Reducing antibiotics: Evidence from an Experiment among Poultry Farmers in China

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Abstract:

China's expanding poultry industry relies heavily on antibiotics use. This has given rise to concerns regarding bacterial resistance. In this study we worked together with a broiler contractor and evaluated the effects of a two-pronged approach through a randomized controlled trial: Providing micro subsidies for alternative production methods and exposing farmers to role models and differential social norms (within their farmer groups). Farmers responded to the social norms treatment and took up the alternative technologies. However, the degree of take-up was limited, and the recommended accompanying changes in sanitation measures were not fully implemented. This resulted in an increase in (chicken) mortality in some cases, and an overall null-effect on profits. Combining the social norms treatment with the micro-subsidies amplifies these effects, while the subsidies by themselves had no consistent impacts.

JEL Codes: H41, O13, O33, Q16, Q51

Keywords: Antibiotics; Poultry; China; Technology Adoption; Social Norms

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1. Introduction

Antibiotic resistance has become a major public health challenge over the last few decades and poses a significant challenge in terms of achieving the Sustainable Development Goals, in particular Goal 3: Good Health and Wellbeing (UN 2017, 2018). To combat rising levels of drug resistance and maintain drug effectiveness, reducing the use of antibiotics in global food systems is critical (Williams-Nguyen 2016; Maclean and San Millan 2019; Moore 2019).

Excessive use of antibiotics in intensive livestock farming for growth promotion, disease prevention and treatment is considered a major driver of global antibiotic resistance (WHO 2012; Laxminarayan et al. 2013). Antibiotics overuse in animal rearing leads to the transmission of antibiotics residues from farms to water and soils, contaminating the environment (Campagnolo et al., 2002; Kumar et al., 2005; Jechalke et al., 2014). Moreover, antibiotics overuse in this sector, through selection pressure for antibiotic-resistant bacteria, causes increasing prevalence of antibiotic-resistant bacteria in animals, which can then spread to humans and the environment (FAO 2016; Heuer et al. 2011).

In livestock farming, antibiotics are often over-used as they are seen as growth promoters, low-cost substitute for hygiene, or general welfare measures to prevent infections (rather than merely disease treatment) (Van Boeckel et al. 2017). Changes in the production process hence have the potential to substantially reduce the amount of antibiotics used in animal rearing. Previous research suggests that policy measures can be effective in inducing these changes. In the U.S., e.g., government restrictions on the use of specific classes of antibiotics in combination with changing consumer preferences for antibiotics-free products led to producers' change in farm management and practices and further achieved a significant decrease in antibiotics sales for animal production (Sneeringer et al. 2019). Similarly, several EU countries including Denmark, Sweden, and the Netherlands have achieved significant reductions in antibiotics use for animal rearing by prohibiting the use of antibiotics for growth promotion and providing relevant supportive measures for the producers since the 1990s (Cogliani et al. 2011).

However, the success of these prohibitions and regulations in high-income countries relies on national surveillance systems that monitor antibiotics use at various stages of the production process. Such surveillance systems are often missing in low and middle-income countries, which hinders the enforceability of regulations on agricultural antibiotics consumption (Van Boeckel et al. 2017; WHO 2018). Under these circumstances, promoting good agricultural practices in animal rearing becomes a voluntary affair.

With profit-maximizing incentives skewed towards over-use, one must rely on the farmers' concerns for animal welfare, health of others (i.e., altruism), or reputation/status as motivating factors. These, due to the many competing and immediate concerns, might be in short supply in low and middle-income countries (see, among others, Jakiela 2015; Jakiela 2011; Kebede and Zizzo 2015; Urama and Hodge 2006; Weber 2011). In addition, these factors will only have an impact if the farmer is aware of the impacts of antibiotics overuse and has factual knowledge and know-how of alternative technologies. This too might be problematic. The former requires basic knowledge of microbiological processes (which is likely limited, see, among others, Rogers 2002; Redding et al. 2014; Chen et al. 2018; Al-Mustapha et al. 2020). The latter relies on learning from extension services, or other farmers, both which might be challenging among farmers who have limited access to relevant services, reside far from each other, and essentially work by themselves inside barns (Munshi 2004; Oyegbami 2018; Liverpool-Tasie et al. 2012). Any voluntary approach will hence need to relax information constraints and/or trigger social concerns in its various forms.

In this paper, we provide evidence of an approach that builds on these insights. Our study is set in China, a country known for its communal values (Chen 2017; Santos et al 2017; Gorodnichenko and Roland 2017; Said 2012). Fukuyama (1995) famously classified China as a "familistic" society (p.16), a statement which since then has been supported by several empirical studies. Xiong and Payne's (2017) using network analysis describes their sample villages as small worlds structured along kinship ties. Further studies indicate that people in China care about their place in society, care about others, and how others view them. This results in a society which values gift-giving (Chen 2014), reputation (Hartog et al. 2010) and positional spending (Brown et al. 2011).

We selected 847 farmers from the farmer database of a broiler company in the Jiangsu province in the eastern location from China. These 847 farmers presented the census, i.e., all farmers in two locations of Jiangsu Province who were working with the company at the end of 2018 in two locations: Changzhou (south Jiangsu) and Xuzhou (north Jiangsu). We measured these farmers' portrait values (egoistic, hedonic, altruistic, and biospheric value) in 2019 and confirm that in this sample farmers care deeply about their social status too.

Farmers in our sample contract with a broiler company, which provides them with inputs and purchases mature broilers from the farmers at an agreed-upon price (with an insurance system against severe yield losses in place). The company also has an extension system in place, grouping nearby contracting farmers in extension groups of 40 to 50 farmers. The farmers, perhaps because of their affiliation with the company, had some knowledge about the negative externalities entailed by excessive use of antibiotics. In 2019, 68% of farmers agreed that antibiotics overuse can promote the development of antibiotic-resistant bacteria, 54% knew that antibiotics overuse would harm human health, but only 35% knew that antibiotic overuse would lead to environment pollution.[1] This knowledge does not necessarily translate into care about the environment, animal welfare, or human health. They live far away from each other and hence have little face-to-face interaction barring the annual meetings organized by the company. This situation was further exacerbated by COVID-19 restrictions: Our study took place between 2018 and 2020 – a period when COVID-19 travel restrictions were in place.

We conducted a randomized controlled trial among these farmers with two main treatments. In the first treatment, we provided a one-off subsidy, delivered via a coupon, to purchase one of two alternatives to antibiotics: probiotics and acidifiers. Both technologies, if applied correctly, can effectively prevent infections, and reduce animal mortality, thus providing the basis for antibiotics reductions (O'Neill, 2015). While these technologies imply a reduced need for antibiotics, their success depends on appropriate levels of hygiene and sanitation. This implies that a successful, profitable, adoption of these technologies requires a substantial change in overall production methods.

The subsidy provided was small, sufficient for 7% of the annual amount needed for an average sized farm of 20 thousand broilers in the case of acidifiers, and 2% in the case of probiotics. As farmers in our sample were relatively wealthy, these subsidies represent less than 0.1% of their average annual income. As such, the subsidy should not be seen as financial instrument which relaxes credit constraints (in effect, while we recognize the importance of capital,[2] the contracting farmers do not have credit limit in input purchase). Instead, the subsidy should be seen as a nudge, a go-ahead to try something different and learn how these new technologies might work on your farm (this learning process is well-established in the field of health economics: Ashraf et al. 2013; Dupas 2014, see also Sunstein 2017). Piñeiro et al. (2020) conduct a meta-analysis on the incentives to adopt green technologies in agriculture and note the importance of financial incentives to complement any information, even if short-term (see also de Janvry et al. 2016 for a review on agricultural field experiments; and Meriggi et al 2021 for recent evidence from Cameroon).

We opted to implement the subsidy treatment using a coupon. Not only do coupons serve as a price reduction mechanism, nudging the farmer to experiment, but they can also be considered a promotional tool (Gardener and Trivedi 1998). They also maintain the price, and hence the associated perceived perception of quality, and can create a sense of exclusivity relative to other buyers (Chen et al. 1998; Lichtenstein et al. 1993).

In the second treatment, we aim to trigger social concerns of farmers, and expose them to role models through videos, structured quizzes, and conversations within their existing extension group. During these activities, our goal is again to encourage the reduction of antibiotics through the uptake of the alternative technologies: acidifiers, probiotics, together with improved sanitation and hygiene practices. We hereby build on an extensive literature in both economics and sociology on social norms, pressures, and persuasion among peers (see, among others, Cialdini et al. 1999, Maertens 2017, Moser and Barrett 2006). As we detail in Section 3, unlike previous studies aiming to provide social pressures (see a review from Bursztyn and Jensen 2017), our treatment could not be implemented in-person, and had to be conducted via phone-services (WeChat, a popular messaging & social media APP in China), both because of distance limitations and COVID-19 travel restrictions.[3] It is notable that the core of our approach builds on a long history of using role models in China to induce desirable actions, particularly in the areas of health and fertility (see, among others, Yang et al 2014 and Reed 1995) and farming (Aregay et al. 2018).[4]

To create an equal base of knowledge, prior to the randomized controlled trial taking place, all farmers (including the farmers in the control group) were exposed to an information intervention, which included information about the negative externalities of antibiotics overuse. Farmers were also provided with information on the effectiveness of acidifiers and probiotics, and how to use them. Finally, they were reminded of optimal sanitation practices.

We started with a baseline sample of 847 farmers in late 2018. After conducting an in-person baseline survey in mid-2019, we implemented the information treatment among the full sample through the existing extension network: Each company extension agent is assigned to a group of 40 to 50 farmers and visits their assigned farmers regularly to provide technical guidance and services. We then proceeded in early 2020 with two treatments. Half of the sample, randomly selected, received a coupon, to be claimed in the company shop. We cross-randomized this treatment with the social norm treatment, implemented at the extension group level. In mid-2020 we conducted our endline survey. Considering attrition, the balanced panel consists of 759 farmers.

To account for some degree of baseline imbalance and some degree of autocorrelation, we report our results using both ANCOVA and difference-in-difference specification and focus on intent-to-treat (as the social norms treatment had variable uptake across the extension groups). We find no statistically significant effects on farmers' outcomes, such as profits, mortality (of broilers) and limited effects on the use of antibiotics. However, the treatments affect the adoption of acidifiers and probiotics and alter sanitation practices. We find that the norm treatment increases the adoption of probiotics and that the subsidy treatment increases the adoption of acidifiers (although the degree to which differs in the two locations) and that some aspects of sanitation improve as a response to both the subsidy and norm treatments. However, the changes in production practices appear insufficient, and in one location is associated with increased mortality. We note an increase in the knowledge of antibiotic resistance in the combined treatment, but limited effects on the beliefs regarding the effectiveness of altering production practices on (broiler) mortality. While we note no effects on between-farmer communication frequency, we do observe an across-the-board improved relationship with one's extension agents in the combined treatment. While overall, the combined treatment appears the most effective in inducing meaningful changes (although the norms treatment by itself too has statistically significant effects), it is notable that we do not note any differential effects of the norms-based treatments by concerns about social status, or portrait values, more general. Overall, it appears that acidifiers were seen as substitutes for antibiotics, but application resulted in an effectively increased mortality and corresponding pessimistic beliefs. Probiotics, as a food additive, were less subject to this concern, but were more expensive, and should be accompanied by increased sanitation, which again was not improved to the extent it was needed.

The remainder of this paper is structured as follows. Section 2 provides the background and introduces the study area. Section 3 sets the theoretical framework. Sections 4 and 5 describe the interventions and experimental design. Section 7 presents the analysis and results. Section 8 concludes.

2. Background

2.1 China's broiler industry

Since the 1978 reform of the Chinese economy, China's broiler industry, the largest part of the poultry industry, has developed rapidly (Lu et al. 2019). China's chicken meat output has increased from 1,077,582 tons in 1978 to 15,147,189 tons in 2019, an increase of 14.06 times (FAO 2021). This accounts for 12.8% of the world's chicken meat output, making it the second largest producer, after the US (FAO 2021). Chicken meat is also an increasingly important component of the Chinese diet. Consumption per capita has increased from 7.2kg to 10.8kg (NBSC 2020), following an increase in income which has driven an increase in demand for meat products (Ortega et al. 2009).

Production of chicken meat has become more intensive in the past 20 years. Small farms left the sector, and consequently, the scale of farming increased. From 2004 to 2017, the number of farms with annual production of 2,000 to 10,000 animals was reduced by half, while the number of farms with annual production of more than 50,000 animals increased by four times (MARAC 2005-2018). Compared with backyard systems, intensification can increase output and income (Chaiban et al. 2020). However, the rise of these intensive systems induced an increase in the use of veterinary antibiotics. Because animals are concentrated and reared in a smaller space, diseases can quickly spread among animals and infect entire flocks. To prevent disease spread, farmers tend to treat an entire flock of animals with sub-therapeutic antibiotics through feed or water (MacDonald and Wang 2011). As opposed to antibiotics for disease treatment, sub-therapeutic antibiotics refer to low levels of antibiotics used for disease prevention and growth promotion, which can inhibit microflora within animals' gastrointestinal system and thereby enable more energy to be expended for nutrient use and make animals grow faster (Hays 1991).

According to the China Animal Husbandry and Veterinary Yearbook and Aquatic Product Statistics Annual Report China used 44,185.75 tons of antibiotics in the livestock and poultry sector in 2016. On average, farmers use 199g[5] antibiotics for every ton of animal product. 53.2% of the antibiotics used is estimated to be aimed at promoting growth or preventing disease, and not for treating disease (MARAC 2019).[6]

The overuse of antibiotics has been linked to a range of health and environmental problems, including the emergence of bacterial resistance (Zhang et al., 2017). As a response, in 2016, the Ministry of Agriculture and Rural Affairs and the National Development and Reform Commission jointly formulated a national action plan for 2017-2020 (for curbing resistance of animal-derived bacteria). In 2018, the ministry designated 100 livestock and poultry farms as pilot farms to trial the Veterinary Antimicrobial Use Reduction Action. Pilot farms were recommended to use antibiotics in a standard and scientific way and reduce the use of antibiotics for growth promotion to reach the goal of antibiotics use reduction. Experiences from the trial would be introduced nationally. Our study is one of these pilot farms.[7]

2.2 The contract farming relationship

Contract farming is on the rise in China (Wang et al. 2014). The company we work with in this study provides the farmers with the young chicks (aged 1 day, the day they are hatched) and other inputs via their network of shops: feed, antibiotics, and other medication. Farmers pay for these inputs at pre-set prices, usually on a credit basis (although a security deposit is requested as well).[8] Farmers also receive a small subsidy for the transportation cost by the company.[9] Farmers are provided price a deductions regarding building barns, implementing sanitation practices, feeding, and applying antibiotics.[10] When the broilers are approximately 12 weeks old, the company checks the quality of the broilers, purchases the product at a pre-set price, and pays the farmers post slaughtering.[11]

The company bears the market risk and part of the breeding risk, while the farmers receive stable prices, but also bear a part of the farming risk that includes the risk of disease pressure and other environmental factors, such as heat. To insulate farmers further the company launched a risk fund in 2004. If the total broiler mortality exceeds 2% due to certain infectious diseases (colibacillosis, coccidiosis or mycoplasma infections) the farmer can apply for a refund of his direct variable costs, such as feed, chicks, and antibiotics.[12] These terms are written in the contract of each farmer (and well known by them).

It is notable that at no stage, farmers own the broilers. If the farmer violates the terms of the contract, the company has the right to terminate the contract. The company only tends to sign contracts with farmers who have sufficient farming capacity (at least 5,000 broilers per farming cycle) as they are perceived to be less risky (Hou et al. 2018). Although all the inputs are provided by the company, farmers still have a certain degree of decision freedom. Farmers can choose the type of breed and the number of young chicks. They can decide the details of the sanitation regime, and vary feed, watering, and medication within a specified range.

2.3 The broiler farming cycle

A complete broiler farming cycle consists of the production period and a down-time period. The length of the production period depends on the broiler type which can be classified into three groups: fast-, medium-, and slow-growing broilers (Szőllősi et al. 2014). Fast-growing broilers are raised for about 9 weeks, while medium- and slow-growing broilers are raised for 11 and 14 weeks, respectively. At the end of the production period, fast-, medium-, and slow-growing broilers reach an average live weight of 2kg, 2kg and 1.6kg, respectively.

The down-time period is the period spent on cleaning and disinfecting the empty barn and resting. The company has set this period at 3 weeks. Therefore, a complete farming cycle is between 12 and 17 weeks long. The farmers are required to complete 3 to 4 broiler farming cycles annually. In our data collection, we aimed to collect data on the past three cycles but focus our attention on the cycle prior to the interviews (as data quality was limited of the earlier cycles). As we returned to the farmers at the same time the following year, we avoid issues related to seasonality in these farming cycles (to which we return below).

2.4 Disease management

Farmers' disease management is regulated by the company and supported by the company's extension agents. All farmers are invited to attend a training session held by the company once per year. Groups of 40-50 farmers, who live near each other, are assigned to a company extension agent, which is referred to as the company technician. These technicians are veterinarians. They are supposed to visit their assigned farmers regularly (at least once a week) to provide technical guidance and services.[13]

If the farmer suspects the presence of a disease, the farmer can contact the technician for diagnosis and treatment. Based on the diagnosis, the technician will write a prescription, which the farmer can use at the company's pharmacy. The contract stipulates that farmers are not allowed to purchase medication through other channels. The use of illegal medications or additives are (evidently) prohibited. The company also has procedures regarding the use of sub-therapeutic antibiotics. Technicians regularly write prescriptions for sub-therapeutic antibiotics, and farmers use the prescriptions to collect the medication from the company's pharmacy. Although farmers should use antibiotics as prescribed, some farmers use more antibiotics than the recommended dosage.[14]

The company conducts drug residual testing prior to the collection of mature broilers. The company's testing department randomly selects some broilers and inspects the drug residue levels. If the inspected broilers pass the drug residue tests, the farmer is paid a 0.2 Yuan/broiler premium in addition to the usual price of the broiler (at baseline, the average price is 24.6 per broiler). Thus, the farmer's net-earnings are price plus premium, minus the cost of inputs (at baseline, these earnings average 3.40 Yuan/broiler). If the broilers do not pass the drug residue tests, farmers face fines.[15] The technicians share joint responsibility for the drug residue testing results with their assigned farmers. In the case of excess drug residues, the concerned technician faces a fine of 50 to 200 Yuan per farming cycle. If all farmers in the technician group pass the monthly drug residue tests, the technician receives a bonus of 200 Yuan per farming cycle. The farmers are familiar with these regulations (as they are part of the contract). At the end of each production cycle, there is a drug withdrawal period. During this drug withdrawal period the company does not supply any antibiotics to farmers.[16]

2.5 Study area

While the company works nation-wide, we focus our research on the company's operation in Jiangsu Province.[17] Many similar companies have established subsidiaries in Jiangsu and engage in contract farming. The province is a major poultry producer, ranking ninth in terms of broiler output in China. It is located on the eastern coast of mainland China, with flat terrain, numerous rivers and lakes, moderate rainfall, and four distinct seasons. The coldest month is January, with an average temperature of 3.3℃; the hottest month is July, with an average temperature of 28℃ in 2019. The province is relatively wealthy, with the highest per capita GDP and overall high levels of agricultural industrialization (see Appendix Table A1).

We worked in two locations: Xuzhou and Changzhou (see Figure 1). Xuzhou is in the northern part of Jiangsu and has a temperate monsoon climate with an annual average temperature of 16.1°C, while Changzhou in southern Jiangsu has a subtropical monsoon climate with an annual average temperature of 17.2°C in 2019 (Jiangsu Statistical Yearbook, 2020). Temperature is a key factor influencing the prevalence of diseases.

Farmers use less antibiotics in summer. Figure 2 depicts the average cost of antibiotics, by month, in the 2018 (using the month when the broilers are delivered to the company): One can note that the cost of antibiotics is lower in the summer months.

As reported in Appendix Table A1, Changzhou is more developed than Xuzhou. The per capita gross locational product of Changzhou was almost twice as that of Xuzhou, road access is considerably better (1.12% of land in Changzhou was paved roads versus 0.39% in Xuzhou) and access to internet is more widespread in Changzhou.

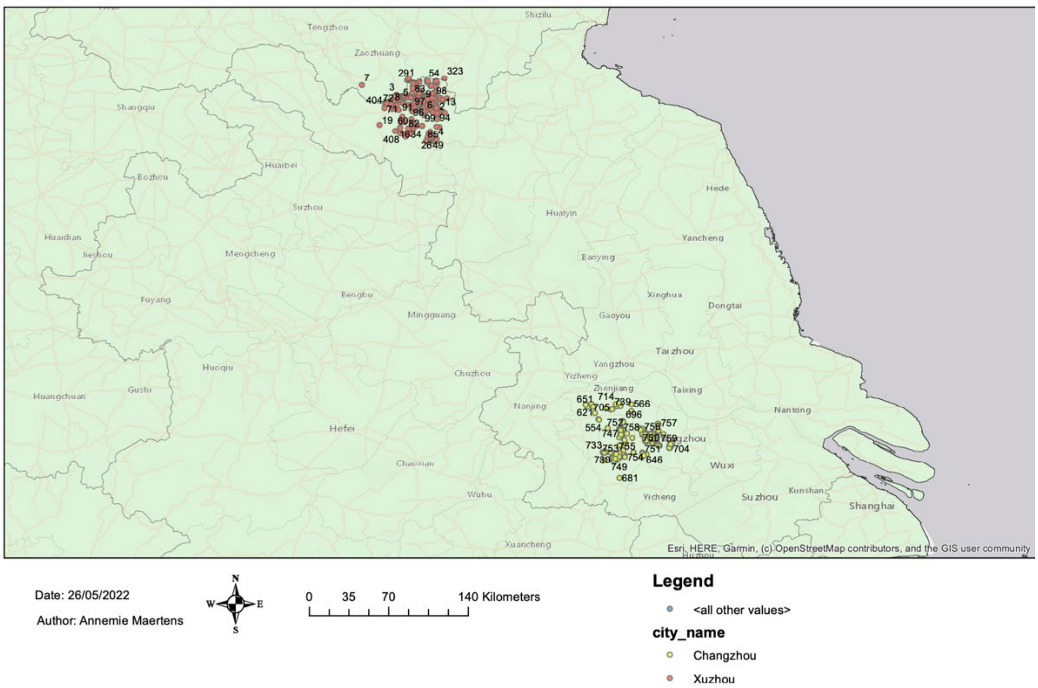

Figure 1. Locations of sample farmers in Changzhou (south Jiangsu) and Xuzhou (north Jiangsu)

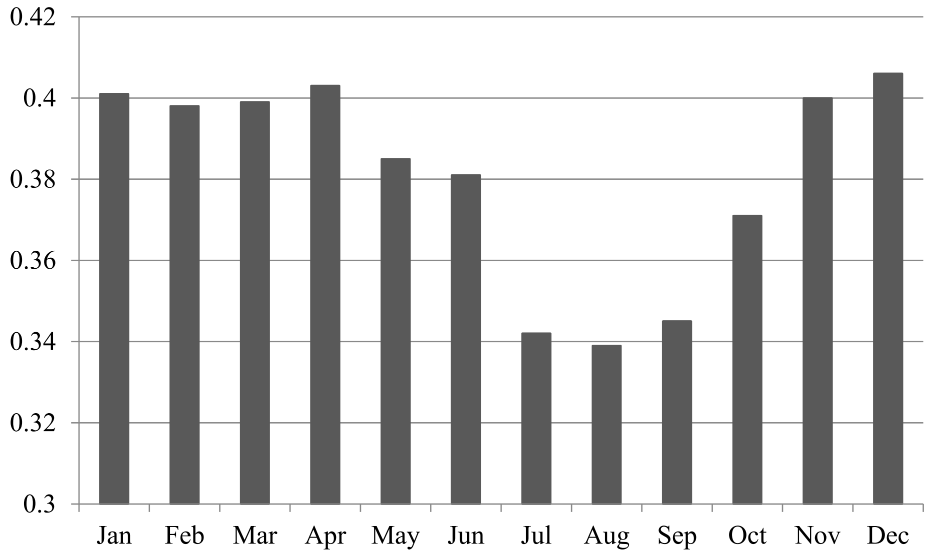

Figure 2. Monthly average cost of antibiotics in 2018

Note: We use administrative data from the company purchase records to calculate these per-broiler antibiotics cost. The month is the month when the broiler is delivered to the company. For example, for broilers produced during January to March, the overall cost of antibiotics is captured in the March data.

A series of Appendix figures further explore this seasonality, and the two survey years. Appendix Figure A1 compares the monthly number of young chicks the company provided to the contract farmers from February to April in years 2019 and 2020 (again using company data). The production scale is lower in February compared to the other months as farmers are reluctant to breed in winter due to higher heating cost, disease pressure and celebrations of the Chinese New Year.[18] In late January 2020, the number of COVID-19 infections spiked in China. Mobility of people and vehicles was restricted from late January until the end of February. Due to these restrictions, and concerns of farmers about additional disease pressure and supply chain issues, the number of young chicks obtained by farmers in February 2020 was nearly 20% lower than that in February 2019.[19] But in March 2020, this number increased by 5% compared to that in March 2019. As a whole, 2020 appears comparable to 2019 in terms of number of broilers sold and gross profit[20] in the two years (see Appendix Figures A2 and A3).

3. Interventions

Our interventions aimed to encourage a reduction in the use of antibiotics by encouraging alternative technologies. Probiotics and acidifiers are feed additives that improve intestinal health of animals and thus can be a promising alternative to antibiotics for preventing bacterial infections in food animal production (Reid and Friendship 2002; Patterson and Burkholder 2003; Kim et al. 2005; Papatsiros and Billinis 2012). Acidifiers, composed of organic and inorganic acids, help to lower the pH of the gastrointestinal tract, and thereby improve the digestion of nutrients and inhibit the growth of pathogenic bacteria such as Escherichia coli (Van Immerseel et al. 2006; Abdel-Fattah et al. 2008). Probiotics are preparations containing microorganisms that help support a healthy gut and immune system in animals (Khaziakhmetov et al. 2018). Acidifiers and probiotics are administered to the broilers as feed or drinking water additives. It should be noted that in one location (Xuzhou) acidifiers remained unavailable for purchase.[21] Hence, the components of the analysis will be presented by location.

Probiotics and acidifiers are both substitutes for the (especially) preventative use of antibiotics, in this sense that one can use fewer preventative antibiotics when utilizing these technologies as prescribed (Banupriya et al. 2016). However, both require a certain standard in terms of cleanliness and sanitation to be effective. In particular, the feeding stationss need to be sanitized on a regular basis and so does the surrounding environment. So, investment in both labor and cleaning products is a precondition for effectiveness of these two new technologies. Given this relatively complex production relationship, and their relationship with (poultry) mortality and profits, the effect of our interventions on the adoption of these alternatives, in its relation to the use of antibiotics, mortality and profits is ambiguous.

3.1 Information campaign: Posters

The baseline survey indicated that most farmers did not know much about acidifiers or probiotics.[22] To avoid that the lack of information would render the interventions ineffective, we organized an information campaign after the baseline survey and before the implementation of the two interventions. The goal of this campaign was to alert farmers to the dangers of over-use of antibiotics, and to inform them about the availability of these alternatives. During the information campaign, technicians delivered posters in A3 format to farmers. As shown in Appendix Figure A4, the content of the poster consists of three parts: the harmfulness of excessive use of antibiotics (resulting in drug resistance and endangering human health), government's call for antibiotics reduction, and the measures recommended by the company for reducing antibiotics (using acidifiers or probiotics and improving sanitation measures). We asked technicians to distribute the posters to the farmers during their field visits in September 2019. Our endline survey shows that over 60% of the sample farmers received the poster.

3.2 Subsidy intervention: Coupons of 100 Yuan

The aim of the subsidy intervention was to nudge farmers into trying some well-established alternatives to using non-therapeutic antibiotics. We designed a 100 Yuan coupon for probiotics or acidifiers purchase (as shown in Appendix Figure A5). At going prices, this coupon was worth 1 kg of probiotics (in 2 large bags of 500g/bag or 10 small bags of 100g/bag) or, alternatively, 3.3 kg of acidifiers (1/3 of a barrel of acidifiers of 10kg/barrel). Based on the recommendation that 20 thousand broilers (which is our average farm size) with a farming cycle of 60 days need to consume 60 kg of probiotics or 50 kg of acidifiers, the cost of acidifiers is less than 0.1 yuan per broiler, while the cost of probiotics is around 0.3 yuan per broiler. The subsidy only covers 1/60 of what is needed in the case of probiotics, and 1/15 of what is needed in the case of acidifiers for 20 thousand broilers. In the case of acidifiers, the remainder cost to pay is smaller. However, for both technologies, the amount to be paid by the farmer remains significant. Hence, our intervention can be viewed more as a nudge rather than a financial incentive.

There are some other advantages from using a small subsidy. As the subsidy was randomized at an individual level, this small amount would be less likely to create feelings of jealousy among those who did not receive the subsidy but heard about it; meaning, it does not create an overwhelming undue financial advantage for treated farmers over their untreated peers as can be the case with coupons (Omotilewa et al. 2019; Chen et al. 1998). It should be noted that agricultural subsidies in China are mostly targeted at grain growers; subsidies for animal husbandry are not common. Our baseline data show that our sample farmers do not receive any government subsidies.[23] Hence, we suspect that our coupons will have its expected promotional value as well (Gardener and Trivedi 1998).

In mid-January 2020, we asked technicians to deliver the coupons to farmers in the subsidy treatment groups during their field visits. The coupon has the name of the assigned farmer on the front and had to be used before the expiry date of May 31, 2020. The coupon could be redeemed in the company's store (pharmacy). On average, farmers live 20 kilometers from the store (and it takes them about 40 minutes to get there by motorbike). Since farmers' purchases are on credit, this implies that the cost of acidifiers or probiotics will be reduced by 100 Yuan at the final settlement of accounts. If the cost of acidifiers or probiotics purchased by a farmer is less than 100 Yuan, the remaining value of the coupon will not be given back to the farmer. Our endline survey indicates that among all farmers assigned to receive the coupon, 76% received it, and 53% used the coupon. More farmers in Changzhou received and used the coupon. Among all farmers in Changzhou assigned to subsidy treatment, 84% received the coupon and 63% used it. However, in Xuzhou, only 70% of the farmers assigned to subsidy treatment received the coupon and 45% used it.

3.3 Social norms intervention: Model farmers and WeChat activities

The aim of the social norm intervention was to expose farmers to model farmers and peer pressure. The social norm intervention consists of a pamphlet introducing the model farmers, a two-minute video in which the model farmers share their farming experiences, and a WeChat group in which the model farmers lead a weekly quiz that we created. Since each technician manages a group of 40-50 farmers, this intervention was implemented at the technician level. This avoids unintended spillovers through the technician, or by mixing farmers who would not usually interact with each other.[24]

This intervention started with the selection of four model farmers, two per location. We asked the company for assistance, and utilized our baseline data to identify dynamic, well-spoken individuals. The individuals selected had an excellent per-broiler profit (3.9 yuan/broiler Versus the average level of 3.2 yuan/broiler), good sanitation practices (with the disinfectant cost of 0.021 yuan/broiler, versus the average level of 0.017 yuan/broiler) and used significantly less antibiotics than the average farmer (0.35 yuan/broiler versus the average level of 0.43 yuan/broiler). Both also had experience with probiotics or acidifiers (for three farming cycles). We visited the model farmers in mid-January 2020, and made a video for each model farmer, on the spot, at their farm. In the video, each model farmer talked about their experience with chicken farming, focusing on disease prevention. While their experiences were naturally different, the main message was the same, that is, using alternatives and strengthening disinfection and sanitation one can reduce antibiotic usage and improve the cost-efficiency of breeding. We then proceeded to make a pamphlet for each location based on the videos. These pamphlets contained contact information of the model farmer and his/her latest production cycle (breed, number of heads, output rate, antibiotics cost and total cost of drugs). It also contained a transcript of the video message. Appendix Figure A6 shows the pamphlet of model farmers in Changzhou (with their identity protected).

Farmers were invited to watch the videos (on the technician's phone) and received the pamphlet (in-person) from the technicians. Farmers in Changzhou received information only about the two model farmers from Changzhou and farmers in Xuzhou received information only about the two model farmers from Xuzhou. The endline survey indicates that among all farmers that were assigned to this treatment, 48% watched the video and 29% received the pamphlet. There is no significant difference in the percentage of farmers watching the video or receiving the pamphlet between the two locations.

To further promote interactions between farmers and model farmers, we created 12 WeChat groups. All farmers advised by the same technician were assigned to the same WeChat group. Model farmers were invited to all groups in their respective location. Among all farmers assigned to social norms treatment, 59% joined the WeChat groups (66% in Changzhou and 52% in Xuzhou). After a while we noticed that there was limited communication among farmers in the WeChat group[25], we made the somewhat unusual decision to alter our planned intervention a little and deviate from our original plan. To increase the activity in the WeChat groups, we introduced a quiz game (see details on the quiz in the online Appendix). Every Monday, Wednesday and Friday, the technician posted a question related to the reduction of antibiotics and the use of alternatives. In each group, the first farmer giving the correct answer was rewarded with 2 Yuan at noon of the next day, when the model farmers announced the correct answer. The quiz continued for a month. During that time, discussions on how to reduce antibiotics, especially on the effectiveness of alternatives, increased in the WeChat groups.

3.4 Timeline

The timeline of interventions is presented in Figure 3. The implementation of the subsidy intervention started on 12th January 2020. However, due to the COVID-19 outbreak, field visits of technicians were limited between 24th January and 24th February 2020, and few farmers in the subsidy treatment groups received the coupon before March 2020. Only after 9th March, did the distribution of coupons proceeded normally.

The implementation of the social norm intervention started on 9th March 2020. On 11th March 2020, we created the WeChat groups. The technicians added their farmers to the respective WeChat groups and encouraged them to discuss antibiotics reduction with model farmers in the WeChat group. To increase interactions and information exchange in the WeChat groups, we held a quiz game about antibiotics reduction three times a week from 29th April 2020 to 31st May 2020.

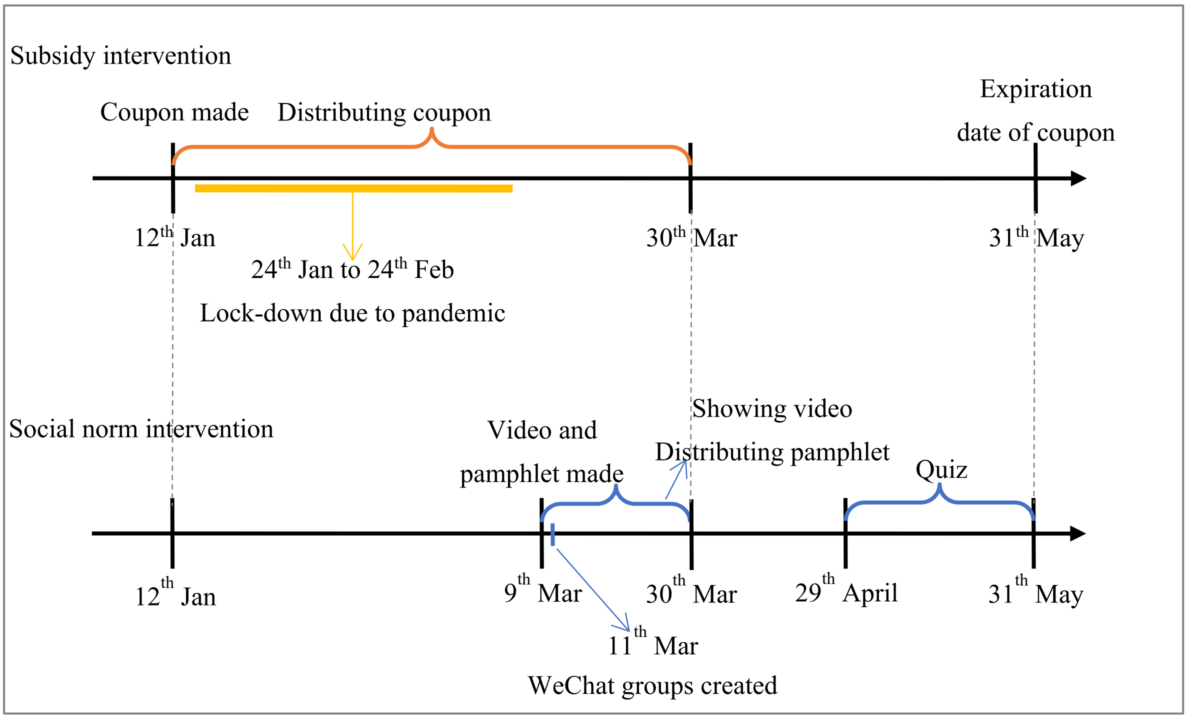

Figure 3. Timeline of the interventions

4. Theoretical framework

The farmer maximizes a stream of expected utilities over time given his preferences, beliefs, and constraints. This leads to input choices, which in turn, result in outcomes: mortality, and relatedly, profits. Input choices include technology choices, such as the choice of breed and feed, but also the choice of antibiotics, and its alternatives we introduced through our interventions, probiotics, and acidifiers. It also includes labor and variable inputs regarding hygiene and sanitation practices.

The central mechanism through which our interventions affect this process is through beliefs. There are two sets of beliefs which are of relevance. First, our interventions might change the perception of the effectiveness of various combinations of antibiotics, acidifiers, probiotics, sanitation practices, in terms of altering mortality outcomes, profit outcomes, but also health and environmental outcomes (i.e., the knowledge regarding the impacts of excessive antibiotics use). Second, our interventions might alter the (perceived) social status of the farmer, thereby indirectly changing outcomes. The degree to which beliefs change depends on the farmer's baseline beliefs, which are in turn affected by their prior experience with antibiotics and investments in sanitation and hygiene. For example, farmers who use a significant amount of antibiotics might be experiencing a low marginal efficacy of any additional use, and hence have more scope to change their beliefs.

As noted, the subsidy is small, and we view it as a nudge, a little push to try out something new. As farmers gain experience with these new technologies, through experimentation and social learning, we expect beliefs to change in the following period. The social norms treatment too, is expected to alter beliefs. We expect the social norms treatment to draw attention to the discrepancy between the farmer's behavior and the behavior of the role models, and others, in terms of the use of antibiotics and alternatives as well as sanitation practices. As farmers learn about their status compared to others (and are concerned about this), additional increased social pressure might further alter behavior.

The effects of the two interventions will depend on the farmers' preferences and characteristics as well as external factors, such as climate and location. Figure 4 presents an overview of the theory of change we have in mind.

Environmental preferences are key. While the use of the alternatives allows farmers to reduce the use of especially preventative antibiotics, thereby decreasing their negative impacts on the environment, how the farmers see this relationship will depend on their environmental preferences. In addition, one needs to keep in mind that the relationship, and their joint effects on the environment might not be understood by all farmers. In qualitative interviews preceding the impact evaluation, some farmers noted that acidifiers sounded like a chemical and they deducted it might not be beneficial for the environment. Overall, we would expect farmers who care about more the environment to reduce their antibiotics use more strongly in response to both treatments.

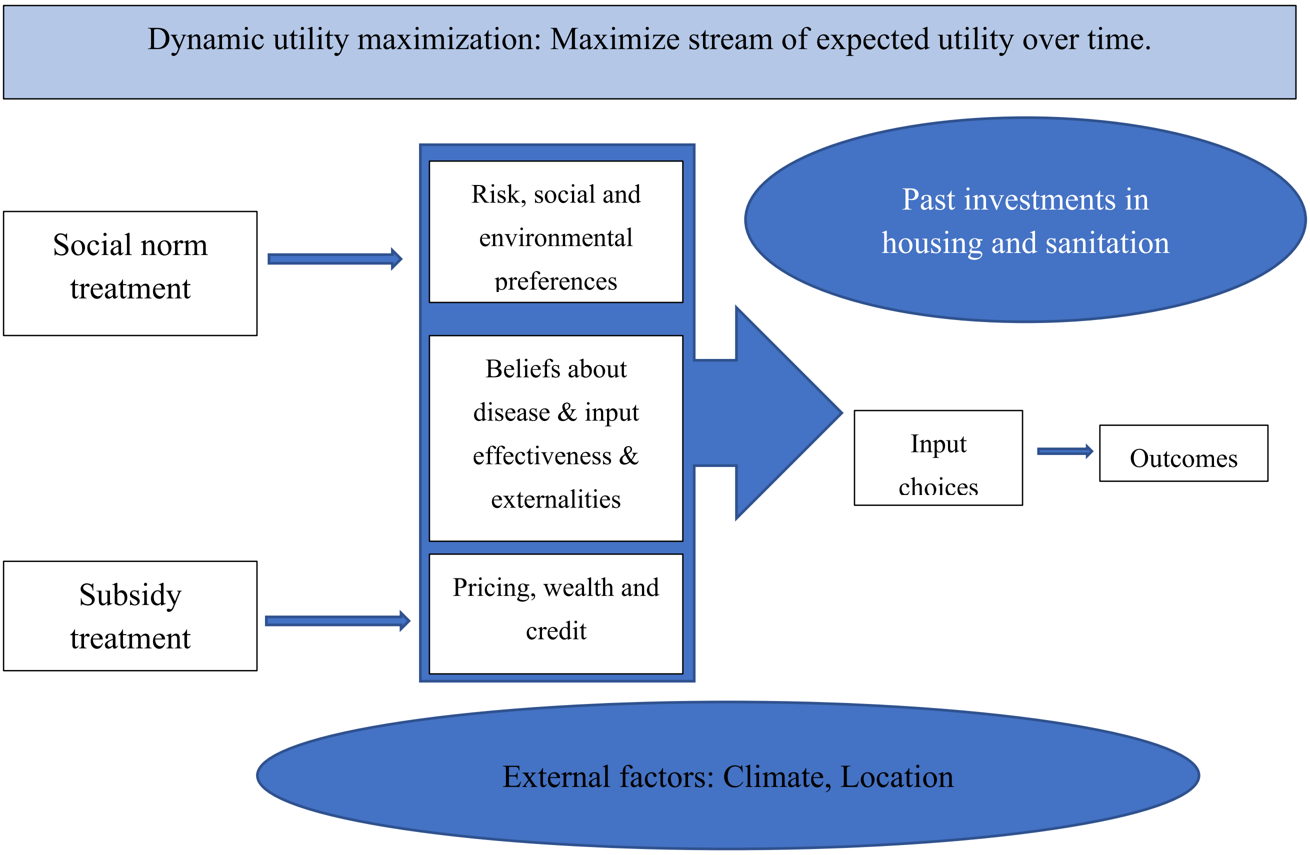

Figure 4. Flow diagram of theory of change

Social preferences too are central. Farmers care about others, their health, but also care about their position in society (social status). Farmers who care more about others are more likely to respond strongly to our two treatments. Similarly, farmers who are concerned about their social status are expected to respond more strongly to the social norm treatment.

Risk preferences matter too. Any technology adoption comes with risks. Especially in this case, the reduction of antibiotics use requires a complex recalibration of the alternative options, and an altered sanitation and hygiene regime. It takes time for farmers to find this new balance, and at first, risk averse farmers might be inclined to adopt the technologies first without reducing the use of antibiotics, worried about the lower tail in the profit distribution. This degree of risk aversion is likely to correlate with the farmer's wealth position. Overall, we would expect more risk averse farmers to reduce their antibiotics use less compared to other farmers in response to the treatments.

To conclude, all farmers are subject to external factors which will determine the degree of disease pressure, i.e., the prevalence of disease among the chickens. We noted before the importance of the seasons, but climate more general, matters, as colder days imply an increased chance of getting ill. Past investment choices in housing and sanitations matters too. A larger barn will allow the chickens more space, thereby reducing their social interaction which could stimulate the spread of diseases. A modern ventilation system, exchanging the inside air for outside air on a regular basis, too limits the spread of disease. A modern feeding system will allow one to implement the alternatives more easily.

5. Sample, randomization, and data collected

5.1 Sample and randomization

Prior to conducting the baseline survey, the company provided us with a list of all contract farmers in the two locations, a total of 847 farmers. Our analysis sample consists of 759 farmers (representing a balanced panel containing base and endline data).[26] The farmers are managed by 24 technicians. We selected the treatment groups in a randomized manner. First, we stratified at the location level and randomly selected half of the (slightly larger baseline) sample to participate in the subsidy intervention. In each location, 50% of farmers were selected to receive the coupon. Then we randomly selected half of the 24 technicians' groups to participate in the social norm intervention: six technician groups in Xuzhou and six technician groups in Changzhou.[27]

Table 1 shows an overview of the analysis sample by treatment status: 186 farmers are assigned to the control group. Around 25% of the sample (183 farmers) are assigned to the subsidy treatment and around 25% of the sample (192 farmers) are assigned to social norms treatment. We refer to them as subsidy treatment group and social norm treatment group, respectively. Note that 198 farmers (again around 25% of the sample) are assigned to both subsidy and social norm treatment, and they are referred to as the combined treatment group.

Table 1. Treatment randomization of the analysis sample

		Subsidy (Coupon)		Total
		Control	Treatment	
Social Norms	Control	186	183	369
	Treatment	192	198	390
Total		378	381	759

The group-level nature of the social norm intervention implies that we have different types of groups. Within the 12 groups assigned to the social norms control group there are farmers who receive the subsidy and farmers that do not receive the subsidy. Within the 12 groups assigned to social norm treatment group, there are farmers who, in addition, receive the subsidy, while others in the group do not (and are only exposed to the social norms treatment directly). Figure 5 displays the percentage of farmers with subsidy assignment in the agent group in the analysis sample. We note that this ranges from 35% to 59%, with an (expected) average of 51%. This percentage can be interpreted at the level of exposure to the subsidy intervention for those farmers who did not receive a coupon. Importantly, note that there are no groups which are true control groups, where none of the farmers receive subsidies and none of the farmers are exposed to the social norm treatment.

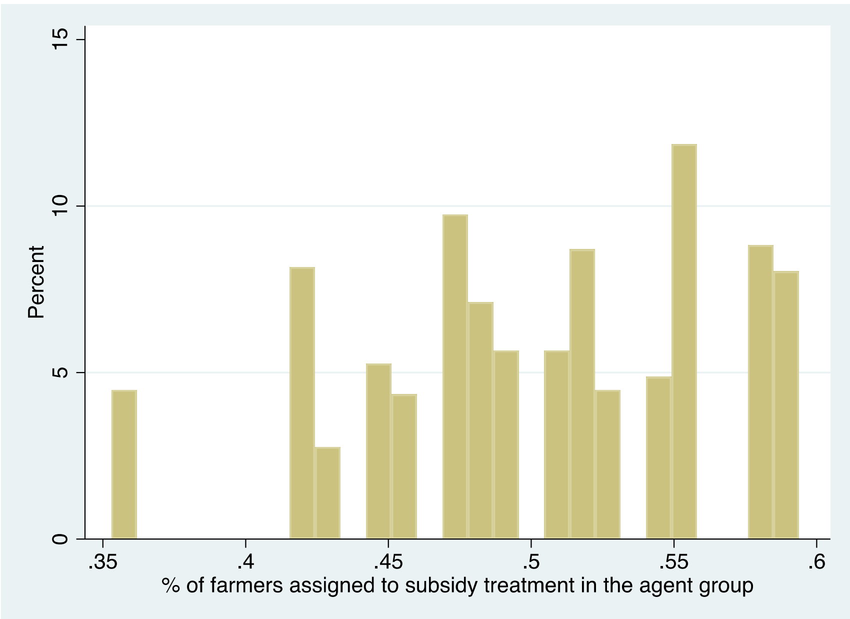

Figure 5. The distribution of the percentage of farmers assigned to the subsidy treatment (in all the extension groups, i.e., the full analysis sample)

5.2 Data collection

We collected baseline data in May 2019, before the interventions (in January-May 2020). We interviewed farmers using a pre-tested questionnaire, in person and collected data for 847 farmers (55% from Xuzhou and 45% from Changzhou). [28] One year later, in June 2020, we had planned to also collect endline data in person. However, due to safety concerns related to the COVID-19 pandemic, we settled on a shorter phone survey. Before making the phone calls, the technicians informed their farmers about our upcoming phone calls. Our enumerators called the farmers and explained our research purpose and procedures. With the farmer's consent, the enumerator interviewed the farmers with, again, a pre-tested questionnaire. [29] We collected endline data from 759 farmers: 54% of the farmers from Xuzhou and 46% from Changzhou. Therefore, we created a panel dataset of 759 farmers (54% from Xuzhou and 46% from Changzhou).

In addition, we interviewed 24 agents at baseline and collected data from the company in 2020. We discuss these data sources in turn below.

5.2.1 Farmer survey

The baseline survey was conducted in May 2019, when most farmers had completed the first farming cycle of the year and were planning for the next farming cycle. The previous cycle ran from February to April 2019.[30] In the endline survey, which was conducted in June 2020, we focused on this same cycle, from February to April 2020. In most cases, we interviewed the head of the household. We interviewed the spouse of the household head only when the household head was not present. At both baseline and endline, we collected information on farmers' use of antibiotics, adoption of probiotics and acidifiers, sanitation frequency, risk perceptions, and aspects of social pressures. At baseline, we additionally collected data on household characteristics, risk preferences, and social preferences. At endline, we additionally collected data on farmer's participation in the randomized interventions.

Antibiotics use

At baseline, we asked farmers about their use of 22 classes of veterinary antibiotics in the last farming cycle, including the total used amount and the amount for disease treatment. The selection of the antibiotics is based on our visit to the company prior to the household survey. At endline (where we had to be shorter, as this was via the phone), we asked farmers about their use of five classes of antibiotics that were most frequently mentioned by farmers in baseline, including the total used amount and the amount for preventative purposes. However, we noted that the quality of these data was poor, with many farmers not recalling how much they used of any given type of antibiotics. Hence, for the main analysis we employ the administrative data given to use by the company on antibiotics purchases.

Probiotics and acidifiers use

At baseline, we asked farmers whether they used acidifiers or probiotics in the previous farming cycles, and if so, inquired as to how much was used. The same questions were repeated in the endline survey. Additionally, at endline, we asked about the reasons for non-adoption.

Sanitation

At baseline, we asked farmers about their sanitation frequency (in times/week) in the last farming cycles, including disinfecting the barns, the barn's surrounding environment, drinking water, and feeding stations. At endline, we repeated these questions but only related to the last farming cycle. Based on the company's recommendations regarding sanitation frequencies we generated four sanitation indices measuring whether the farmer meets the company's recommended frequency of disinfecting the barns, the environment, the drinking water, and the feeding stations.[31]

Input and Output

At baseline, we asked farmers about their inputs and outputs in the last three broiler farming cycles. We included the starting time of the farming cycle, number of chickens, broiler types, number of barns, cost of the young chicks, cost of feed, cost of electricity, cost of water and fuels, labor used (including family) and rents. This section included the questions on antibiotics, probiotics and acidifier use. In terms of outputs, we included the delivery date, the average weight of the broilers, the mortality rate (% of broilers that died during the cycle), and the price. We also inquired about the use of subsidies, and revenues for any by-products, such as manure and recycling of dead broilers. At endline, we repeated these questions for the last cycle only. We obtained a similar set of data from the company as well and use the latter to compute measures of profits and mortality.

Knowledge regarding antibiotics

At baseline, we measured farmers' knowledge regarding antibiotics by asking them to rate four statements: 1) Overuse of antibiotics in food animal production promotes the development of antibiotic drug-resistant bacteria; 2) Residual antibiotics and resultant antibiotic-resistant bacteria resulting from broiler farming can be transferred to humans and harm human health; 3) Residual antibiotics and resultant antibiotics-resistant bacteria from broiler farming can be transmitted into the environment and lead to soil and water pollution; 4) Antibiotics overuse in broiler farming is responsible for a significant share of antibiotics overuse in China. Farmers were asked to rate the four statements on a five-point Likert scale, ranging from "strongly disagree" to "strongly agree". In addition, we asked farmers how they believe other farmers in the company and other villagers would rate the four statements, ranging from (I think they would) strongly disagree to strongly agree. At endline, we repeated these questions.

Risk perceptions

At baseline, we described five scenarios of broiler farming to the farmers: 1) business as usual (based on the farmer's broiler production in the last three years); 2) no antibiotic use for disease prevention, i.e. sub-therapeutic (other practices are business as usual); 3) no antibiotic use for disease treatment or prevention (other practices are business as usual); 4) use probiotics with dosage recommended by the company (other practices are business as usual); 5) implementing disinfection (barn, drinking water, feeding stations, and environment) as required by the company (other practices are business as usual). We opted for probiotics instead of acidifier in scenario (4) as, at baseline, none of the farmers in Xuzhou had heard of acidifier as this product was not available (and remained unavailable throughout our study in this location).

To obtain risk perceptions, we first asked the minimum value and the maximum value of mortality (in % of broilers died). Based on the answers of minimum and maximum mortality and cost, we evenly distributed the mortality and cost using the formula: [maximum - minimum]/5 and noted down the boundary numbers. Then, we made five boxes, evenly distributed between the minimum and maximum values. Second, we used these boxes to elicit a distribution from the respondent using ten equal sized stones. We noted to the respondent that each stone corresponds with a 10% chance and asked the respondent to distribute the stones according to the chances of being in each box of the distribution. Third, we told the respondent to make the distribution for each scenario. We noted that the answers for scenario (1) should be based on the farmer's experience in the last three years, while the answers to the other scenarios would be based on the farmer's expectations.

At endline, we described these scenarios except scenario (3) because 93% of the farmers at baseline reported not willing to give up antibiotic treatment when their broilers get sick. Then, as this was a phone survey, we simplified the beliefs elicitation, and asked the respondent the average, minimum and maximum mortality.

Additional baseline data: Household characteristics and preferences

We collected data on household composition, farming experience and farm characteristics: 1) gender, age, and education level of the household head; 2) household size, number of children, adults and male adults within household, number of family members engaged in rearing broilers; 3) Household income from different sources (plantation, broiler rearing, salary, property, and transfer income) in the year 2018, experience with poultry farming (in years).

We measured the farmers' degree of risk aversion by using a choice experiment which was financially compensated. This experiment was based on the work of Andersen et al. (2006) and Liebenehm and Waibel (2014) and assumes that each participant has consistent risk preferences. We used this experiment to compute a measure of risk aversion. The protocol is detailed in Appendix Figure A7.

We measure farmers' social and environmental preferences. First, we adopted the E-PVQ methodology (Environmental-Portrait Value Questions) from Bouman et al. (2018) to measure farmers' egoistic value, hedonic value, altruistic value, and bio-spheric value. Each portrait value measurement consists of two to five questions. The responses follow a five-point Likert scale and range from "very unimportant" to "very important". In four egoistic questions, we asked the respondents how important it is for them to have control over others' actions, influence others, have money and possessions, and work hard and be ambitious. In three hedonic questions, farmers reported how important it is for them to have fun, enjoy life and do things they enjoy. In four altruistic questions, farmers reported how important it is for them to take care of worse-off people, to help others, and how important it is for them that everyone is treated justly and there is no conflict. In three bio-spheric questions, farmers answered how important it is for them to prevent environmental pollution, protect the environment, and respect nature. In the analysis, we use the third set to measure altruism, and the fourth set to obtain a measure of environmental preferences.

We also used three questions to measure the importance of social status to the farmer. We asked: 1) how much do you care about what your peers think of your personal quality; 2) how much do you care about what your peers think of your wealth status (responses to these two questions range from "I don't care at all" to "I care lot"); and 3) Do you want to improve your social status? (Yes or No).

5.2.3. Company agent survey

At baseline, we interviewed 24 company agents. We collected data on the agents' demographics (gender, age, education level), work experience (number of farmers in the agent's group, years of experience, how many farmers they see each day), and recommendation of probiotics to farmers (as in Xuzhou acidifier was not available). We asked the agents about their attitudes to the four knowledge statements about antibiotics (as in farmer questionnaire), and obtained portrait values, and measures of the importance of social status and their risk perception (again as in the farmer questionnaire). We also used the same experiment to measure the agent's degree of risk aversion.

5.2.4 Company data

Due to the contract-farming nature of their relationship, the company has records of inputs provided to the farmer, as well as the outputs purchased. We obtained these administrative data for the two farming cycles immediately preceding our surveys (early 2019 and early 2020 for the baseline and endline surveys, respectively). These farmer-level data include all drug purchases: antibiotics, disinfectants, vaccinations, probiotics and acidifiers (in Yuan). They also include the number of baby chicks delivered, and the number of broilers bought, as well as the price. From these data we derived the market rate (broilers sold/broilers produced), survival rate (broilers produced/baby chicks), mortality rate (1 – survival rate) and a measure of profit (output in weight * unit price per weight + transportation subsidy + price premium - (cost of young chicks, feed, drugs, and transportation) – drug testing penalty).

5.3 Descriptive statistics

Table 2 introduces the sample. 93% of the farmers are male. The average age is 48 and 63% graduated from middle school (equivalent to nine years of schooling). On average, households have four family members, and two members are engaged in the farm. According to self-reported household data, farmers earned around 100,000 Yuan (equivalent to 15,083 USD) from broiler farming (note this does not consider the value of family labor), with the share of broiler income in total household income 81%. The farmer has, on average, 9 years of experience in the industry. In the last farming cycle farmers reared, on average, 22,142 broilers.

Table 2. Descriptive statistics at baseline in 2019

Variables	N	Mean	S.D.	Min	Max
Gender of household head (1=male; 0=female)	759	0.930	0.255	0	1
Age of household head (in years)	759	48.142	9.349	25	74
Education of household head (1=at least graduating from middle school; 0=otherwise)	759	0.631	0.483	0	1
Number of household members	759	3.744	1.333	1	8
Number of children in the household	759	0.192	0.516	0	4
Number of adults in household	759	2.813	0.910	1	6
Number of male adults in household	759	1.481	0.601	0	4
Number of family members engaged in the farm	759	1.960	0.619	0	5
Location dummy (1=Changzhou, 0=Xuzhou)	759	0.458	0.499	0	1
Risk aversion	759	0.559	0.539	0.05	1.50
Income from broiler farming in year 2018 (in 10,000 Yuan)	755	9.857	6.513	-2	45
Degree of specialization: ratio of broiler income in total household income in 2018	758	0.809	0.242	0	1
Experience of large-scale broiler farming (in years)	759	8.580	3.733	0	30
Number of reared broiler types in the last farming cycle	752	1.324	0.542	1	4
Number of reared broilers in the last farming cycle (in 1,000 broilers)	759	22.142	12.390	6.225	88.92
Distance to the nearest other farmer (in km)	759	0.517	1.384	0	22.85

Note: Risk aversion of the household head ranges from 0.05 to 1.50, with a higher value indicating a higher degree of risk aversion.

Table 3 continues with the statistics of dependent variables at baseline. Panel A shows descriptive statistics of the administrative data provided by the company (referring to the last farming cycle of our baseline survey in May 2019). Broiler mortality is, on average, 4.5% and the average profit is Yuan/broiler. The cost of antibiotics is 0.43 Yuan/broiler, on average. As displayed in Figure 6, there is a significant amount of variation in this variable. This variation cannot be explained by the variation in local conditions such as climate and related disease pressure, as indicated by the regression results in Appendix Table 2. When regressing baseline antibiotics cost on household and farm characteristics, we find that location and time fixed effects only explain about 30% of the variation (with other factors, like farming scale, risk aversion and the number of broiler types playing a modest role as well).

Panel B of Table 3 presents statistics on the use of acidifiers and probiotics at baseline. Only 13% and 10% of the farmers adopted probiotics and acidifiers, respectively (in the last farming cycle prior to the baseline survey). While probiotics are available in both research locations, acidifiers were only available in Changzhou. In Changzhou, 16% and 22% of the farmers adopted probiotics and acidifiers, respectively. In Xuzhou, 10% of the farmers adopted probiotics (see also Appendix Table 3 which presents the location-specific descriptive statistics).

Recall that the company stipulates sanitation measures in their contract with the farmer: the farmers should disinfect the barns seven times a week, the surrounding environment once a week, drinking water twice a week, and feeding stations seven times a week. We construct four corresponding sanitation indices indicating whether the farmer meets the required frequency of each sanitation practice. As shown in Panel C of Table 3, in the last farming cycle, less than 5% of the sample met the required sanitation frequency of barns and feeding stations. 52% and 32% of the farmers met the required frequency for the surrounding environment and broiler drinking water, respectively.

During the qualitative interviews, we focused on the farmers' decision-making processes regarding antibiotics, meaning, how much to use, what and when to use antibiotics, and how they make these decisions. As the company has outlined a protocol as to how to manage suspected disease, and, recall, the farmer purchases the antibiotics at the company store on credit, the farmer has seemingly little choice regarding these matters. The qualitative interviews and these descriptive statistics, however, reveal variation in the use of antibiotics (on average, more than prescribed) and sanitation practices (on average, less than prescribed).

Table 3: Descriptive statistics of dependent variables at baseline in 2019

Dependent variables	N	Mean	S.D.	Min	Max
Panel A: Production performance (company data)					
Broiler mortality in last farming cycle (%)	759	4.583	4.669	0.516	61.846
Profit in last farming cycle (in Yuan/broiler)	753	2.870	0.905	0.120	6.020
Cost of antibiotics in the last farming cycle (in Yuan/broiler)	759	0.431	0.168	0.016	1.044
How is your actual antibiotic dosage compared to the drug instructions?	Count		Percent		
-less than the standard specified in the instructions	20		2.64%		
-same as the standard specified in the instructions	624		82.21%		
-more than the standard specified in the instructions	87		11.46%		
-rather casual (not following the instructions)	25		3.29%		
Panel B: Input choices--adoption of alternatives and sanitation (farmer data) –last farming cycle					
Use of probiotics (0/1)	759	0.126	0.333	0	1
Use of acidifiers (0/1)	759	0.099	0.299	0	1
Panel C: Sanitation indices: (1=meet the company's stipulations; 0=otherwise) – last farming cycle (farmer data)					
Barn (0/1)	759	0.045	0.207	0	1
Surrounding environment (0/1)	752	0.523	0.500	0	1
Drinking water (0/1)	748	0.322	0.468	0	1
Feeding stations (0/1)	742	0.047	0.212	0	1
Panel D: Knowledge of antibiotics (farmer data) (1=strongly agree or agree with the respective statement regarding the negative impacts of overusing antibiotics; 0=otherwise)					
Overuse of antibiotics in food animal production promotes the development of antibiotic drug-resistant bacteria	759	0.692	0.462	0	1
Residual antibiotics and resultant antibiotic-resistant bacteria resulting from broiler farming can be transferred to humans and harm human health	759	0.559	0.497	0	1
Residual antibiotics and resultant antibiotics-resistant bacteria from broiler farming can be transmitted into the environment and lead to soil and water pollution	759	0.358	0.480	0	1
Antibiotics overuse in broiler farming is responsible for a significant share of antibiotics overuse in China	759	0.312	0.464	0	1

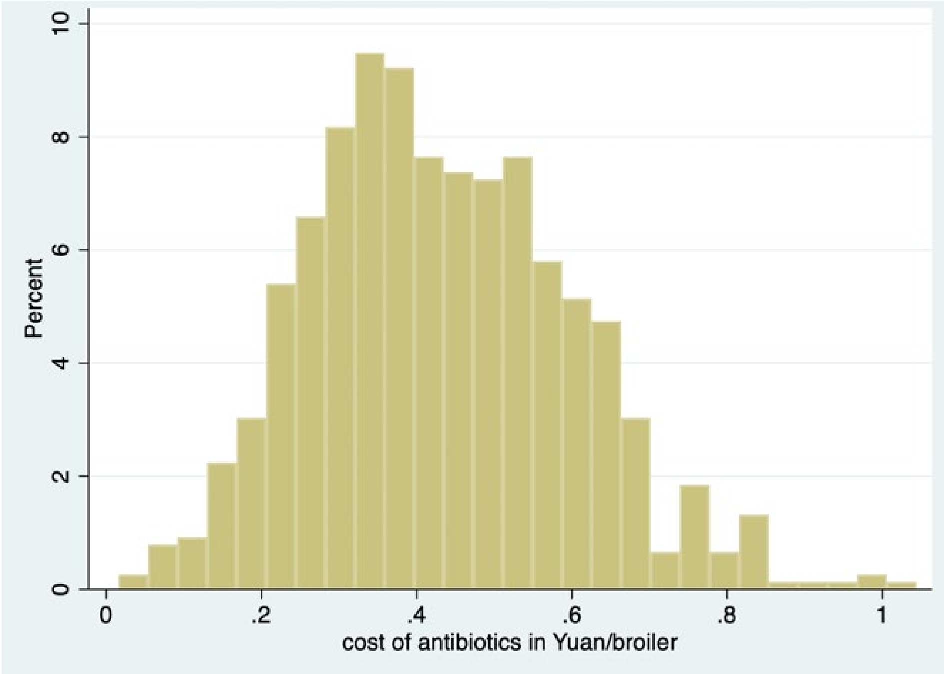

Figure 6. Distribution of antibiotics cost in Yuan/broiler

Panel D of Table 3 describes farmers' knowledge of antibiotics, based on their agreement with four statements. 70% of the farmers strongly agree or agree that antibiotics overuse can promote the development of antibiotic resistance; 56% strongly agree or agree that the residual antibiotics and generated antibiotic-resistance bacteria can be transferred to humans and harm human health; 36% strongly agree or agree that residual antibiotics and generated antibiotic-resistance bacteria can be transferred to the environment and pollute the environment; and 31% strongly agree or agree that China's broiler farming industry represents a significant share of antibiotics overuse in China.

In Appendix Table A3 we present these statistics presented in Tables 2 and 3 by location. Farmers in Xuzhou face higher mortality rates, and therefore perhaps have lower profits. Their scale of farming is smaller, and they are less specialized. They are less well-off (indicated by lower household income and lower broiler farming income), and their knowledge of antibiotics is more limited compared to farmers in Changzhou.

We provide statistics on the 24 extension agents in Appendix Table A4. The agent is, on average, 32 years old. The agents are well educated: 30% of agents have a bachelor's degree and 54% have a college diploma. On average, the agent has worked for the company for seven years and manages a farmer group of 41 farmers. Each day, the agent visits between three and seven farmers.

After our baseline survey and before our interventions, the company made some staff changes. Five agents at baseline were transferred out of our study area and five new agents replaced them, leaving us with 19 observations for the balance check in Appendix Table A5. Comparing the agents assigned to the social norm treatment with those not assigned to the social norm treatment, we report no meaningful differences.

5.4 Balance check

We present a balance check in Appendix Table A5. We find that farmers in the control group are a little younger (1.5 years) than the combined treatment group, are more specialized in broiler farming (0.5% higher degree of specialization compared to the subsidy group), and a little more experienced (one more year of experience in large-scale broiler farming compared to social norms and combined treatment groups). We control for these baseline characteristics in our analysis.

In terms of the dependent variables, we note no significant differences in antibiotics use, profits and mortality, but find that the control group has a 9% higher adoption rate of acidifiers than the social norms and combined treatment group. The control group also appears to start from an advantageous position in other respects. We note that the control group has a 10% to 33% higher proportion of farmers agreeing with the four knowledge statements than the combined treatment group. However, using measures of perceived mortality, we note that farmers in the social norm and combined treatment groups perceive a lower mortality for the "using probiotics" scenario.

Considering aspects of heterogeneity, we note that farmers in the social norm treatment group are slightly more risk averse but are more optimistic about the risks associated with using probiotics. There are no meaningful group differences in any of the portrait values, including those capturing altruism and environmental preferences. However, the social norm and combined treatment group appears to care more about their social status than the control group.

6. Econometric approach

We conduct an intent-to-treat (ITT) analysis on the analysis sample of 759 farmers (which includes farmers interviewed at both end- and baseline) on antibiotics use, mortality, profits, the use of acidifiers and probiotics, and sanitation practices. We also consider the various measures of knowledge and beliefs to explore mechanisms.

We estimate the average effect on those invited to participate in our interventions. Our main specification follows ANCOVA:

$$y_i = \beta_0 + \beta_1 T_{1i} + \beta_2 T_{2i} + \beta_3 T_{3i} + \beta_4 X_i + \beta_5 Y_{i,PRE} + \epsilon_i$$

Where y_i is the outcome of farmer i. T_{1i} equals 1 if farmer i was assigned to T_1 (subsidy treatment). T_{2i} takes the value of 1 if farmer i was assigned to T_2 (social norm treatment). T_{3i} takes the value of 1 if farmer i was assigned to T_3 (combined treatment). X_i is a vector of covariates including i's socio-demographics, production characteristics, and location at baseline (gender, age, and education of the household head, household's degree of specialization in broiler farming, dummy of production scale larger than 20,000 broilers/production cycle, number of household laborers engaged in broiler rearing, years of experience in broiler rearing, the number of broiler types, the degree of risk aversion of the household head, the distance to the nearest other farmer in the sample, and a location fixed effects). We include the baseline value of the outcome variable Y_i^{PRE} as an ANVOCA estimator). ε_i is an individual-specific robust error term clustered at the agent level. The coefficients β_1, β_2, β_3 are estimates of the causal effects of the respective treatment assignments. We use linear regressions to estimate the continuous outcomes i.e., production performance measures including antibiotics costs, broiler mortality, and profit of broiler production. We employ a logit regression, which is recommended for ANCOVA estimation of dichotomous outcome variables (Huitema, 2011, p. 321), to conduct estimations for binary outcomes i.e., adoption of alternatives to antibiotics and sanitation indices.

Following McKenzie (2012), we present an alternative specification for those variables which displayed a high autocorrelation between the base- and the endline (i.e., antibiotics cost). For these variables we conduct a DiD (difference-in-difference) as a robustness check. We use a cut-off of 0.4 autocorrelation where DiD (difference-in-difference) is preferred to an ANCOVA estimation (McKenzie, 2012). For example, antibiotics cost has an autocorrelation between baseline and endline higher than 0.4, namely 0.43. We estimate the ITT effect on the outcome variable Y_i using the following DiD specification:

$$y_{it} = \beta_0 + \beta_1 T_{1i} + \beta_2 T_{2i} + \beta_3 T_{3i} + \beta_4 T_{1i} POST_{it} + \beta_5 T_{2i} POST_{it} + \beta_6 T_{3i} POST_{it} + \beta_7 X_{it} + \beta_8 POST_{it} + v_i$$

Where $POST_{it}$ is the post-treatment indicator and β_8 is a time-trend effect. In this case, the causal effects are captured through β_4, β_5, β_6. X_{it} is the same set of characteristics as in the previous specification but uses the endline variant where available (production scale, number of household labor in farming, and degree of specialization in chicken farming). v_i is the error term, again clustered at the agent level. The DiD specification is also preferred for those variables which have significant imbalance at baseline, including the use of acidifiers, knowledge of antibiotics and risk perceptions.

To test for heterogenous effects, we provide the results of the main regressions also by sub-groups classified by wealth, farming size, risk aversion, social and environmental preferences, and perceived importance of social status.

7. Results

7.1. Main results

In this section we estimate the ITT effects of the subsidy, norm, and combined treatments against the control group on the primary outcomes of interest: production performance (mortality and profit) and input choices (antibiotics use, adoption of alternatives and sanitation choices).

Table 4 reports the ITT effects of subsidy, norm, and combined treatments on farmers' production performance and antibiotics cost, measured in natural log. Note that as we employ company data for antibiotics, we use the cost to substitute for the use. The coefficient on log antibiotics cost indicates that the group assigned to the subsidy treatment has 7% lower antibiotics cost than the control group. The treatments do not have any statistically significant effects on broiler mortality or profits.

Table 4: ANCOVA estimation of treatment effects on antibiotics cost, broiler mortality and profit

	Log antibiotics cost (Yuan/broiler)	Log mortality (%)	Log profit (Yuan/broiler)
Subsidy treatment	-0.072*	0.092	0.006
	(0.042)	(0.073)	(0.034)
Norm treatment	0.011	-0.039	-0.042
	(0.066)	(0.091)	(0.048)
Combined treatment	0.024	-0.036	-0.014
	(0.065)	(0.100)	(0.046)
Controls included	Yes	Yes	Yes
Outcome mean at baseline	-0.900	-3.309	1.021
Outcome autocorrelation	0.429	0.215	0.064
Observations	759	759	748
R-squared	0.224	0.794	0.034

Notes: This table presents the results of the treatment effects following the ANCOVA specification. Covariates include the baseline variables of the outcome, household characteristics (gender, age, education dummy indicating whether the household head graduated from middle school, the degree of specialization in broiler farming measured by the rate of broiler farming income in total household income), farm characteristics (whether the production scale is larger than 20,000 broilers/production cycle, the number of household laborers engaged in broiler rearing, years of experience in broiler rearing, and the number of broiler types), the degree of risk aversion of the household head, and location (distance to the nearest neighboring farmer in the sample and location fixed effect). Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Considering the sizable autocorrelation on antibiotics cost (0.429), we provide the DiD estimation results in Appendix Table A7. These results indicate an insignificant effect of subsidy treatment on antibiotics costs (the coefficient on the interaction term of post-treatment and subsidy treatment is -0.029 but insignificant). However, we now also observe a statistically significant impact on mortality as well from the subsidy treatment.

Table 5 displays the ITT effects on the adoption of acidifiers and probiotics using an ANCOVA specification. Recall that while probiotics were available in both locations, acidifiers were only available in Changzhou by the time of our farm surveys. We therefore conduct the estimations by location.

We find no statistically significant effects in the sample but discern regional variations. In Changzhou, farmers assigned to the social norm intervention have an 8.6 percentage points higher probability in adopting probiotics than those assigned to the control group, or a 44% overall increase. Farmers assigned to the combined intervention have a 25 percentage points higher probability of adopting acidifiers, or an 80% increase. However, in the other location, Xuzhou, we do detect any statistically significant effects.

Table 5: ANCOVA estimation of treatment effects on adoption of probiotics and acidifiers – by location

	Whole sample	Changzhou		Xuzhou
	Probiotics (0/1)	Probiotics (0/1)	Acidifiers (0/1)	Probiotics (0/1)
Subsidy treatment	-0.000	0.001	0.086	-0.004
	(0.021)	(0.026)	(0.088)	(0.036)
Norm treatment	0.048	0.086*	-0.073	0.001
	(0.035)	(0.054)	(0.087)	(0.044)
Combined treatment	0.032	0.046	0.246**	0.015
	(0.040)	(0.049)	(0.107)	(0.059)
Controls included	Yes	Yes	Yes	Yes
Outcome mean at baseline	0.124	0.193	0.307	0.061
Outcome autocorrelation	-0.014	-0.031	0.243	-0.002
Observations	759	348	348	411

Notes: This table presents the results of the treatment effects following the ANCOVA specification. We report the average marginal effects of a logit regression. Covariates include the baseline variables of the outcome, household characteristics (gender, age, education dummy indicating whether the household head graduated from middle school, the degree of specialization in broiler farming measured by the rate of broiler farming income in total household income), farm characteristics (whether the production scale is larger than 20,000 broilers/production cycle, the number of household laborers engaged in broiler rearing, years of experience in broiler rearing, and the number of broiler types), the degree of risk aversion of the household head, and location (distance to the nearest neighboring farmer in the sample and location fixed effect). Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Considering the baseline imbalance between control and treatment groups regarding acidifiers use, we provide the DiD estimation in Appendix Table A8. The results of DiD estimations are comparable to the ones presented in Table 5, i.e., in Changzhou the social norm intervention and combined intervention significantly increased the probability of using probiotics and acidifiers, respectively. No effects are detected for Xuzhou.

Both ANCOVA and DiD results show that the effects of subsidy treatment on the adoption of probiotics or acidifiers are insignificant, suggesting that the subsidy alone is insufficient to induce farmers' experimentation with these alternatives. Only when the subsidy is combined with the social norm intervention (combined treatment), do we observe positive effects on the adoption of acidifiers.

To place the lack of effects in perspective, Table 6 presents base and endline statistics on the use of probiotics and acidifiers across the two locations. In both locations, few farmers used probiotics at baseline, and in both locations, even fewer do so at endline (a decrease of about 50% in both locations). It appears that our norms treatment is able to counter this trend, at least in Changzhou. It is notable though that conditional on using probiotics the farmers use exceeds what is recommended.

Farmers in Changzhou, where acidifiers are available, appear to prefer acidifiers over probiotics at baseline. Recall that this represents the cheaper option compared to probiotics in terms of average cost per broiler. The use of acidifiers dramatically increases from base to endline in this location, a trend where the combined treatment likely played an important role. Again, the use dramatically exceeds what is recommended.

Table 6: Conditional on adopting acidifiers and probiotics, the usage acidifiers and probiotics at baseline and endline – by location.

	Changzhou		Xuzhou	
	Baseline	Endline	Baseline	Endline
Acidifiers use (0-1)	0.216	0.489	0.000	0.000
Probiotics use (0-1)	0.155	0.075	0.102	0.049
Acidifiers use (kg/100 broilers)	6.584	6.451	N/A	N/A
Probiotics use (kg/100 broilers)	1.791	1.965	0.875	2.687

Note: the last two rows are conditional on use. The recommended amount of acidifiers is 0.25 kg per 100 broilers. The recommended amount of probiotics is 0.3 kg per 100 broilers.

Table 7 presents the effects on sanitation using an ANCOVA specification. Recall that the company stipulates sanitation measures in their contract with the farmer: the farmers should disinfect the barns seven times a week, the surrounding environment once a week, drinking water twice a week, and feeding stations seven times a week. We construct four corresponding sanitation indices indicating whether the farmer meets the required frequency of each sanitation practice. Table 7 presents the effect of these four indices. Recall that keeping the environment clean, and the feeding stations clean is particularly important for the success of the alternatives.

At baseline, few farmers sanitize their feeding stations as required. The treatments did not have any impact on this component of sanitation. About half of the farmers met the required sanitation frequency for the surrounding environment, and the social norm treatment further increased this by about 13%. Furthermore, we find that farmers assigned to the subsidy treatment have an almost 90% increased chance of implementing the barn sanitation measures at the required frequency.

Table 7: ANCOVA estimation of the treatment effects on sanitation practices

	Binary variable to indicate whether farmer met the required sanitation frequency for:			
	Barn	Environment	Drinking water	Feeding stations
Subsidy treatment	0.033*	0.005	0.009	0.041
	(0.018)	(0.028)	(0.055)	(0.039)
Norm treatment	-0.026	0.069**	0.013	-0.084
	(0.030)	(0.027)	(0.061)	(0.060)
Combined treatment	-0.023	0.022	-0.007	-0.083
	(0.034)	(0.027)	(0.071)	(0.069)
Controls included	Yes	Yes	Yes	Yes
Outcome mean at baseline	0.038	0.503	0.331	0.066
Outcome autocorrelation	0.078	0.033	0.131	-0.014
Observations	759	752	748	742

Notes: This table presents the results of the treatment effects following the ANCOVA specification. We report the average marginal effects of a logit regression. Covariates include the baseline variables of the outcome, household characteristics (gender, age, education dummy indicating whether the household head graduated from middle school, the degree of specialization in broiler farming measured by the rate of broiler farming income in total household income), farm characteristics (whether the production scale is larger than 20,000 broilers/production cycle, the number of household laborers engaged in broiler rearing, years of experience in broiler rearing, and the number of broiler types), the degree of risk aversion of the household head, and location (distance to the nearest neighboring farmer in the sample and location fixed effect). Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The DiD results are reported in Appendix Table A9 and are not consistent with the results in Table 7.

In the results so far, we find that the treatments do not appear to significantly influence farmers' production performance, however, they have significant effects on farmers' input choices. To gain a better understanding of the limited effects on antibiotics use, we perform something akin to a mediation analysis. We investigate whether the changes in input choices and knowledge related to antibiotics are associated with a reduction in antibiotic costs. We use the following DiD specification:

$$A_{it} = \beta_0 + \beta_1 M_i + \beta_2 M_i POST_{it} + \beta_3 X_{it} + \beta_4 POST_{it} + v_i$$

Where A_{it} is the antibiotic cost of farmer i; M_{it} is the binary variable of farmer i's input choices (i.e., probiotics/acidifiers adoption and sanitation indices) or the knowledge related to antibiotics (four dummies measuring i's agreement of the negative impacts of overusing antibiotics in four aspects); $POST_{it}$ is the post-treatment indicator and X_{it} is the same control vector as the main DiD specification. v_i' is an unobserved random error term clustered at the agent level. β_2 captures the effect of the input/belief M_i on the antibiotic cost of farmer i.

The results are reported in Appendix Table A10, A11 and A12. In Changzhou, endline use of probiotics is associated with 13% lower antibiotics costs (but no significant correlations are detected for acidifiers). Meeting the frequency of environmental sanitation (once a week) is associated with a 15% decrease in their antibiotic costs, while water sanitation at the required frequency (twice a week) is associated with an 8% decrease in antibiotic costs. Farmers' improved knowledge of antibiotics does not appear to correlate with antibiotics cost at endline.

7.2. Mechanisms

In this section we explore the mechanisms through which the observed effects may be taking place. The primary channel of interest is a change in knowledge about the effects of antibiotics, and the role of their alternatives. This change could be established through increased communication with one's peers as well as one's company agent. A secondary channel of interest is perceived increased social pressures, especially through the social norms treatment where farmers are exposed to, and interact with, role model peers.

We use DiD to analyze the treatment effects on farmers' knowledge of antibiotics (given the significant baseline imbalance). This allows us to account for baseline imbalance in these variables (see Appendix Table A6).[32] Recall that farmer's knowledge of antibiotics was measured through Likert scales – asking farmers to what extent they agree with a series of statements regarding the role of antibiotics. In Table 8, the dependent variable equals 0 if the farmer states to 'agree' or 'strongly agree' with the respective statement and 0 otherwise).

Table 8: DiD estimations of the treatment effects on farmers' knowledge of antibiotics.

	Antibiotic Resistance	Impact on human health	Impact on the environment	Responsibility of chicken farming
Post*Subsidy treatment	0.137**	0.026	0.043	0.027
	(0.061)	(0.064)	(0.058)	(0.050)
Post*Norm treatment	0.153**	0.066	0.112	0.064
	(0.072)	(0.102)	(0.084)	(0.102)
Post*Combined treatment	0.098	0.114	0.212**	0.125
	(0.070)	(0.112)	(0.095)	(0.109)
Post	0.000	0.018	0.008	0.080
	(0.049)	(0.065)	(0.058)	(0.069)
Subsidy treatment	-0.165***	-0.045	-0.046	-0.066
	(0.037)	(0.058)	(0.062)	(0.053)
Norm treatment	-0.174***	-0.090	-0.078	-0.078
	(0.045)	(0.080)	(0.057)	(0.076)
Combined treatment	-0.135***	-0.140*	-0.189***	-0.122
	(0.045)	(0.082)	(0.059)	(0.078)
Controls included	Yes	Yes	Yes	Yes
Outcome mean at baseline	0.812	0.634	0.435	0.376
Outcome autocorrelation	0.047	0.052	0.123	0.075
Observations	1,518	1,518	1,518	1,518

Notes: This table presents the results of the treatment effects following a DiD specification. We report the average marginal effects of probit regressions. The dependent variable = 1 if the farmer notes to "agree" or "strongly agree" with four statements: Column (1) Overuse of antibiotics in food animal production promotes the development of antibiotic drug-resistant bacteria; Column (2) Residual antibiotics and resultant antibiotic-resistant bacteria resulting from broiler farming can be transferred to humans and harm human health; Column (3) Residual antibiotics and resultant antibiotics-resistant bacteria from broiler farming can be transmitted into the environment and lead to soil and water pollution; Column (4) Antibiotics overuse in broiler farming is responsible for a significant share of antibiotics overuse in China. Covariates include the baseline variables of the outcome, household characteristics (gender, age, education dummy indicating whether the household head graduated from middle school, the degree of specialization in broiler farming measured by the rate of broiler farming income in total household income), farm characteristics (whether the production scale is larger than 20,000 broilers/production cycle, the number of household laborers engaged in broiler rearing, years of experience in broiler rearing, and the number of broiler types), the degree of risk aversion of the household head, and location (distance to the nearest neighboring farmer in the sample and location fixed effect). The variables production scale, number of household labor in farming, and degree of specialization in chicken farming are time=dependent. Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Before considering these results, recall that all farmers, in control and in all treatment groups, were provided with general information about antibiotics. As such, we don't expect much impact on these generic questions. Table 8 indicates that the treatments indeed had limited impact. Recall that farmers baseline awareness of antibiotics was relatively high, with over 80% of farmers aware of its effects on antibiotic resistance, and over 60% aware of its effects on human health. While both treatments affected the farmers awareness of antibiotics resistance, given the baseline high levels, the effect size is limited (around 15%). A more significant effect can be observed in awareness of the impacts on the environment. The combined treatment increases this awareness by 50%.

We expected treated farmers would change their risk perception regarding antibiotics and their alternatives. Recall that we asked farmers to judge the mortality rates corresponding to several scenarios, including, business-as-usual, no sub-therapeutic antibiotics use, and combining probiotics with antibiotics in a business-as-usual scenario. We present the results on differences in perceived mortality rates using an ANCOVA specification in Table 9, this time by location to account for the differential availability of the alternatives. We note limited impacts on risk perceptions. Only in Changzhou (where more of the alternatives were available), farmers in the subsidy group perceive a 1.3% decrease in mortality between not using sub-therapeutic antibiotics and business-as-usual (this represents a 30% effect size).

These changes in perceptions can come through farmers' own experimentation, or through increased interaction with other farmers, and their company agent as a response to the treatments. In Appendix Tables A15, A16 and A17 we study the effects on the farmers' relationships with their company agent, and each other.

Table A13 presents the treatment effects on the farmers' relationship with their agents for the farmers who have the same agent over the two rounds of survey estimated using an ANCOVA specification. [33] We create an index from a series of five variables which measure this relationship, with 5 being the highest score. We find that only farmers in the combined treatment group experience a significantly better relationship with their agent; their score increases by 7.3%.

Table 9: ANCOVA estimation of the treatment effects on the difference in farmers' perceived mortality between hypothetical scenarios

	Difference in mortality between no antibiotics use and business-as-usual (%)			Differences in mortality between probiotics use and business-as-usual (%)		
	Whole sample	Changzhou	Xuzhou	Whole sample	Changzhou	Xuzhou
Subsidy treatment	-0.585	-1.295*	0.134	0.254	0.252	0.213
	(0.691)	(0.617)	(1.001)	(0.185)	(0.268)	(0.237)
Norm treatment	1.102	-0.564	2.233	0.159	0.068	0.332
	(1.188)	(1.692)	(1.937)	(0.147)	(0.113)	(0.311)
Combined treatment	1.218	0.224	1.970	0.072	0.083	0.128
	(1.279)	(2.309)	(1.631)	(0.129)	(0.099)	(0.253)
Controls included	Yes	Yes	Yes	Yes	Yes	Yes
Outcome mean at baseline	4.673	4.655	4.688	-0.329	-0.393	-0.275
Outcome autocorrelation	-0.045	-0.016	-0.070	-0.049	-0.025	-0.048
Constant	6.191*	3.776	7.058	0.020	0.205	-0.480
	(3.491)	(5.466)	(4.713)	(0.418)	(0.659)	(0.613)
Observations	429	211	218	362	203	159
R-squared	0.033	0.050	0.043	0.035	0.022	0.060

Notes: This table presents the results of the treatment effects following the ANCOVA specification. The dependent variable in the first three columns is the difference between the mortality of the no sub-therapeutic antibiotics and business as usual. The dependent variable in the second set of three columns is the difference between the mortality associated with the use of probiotics and business-as-usual. Covariates include the baseline variables of the outcome, household characteristics (gender, age, education dummy indicating whether the household head graduated from middle school, the degree of specialization in broiler farming measured by the rate of broiler farming income in total household income), farm characteristics (whether the production scale is larger than 20,000 broilers/production cycle, the number of household laborers engaged in broiler rearing, years of experience in broiler rearing, and the number of broiler types), the degree of risk aversion of the household head, and location (distance to the nearest neighboring farmer in the sample and location fixed effect). Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A14 presents the treatment effects on the farmers' communication within their agent group. In the endline survey, we asked the farmers whether they communicated with other farmers in the agent group (in the last three months) about six topics related to alternatives and antibiotics: probiotics, acidifiers, disinfection, broiler daily management, how to reduce drug cost, and how to use drugs for sick broilers. We create six dummies indicating whether they talked with peers about these six topics, and an overall communication index by adding the six dummies. As we do not have the baseline variants of these variables, we conduct a simple regression with controls. We note no statistically significant effects.

Table A15 presents the treatment effect on the farmers' social network. In the endline survey, we match each respondent with four randomly selected farmers from their agent group and ask them whether they know the match. We examine the group difference in the number of peers known using a simple regression with controls. We again find no statistically significant effects.

Finally, we expect that our treatments, especially the social norm treatment, might affect social pressure. We have no direct measures of these social pressures but did inquire with farmers as to what they perceive other's farmers knowledge to be on antibiotics (i.e., the questions we covered in Table 8 were repeated but this time with respect to 'other farmers'). Table A16 presents the results of an ANCOVA estimation, mirroring the set-up of Table 8. We find no statistically significant impacts of the treatments on farmers' perception of other farmers' knowledge.

7.3. Heterogeneity

In this section we examine whether the treatment effects depend on the farmers' social and environmental preferences (Appendix Table A17), their status concerns (Appendix Table A18), their degree of risk aversion (Appendix Table A18) and farming scale (Appendix Tables A19 and A20). To keep our discussion focused we present only the ANVOVA specifications for two sub-samples (split along the median), and consider only three dependent variables: antibiotics cost, a 4-point sanitation index, and the use of acidifiers and probiotics.

Farmers who are more altruistic appear to respond strongly to the combined treatment. However, an increased concern for the environment does not result in an equally strong treatment response.

More risk-averse farmers do not have differential response to our treatments, but other farming characteristics matter. We find that small-scale farmers (smaller than sample medium of 19660 broilers/cycle) and less wealthy farmers (annual income from broiler farming smaller than the sample medium of 90,000 yuan) respond more strongly to our treatments. Small-scale farmers are more likely to adopt acidifiers in response to the subsidy and combined treatment, and less wealthy farmers in the subsidy group are more likely to reduce antibiotic costs and adopt acidifiers.

8. Conclusion

A rising number of randomized controlled trials in low and middle-income countries investigates the effectiveness of financial incentives and extension interventions in promoting the adoption of advanced agricultural practices. However, we are not aware of similar studies on interventions to reduce the use of antibiotics in animal production, which is a concern across many countries.

To fill this research gap, in this study, we use a randomized controlled trial to investigate the role of micro-subsidies and role models in promoting the adoption of alternatives and improved sanitation practices. Disease prevention is essential for antibiotics reduction in broiler production. Adopting these alternatives to antibiotics and strengthening the implementation of sanitation measures are potential avenues to prevent infections and reduce farmers' dependence on antibiotics.

Our results show that role model based social norm treatments can promote the adoption of probiotics and acidifiers, and both subsidy and social norm treatments can improve sanitation practices. However, we observe no consistent treatment effect on farmers' antibiotic use.

These results suggest that a financial incentive alone, especially when it is relatively small, may not be effective in encouraging the adoption of these new technologies. Instead, combining the financial incentive with other interventions may be more promising. In our study, the social norm treatment alone was effective in combating a reduction in probiotics over time (probiotics were used by 13% sample farmers before our intervention). The social norm intervention partly took place via the social media channel WeChat, suggesting that peer-to-peer information exchange on existing technologies can work even through an online platform. To promote the adoption of acidifiers – a relatively cheaper option than probiotics – the combination of subsidy and social norm intervention was most effective, providing farmers with both financial and peer support for the adoption decision.

We notice considerable differences between the two locations. While the social norms treatment significantly increases the likelihood of adoption of alternatives in Changzhou, it had no effect on adoption in Xuzhou. Although farmers in the two locations belong to the same broiler company and operate under the same contract scheme, there are still some notable differences between the two locations. For instance, on average, farmers in Changzhou have bigger production capacity and more income from broiler rearing than farmers in Xuzhou.

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Endnotes

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[1] Farmers in our sample appear to be more aware than consumers about the environmental attributes of their production. Shimokawa et al. (2021) note a limited understanding of green and organic food labels, especially among Chinese rural consumers.

[2] Mao et al. (2021) focus on time preferences but also note that large-scale rice farmers in China were more likely to adopt new green technologies compared to small-scale farmers (see also Foster and Rosenzweig for an overview on the determinants of agricultural technology adoption).

[3] Most studies in agricultural extension and learning consider person-to-person interactions in its various forms (see among others, Maertens 2017, Moser and Barrett 2006, and Buck and Alwang 2011).

[4] Again, evidencing the concern of the Chinese consumer for others, He et al. (2021) find that providing consumers in Beijing with information on the societal impact of antibiotic resistance is particularly effective in reducing antibiotics use (among humans).

[5] According to the China Animal Husbandry and Veterinary Yearbook and Aquatic Product Statistics Annual Report the total output of livestock and chicken meat, eggs, milk, and aquatic products was 222,460,000 tons. The total amount of veterinary antibiotics used was 44,186 tons. Dividing the two items, the veterinary antibiotics used per ton of animal products was 199g. This calculation method draws on the Report on the Use of Veterinary Antibiotics of China in 2018 and refers to 2016 data.

[6] In practice, it is difficult to distinguish between the purpose of disease prevention and growth promotion; hence, this report classified antibiotics use purpose into two categories, namely growth promotion and disease treatment.

[7] The company in our study sold approximately 261 million broilers in 2018 with sales revenue of 7.2 billion Yuan.

[8] The security deposit is 20 yuan per chicken and is returned to the farmer at the end of the production cycle. This ensures that the farmer does not engage in any side-selling.

[9] This transportation subsidy is 0.8 yuan per ton when over the distance exceeds 40 km. Note that the transportation charge is 1.25yuan per ton per km.

[10] Regarding sanitation, the company recommends that farmers disinfect the barns at least 7 times a week, the surrounding environment at least once a week, drinking water at least twice a week, the feeding stations at least 7 times a week (all during the production period with additional recommendations during the rest period).

[11] The company provides credit for young chickens, feed, and antibiotics. The farmers invest in chicken sheds and pay a security deposit in advance. According to the assessment of the head office, the cost of the shed and supporting facilities (water line, material line, fan, wet curtain, heater, etc.) is about 190 yuan per square meter, conditional on access to piped water, electric grid, and a paved road. For a barn of 850 square meters, the shed and supporting facilities will hence cost 160,000 yuan. Although the company provides a subsidy of 30 yuan per square meter, this cost is still high.

[12] The compensation ratio can be up to 90% of the costs (feed, chicks and medication). However, if farmers violate aspects of the contract, e.g., if farmers buy medication privately, fail to pass the drug residue test, or fail to use the medication as specified, they will not receive full compensation.

[13] Our baseline survey (pre-pandemic) indicates that technicians visited farmers, on average, 5 times per month. In addition, farmers contact their technician frequently. On average, farmers call their technician 10 times per month.

[14] When inquiring about to what extend farmers follow the technician's instructions regarding antibiotics use, in the baseline survey, 15% of farmers reported that they used more antibiotics than prescribed by the technician. Note that as long as the drug withdrawal periods are respected, farmers can get their decide on their desired amount of antibiotics.

[15] If an illegal drug is detected by company, a fine of 0.3 yuan per broiler is imposed, and the broilers are confiscated at a low price or destroyed without compensation. If residues of legal antibiotics are detected, such as, tetracyclines and sulfonamides exceed the standard, the fine is 0.1 to 0.2 yuan per broiler. In addition, drug residue tests are conducted by the government's

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quality inspection department as well as downstream food processing enterprises. If these institutions detect excess residues, a fine of 0.3 yuan per broiler will be imposed. According to company records, in 2018, 1.5% of broilers did not pass the company's residue test.

[16] The duration between receiving antibiotics and breaking down antibiotics until it is no longer present in the body is called the withdrawal period. The withdrawal period is different for different antibiotics. For example, the withdrawal period for doxycycline is 28 days while that for neomycin is 5 days. The withdrawal period is determined by the company based on which antibiotics were used.

[17] The company has 22 subsidiaries located in Jiangsu, Anhui, Zhejiang, Shandong, Guangdong, Henan, Sichuan, Hunan provinces and other places.

[18] The most important Chinese festival, the Chinese New Year, is usually in February. The festival lasts around 15 days. During that time, family members gather and visit relatives and friends.

[19] At endline, almost 60% of farmers noted that their business was significantly affected by the COVID-19 pandemic. Half of the farmers noted that the delivery of young chicks was delayed. Two-third of farmers faced transportation problem to obtain other inputs.

[20] Data on gross profit was provided by the company following = (output in weight) * (unit price per weight) + (transportation subsidy) + price bonus - (cost of chicks, feeds, drugs, and transportation) – drug testing penalty.

[21] The company in Xuzhou did not provide acidifiers to farmers due to a negotiation problem with the supplier of acidifiers.

[22] At baseline, 17% of farmers heard of acidifiers and 14% farmers heard of probiotics. 5% of farmers heard of both products.

[23] Since the reform in 1978 the government provides subsidies to grain farmers, which include general subsidies for purchasing agricultural supplies and subsidies for planting hybrid seeds.

[24] The other two papers of the research group members used baseline data and showed that farmers' awareness of antibiotics related hazards transmit in their social networks (Wei et al., 2023a) and farmers' antibiotic use positively correlates with their neighbors' antibiotic use (Wei et al., 2023b).

[25] Before the quiz, there was basically no discussion in the group. After the quiz, on average, five farmers per group would answer the questions.

[26] Appendix Table A2a shows the indicated reasons for attrition.

[27] There are a total of 24 technicians in the company who manage the surveyed farmers. Our baseline survey (May 2019) and information treatment (September 2019) was based on a farmer-technician list of April 2019. In October 2019 to February 2020, the company changed some off the previously assigned technicians. Our randomization is based on the new farmer - technician list of February 2020.

[28] The baseline questionnaire was pre-tested through among 10 contract farmers in another city in Jiangsu in April 2019.

[29] The endline questionnaire was pre-tested through phone survey on 3 contract farmers. These farmers contracted with the company after our baseline survey. Therefore, they do not participate in our baseline and endline survey.

[30] While the survey requests information about the previous three farming cycles, we noted that the quality of these earlier cycle data was poor at baseline – with many don't know answers. Hence, our analysis only uses data on last farming cycle, and the endline cycle only asked about the last farming cycle.

[31] Recall that the company recommends that farmers disinfect the barns at least 7 times a week, the surrounding environment at least once a week, drinking water at least twice a week, the feeding stations at least 7 times a week (during the production period with additional recommendations during the rest period).

[32] Results of baseline balance show that at baseline the control group has 17%, 18% and 14% higher proportion of farmers agreeing with "Antibiotic resistance" than the subsidy, social norm, and combined treatment group, respectively. At baseline, the control group has 15% and 18%

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higher proportion of farmers agreeing with "Impact on human health" and "Impact on the environment", respectively, than the combined treatment group.

[33] Out of the 759 farmers in our analysis sample, 390 farmers have the same agent in baseline and endline survey and 369 farmers have different agents in the two rounds of survey.

Online Appendix:

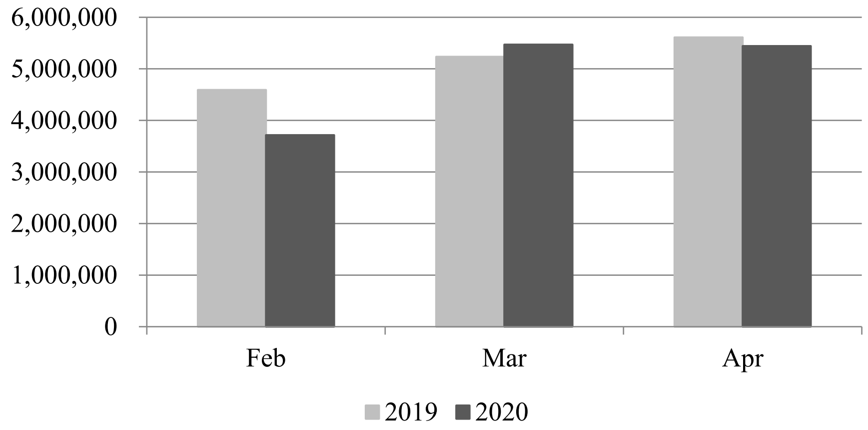


Figure A1: The monthly number of young chicks provided to the farmers (in 2019 and 2020)

Note: We use administrative data from the company for this figure.

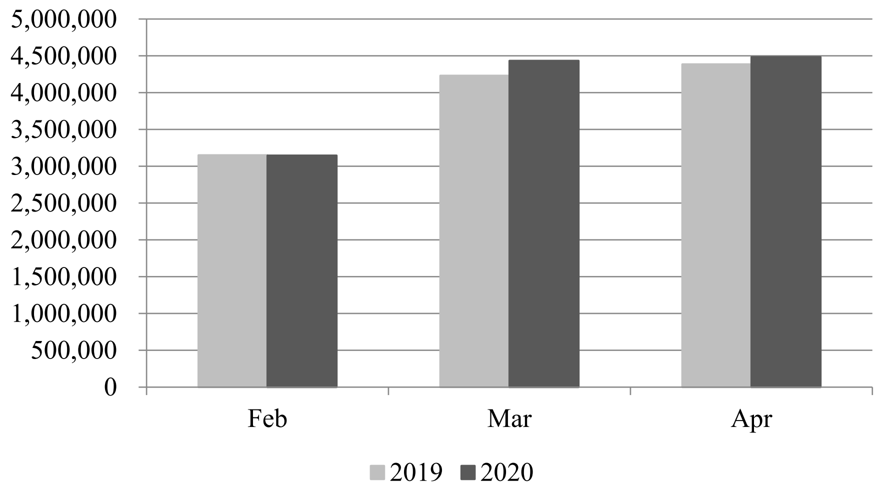
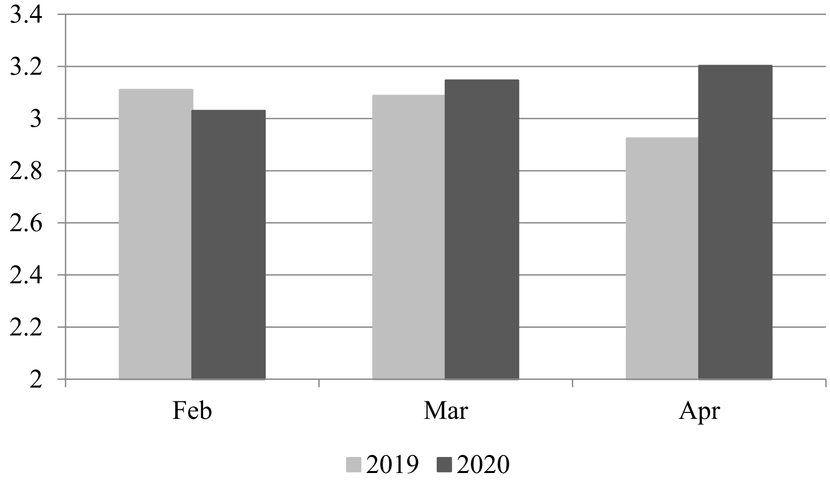


Figure A2. The monthly number of broilers slaughtered (in 2019 and 2020)

Note: the farming cycle lasts, on average, 3 months. Therefore, broilers slaughtered in a particular month are often young chicks provided to farmers 3 months ago. We use administrative data from the company for this figure.



Appendix Figures A3. The gross profit in Yuan per broiler (in 2019 and 2020)
Note: We use administrative data from the company for this figure.

Table A1. Comparison of the two locations in 2018

	Changzhou	Xuzhou
Total land area of administration location (sq.km)	4372	11765
Population density at year-end (persons/sq.km)	873	888
Per capita gross locational product (Current prices in yuan)	149,277	76,915
Percentage of city paved roads at year-end (%)	1.12%	0.39%
Number of household subscribers of Internet services / number of total households at year-end (persons/household)	1.76	1.03

Notes: Data source: China City Statistical Yearbook (2019). https://data.cnki.net/Yearbook/Single/N2020050229

Table A2a. Sample attrition: sample size in baseline survey, randomization design and endline survey

Period	Sample size (in households)	Reason for change of sample size (in households)
Baseline 2019	847	
RCT experiment	826	21 farmers ended contract with the company
Endline 2020	760	30 farmers ended contract with the company 8 farmers stopped farming 3 farmers have repeated contract account (rear broilers together with the spouse or parents, but use two accounts in the company) 25 refused to participate in the endline survey

Table A2b. Experiment compliance: number of participants divided by the number assigned

Participation/Assignment		Subsidy	
		Control	Treatment
Social Norms	Control	146/186	103/183
	Treatment	146/192	129/198

Note: Interpretation of 103/183 is out of the 183 farmers who were assigned to the subsidy treatment, 103 of them received the subsidy. The social norms participation is defined as receiving at least one form of the social norm interventions (receiving the pamphlet, watching the video, or in the WeChat group). The subsidy participation is defined as receiving the coupon.

Table A3. Descriptive statistics by location at baseline, in 2019

	Changzhou (N=348)		Xuzhou (N=411)		Xuzhou-Changzhou	
	Mean	S.D.	Mean	S.D.	Diff	p-value
Gender of household head (1=male; 0=female)	0.934	0.249	0.927	0.260	-0.007	0.710
Age of household head (in years)	46.718	8.498	49.348	9.864	2.630	0.000
Education of household head (1=at least graduating from middle school; 0=otherwise)	0.526	0.500	0.720	0.449	0.195	0.000
Number of family members engaging in rearing broilers	2.049	0.498	1.886	0.608	-0.163	0.000
Income from broiler farming in the last year (in 10,000 Yuan)	13.576	6.160	6.686	4.947	-6.889	0.000
Degree of specialization: rate of broiler income in total household income	0.879	0.197	0.749	0.260	-0.131	0.000
Experience of large-scale broiler farming (in years)	8.562	3.534	8.595	3.898	0.033	0.902
Number of reared broiler types in the last farming cycle	1.667	0.620	1.029	0.169	-0.638	0.000
Number of reared broilers in the last farming cycle (in 1,000 broilers)	30.196	9.162	15.322	10.539	-14.874	0.000
Household income in year 2018 (in 10,000 Yuan)	16.085	8.044	9.598	7.404	-6.487	0.000
Care about what your peers think of your personal quality (0-1)	0.563	0.497	0.630	0.483	0.067	0.061
Care about what your peers think of your wealth status (0-1)	0.307	0.462	0.265	0.442	-0.043	0.201
Broiler mortality in the last farming cycle (0%-100%)	3.750	3.239	5.288	5.508	1.538	0.000
Average profit in the last farming cycle (in Yuan/broiler)	3.067	0.836	2.702	0.929	-0.365	0.000
Average cost antibiotics in the last farming cycle (in Yuan/broiler)	0.526	0.159	0.351	0.127	-0.176	0.000
Whether used probiotics in the last farming cycle	0.155	0.363	0.102	0.303	-0.053	0.031
Whether used acidifiers in the last farming cycle	0.216	0.412	0.000	0.000	-0.215	0.000
Chicken house sanitation (0-1)	0.034	0.183	0.054	0.225	0.019	0.199
Environment sanitation (0-1)	0.628	0.484	0.432	0.496	-0.196	0.000
Drinking water sanitation (0-1)	0.329	0.471	0.316	0.465	-0.013	0.693
Feeding facilities sanitation (0-1)	0.046	0.210	0.048	0.214	0.002	0.911
Concept of antibiotic resistance (0-1)	0.733	0.443	0.657	0.475	-0.076	0.024
Impact on human health (0-1)	0.649	0.478	0.482	0.500	-0.168	0.000
Impact on the environment (0-1)	0.376	0.485	0.343	0.475	-0.034	0.341
Contribution of China's chicken farming industry (0-1)	0.330	0.471	0.294	0.456	-0.036	0.287

Notes: p-values are obtained from t-test statistics.

Table A4. Descriptive statistics of 24 agents at baseline

Variables	N	Mean	S.D.	Min	Max
Agent age in years	24	31.958	6.196	23	47
Agent education level					
1=middle school	24	.042	.204	0	1
2=high school	24	.125	.338	0	1
3=college	24	.542	.509	0	1
4=bachelor	24	.292	.464	0	1
Agent work years in the company	24	7.167	4.869	2	20
Agent group size	24	41.083	6.507	23	49
Farm visits per day	24	7	1.888	3	10

Table A5. Balance test of 19 agents prior to intervention

	Mean of Group 1	Mean of Group 2	Diff: Group 1-Group 2	St Err	t value	p value
Agent age in years	31.111	30.900	0.211	2.489	0.100	0.933
Agent education level (1=middle school, 4=bachelor degree)	3.111	3.300	-0.189	0.360	-0.500	0.608
Agent work years in the company	7.111	7.400	-0.289	2.497	-0.100	0.909
Agent group size	40.889	40.100	0.789	3.089	0.250	0.801
Farm visits per day	6.778	6.900	-0.122	0.842	-0.150	0.887

Note: Differences in group mean between agents in control group and social norm treatment group. Group 1=non-social norm treatment, Group 2=social norm treatment

Table A6. Balance check of analysis sample (759 farmers): Differences in group mean between control group and treatment groups at baseline in 2019

	(1) All		(2) Control-Subsidy		(3) Control-Social Norm		(4) Control-Combined	
	Mean	Std. Dev.	Diff in means	P value	Diff in means	P value	Diff in means	P value
Dependent variables:								
From administration data								
Cost of antibiotics (Yuan/broiler)	0.431	0.168	0.011	0.572	0.013	0.432	0.025	0.155
Broiler mortality (0-1)	0.046	0.047	0.004	0.460	0.003	0.706	0.005	0.450
Profit (Yuan/broiler)	2.870	0.905	0.038	0.723	0.163	0.223	0.189	0.230
From survey data								
Income from broiler farming (in 10,000 Yuan)	9.842	6.514	0.379	0.596	0.398	0.555	0.563	0.417
Whether use probiotics (0-1)	0.084	0.278	0.015	0.608	0.013	0.649	0.021	0.464
Whether use acidifiers (0-1)	0.130	0.337	0.003	0.933	0.088***	0.005	0.089***	0.004
Whether barn disinfection freq. meets the company's requirement (0-1)	0.089	0.285	0.005	0.852	-0.022	0.468	0.011	0.689
Whether environment disinfection freq. meets the company's requirement (0-1)	0.700	0.459	-0.044	0.347	0.073	0.131	0.010	0.834
Whether drinking water disinfection freq. meets the company's requirement (0-1)	0.396	0.489	-0.038	0.456	0.017	0.744	0.007	0.897
Whether feeding facility disinfection freq. meets the company's requirement (0-1)	0.066	0.249	0.044**	0.042	0.018	0.463	0.015	0.538
Whether freq. of changing disinfectants in the barn entrance meets the company's requirement (0-1)	0.478	0.500	0.022	0.667	0.011	0.827	-0.019	0.716
Whether the overall sanitation freq. meets the company's requirement (0-1)	0.008	0.089	0.011	0.160	-0.010	0.434	0.011	0.144
Control variables								
Demographics: survey data								
Gender of the household head	0.930	0.255	0.028	0.271	0.035	0.173	0.022	0.358
Age of the household head	48.157	9.351	-0.709	0.452	-1.441	0.140	-1.537*	0.099
Education level of the household head	1.701	0.847	0.122	0.174	0.071	0.395	0.077	0.381
Household size (in person)	3.743	1.332	0.121	0.379	0.142	0.320	0.178	0.180
Number of children within household	0.192	0.516	0.041	0.495	0.106*	0.051	0.050	0.372
Number of adult within household	2.813	0.909	0.024	0.796	0.026	0.779	0.010	0.915
Number of male adult within household	1.480	0.601	0.027	0.660	0.026	0.674	0.005	0.939
Number of family members engaging in raising broilers	1.962	0.620	0.092	0.149	0.069	0.232	0.098	0.162
Experience and farm: from survey data								
Degree of specialisation: rate of broiler income in total household income (0-1)	0.802	0.252	0.061**	0.015	0.022	0.334	0.017	0.495
Experience of large-scale chicken farming (in years)	8.599	3.718	0.347	0.366	0.912**	0.019	1.127***	0.003
Number of reared breed types	1.324	0.542	0.082	0.174	0.058	0.308	0.104*	0.061

	(1)		(2)		(3)		(4)	
	All		Control-Subsidy		Control-Social Norm		Control-Combined	
	Mean	Std. Dev.	Diff in means	P value	Diff in means	P value	Diff in means	P value
Number of chickens reared in								
	20901	12144	1810	0.142	-479	0.728	597	0.641
Mechanism variables: perceived risk and mortality (from survey data)								
Risk preferences								
Degree of risk aversion of the farmer (sigma)								
	0.559	0.539	-0.092	0.103	-0.098*	0.069	-0.048	0.373
Risk perception: expected mortality (%)								
- Business as usual (%)								
	4.493	2.633	0.026	0.937	0.314	0.182	0.183	0.453
- Scenario 1: No prevention drug use (%)								
	9.200	8.200	-1.008	0.252	-0.164	0.844	-0.046	0.956
- Scenario 2: Using preventative drug and probiotics (%)								
	4.164	3.263	-0.160	0.638	0.218	0.418	-0.045	0.890
- Scenario 3: With preventative drug and recommended disinfection (%)								
	4.631	3.857	0.376	0.411	1.224***	0.001	0.725*	0.086
Risk perception: difference in expected mortality between Scenario 1-3 and Business as usual (BAU):								
Scenario 1 (No preventive antibiotic use) - Business as usual								
	4.673	7.857	-0.896	0.283	-0.478	0.554	-0.230	0.775
Scenario 2 (Use probiotics as recommended dosage) - Business as usual								
	-0.329	2.730	-0.189	0.411	-0.097	0.688	-0.230	0.416
Scenario 3 (Sanitize as recommended frequency) - Business as usual								
	0.138	2.983	0.350	0.282	0.910	0.003	0.541	0.128
Mechanism variables: portrait and social status (1=important/very important; 0=otherwise) ***(Survey data)***								
How important for you to have control over others' actions?								
	0.172	0.378	-0.018	0.642	-0.052	0.188	0.005	0.905
How important for you to be influential?								
	0.378	0.485	-0.004	0.939	-0.119**	0.019	0.032	0.514
How important for you to have money and possessions?								
	0.541	0.499	-0.108*	0.037	-0.164***	0.002	-0.125**	0.015
How important for you to work hard and be ambitious?								
	0.963	0.188	-0.026	0.196	-0.012	0.582	-0.029	0.150
How important for you to have fun?								
	0.930	0.255	-0.032	0.197	0.008	0.772	0.001	0.986
How important for you to enjoy life?								
	0.913	0.282	-0.010	0.706	0.034	0.254	0.021	0.471
How important for you to do things that you like?								
	0.930	0.255	-0.010	0.680	0.024	0.382	0.006	0.810
How important: everyone has equal opportunities?								
	0.936	0.246	-0.015	0.537	0.003	0.909	-0.009	0.714
How important: take care of worse-off people?								
	0.889	0.314	-0.009	0.766	0.028	0.419	-0.027	0.377
How important: everyone is treated justly?								
	0.967	0.178	-0.011	0.572	0.004	0.842	-0.013	0.487
How important: there is no conflict?								
	0.949	0.221	-0.021	0.319	0.019	0.447	-0.009	0.709
How important: help others in need?								
	0.941	0.236	0.006	0.787	0.025	0.296	0.033	0.177
How important: prevent environmental pollution?								
	0.982	0.135	-0.022	0.103	0.005	0.801	-0.017	0.221
How important: protect the environment?								
	0.983	0.130	-0.016	0.181	0.009	0.556	-0.011	0.369
How important: respect the nature?								
	0.978	0.148	-0.016	0.260	0.009	0.597	-0.011	0.422
How much do you care about what your peers think of your personal quality?								
	0.600	0.490	-0.007	0.896	-0.022	0.652	0.077	0.126
How much do you care about what your peers think of your wealth?								

	(1) All		(2) Control-Subsidy		(3) Control-Social Norm		(4) Control-Combined	
	Mean	Std. Dev.	Diff in means	P value	Diff in means	P value	Diff in means	P value
	0.284	0.451	-0.062	0.172	-0.092**	0.045	-0.077*	0.088
(Survey data)Mechanism variables: farmer's own attitudes to antibiotic statements (Dummies: 1=agree/strongly agree; 0=otherwise)								
Concept of antibiotic resistance								
	0.692	0.462	0.165***	0.001	0.176***	0.000	0.135***	0.003
Impact on human health								
	0.559	0.497	0.053	0.298	0.092*	0.068	0.149***	0.003
Impact on the environment								
	0.358	0.480	0.050	0.334	0.076	0.131	0.178***	0.000
Responsibility of China's chicken farming industry								
	0.312	0.464	0.061	0.217	0.074	0.128	0.119**	0.012
(Survey data)Mechanism variables: farmer's perceived other farmers' attitudes to antibiotic statements (Dummies: 1=agree/strongly agree; 0=otherwise)								
Concept of antibiotic resistance								
	0.484	0.500	0.057	0.278	0.080	0.123	0.099*	0.053
Impact on human health								
	0.397	0.490	0.426	0.700	0.386	0.232	0.334**	0.024
Impact on the environment								
	0.245	0.430	0.039	0.409	0.046	0.321	0.135***	0.002
Responsibility of China's chicken farming industry								
	0.235	0.424	0.257	0.545	0.219	0.139	0.182**	0.017
Correlation coefficients between farmer's own attitudes (dummy) and perceived other farmers' attitudes (dummy)								
Concept of antibiotic resistance								
	0.5568							
Impact on human health								
	0.6744							
Impact on the environment								
	0.7336							
Responsibility of China's chicken farming industry								
	0.7602							
(Survey data)Mechanism variables: farmer's perceived other villagers' attitudes to antibiotic statements (Dummies: 1=agree/strongly agree; 0=otherwise)								
Concept of antibiotic resistance								
	0.181	0.385	0.008	0.843	0.011	0.781	-0.009	0.820
Impact on human health								
	0.191	0.393	-0.004	0.934	0.028	0.506	0.069*	0.081
Impact on the environment								
	0.115	0.319	-0.013	0.715	0.015	0.668	0.053*	0.085
Responsibility of China's chicken farming industry								
	0.111	0.314	-0.029	0.379	-0.023	0.473	-0.004	0.890
Correlation coefficients between farmer's own attitudes (dummy) and perceived other villagers' attitudes (dummy)								
Concept of antibiotic resistance								
	0.2563							
Impact on human health								
	0.3487							
Impact on the environment								
	0.4202							
Responsibility of China's chicken farming industry								
	0.3941							

Note: In the Panel of "Mechanism variables: portrait values and social status", we define the portrait value is equal to one if the farmer's attitude is important/very important.

Table A7: DiD estimation: treatment effects on natural log transformation of antibiotics cost, mortality and profit.

	Log antibiotics cost (Yuan/broiler)	Log mortality (0-1)	Log profit (Yuan/broiler)
Post	0.184**	1.877***	0.015
	(0.070)	(0.390)	(0.038)
Subsidy	-0.050	-0.037	-0.003
	(0.036)	(0.053)	(0.042)
Social norms	-0.005	-0.030	-0.055
	(0.057)	(0.264)	(0.045)
Combined	-0.059	-0.046	-0.072
	(0.065)	(0.267)	(0.057)
Post*Subsidy	-0.029	0.162*	0.003
	(0.043)	(0.088)	(0.049)
Post*Norm	0.023	0.003	0.006
	(0.088)	(0.536)	(0.065)
Post*Combined	0.069	0.042	0.049
	(0.094)	(0.520)	(0.074)
Controls included	Yes	Yes	Yes
Control means (baseline)	-0.900	-3.309	1.021
Outcome auto-correlation	0.429	0.215	0.064
Observations	1,518	1,518	1,507
R-squared	0.153	0.649	0.043

Notes: Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table A8: DiD estimation: treatment effects on adoption of probiotics and acidifiers – by location

	Full sample	Changzhou		Xuxhou
	Probiotics	Probiotics	Acidifiers	Probiotics
Post	-0.094	-0.160*	0.129***	-0.030
	(0.058)	(0.093)	(0.049)	(0.065)
Subsidy	0.013	-0.001	0.024	0.037*
	(0.019)	(0.033)	(0.073)	(0.021)
Norm	0.001	-0.091	-0.207*	0.068*
	(0.038)	(0.058)	(0.110)	(0.040)
Combined	-0.002	-0.031	-0.193*	0.029
	(0.035)	(0.053)	(0.117)	(0.042)
Post*Subsidy	-0.016	-0.004	0.054	-0.035
	(0.034)	(0.048)	(0.064)	(0.040)
Post*Norm	0.061	0.209*	0.090	-0.060
	(0.074)	(0.118)	(0.104)	(0.080)
Post*Combined	0.045	0.085	0.354***	0.002
	(0.069)	(0.102)	(0.108)	(0.085)
Control vector	Yes	Yes	Yes	Yes
Observations	1,518	696	696	822

Notes: Marginal effects of Probit regressions are reported in the table. Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses (cluster robust standard errors).*** p<0.01, ** p<0.05, * p<0.1.

Table A9: DiD estimation: treatment effects on sanitation indices of whether the implemented sanitation practices meet the required frequency (0-1)

	Barn	Environment	Drinking water	Feeding facilities
Post	0.047	0.310***	0.255***	0.203***
	(0.031)	(0.066)	(0.056)	(0.041)
Subsidy	0.004	0.034	0.035	-0.099**
	(0.028)	(0.044)	(0.079)	(0.047)
Norm	0.023	-0.019	-0.028	-0.019
	(0.029)	(0.058)	(0.077)	(0.061)
Combined	0.021	0.037	-0.002	-0.007
	(0.028)	(0.056)	(0.078)	(0.065)
Post*Subsidy	0.021	-0.029	-0.037	0.122***
	(0.034)	(0.069)	(0.060)	(0.044)
Post*Norm	-0.043	0.116	0.019	-0.045
	(0.042)	(0.074)	(0.074)	(0.062)
Post*Combined	-0.039	-0.002	-0.027	-0.047
	(0.040)	(0.079)	(0.086)	(0.068)
Control vector	Yes	Yes	Yes	Yes
Control mean (baseline)	0.038	0.503	0.331	0.066
Observations	1,518	1,511	1,507	1,501
Outcome auto-correlation	0.078	0.033	0.131	-0.014

Notes: Marginal effects of Probit regressions are reported. Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses (cluster robust standard errors).*** p<0.01, ** p<0.05, * p<0.1.

Table A10: DiD estimations of adoption of probiotics, acidifiers on antibiotic costs, with control for treatment effects.

	Log antibiotic costs			
	Whole sample	Changzhou		Xuzhou
Post	0.213***	0.023	-0.010	0.371***
	(0.065)	(0.046)	(0.042)	(0.088)
Probiotics	0.204***	0.135**		0.224***
	(0.039)	(0.060)		(0.044)
Acidifiers			-0.051	
			(0.050)	
Post*Probiotic	-0.133*	-0.137*		-0.034
	(0.076)	(0.069)		(0.126)
Post*Acidifiers			0.030	
			(0.077)	
Subsidy	-0.053	0.011	0.011	-0.095*
	(0.038)	(0.024)	(0.024)	(0.049)
Social norm	-0.006	-0.008	-0.030	-0.021
	(0.052)	(0.076)	(0.079)	(0.058)
Combined	-0.060	-0.031	-0.045	-0.085
	(0.059)	(0.082)	(0.086)	(0.054)
Post*Subsidy	-0.033	-0.066	-0.064	-0.022
	(0.044)	(0.042)	(0.042)	(0.076)
Post*Social norm	0.013	0.027	0.047	0.008
	(0.086)	(0.082)	(0.081)	(0.111)
Post*Combined	0.063	0.071	0.089	0.046
	(0.090)	(0.073)	(0.080)	(0.112)
Control vector	Yes	Yes	Yes	Yes
Observations	1,518	696	696	822
R-squared	0.164	0.061	0.055	0.206

Notes: Marginal effects of Probit regressions are reported in the table. Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses (cluster robust standard errors).*** p<0.01, ** p<0.05, * p<0.1.

Table A11: DiD estimation: effects of sanitation indices on farmers' antibiotic costs, with control for treatment effects.

	Log antibiotic costs			
Post	0.187**	0.266***	0.202***	0.196***
	(0.068)	(0.091)	(0.070)	(0.068)
House _index	0.007			
	(0.071)			
Post*House index	0.042			
	(0.081)			
Environ index		0.161***		
		(0.039)		
Post*Environ index		-0.151**		
		(0.062)		
Water _index			0.132***	
			(0.025)	
Post*Water index			-0.077*	
			(0.038)	
Facility index				0.034
				(0.087)
Post*Facility index				-0.034
				(0.089)
Subsidy	-0.050	-0.057	-0.059	-0.052
	(0.036)	(0.033)	(0.035)	(0.033)
Social norm	-0.006	-0.003	-0.002	-0.003
	(0.056)	(0.051)	(0.055)	(0.057)
Combined	-0.060	-0.066	-0.058	-0.061
	(0.064)	(0.059)	(0.063)	(0.066)
Post*Subsidy	-0.038	-0.029	-0.027	-0.035
	(0.044)	(0.043)	(0.047)	(0.043)
Post*Social norm	0.017	0.011	0.012	0.012
	(0.088)	(0.085)	(0.090)	(0.086)
Post*Combined	0.066	0.070	0.064	0.065
	(0.094)	(0.090)	(0.097)	(0.094)
Control vector	Yes	Yes	Yes	Yes
Control mean (baseline)	0.038	0.503	0.331	0.066
Observations	1,518	1,511	1,507	1,501
R-squared	0.152	0.169	0.163	0.154

Notes: Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses (cluster robust standard errors).*** p<0.01, ** p<0.05, * p<0.1.

Table A12. Ancova estimation on the 5-score relationship with the agent: 390 farmers with the same agent at baseline and endline.

	Whole sample	Changzhou city	Xuzhou city
subsidy	0.005	-0.101	0.069
	(0.059)	(0.088)	(0.043)
norm	0.182	0.394	0.054
	(0.142)	(0.235)	(0.179)
cross	0.291**	0.420	0.185
	(0.123)	(0.235)	(0.130)
Baseline outcome	Yes	Yes	Yes
Baseline control vector	Yes	Yes	Yes
Constant	3.235***	3.133***	3.123***
	(0.412)	(0.515)	(0.473)
Observations	386	162	224
R-squared	0.128	0.185	0.089

Note: Note: coding of the the 5-score relationship is defined as 1=very bad, 2=bad, 3=neutral, 4=good, 5=very good, which is based on the question "How is your relationship with your technician". Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table A13. OLS estimation: communication score (0-6) with other farmers in the agent group (in the last 3 months) about the six topics: probiotics, acidifiers, disinfection, broiler daily management, how to reduce drug cost and how to use drugs for sick broilers.

VARIABLES	Whole sample	Changzhou city	Xuzhou city	Whole sample	Changzhou city	Xuzhou city
Subsidy	-0.037	-0.171	0.043	0.001	-0.170	0.131
	(0.209)	(0.347)	(0.211)	(0.207)	(0.330)	(0.208)
Norm	-0.263	0.257	-0.721	-0.242	0.238	-0.612
	(0.358)	(0.542)	(0.436)	(0.344)	(0.511)	(0.405)
Cross	-0.227	0.330	-0.708	-0.233	0.264	-0.651
	(0.380)	(0.584)	(0.476)	(0.364)	(0.559)	(0.451)
Baseline control vector	No	No	No	Yes	Yes	Yes
Endline outcome mean	2.279	2.270	2.287	2.279	2.270	2.287
Observations	759	348	411	757	347	410
R-squared	0.004	0.011	0.036	0.022	0.049	0.054

Note: Robust standard errors clustered at endline agent level (shown in parentheses); *** p<0.01, ** p<0.05, * p<0.1. First, we create six dummy variables if the farmer reported to talk about the six topics, respectively. Then, we define the outcome variable as the sum of six dummies. Baseline control vector includes household characteristics (gender, age, education dummy indicating whether the household head graduated from middle school, the degree of specialization in broiler farming measured by the rate of broiler farming income in total household income), farm characteristics (whether the production scale is larger than 20,000 broilers/production cycle, the number of household laborers engaged in broiler rearing, years of experience in broiler rearing, and the number of broiler types), the degree of risk aversion of the household head, and location (distance to the nearest neighboring farmer in the sample and location fixed effect).

Table A14. OLS estimation on the number of people known from random matching

VARIABLES	Whole sample	Changzhou city	Xuzhou city	Whole sample	Changzhou city	Xuzhou city
Subsidy	-0.078	-0.132	0.003	-0.053	-0.104	0.025
	(0.105)	(0.185)	(0.113)	(0.092)	(0.169)	(0.118)
Norm	0.164	0.117	0.218	0.194	0.071	0.257
	(0.241)	(0.373)	(0.212)	(0.194)	(0.350)	(0.212)
Cross	0.157	0.297	0.063	0.188	0.297	0.093
	(0.263)	(0.393)	(0.178)	(0.191)	(0.353)	(0.155)
Baseline control vector	No	No	No	Yes	Yes	Yes
Constant	1.247***	1.614***	0.918***	1.783***	4.004***	0.672
	(0.179)	(0.277)	(0.167)	(0.340)	(0.824)	(0.441)
Endline outcome mean	1.311	1.690	0.990	1.311	1.690	0.990
Observations	759	348	411	757	347	410
R-squared	0.008	0.015	0.009	0.124	0.090	0.019

Note: Robust standard errors clustered at endline agent level (shown in parentheses); *** $p<0.01$, ** $p<0.05$, * $p<0.1$. In endline survey, we matched each respondent with four randomly selected farmers from their agent group and asked them whether they know the match. The outcome variable is the number of matches known by the farmer.

Baseline control vector includes household characteristics (gender, age, education dummy indicating whether the household head graduated from middle school, the degree of specialization in broiler farming measured by the rate of broiler farming income in total household income), farm characteristics (whether the production scale is larger than 20,000 broilers/production cycle, the number of household laborers engaged in broiler rearing, years of experience in broiler rearing, and the number of broiler types), the degree of risk aversion of the household head, and location (distance to the nearest neighboring farmer in the sample and location fixed effect).

Table A15. Social pressure variables: perceived attitude of other farmers to the antibiotic statements.

	(1)	(2)	(3)	(4)
	ABR	Human	Envir	Respon
Subsidy	-0.005	-0.011	0.017	-0.028
	(0.054)	(0.062)	(0.041)	(0.041)
Norm	0.083	0.063	0.059	0.014
	(0.066)	(0.070)	(0.066)	(0.066)
Cross	0.009	0.064	0.102	0.045
	(0.068)	(0.066)	(0.066)	(0.058)
Baseline outcome	Yes	Yes	Yes	Yes
Baseline control vector	Yes	Yes	Yes	Yes
Observations	757	757	757	757

Note: Marginal effects of logit regressions are reported in the table; Robust standard errors clustered at endline agent level (shown in parentheses); *** p<0.01, ** p<0.05, * p<0.1. Dependent variabes are dummy variables (=1 if the farmer thinks other farmers agree/strongly agree, otherwise=0) of whether perceived other farmers' agreeing on antibiotic resistance (**ABR**), hazards to humans (**Human)**, hazards to the environment (**Envir**), and the responsibility of poultry farming (**Respon**).

Table A16. Whether the effects of the interventions varies by the farmer's Biospheric values (environmental preferences)

	Less biospheric				More biospheric			
	(4)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln_antibiotics	Probiotics	Acidifiers	Sani index	ln_antibiotics	Probiotics	Acidifiers	Sani index
Subsidy	-0.082	-0.006	0.391***	-0.050	-0.071	-0.011	0.090	-0.009
	(0.088)	(0.041)	(0.095)	(0.049)	(0.051)	(0.025)	(0.104)	(0.036)
Norm	0.022	-0.005	0.235*	0.024	-0.001	0.068	-0.086	0.019
	(0.108)	(0.061)	(0.140)	(0.054)	(0.058)	(0.043)	(0.109)	(0.032)
Combined	0.027	0.030	0.505***	-0.061	0.048	0.025	0.237**	0.025
	(0.118)	(0.053)	(0.155)	(0.046)	(0.055)	(0.047)	(0.110)	(0.027)
Constant	-0.396***				0.088			
	(0.137)				(0.150)			
Baseline outcome and controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	347	347	82	331	410	410	265	402
R-squared	0.149				0.328			

Note: Above the medium of biospheric values is defined as more biospheric. Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table A17. Whether the treatment effects vary with the farmer's egoistic values (status concerns)

	Less egoistic				More egoistic			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln_antibiotics	Probiotics	Acidifiers	Sani index	ln_antibiotics	Probiotics	Acidifiers	Sani index
Subsidy	-0.135***	-0.021	0.134	-0.017	-0.005	0.013	0.033	-0.041
	(0.040)	(0.027)	(0.121)	(0.028)	(0.063)	(0.038)	(0.103)	(0.052)
Norm	-0.045	0.043	0.065	0.032	0.081	0.043	-0.204**	0.002
	(0.080)	(0.039)	(0.139)	(0.040)	(0.069)	(0.041)	(0.080)	(0.047)
Combined	0.021	-0.002	0.339**	-0.034	0.042	0.057	0.119	-0.027
	(0.065)	(0.043)	(0.153)	(0.029)	(0.082)	(0.050)	(0.133)	(0.060)
Constant	-0.111				-0.200			
	(0.157)				(0.177)			
Baseline outcome and controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	418	418	187	405	339	339	160	328
R-squared	0.259				0.209			

Note: Above the medium of egoistic values is defined as more egoistic. Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table A18. Whether the treatment effects of the interventions vary with the farmer's risk preference

	Below the medium				Above the medium (more risk-averse)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln_antibiotics	Probiotics	Acidifiers	Sani index	ln_antibiotics	Probiotics	Acidifiers	Sani index
Subsidy	-0.080	-0.045	0.072	-0.038	-0.101	0.035	0.105	-0.012
	(0.048)	(0.044)	(0.047)	(0.037)	(0.084)	(0.033)	(0.150)	(0.036)
Norm	0.011	0.046	-0.002	-0.003	0.007	0.058	-0.064	0.038
	(0.076)	(0.032)	(0.101)	(0.043)	(0.075)	(0.051)	(0.112)	(0.042)
Combined	0.027	0.029	0.242*	-0.041	0.015	0.026	0.291***	-0.002
	(0.066)	(0.043)	(0.127)	(0.035)	(0.093)	(0.051)	(0.108)	(0.042)
Constant	-0.031				-0.310			
	(0.215)				(0.191)			
Baseline outcome and controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	390	390	203	377	367	367	144	331
R-squared	0.253				0.218			

Note: Above the medium of risk preferences is defined as more risk-averse. Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table A19. Whether the effects of the interventions vary with the farming scale.

	Below the medium				Above the medium			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln_antibiotics	Probiotics	Acidifiers	Sani index	ln_antibiotics	Probiotics	Acidifiers	Sani index
Subsidy	-0.077	0.057	0.853***	-0.045	-0.060	-0.053	0.090	-0.004
	(0.067)	(0.054)	(0.190)	(0.043)	(0.038)	(0.039)	(0.083)	(0.038)
Norm	0.004	0.065		-0.010	0.021	0.033	-0.041	0.039
	(0.096)	(0.067)		(0.037)	(0.073)	(0.042)	(0.102)	(0.036)
Combined	0.026	0.080	0.886***	-0.051	0.037	-0.012	0.251**	0.008
	(0.095)	(0.081)	(0.198)	(0.045)	(0.069)	(0.040)	(0.117)	(0.027)
Constant	-0.536**				-0.181			
	(0.201)				(0.286)			
Baseline outcome and controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	380	371	24	355	377	377	310	345
R-squared	0.147				0.359			

Note: Split the sample according to whether above the medium of farming scale. Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

Table A20. Whether the treatment effects vary with the farmer's income from broiler farming

	Below the medium				Above the medium			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln_antibiotics	Probiotics	Acidifiers	Sani index	ln_antibiotics	Probiotics	Acidifiers	Sani index
Subsidy	-0.092*	-0.002	0.543***	-0.795	-0.063	-0.005	0.059	0.003
	(0.051)	(0.037)	(0.105)	(0.000)	(0.042)	(0.026)	(0.099)	(0.039)
Norm	-0.061	0.055	0.144	-0.776	0.069	0.035	-0.076	0.087**
	(0.089)	(0.052)	(0.159)	(0.000)	(0.070)	(0.037)	(0.097)	(0.037)
Combined	-0.012	0.045	0.397**	-0.809	0.062	0.012	0.236**	0.024
	(0.097)	(0.071)	(0.155)	(0.000)	(0.060)	(0.033)	(0.113)	(0.025)
Constant	-0.430**				-0.006			
	(0.206)				(0.190)			
Baseline outcome and controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	376	376	67	323	381	381	280	373
R-squared	0.181				0.317			

Note: Split the sample according to whether above the medium of farmer's income from broiler farming. Standard errors are clustered at the agent level (endline agent group) and are shown in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

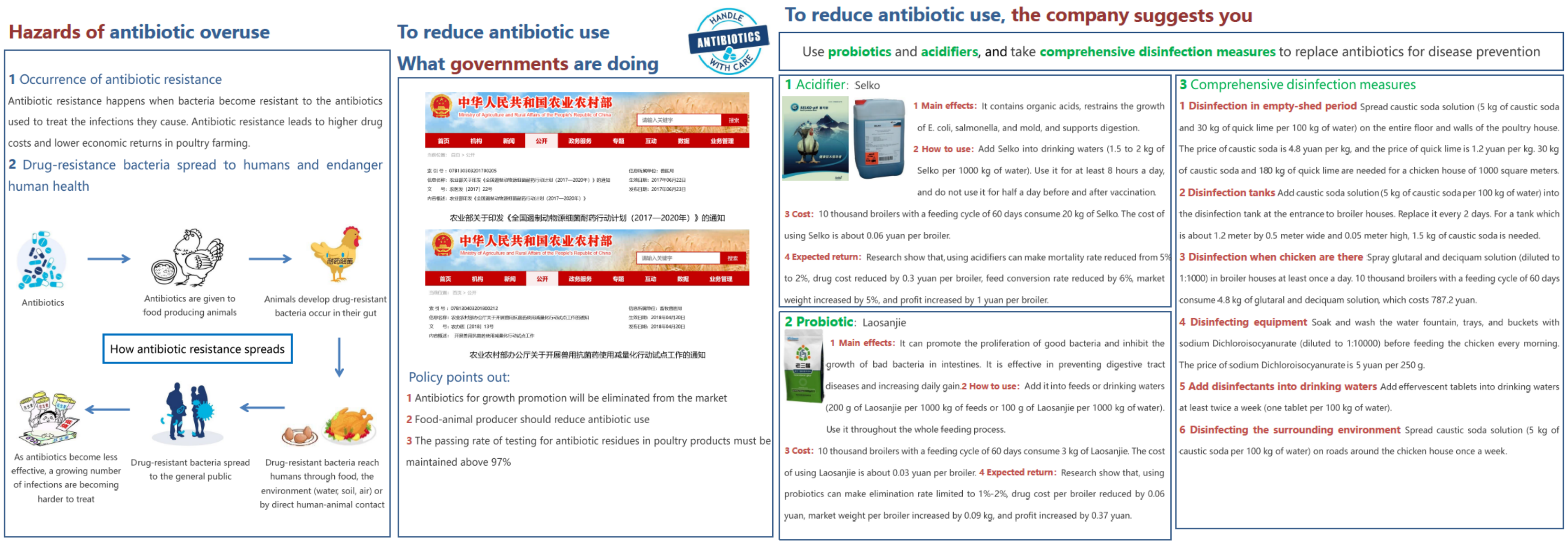


Figure A4. Poster of the information intervention.

The observe side (20cm*5cm, print size standard):

Coupon

100yuan

No. 001
Farmer Name

Equivalent to 2 bags of probiotics (500g/bag) or 1/3 barrel of acidifier (10kg/barrel)

The date of using this coupon: 31.05.2020

The reverse side:

Instruction for use:

- Valid before the expiry data 31.05.2021.
- For only one-time use.
- Please give this coupon to the company when you collect probiotics/acidifier.
- The company has the record of who receive the coupon. After settling with the company, your expenses of buying acidifiers/probiotics will be deducted by 100 yuan automatically from your account.

Figure A5. A sample of the designed couple for subsidy treatment.

Name: XXX
Phone number: XXX
Address: XXX Village

Photo of the model farmer

Breeding efficiency:
Breed: Qingjiaoma chicken
N of chicks: 8050 heads
Market rate: 90.00%
Cost of antibiotics: 0.53 yuan/chick
Cost of drugs: 0.97 yuan/chick

Why is he so successful? Have a look:

I am XXX, and my wife is XXX. We have six years of experience in broiler breeding. At the beginning, about 20,000 chickens were raised, and now the scale is about 26,000. If you want the medicine cost to be low, you have to make the chickens less sick.

The temperature must be well controlled for young chicks. Otherwise, chickens are easy to get sick in the later stage.

To control the temperature, you don't have to look at the thermometer all the time. You can look at the distribution of chickens:

If chickens huddle together, the temperature is too low.
If chickens are equally distributed, the temperature is just right.
If chickens cluster beside the walls, the temperature is too high.

Chickens with bad ventilation are prone to respiratory diseases. At first, we only tried to keep temperature constant and ignored ventilation in winters. As a result, chickens got very serious respiratory diseases and the medicine cost was very high.

In the past, we listened to the suggestions given by other experienced farmers and used antibiotics to prevent intestinal diseases. Now recommended by the company, we use acidifier and probiotics. They are as effective as antibiotics.

If chickens are ill, we use medicine according to the requirements of the agent.

Tingting's Wechat ID: XXX
"To reduce antibiotics" WeChat group: XXX
You are welcome to contact them via Wechat (or calling)!

Name: XXX
Phone number: XXX
Address: XXX Village

Photo of the model farmer

Breeding efficiency:
Breed: Qingjiaoma chicken
N of chicks: 24780 heads
Market rate: 94.79%
Cost of antibiotics: 0.49 yuan/chick
Cost of drugs: 0.76 yuan/chick

Why is he so successful? Have a look:

I am XXX, and my wife is XXX. We started raising in 2014 and raised 20,000 chickens in two sheds at the beginning. Now we have three sheds and raise 34,000 chickens. The medicine cost is significantly lower than before, mainly thanks to good temperature control and ventilation, as well as use of acidifier and probiotics.

The temperature must be well controlled. We used to use ground stove and it was not good at keeping temperature. Now it becomes much better with a hot-blast stove.

In the past, the company didn't provide acidifiers or probiotics. Now we use them to prevent intestinal diseases and the cost of antibiotics is reduced significantly. When chickens are not ill, we basically do not use antibiotics.

When the temperature is well controlled, the ventilation and disinfection are well done, and the acidifier and probiotics are used regularly, chickens seldom get sick. Once chickens get sick, we use medicines as required by the technician.

Yagang's Wechat ID: XXX
"To reduce antibiotics" WeChat group: XXX
You are welcome to contact them via Wechat (or calling)!

Figure A6. The pamphlet of information on one model farmers in Changzhou.

Number	Option A		Option B	
	The first round			
	Probability 30%	Probability 70%	Probability 10%	Probability 90%
1	20	5	34	2.5
2	20	5	37.5	2.5
3	20	5	41.5	2.5
4	20	5	46.5	2.5
5	20	5	53	2.5
6	20	5	62.5	2.5
7	20	5	75	2.5
8	20	5	92.5	2.5
9	20	5	110	2.5
10	20	5	150	2.5
11	20	5	200	2.5
12	20	5	300	2.5
13	20	5	500	2.5
14	20	5	850	2.5
Number	The second round			
	Probability 90%	Probability 10%	Probability 70%	Probability 30%
15	20	15	27	2.5
16	20	15	28	2.5
17	20	15	29	2.5
18	20	15	30	2.5
19	20	15	31	2.5
20	20	15	32.5	2.5
21	20	15	34	2.5
22	20	15	36	2.5
23	20	15	38.5	2.5
24	20	15	41.5	2.5
25	20	15	45	2.5
26	20	15	50	2.5
27	20	15	55	2.5
28	20	15	65	2.5
Number	The third round			
	Probability 50%	Probability 50%	Probability 50%	Probability 50%
29	12.5	-2	15	-10.5
30	2	-2	15	-10.5
31	0.5	-2	15	-10.5
32	0.5	-2	15	-8
33	0.5	-4	15	-8
34	0.5	-4	15	-7
35	0.5	-4	15	-5.5

Figure A7. Design of the risk preference experiment.

Questions of the quiz in social norm WeChat groups:
Q1: What you should do about controlling temperature, ventilation and humidity of the chicken house, when taking care of baby chicks?
Answer: keep the room temperature constant, ventilate the chicken house regularly, keep a relatively high humidity for wet deposition of dust.
Q2: How to decide the room temperature of the chicken house except using a thermometer?
Answer: observe distribution of the chicks: at a suitable room temperature, chicks should distribute evenly, look active and eat well.
Q3: What disease will the chickens catch without good ventilation?
Answer: respiratory disease.
Q4: When would chickens easily get intestinal diseases? How can you tell your chickens are getting intestinal diseases?
Answer: When chickens are 40-days old. There are foamy or row feces of chickens on the floor.
Q5: What drugs can prevent chickens from getting intestinal diseases except antibiotics?
Answer: probiotics or acidifiers.
Q6: What diseases can be prevented if using probiotics?
Answer: intestinal diseases such as chicken diarrhea and enteritis.
Q7: What is the recommended dosage of probiotics: how many grams of probiotics per 1000 kg water and per 1000 kg feed?
Answer: 100 g; 200 g.
Q8: how to prevent respiratory diseases and viral infection of chickens?
Answer: implement sanitation and dust deposition.
Q9: Which disinfectant can be applied with chickens in the barn? What is the application dosage?
Answer: Weike disinfectant; dilute it with water at a ratio of 1: 1000.
Q10: What is the regulated disinfestation frequency (with chickens in the barn)?
Answer: once a day (regulated by the company); twice a week (done by the model farmers)
Q11: What disinfectants can be used to disinfect drinking water for chickens?
Answer: iodophor and effervescent tablets.
Q12: What is the recommended dosage of effervescent tablets for water disinfection?
Answer: add one effervescent tablet in 100 kg water.
Q13: How to disinfect the road next to your chicken house? At which frequency?
Answer: splash water with 5% caustic soda over the road once a week.
Q14: What kinds of disinfection should be done before you feed chickens in the morning?
Answer: disinfect the drinking fountains, feed trays and feed barrels.
Q15: How to disinfect feeding materials (drinking fountains, feed trays and feed barrels)?
Answer: wash them with Mieduling (1 g/10 L water).
Q16: How to disinfect the chicken house in empty shed period?

Answer: disinfect the whole floor with 5% caustic soda water and whitewash the walls.
Q17: What should be added in the tank at the entrance of the chicken house?
Answer: water with 5% caustic soda.
Q18: what hazards would antibiotics abuse cause?
Answer: promote the development of antibiotics-resistant bacteria, which would harm the benefits of rearing broilers. The generated antibiotics-resistant bacteria can be transmitted into human body and harm human health.
Q19: What measures should be taken to reduce antibiotics use (list three measures)?
Answer: disinfect the chicken house and feeding materials according to the recommended methods and frequency; use alternative drugs such as probiotics and acidifiers for disease prevention; follow the technician's instruction (dosage, use method) when using antibiotics.