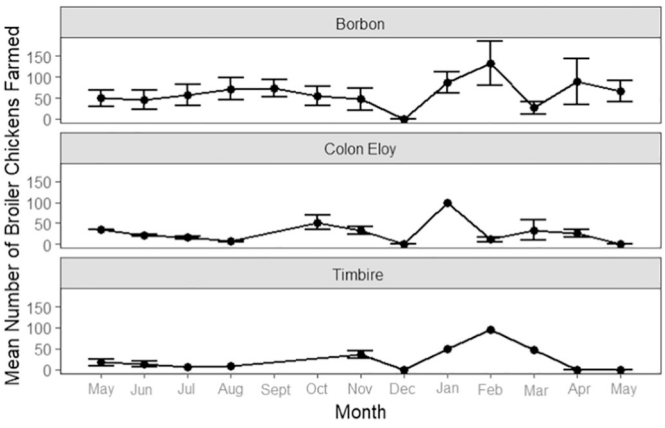

Fig. 1. May 2016 – May 2017 monthly mean (± SE) number of broiler chicken farmed in three communities within the Esmeraldas Province, Ecuador. Standard error was calculated by the square root of the number of houses actively farming (points without SE bars indicate n households ≤1).

2016 to June 2016, we surveyed enrolled households during three periods (S1-S3) in two-week intervals. During surveys, we recorded the number of broiler chickens present through two reporting mechanisms: (1) self-reported data via heads of households and (2) observational counts from surveyors.

2.4. Semi-structured questionnaires

From May 2016 to June 2016, semi-structured questionnaires were conducted to describe the perceptions of small-scale farming among seven communities. The study design consisted of snowball sampling in which key informants (village leaders) directed us to other informants. The target demographic of this study included heads of households within villages that have previous history partnering with agricultural development organizations. All questions were originally written by a native Spanish speaker and first tested with local village partners. Responses were recorded and transcribed for thematic analyses [43].

2.5. Data analysis

Responses were recorded using Qualtrics software (www.qualtrics.com). Data analyses were conducted with R Statistical Software version 4.0.4 [44]. Questionnaire data were coded into four category themes that included topics of: (1) micro-economics of poultry farming, (2) risk perception of financial security, (3) environmental stressors that influence broiler farming, and (4) purpose of raising broiler chickens.

Logistic regression models were used to compare observational survey counts between survey period one and two as well as survey periods two and three. In these models, the predictor was the number of observed chickens and the outcome was a binary categorial variable for the sample period comparison. To analyze differences in chicken counts between self-reported and observational surveys, we used logistic regressions with a binary categorial variable for the type of survey implemented.

3. Results

3.1. Small-scale broiler demographic surveys

Monthly surveys revealed variability in the number of households farming broiler chickens (mean: 12 ± 1.9 SE; range: 3–24) and mean broiler chicken flock sizes (mean: 51 ± 7.2 SE; 1–300). The overall trajectory of farming activity was dynamic (Fig. 1). We observed no farming in December 2016 followed by a rebound peak in activity in February 2017. The decrease in December 2016 in broiler farming was due to an earthquake in the region.

3.2. Higher chicken count recorded in self-reported vs. observational surveys

Between survey period 1 and 2 as well as 2 and 3, we observed a substantial decline in chicken survivorship (mean chicken count decrease (50 to 35 and 35 to 20.3 respectively) (Fig. 2). These differences were statistically significant (Table 1). Self-reported survey counts from heads of households were substantially larger than observational survey counts in period 2 (mean number of chickens: 46 vs. 35) and 3 (mean number of chickens: 44.3 vs. 20.3). These differences were statistically significant (Table 2). Self-reported survey chicken counts exhibited no statistically meaningful difference between period 1 and 2 (OR: 0.9; 95% CI: 0.8 — 1.1) and between period 2 and 3 (OR: 1.0; 95% CI: 0.8 —1.1).

3.3. Themes from survey responses

3.3.1. Micro-finances of poultry farming

Nearly every respondent who was not currently engaged in farming

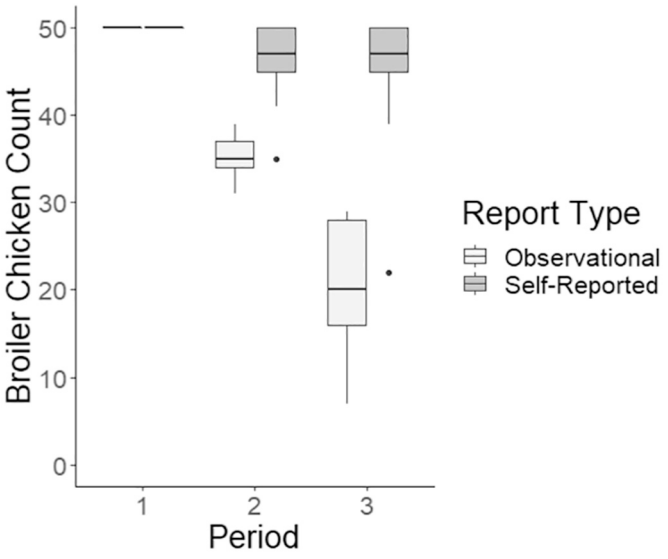

Fig. 2. In May 2016, a non-governmental organization (NGO) enrolled 10 households in a small-scale poultry development program and provided each household with 50, one-day-old chickens. From May 2016 to June 2016, two-week observational surveys were conducted to monitor the number of broiler chickens alive during the course of the development project. The boxplot displays the distribution observational and self-reported broiler chickens counted during each two-week survey period.

Table 1
Comparison of observed broiler chicken survivorship between survey periods among households enrolled in a small-scale poultry development project in northwestern Ecuador. Odds ratio (OR) and 95% CI obtained through a logistic regression model comparing chicken count observed during successive survey periods.

Survey period comparison	OR	95% CI
S1 vs. S2	0.7	0.6 — 0.8
S2. vs. S3	0.6	0.5 — 0.7

Table 2
Comparison of self-reported and observed broiler chicken survivorship between survey periods among households enrolled in a small-scale poultry development project in northwestern Ecuador. Odds ratio (OR) and 95% CI obtained through a logistic regression model comparing number of alive chickens through self-reported vs. observed during survey periods 2 and 3.

Self-reported vs. Observed	OR	95% CI
S2	1.3	1.1— 1.5
S3	2.2	1.8 — 2.6

stated that limited financial resources were their primary constraint to engaging in small-scale broiler farming. Many households reported cultural and social celebrations (e.g. graduation ceremonies, Christmas, New Year's) throughout the year as drivers for determining when to anticipate optimum poultry husbandry.

> *I do not sell because* [of] *the money…I lack the cash and … time. The time is the thing. And at times, I say, I do not want to work on the mountain anymore. I want to dedicate myself to improving raising my pigs and my chickens.* (INT 2)
>
> *I decided to raise broiler chickens for my kids.*

3.3.2. Risk perception of financial security

Most respondents reported small-scale broiler farming as a secure

investment. Many of the respondents described expecting quick turnaround in profit. Those who did not believe broiler farming was a safe investment described the high mortality risk of broiler chickens as a limiting factor. In open-ended interviews mothers described raising broiler chickens as more difficult than raising children. The term "luck" was frequently used by respondents who described it as a safe and unsafe investment.

> *Yes, it is a secure investment because it gives fast money in 4–6 weeks one sees what one invests.* (INT 7).
> *No, it is not a secure investment. For example, Mrs. [individual in the village] had a flock of 100 chickens and all of them died. Then the investment is lost.* (INT 13).
> *You have to have luck or to provide more attention so that they have good coverage*. (INT 19).

> *Safe depending on the weather factors. Because if you do it in the winter season, you are tending to lose your money. But if it happens in summer, combining with the luck of God, then it is safe.* (INT 9).

> *Yes, like any business, it is a matter of random luck. One that can dedicate time and perseverance to it can get it.* (INT 14).

3.3.3. Environmental stressors influencing broiler farming

Most respondents describe some form of environmental stress impacting their farming productivity. Some respondents also described broiler chickens as extremely vulnerable to the seismic activity in the region. We speculated that seismic activity could lead to physical harm via destruction of the coop environment or obstruction to nutrition and water access in additional to psychological stress. In December 2017, we documented a complete die-off of broiler chickens due a regional earthquake (Fig. 1). Most respondents discussed summer as an ideal farming period, while winter (i.e. rainy season) as an unfavorable farming period. Many respondents described the high frequency of flooding during the rainy season as a risk for disease transmission (likely from runoff of fecal pollutant). Proponents of farming in winter described summer (i.e. dry season) as having excessively high ambient temperatures, leading to higher mortalities.

> *When we raise chickens, we always look to do so in the summer… Because it is bone dry in the summer. The broiler chicken is more delicate … because while there is more rain it becomes sick. The humidity… [broilers] always have to be dry for good farming for this chicken… because I already told you, you have to be very careful with this chicken, it is more delicate than the criollo. Because once the bone falls sick from the fungus, the whole chicken is sick. Due to this, we have to be very careful with [broilers].* (INT 5).

3.3.4. Raising broiler chickens

Most respondents with previous broiler farming experience reported the primary reason for rearing broiler chickens was to feed their family. Some, but not all households, reported the practice as an additional source of income to sell within their village. Respondents frequently mentioned the benefit of having more funds from broiler farming to sustain the household. Households that have sold broiler chickens or meat described time of year and financial constraints as key limiting factors. The access to high-costing *balanceado* (the local term for commercial animal feed) [48] was prevalent among respondents who had previous experience with broiler farming.

> *I do not raise broiler chickens because I do not have enough money for vitamins, also, I do not sell while a chicken is sick… we have to be very careful with [broilers].* (INT 4).

4. Limitations

Despite the key findings of our study, there are select areas that can enhance our work and future studies. We reported perceptions, attitudes, and beliefs that are not static and subject to change from outside influences such as NGO projects or natural disasters. Additionally, timing of agricultural development projects is dynamic and difficult to predict. Environmental stressors, such as infectious disease outbreaks and natural disasters are sporadic, which can have substantial impacts on motivation and timing of poultry farming operations.

5. Discussion

Small-scale animal production is a valuable source of income and quality nutrition for many households in Ecuador and around the world. As development organizations continue to promote intensive small-scale poultry farming, it is important to monitor survivorship of animals and perceptions of smallholders. We studied the impacts of small-scale poultry through three approaches: monitoring broiler demography and village farming dynamics, following a cohort of households engaged with a developmental organization, and surveying community members about their perceptions of broiler chicken farming. Our observational study in coastal Ecuador demonstrates that small-scale broiler chicken farming is a dynamic process that has low survivorship and variable perceptions and motivations surrounding the practice.

We followed up with the NGO that delivered 50, one-day-old chickens to 10 households. They reported that they did not provide any additional training, veterinary services, or financial support because these were the terms of agreement established with the participating households. We speculate that this agreement strategy burdened households with almost the entire financial costs associated with intensive poultry husbandry. Because of the limited support, it is likely that households did not have sufficient access to vaccines, commercial feed, or sanitation supplies. In addition, the absence of professional training could have exacerbated these challenges for households with less experience in poultry farming. Enrolled household inaccurately self-reported substantially lower number of broiler deaths than the number of broiler chickens present during survey periods. Self-reporting can lead to a social desirability bias as recognized in other studies investigating animal farmer practices and behaviors [37,49,50]. We speculate that households engaged in small-scale poultry development programs were not comfortable relaying accurate metrics to surveyors because they did not want to lower their credibility as poultry farmers. Enrolled households with high chicken mortality could potentially be uncomfortable sharing these outcomes with NGOs, thus perpetuating a negative feedback loop where NGOs continue the same intervention practices without receiving accurate outcome measurements.

In the absence of proper husbandry infrastructure, intensively farmed poultry are especially vulnerable to environmental stressors, such as infectious diseases, temperature changes, and natural disasters. One of the most common diseases in poultry is Newcastle disease virus (NDV) (*Paramyxoviridae*) [51]. In Latin America, NDV has been proposed as endemic or re-emerging, posing an enormous threat to poultry health [52,53]. Although there are many other deleterious avian diseases, NDV is a preventable disease: many community-scale vaccination programs have reduced poultry mortality from NDV [52,54,55]. One study from Mozambique reported that small-scale flocks without Newcastle vaccine were approximately five times more likely to die of NDV compared to vaccinated flocks [56]. Infectious diseases risk is compounded with deprived nutrition [57], temperature stress [58], or natural disasters such as floods or earthquakes [59,60]. In December 2016, our annual poultry demographic survey reported a regional collapse in broiler chicken farming following a regional earthquake. The regional collapse following the earthquake could have impacted smallholders' perceptions that continuing broiler farming after the earthquake would pose higher mortality risk.

Our qualitative interviews corroborate with themes of environmental stressors. Most heads of households said that the wet season (October to May) was a higher risk period to engage in farming due to increased risk of fecal contamination from flooding events. Most heads of households did not perceive broiler chicken farming as a risky endeavor despite the economic and environmental constraints. The perception of intensive broiler chicken farming as no or even low-risk could reflect limited diversity in the types of food-animals promoted by NGOs, and an overall strong cultural preference for poultry products. In western Kenya, heads of households also reported conflicting responses in their risk perception of farming cash crops despite variable crop yields [61]. A similar study demonstrated that chicken farmers' perception of risk varied: farmers with more formal education were more likely to adopt agricultural insurance [62]. Respondents commonly discussed themes of infectious diseases, temperature fluctuations, seismic activity, and flooding negatively affecting broiler chicken farming. Other studies have documented that smallholder poultry farmers' perception of risk and management are not uniform at the community level and do not always align with national policies towards biosecurity [63,64]. Our findings collectively suggest smallholders' perceptions of risk related to intensive poultry farming are highly variable and not directly linked to productivity.

As countries continue to transition from traditional scavenging to intensive poultry farming systems, integrated research that evaluates the smallholder perceptions to NGO small-scale animal husbandry development projects is essential. Intensive small-scale poultry production is an important activity within our study region. This intervention approach exhibits questionable outcomes that are prone to environmental stressors and fluctuations in local demands for poultry products. Our study highlights that partnerships between NGOs and communities can potentially be ineffective without initial training and other resource investments. Further investigations could conduct follow-up surveys with households that engage in small-scale poultry development programs to evaluate change in perceptions and motivations to farm poultry. New research could also survey larger population sizes to clarify how and if motivations and perceptions towards poultry farming vary by demographics. These findings could contextualize which subpopulations are most impacted by small-scale poultry development programs leading to better development goals.

Author statement

Hayden Hedman: Conceptualization, Methodology, Formal analysis, Writing Original Draft; **Lixin Zhang**: Writing - Review & Editing; **Bilal Butt**: Writing - Review & Editing; **Priscila Papias**: Writing - Review & Editing; **James A. Trostle**: Writing - Review & Editing, Formal analysis; **Joseph N. S. Eisenberg**: Supervision, Writing - Review & Editing, Formal analysis.

Declaration of Competing Interest

The authors declare that they have no conflict of interests.

Acknowledgements

We are grateful for the invaluable contributions of the field team: Jorge Mejía Zamora, Leonar Hurtado, and Evelin Melisa Valdéz. We are grateful for the invaluable contributions of the Field Coordinator Jorge Mej'ıa Zamora and the entire "Resistencia Zoonotica" field team members: Eduardo Zamora Castillo, Mauricio Ayovi, Leonar Hurtado, Sulay Borja Perlaza, Evelin Melisa Valdéz, Sulay Borja Perlaza, and Eduardo Zamora Castillo. This project was funded through the Dow Sustainability Fellowship and the Integrated Training in Microbial Systems program at the University of Michigan. The authors assert that all procedures contributing to this work comply with the ethical standards reviewed and approved by the University of Michigan Institutional Review Board (HUM00121496) and the Universidad San Francisco de Quito Bioethics Committee (MSP-SDM-10-2013-1019-O). The animal use protocol was approved by the Institutional Animal Care & Use Committee at the University of Michigan (protocol: PRO00006200) and NIH (grant #R01AI137679).

References

[1] R.G. Alders, R.A.E. Pym, Village poultry: still important to millions, eight thousand years after domestication, Worlds. Poult. Sci. J. 65 (2009) 181–190, https://doi.org/10.1017/S0043933909000117.
[2] J.T. Wong, J. De Bruyn, B. Bagnol, H. Grieve, M. Li, R. Pym, R.G. Alders, Small-scale poultry and food security in resource-poor settings : A review 15, 2017, pp. 43–52, https://doi.org/10.1016/j.gfs.2017.04.003.
[3] B.D. Perry, D. Grace, K. Sones, Current drivers and future directions of global livestock disease dynamics, Proc. Natl. Acad. Sci. 110 (2013) 20871–20877, https://doi.org/10.1073/pnas.1012953108.
[5] L.L. Founou, R.C. Founou, S.Y. Essack, Antibiotic Resistance in the Food Chain : A Developing 7, 2016, pp. 1–19, https://doi.org/10.3389/fmicb.2016.01881.
[6] H.D. Hedman, K.A. Vasco, L. Zhang, A review of antimicrobial resistance in poultry farming within low-resource settings, Animals. 10 (2020) 1264, https://doi.org/10.3390/ani10081264.
[7] R.G. Alders, S.E. Dumas, E. Rukambile, G. Magoke, W. Maulaga, J. Jong, R. Costa, Family poultry: multiple roles, systems, challenges, and options for sustainable contributions to household nutrition security through a planetary health lens, Matern. Child Nutr. 14 (2018), e12668, https://doi.org/10.1111/mcn.12668.
[8] FAO (Food and Agriculture Organization), Decision tools for family poultry development FAO, in: Animal Production and Health Guidelines No. 16. Rome, Italy, 2014. http://www.fao.org/3/i3542e/i3542e.pdf.
[9] R. Laxminarayan, P. Matsoso, S. Pant, C. Brower, J.A. Røttingen, K. Klugman, S. Davies, Access to effective antimicrobials: a worldwide challenge, Lancet. 387 (2016) 168–175, https://doi.org/10.1016/S0140-6736(15)00474-2.
[10] T.P. Van Boeckel, E.E. Glennon, D. Chen, M. Gilbert, T.P. Robinson, B.T. Grenfell, S.A. Levin, S. Bonhoeffer, R. Laxminarayan, Reducing antimicrobial use in food animals, Science (80-.). 357 (2017) 1350–1352. doi:https://doi.org/10.1126/science.aao1495.
[11] T. Ahmed, H.A. Ameer, S. Javed, Pakistan's backyard poultry farming initiative: impact analysis from a public health perspective, Trop. Anim. Health Prod. 53 (2021) 210, https://doi.org/10.1007/s11250-021-02659-6.
[12] Y. Hu, H. Cheng, S. Tao, Environmental and Human Health Challenges of Industrial Livestock and Poultry Farming in China and Their Mitigation Environmental and human health challenges of industrial livestock and poultry farming in China and their mitigation, 2017, https://doi.org/10.1016/j.envint.2017.07.003.
[13] M. Vaarst, S. Steenfeldt, K. Horsted, D. Centre, F. Food, Reviews Sustainable development perspectives of poultry production 71 (2020) 609–620, https://doi.org/10.1017/S0043933915002433.
[14] A. Permin, J.C. Riise, K.N. Kryger, Strategies for developing family poultry production at village level - experiences from West Africa and Asia, Worlds. Poult. Sci. J. 61 (2005) 15–22, https://doi.org/10.1079/WPS200437.
[15] A. Mottet, G. Tempio, Global poultry production: current state and future outlook and challenges, Worlds. Poult. Sci. J. 73 (2017) 245–256, https://doi.org/10.1017/S0043933917000071.
[16] T.P. Van Boeckel, C. Brower, M. Gilbert, B.T. Grenfell, S.A. Levin, T.P. Robinson, A. Teillant, R. Laxminarayan, Global trends in antimicrobial use in food animals, Proc. Natl. Acad. Sci. 112 (2015) 5649–5654, https://doi.org/10.1073/pnas.1503141112.
[17] M.J. Gilchrist, C. Greko, D.B. Wallinga, G.W. Beran, D.G. Riley, P.S. Thorne, The Potential Role of Concentrated Animal Feeding Operations in Infectious Disease Epidemics and Antibiotic Resistance 115, 2007, pp. 2005–2008, https://doi.org/10.1289/ehp.8837.
[18] J.P. Graham, J.N.S. Eisenberg, G. Trueba, L. Zhang, T.J. Johnson, Small-scale food animal production and antimicrobial resistance: mountain, molehill, or something in-between? Environ. Health Perspect. 125 (2017) 104501, https://doi.org/10.1289/EHP2116.
[19] J.L. Leroy, E.A. Frongillo, Can Interventions to Promote Animal Production Ameliorate Undernutrition ? 1 , 2, 2007, pp. 2311–2316.
[20] H. Miller, P.H. Thrall, J. Antonovics, A.M. Jarosz, P.V. Oudemans, Population Dynamics and Genetics of Plant Disease : A Case Study of Anther-Smut Disease POPULATION DYNAMICS AND GENETICS OF PLANT DISEASE : A CASE STUDY OF ANTHER-SMUT DISEASE1 77, 2014, pp. 990–996.
[21] L.L. Iannotti, C.K. Lutter, D.A. Bunn, C.P. Stewart, Eggs: the uncracked potential for improving maternal and young child nutrition among the world's poor, Nutr. Rev. 72 (2014) 355–368, https://doi.org/10.1111/nure.12107.
[22] Food and Agriculture Organization (FAO), Synthesis - livestock and the sustainable development goals, 2016. http://www.livestockdialogue.org/fileadmin/templates/res_livestock/docs/2016/Panama/FAO-AGAL_synthesis_Panama_-Livestock_and_SDGs.pdf. (Accessed 24 February 2021).
[23] M.E. Hossain, M.A. Hoque, E. Giorgi, G. Fournié, G.B. Das, J. Henning, Impact of improved small-scale livestock farming on human nutrition, Sci. Rep. 11 (2021) 191, https://doi.org/10.1038/s41598-020-80387-x.
[24] M. Nilsson, D. Griggs, M. Visbeck, Policy: map the interactions between sustainable development goals, Nature. 534 (2016) 320–322, https://doi.org/10.1038/534320a.

[25] M. Di Marco, M.L. Baker, P. Daszak, P. De Barro, E.A. Eskew, C.M. Godde, T. D. Harwood, M. Herrero, A.J. Hoskins, E. Johnson, W.B. Karesh, C. Machalaba, J. N. Garcia, D. Paini, R. Pirzl, M.S. Smith, C. Zambrana-Torrelio, S. Ferrier, Opinion: sustainable development must account for pandemic risk, Proc. Natl. Acad. Sci. 117 (2020) 3888–3892, https://doi.org/10.1073/pnas.2001655117.

[26] B. Huttner, S. Harbarth, D. Nathwani, Success stories of implementation of antimicrobial stewardship: a narrative review, Clin. Microbiol. Infect. 20 (2014) 954–962, https://doi.org/10.1111/1469-0691.12803.

[27] M. Kaur, J.P. Graham, J.N.S. Eisenberg, Livestock ownership among rural households and child morbidity and mortality: an analysis of demographic health survey data from 30 sub-Saharan African countries (2005–2015), Am. J. Trop. Med. Hyg. (2017) 16–0664, https://doi.org/10.4269/ajtmh.16-0664.

[28] J.P. Graham, J.N.S. Eisenberg, G. Trueba, L. Zhang, T.J. Johnson, Small-scale food animal production and antimicrobial resistance: mountain, molehill, or something in-between? Environ. Health Perspect. 125 (2017) 1–5, https://doi.org/10.1289/EHP2116.

[29] S. Forman, C. Plante, G. Murray, B. Rey, D. Belton, B. Evans, P. Steinmetz, Position paper: Improving governance for effective veterianry Services in developing countries - a priority for donor funding, Rev. Sci. Tech. l'OIE 31 (2012) 647–660, https://doi.org/10.20506/rst.31.2.2143.

[30] N.P. Braykov, J.N.S. Eisenberg, M. Grossman, L. Zhang, K. Vasco, W. Cevallos, D. Muñoz, A. Acevedo, K.A. Moser, C.F. Marrs, B. Foxman, J. Trostle, G. Trueba, K. Levy, Antibiotic resistance in animal and environmental samples associated with small-scale poultry farming in northwestern Ecuador, MSphere. 1 (2016), https://doi.org/10.1128/mSphere.00021-15 e00021–15.

[31] H.D. Hedman, J.N.S. Eisenberg, K.A. Vasco, C.N. Blair, G. Trueba, V.J. Berrocal, L. Zhang, High prevalence of extended-Spectrum Beta-lactamase CTX-M–producing Escherichia coli in small-scale poultry farming in rural Ecuador, Am. J. Trop. Med. Hyg. 100 (2019) 374–376, https://doi.org/10.4269/ajtmh.18-0173.

[32] H.D. Hedman, J.N.S. Eisenberg, G. Trueba, D.L.V. Rivera, R.A.Z. Herrera, J. V. Barrazueta, G.I.G. Rodriguez, E. Krawczyk, V.J. Berrocal, L. Zhang, Impacts of small-scale chicken farming activity on antimicrobial-resistant Escherichia coli carriage in backyard chickens and children in rural Ecuador, One Heal. 8 (2019) 100112, https://doi.org/10.1016/j.onehlt.2019.100112.

[33] H.D. Hedman, L. Zhang, G. Trueba, D.L. Vinueza Rivera, R.A. Zurita Herrera, J. J. Villacis Barrazueta, G.I. Gavilanes Rodriguez, B. Butt, J. Foufopoulos, V. J. Berrocal, J.N.S. Eisenberg, Spatial exposure of agricultural antimicrobial resistance in relation to free-ranging domestic chicken movement patterns among agricultural communities in Ecuador, Am. J. Trop. Med. Hyg. (2020), https://doi.org/10.4269/ajtmh.20-0076.

[34] K.A. Moser, L. Zhang, I. Spicknall, N.P. Braykov, K. Levey, C.F. Marrs, B. Foxman, G. Trueba, W. Cevallos, J. Goldstick, J. Trostle, J.N.S. Eisenberg, The role of Mobile genetic elements in the spread of antimicrobial resistant Escherichia coli from chickens to humans in small-scale production poultry operations in rural Ecuador, Am. J. Epidemiol. (2017), https://doi.org/10.1093/aje/kwx286.

[35] X. Guo, R.D. Stedtfeld, H. Hedman, J.N.S. Eisenberg, G. Trueba, D. Yin, J.M. Tiedje, L. Zhang, Antibiotic Resistome associated with small-scale poultry production in rural Ecuador, Environ. Sci. Technol. 52 (2018) 8165–8172, https://doi.org/10.1021/acs.est.8b01667.

[36] A. Mcleod, O. Thieme, S.D. Mack, Structural changes in the poultry sector: will there be smallholder poultry development in 2030? Worlds. Poult. Sci. J. 65 (2009) 191–200, https://doi.org/10.1017/S0043933909000129.

[37] H.E. Moore, I.D. Rutherfurd, Researching agricultural environmental behaviour: improving the reliability of self-reporting, J. Rural. Stud. 76 (2020) 296–304, https://doi.org/10.1016/j.jrurstud.2020.04.012.

[38] J.N.S. Eisenberg, W. Cevallos, K. Ponce, K. Levy, S.J. Bates, J.C. Scott, A. Hubbard, N. Vieira, P. Endara, M. Espinel, G. Trueba, L.W. Riley, J. Trostle, Environmental change and infectious disease: how new roads affect the transmission of diarrheal pathogens in rural Ecuador, Proc. Natl. Acad. Sci. U. S. A. 103 (2006) 19460–19465, https://doi.org/10.1073/pnas.0609431104.

[39] E. Suárez, M. Morales, R. Cueva, V. Utreras Bucheli, G. Zapata-Ríos, E. Toral, J. Torres, W. Prado, J. Vargas Olalla, Oil industry, wild meat trade and roads: indirect effects of oil extraction activities in a protected area in North-Eastern Ecuador, Anim. Conserv. 12 (2009) 364–373, https://doi.org/10.1111/j.1469-1795.2009.00262.x.

[40] C.A. Peres, I.R. Lake, Extent of nontimber resource extraction in tropical forests: accessibility to game vertebrates by hunters in the Amazon Basin, Conserv. Biol. 17 (2003) 521–535, https://doi.org/10.1046/j.1523-1739.2003.01413.x.

[41] J.N.S. Eisenberg, J. Goldstick, W. Cevallos, G. Trueba, K. Levy, J. Scott, B. Percha, R. Segovia, K. Ponce, A. Hubbard, C. Marrs, B. Foxman, D.L. Smith, J. Trostle, In-roads to the spread of antibiotic resistance: regional patterns of microbial transmission in northern coastal Ecuador, J. R. Soc. Interface 9 (2012) 1029–1039, https://doi.org/10.1098/rsif.2011.0499.

[42] V.K. Lopez, C. Dombecki, J. Trostle, P. Mogrovejo, A.D. Jones, N. Castro, J.N. S. Eisenberg, Trends of child undernutrition in rural Ecuadorian communities with differential access to roads , 2004–2013, 2018, pp. 1–10, https://doi.org/10.1111/mcn.12588.

[43] H.J. Rubin, I.S. Rubin, Qualitative Interviewing: The Art of Hearing Data, SAGE Publications, Inc, Newbury Park, Third Edit, 2011.

[44] R. Core Team, R: A language and environment for statistical computing, 2021. https://www.r-project.org/.

[48] C. Lowenstein, W.F. Waters, A. Roess, J.H. Leibler, J.P. Graham, Animal husbandry practices and perceptions of zoonotic infectious disease risks among livestock keepers in a rural parish of Quito, Ecuador 95 (2016) 1450–1458, https://doi.org/10.4269/ajtmh.16-0485.

[49] T. Herzfeld, R. Jongeneel, Why do farmers behave as they do? Understanding compliance with rural, agricultural, and food attribute standards, Land Use Policy 29 (2012) 250–260, https://doi.org/10.1016/j.landusepol.2011.06.014.

[50] E. Otiang, Z.A. Campbell, S.M. Thumbi, L.W. Njagi, P.N. Nyaga, G.H. Palmer, Mortality as the primary constraint to enhancing nutritional and financial gains from poultry: a multi-year longitudinal study of smallholder farmers in western Kenya, PLoS One 15 (2020), e0233691, https://doi.org/10.1371/journal.pone.0233691.

[51] G. Cattoli, L. Susta, C. Terregino, C. Brown, Newcastle disease: a review of field recognition and current methods of laboratory detection, J. Vet. Diagn. Investig. 23 (2011) 637–656, https://doi.org/10.1177/1040638711407887.

[52] R.G. Alders, B. Bagnol, M.P. Young, Technically sound and sustainable Newcastle disease control in village chickens: lessons learnt over fifteen years, Worlds. Poult. Sci. J. 66 (2010) 433–440, https://doi.org/10.1017/S0043933910000516.

[53] N. Luzuriaga, X. Rivera, R. Salazar, N. Reyes, I. Santiana, Detección de anticuerpos séricos de influenza aviar tipo A, enfermedad de Newcastle y bronquitis infecciosa y laringotraqueitis infecciosa en aves acuáticas silvestres de tres lagunas andinas del Ecuador, Rev. Investig. Vet. Del Perú. 30 (2019) 1283–1291, https://doi.org/10.15381/rivep.v30i3.16591.

[54] Z.A. Campbell, T.L. Marsh, E.A. Mpolya, S.M. Thumbi, G.H. Palmer, Newcastle disease vaccine adoption by smallholder households in Tanzania: identifying determinants and barriers, PLoS One 13 (2018), e0206058, https://doi.org/10.1371/journal.pone.0206058.

[55] J.A. Nwanta, P.A. Abdu, W. Ezema, Epidemiology, challenges and prospects for control of Newcastle disease in village poultry in Nigeria, Worlds. Poult. Sci. J. 64 (2008) 119–127, https://doi.org/10.1017/S0043933907001766.

[56] J.L. Harrison, R.G. Alders, An assessment of chicken husbandry including Newcastle disease control in rural areas of Chibuto, Mozambique, Trop. Anim. Health Prod. 42 (2010) 729–736, https://doi.org/10.1007/s11250-009-9480-y.

[57] H. Yassin, A.G.J. Velthuis, M. Boerjan, J. van Riel, Field study on broilers' first-week mortality, Poult. Sci. 88 (2009) 798–804, https://doi.org/10.3382/ps.2008-00292.

[58] C.C. Chou, D.D. Jiang, Y.P. Hung, Risk factors for cumulative mortality in broiler chicken flocks in the first week of life in Taiwan, Br. Poult. Sci. 45 (2004) 573–577, https://doi.org/10.1080/000716604000006248.

[59] J.F. Filipe, V. Herrera, G. Curone, D. Vigo, F. Riva, Floods, hurricanes, and other catastrophes: A challenge for the immune system of livestock and other animals, Front. Vet. Sci. 7 (2020), https://doi.org/10.3389/fvets.2020.00016.

[60] S. Glassey, T.M. Wilson, Animal welfare impact following the 4 September 2010 Canterbury (Darfield) earthquake, Australas, Australas. J. Disaster Trauma Stud. 2 (2011) 49–59. http://hdl.handle.net/10092/6130.

[61] M.M. Waithaka, P.K. Thornton, M. Herrero, K.D. Shepherd, Bio-economic evaluation of farmers' perceptions of viable farms in western Kenya, Agric. Syst. 90 (2006) 243–271, https://doi.org/10.1016/j.agsy.2005.12.007.

[62] L.A.F. Akinola, A. Essien, Relevance of rural poultry production in developing countries with special reference to Africa, Worlds. Poult. Sci. J. 67 (2011) 697–705, https://doi.org/10.1017/S0043933911000778.

[63] F. Moffo, M.M. Mouliom Mouiche, F.L. Kochivi, J.B. Dongmo, H.K. Djomgang, P. Tombe, C.K. Mbah, N.P. Mapiefou, J.-P.K. Mingoas, J. Awah-Ndukum, Knowledge, attitudes, practices and risk perception of rural poultry farmers in Cameroon to antimicrobial use and resistance, Prev. Vet. Med. 182 (2020) 105087, https://doi.org/10.1016/j.prevetmed.2020.105087.

[64] T.E. Burns, C. Ribble, M. McLaws, D. Kelton, C. Stephen, Perspectives of an underrepresented stakeholder group, backyard flock owners, on poultry health and avian influenza control, J. Risk Res. 16 (2013) 245–260, https://doi.org/10.1080/13669877.2012.726244.