Increasing Local Disease Preparedness and Surveillance Capacity for Global Health Security: A Cluster-Randomised Control Trial of a One Health Program

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ABSTRACT

Objectives: Most low-income countries are characterized by poor health infrastructures and lack systems needed to timely detect and control disease outbreaks, such as the 2014-16 Ebola Viral Disease and COVID-19. In such contexts, a "One Health" approach, which involves investing in both human and animal health systems, plausibly improves local health outcomes by enabling early detection of zoonotic diseases before they are transmitted to humans, and by timely triggering a health system response needed to mitigate possible outbreaks. There is an urgent call to translate One Health into action and create inclusive and sustainable policies. There is, however, little direct evidence on the gains from One Health approaches. We contribute here by using a randomised intervention to assess the impact of a participatory community-based One Health program.

Evidence before this study: A 2016 systematic review searched Scopus, PubMed, and ISI Web of Science using the term "One Health", restricting publication date between 2003 and 2015.[1] The search yielded 1,839 unique articles, but only four evaluated a One Health intervention using quantitative metrics. We performed the same search on 10 April 2023. Reflecting the burgeoning interest in One Health, we found an additional 9,715 unique articles. In total, only 17 articles, however, evaluated a One Health intervention implemented in real-world settings, utilizing quantitative metrics. Furthermore, these studies did not employ experimental methods to assess impact, relied on datasets with often only few observations, and focused exclusively on disease incidence. In the Supplementary Material (Appendix A), we provide a flowchart of the literature review and summarize these 17 related studies.

Contribution: This study is the first cluster-randomised trial to assess the impact of a participatory community-based intervention establishing local health platforms employing a One Health approach. We evaluate the intervention at scale and explore the impact of the program on human health, but also on key intermediary outcomes like animal health and animal and human health behaviours.

Design: Cluster-randomised control trial.

Setting: 363 villages in rural Sierra Leone

Participants: The Sierra Leone government and communities recruited, trained and installed Community Animal Health Workers (CAHWs) to work alongside Community Health Workers (CHWs) in 300 randomly selected rural villages in Sierra Leone. Another 63 villages were randomly selected as control sites and had CHWs exclusively. CAHWs provided essential animal health services, disseminated information regarding animal and human health best practices, and actively participated in surveillance efforts by reporting suspected disease symptoms to government supervisors.

Main outcome measures: Survey based measures of human health, as well as key intermediary outcomes; including animal health, animal and human health-related behaviours, integration into public services, and household wealth.

Results: In July and August 2017, the community-based One Health program successfully recruited, trained and installed CAHWs across 287 villages. Throughout the program's duration, spanning from July 2017 to July 2019, the CAHWs reported on 19,283 suspected disease-related events. Using survey data from over 2,500 respondents, collected in March and April 2020, we found no evidence for impacts on human health (-0.008 Standard Deviation Units (SDU), 95% CI -0.148, 0.133). The program did however significantly improve core intermediary outcomes, including animal health (0.164 SDU, 95% CI 0.017, 0.311), animal husbandry practices (0.255 SDU, 95% CI 0.087, 0.424), human health behaviours (0.187 SDU, 95% CI 0.025, 0.348), integration into public services (0.339 SDU, 95% CI 0.137, 0.541), and household wealth (0.163 SDU, 95% CI 0.053, 0.273).

Conclusions: Participatory community-based One Health interventions can serve as a guide for policymakers that seek to strengthen the national health systems by improving disease surveillance and preventative practices that are expected to increase health security nationally and globally. More research is needed to understand how the magnitude, modality, and timing of the program and background conditions may shape program impact on human health.

Trial registration: The trial was registered at the National Trail Registry (#21660), which is part of the ICTRP, and OSF (https://osf.io/9xfv3).

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INTRODUCTION

An estimated three quarters of emerging infectious diseases spill over from wild and domestic animals to humans.[2] These zoonotic diseases include Rabies, Salmonella infection, Q-Fever, Anthrax, Brucellosis, Lyme disease, Ringworm, Ebola Viral Disease, Avian Influenza, West Nile virus, Nipah virus, and Severe Acute Respiratory Syndrome (SARS, and SARS-CoV-2 or COVID-19 virus). The threat of zoonotic diseases is rising given the increased pressures from population growth, rapid urbanisation, intensified livestock production, deforestation, and increased complexity in food chains.[3–5]

Low-income countries bear a disproportionate share of the economic and health consequences arising from disease outbreaks. In these countries, the majority of people are dependent on agriculture, including livestock care and hunting activities. Many live in forest edge areas and come in close contact with wildlife. In addition, access to health care is often limited. Consequently, the rural poor face a dual health burden. Given this context, the risk of zoonotic diseases is high and urgent investments in early detection and preparedness is needed. This urgency has sparked calls for the active implementation of One Health principles and substantial investments in global health security that emphasize inclusivity, equity, and sustainability.[6–8] Indeed, because zoonoses are diseases of animals that can infect humans, “veterinarians, physicians, and public health officials need to work more closely together to control, prevent, and understand them”.[9]

In 2014, the Global Health Security Agenda (GSHA) was established with the aim of mitigating the incidence and impact of infectious disease threats. The GHSA, an international partnership of nearly 70 countries and large international organisations, assesses the resilience of public health systems and provides recommendations for improvements. These recommendations include investments in training programs and early detection capabilities through robust surveillance systems for both animal and human diseases. The limited detection and preparedness capacity in low-income countries can significantly affect global health. Therefore, investment in the health systems of these countries is needed to promote both local and global health.[6]

Our research aligns closely with recommendations put forth by the One Health High-Level Expert Panel,[7] which stressed the need to investigate the effectiveness of an inclusive, equitable, and sustainable solution in tackling health security challenges. We collaborated with the Ministries of Health and Sanitation (MoHS) and the Ministry of Agriculture (MAF) of the Government of Sierra Leone (GoSL) to design and implement a two-year community-based One Health program. This program serves as a pioneering model for the practical implementation of the One Health approach at the community level. The program worked with communities to recruit, train and install new Community Animal Health Workers (CAHW) and set up a platform to facilitate interactions amongst animal health workers, human health workers, and the community.

Since the 2014-2016 Ebola crisis, the Government of Sierra Leone has been working to improve the national health system by increasing the capacity for early detection of zoonotic diseases, and the responsiveness of the health system to the threats of zoonotic diseases. Part of this process has been to invest in community-based surveillance to increase early detection of events linked to infectious diseases in animals that can trigger spillover events. By training community-level animal health workers to work alongside human health workers, the government intended to increase capacity to prevent the emergence and spread of diseases by promoting good animal husbandry and human health practices. We use a cluster-randomised trial to evaluate the One Health impacts on human health, and a set of intermediary outcomes: animal health, animal husbandry behaviours, human health behaviours, integration into public services and household wealth. In addition, we explore moderators for disease reporting (attitudes towards institutions, attitudes towards reporting, and relations with CHWs).

RESULTS

Between July 2017 and July 2019, the One Health program was successfully implemented in 287 of 300 villages (96%). The other 13 villages did not have an eligible CAHW. CAHWs were recruited between July and August 2019, and trained during September and November. Baseline data were collected before the start of the program among eight household heads per village: six randomly selected households plus two households owning most animals within the community (identified by the village chief). In total, the baseline data include 2,513 households. Endline data were collected between March and April 2020 from 2,520 households in 344/363 villages; of which 1,921 (76%) were the same respondent at baseline. **Figure 1** presents the trial profile.

Figure 1 here

Administrative data indicate that the One Health program successfully recruited, trained and installed a CAHW in all 287 program villages with an eligible CAHW. Endline survey data corroborate that the program was well implemented. **Table 1** shows that in treatment villages, 80% of households know somebody in the community they can turn to for questions related to animal health, 75 percentage points (pp) more than in control villages. Similarly, households in treatment villages were 76pp more likely to say that there was someone in the community able to treat sick animals. In addition, in treatment villages, respondents were much more likely to mention that there was someone in the community that records sick animals and reports to MAF (72% versus 2%), or that there is a committee in the community specifically for human and animal health (50% versus 17%).

Table 1 here

CAHWs actively engaged in disease symptom surveillance reporting. Between December 2017 (the first month after which all CAHW were installed) and October 2019, 19,283 reports were submitted to MAF supervisors. The majority (75%) of reports contained suspected symptoms in small ruminants (goats and sheep), followed by birds (e.g. chickens, ducks and fowls: 18%) and cows (11%). Respiratory problems, feet or leg problems, and diarrhea were the most common symptoms reported for cows, sheep and goats. Weakness, ruffled feathers, and appetite loss were the most often reported symptoms for birds (for a breakdown of symptomatic events by animal see Appendix C).

Table 2 presents baseline information for survey households in treatment and control villages. Given that the survey targeted the head of the household, it is not surprising that the majority of respondents were male (77%). The typical respondent was married (80%), around 45 years old and had lived in the village for about 28 years. About 20% of respondents received any formal education, and 15% were literate. About half of the households were Christian (51%), while the other half were Muslim (49%). The vast majority of respondents (89%) care for animals (predominantly chickens, goats and sheep), with an average flock size of eleven animals.

On average, almost one child under five died in each second community in the previous year. In addition, 23% of all households had at least one child that suffered from diarrhea, 40% from cough, and 72% from fever during the three months preceding the baseline survey. Animal health was also poor, with a high incidence of goats plague (affecting 52% of those that care for small ruminants) and Newcastle disease (affecting 45% of those that care for birds). In addition, during the year preceding the survey, about 60% of animal rearing household experienced the death of an animal and 30% experienced animal stillbirths. While most respondents would "probably" to "definitely" visit the Peripheral Health Unit (PHU) when someone in the household was sick, few had access to clean water (31%). In terms of wealth, the typical household owns 8.97 animals and 20.42 assets (the summation of assets over a list of 15 different assets), and goes 0.79 days without eating anything because there was not enough food.

Table 2 here

Table 3 presents results on the impact of the One Health program, where we focus on respondents that were interviewed both before and after the program (Supplementary Material Appendix D shows that we obtain similar results when focussing on the full endline sample). We found no evidence for treatment effects on the overall human health index (-0.009 SDUs [95% CI --0.148 to 0.133]), or the components (incidence of under 5 mortality, diarrhea, cough and fever in adults and children in the household).

In contrast, we found important impacts on many intermediary indicators. Overall, animal health improved, for those households with animals at baseline, with 0.164 SDUs [95% CI 0.017, 0.311].

Table 3 here

We also found strong improvements in animal husbandry practices (mean index difference 0.255 SDUs [95% CI 0.087, 0.424]). Unpacking this overall effect, respondents' knowledge about the correct response to PPR symptoms improved by 30% ($p < 0.01$), and their knowledge of overall good animal husbandry practices increased by 27% ($p < 0.01$). Respondents also improved treatment of the mother after a stillbirth (7.9pp, $p < 0.01$).

The One Health program also had an overall positive impact on human health behaviours (mean index difference 0.187 SDUs [95% CI 0.025, 0.348]). More people would visit a PHU for preventative care (10% improvement, $p < 0.01$), and more children under 5 years had completed their full vaccination cycle (5.8%, $p < 0.05$). Treatment households were also 6.2pp more likely to undertake actions to clean water ($p < 0.05$). **Figure 2** suggests that program impact on good human health behaviours may be moderated by households' relationship to the CHW. In the Supplementary Material (Appendix E), we show there are no differences in these relationships between the treatment and control villages.

The program had a strong positive impact on households' integration into to public services by government or NGOs (mean index difference 0.339 SDUs [95% CI 0.137, 0.541]; **Table 3**). Households in program villages are 9.9pp more likely to mention that somebody from the MoHS has visited the community in the preceding six months ($p < 0.01$), and 10.2pp more likely to mention that somebody from MAF has visited the community ($p < 0.01$). Respondents in treatment villages are 8.4pp more likely to say that there has there been a development project in their community in the preceding year ($p < 0.01$). Program impact on integration into public services may be moderated by households' attitudes towards institutions and reporting (**Figure 2**). In the Supplementary Material (Appendix E), we show that the program had a positive and statistically significant impact on household attitudes towards reporting (0.272 SDU, 95% CI [0.114, 0.430]), but no overall impact on attitudes towards institutions (-0.136 SDU, 95% CI [-0.299, 0.027]).

Finally, the data also provide evidence for an overall positive effect on household wealth (mean index difference 0.163 SDUs [95% CI 0.053, 0.273]). Treatment household owned 23.9% more animals (7.32 versus 9.62 animals, $p < 0.01$), and 4.3% more assets (22.13 versus 23.13 animals, $p < 0.01$) compared to those in control villages. In the Supplementary Material (Appendix F), we show that household ownership of small ruminants, birds and cows increased.

As part of the data collection, in each village, we interviewed eight households: six randomly selected households, and two households holding most animals. As expected, results were generally stronger for the latter group (see Supplementary Material Appendix G).

The endline survey was implemented just before the first COVID-19 case was recorded in Sierra Leone. To test whether the program had increased community preparedness, we collaborated with the MoHS to distribute leaflets with COVID-19 information to CHWs in all study villages two weeks before the endline survey. If the program increased information dissemination within villages, we would expect to see higher levels of awareness and knowledge of the disease among respondents in treatment villages. The survey contained questions to learn about respondents' COVID-19 knowledge: whether they have heard of the virus, how it spreads, what the symptoms are, and what precautionary actions can be taken. In the Supplementary Material (Appendix H), we show that there were no differences between respondents in treatment and control villages. About 66% of respondents in control villages had already heard about COVID-19, and knowledge levels were overall high.

DISCUSSION

The data provide evidence that community-based One Health approaches offer a promising solution to making communities better prepared for zoonotic disease outbreaks. We find that the program was successful in recruiting, training and installing new Community Animal Health Workers, who subsequently actively engaged in disease symptom surveillance reporting. Although the program did not generate positive impacts on human health, the program did improve many relevant intermediary indicators: animal health, behaviours related to animal husbandry and human health, integration in to public services and increased household wealth. These factors ultimately increase community preparedness and lower the risk of disease transmission. This study thus provides important lessons for translating One Health into practice.[6,7]

Few other studies explore the impact of the One Health approach in real-world settings, and those that do are more limited in scope compared to this study and do not employ experimental methods (see the Supplementary Material (Appendix A) for an overview). In Canada, increased access to veterinary services helped decrease parasite levels in dogs.[10] Animal health campaigns and increased surveillance improved animal health in Australia.[11] In Sri Lanka, a vaccination and dog sterilization campaign increased the acceptance of dogs roaming in society.[12] Riley and colleagues found no changes in the number of people presenting to the health clinic for a dog bites.[11] While this study found no overall effects of the program on human health, other studies did find improvements in human health outcomes such as disability-adjusted life years,[12] disease incidence[13–16] and deaths[17,18]. Human health challenges are pervasive in much of sub-Sahara Africa and future work should investigate how increases in human and animal health practices can translate into better health outcomes.

Our study has several limitations. First, the data come from seven rural Chiefdoms in eastern Sierra Leone, which were specifically chosen because of the large share of households that own or live with animals. Among these, we focus solely on those villages with community health workers before program onset. The sample may thus not be representative of all villages, and the results we report may thus not capture the impact of a One Health programs on the typical Sierra Leonean household or elsewhere. However, the study's sample consists of subsistence farmers with little access to markets, weak public services, and who are at risk of spillover diseases from wild and domestic animals. Hundreds of millions of people live in similar conditions around the world. Lessons from our study are hence relevant for other One Health interventions, especially those implemented in rural locations.

Second, the outcomes we study are measured using in-person surveys, eliciting information from respondents who may respond strategically. Such bias, however, is muted as each of the outcome families we report on are made up out of many measures often covering different dimensions of the outcome family. In addition, many outcomes rely on knowledge-based questions, which were verified by our enumerators directly.

In conclusion, One Health is increasingly promoted as a key tool for policy makers and donors in public health, particularly in the fight against zoonotic diseases. Yet, few One Health interventions have been implemented and assessed for impact. We are the first randomised study to explore the impact of a One Health program on human and animal outcomes. This study shows that the implementation of a community-based intervention that directly builds on the One Health concept can successfully improve many margins relevant for increasing global health security.

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Author Contributions

K.G., N.M. and M.V. conceived this study and initiated interaction with MoHS and MAF. All authors designed the study. K.G., N.M., M.A.J., M.V. and S.J. led the data collection. M.V. and P.W. did the data cleaning and statistical analyses. All the authors interpreted data, drafted and critically revised the article and approved the final version.

Competing Interests Statement

We declare that none of the authors have competing financial or non-financial interests as defined by Nature Portfolio.

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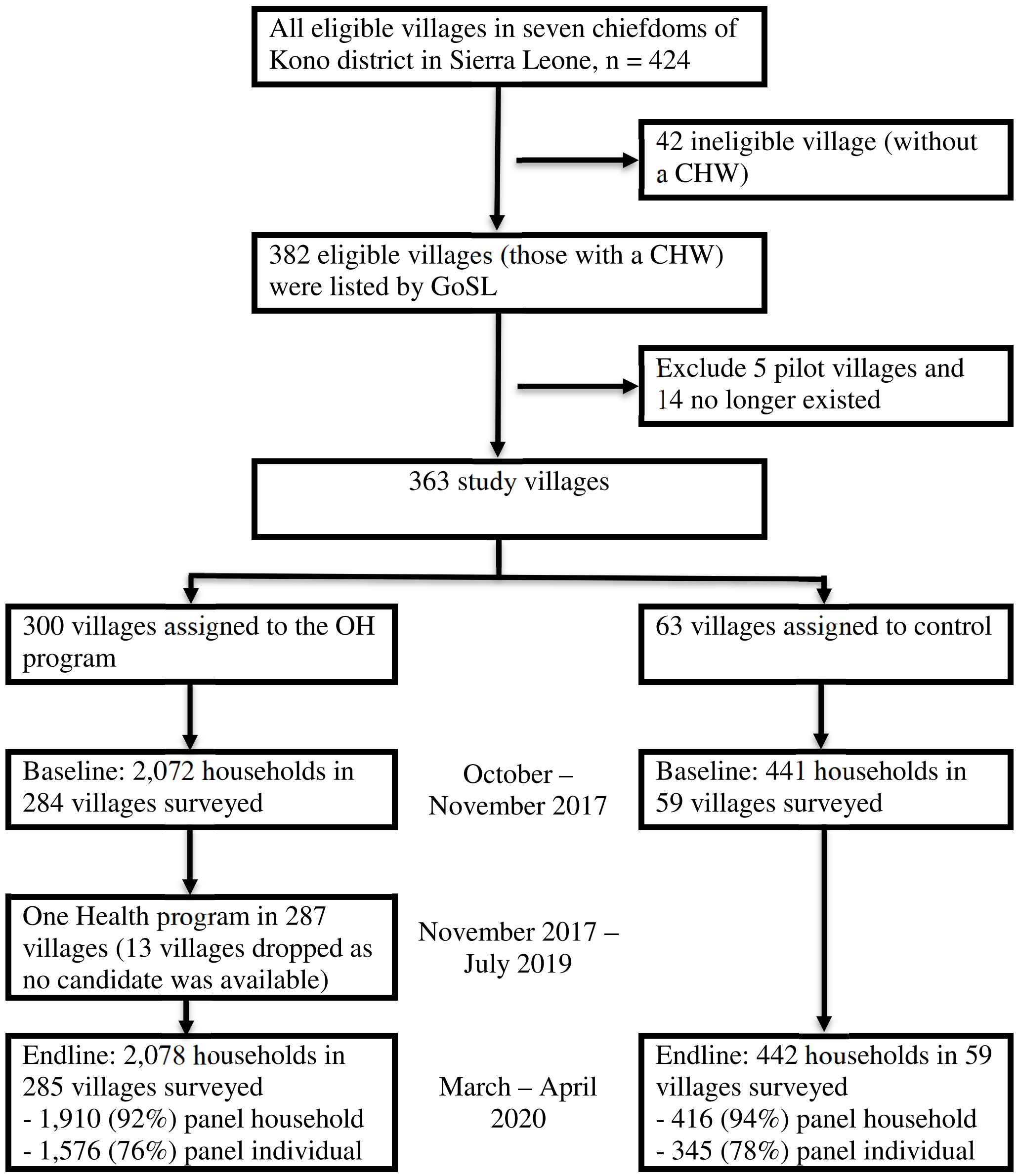
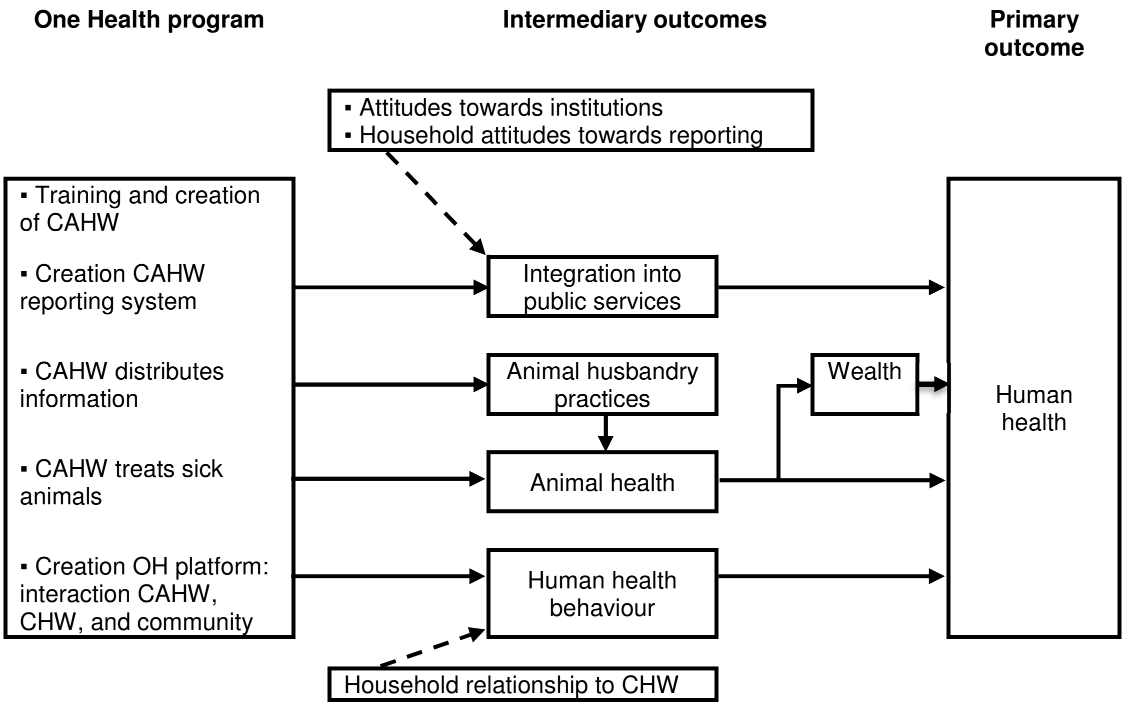
FIGURES

Figure 1. Trial Profile



Note: The number of participants assessed for eligibility, the number randomised to each group, the number of exclusions or dropouts at each stage, and the number assessed for the primary endpoint.

Figure 2. Program and Outcome Mapping



Note: Figure presents a simplified illustration of how the One Health program may influence human health. Solid lines link program, intermediary and final outcomes, dashed lines present factors that may moderate impact.

TABLES

Table 1. Manipulation Check

	Control	Program	T-C	95% CI	N
Someone knows about animal health	0.050	0.802	0.750	[0.701,0.800]	2,433
Someone treats sick animals	0.043	0.804	0.759	[0.710,0.809]	2,432
Someone reports sick animals	0.016	0.722	0.704	[0.662,0.747]	2,431
Committee for animal and human health	0.169	0.502	0.335	[0.269,0.401]	2,432

Note: "T-C" are ITT estimates based on two tailed regressions at the individual level with fixed effects at the Chiefdom level and robust standard errors clustered at village level. Data from endline survey and pooled across respondent types (randomly selected and large animal owners). See the Supplementary Material (Appendix B) for variable definitions.

Table 2. Baseline Characteristics of Households Included in the Study

	Control group (n=441)		Treatment group (n=2,072)	
Female (0/1)	0.22	(0.41)	0.23	(0.42)
Married (0/1)	0.83	(0.38)	0.80	(0.40)
Age in years	45.16	(16.00)	45.41	(16.31)
Years in the community	27.84	(19.26)	27.52	(19.02)
Formal education (0/1)	0.19	(0.40)	0.20	(0.40)
Illiterate (0/1)	0.85	(0.35)	0.85	(0.36)
Christian (0/1)	0.50	(0.50)	0.51	(0.50)
Muslim (0/1)	0.49	(0.50)	0.49	(0.50)
Cares for any animals (0/1)	0.90	(0.30)	0.88	(0.32)
Number of animals cares for (for those that care for animals)	10.73	(9.93)	11.08	(10.92)
U5 deaths community (0/1)	0.400	0.779	0.490	0.999
Diarrhea children (0/1)	0.21	(0.41)	0.23	(0.42)
Cough children (0/1)	0.40	(0.49)	0.40	(0.49)
Fever children (0/1)	0.72	(0.45)	0.72	(0.45)
PPR case (for those with goats and/or sheep at baseline)	141/262	(54%)	649/1,258	(52%)
Newcastle case (for those with chickens and/or ducks at baseline)	171/336	(51%)	665/1,549	(43%)
Animals died (for those caring for any animals at baseline)	258/397	(65%)	1,049/1,839	(57%)
Stillborn (for those caring for any animals at baseline)	118/400	(30%)	507/1,839	(28%)
Visit PHU when sick (1= “definitely not” to 5= “definitely”)	4.36	(0.85)	4.30	(0.93)
High quality water source (0/1)	0.38	(0.48)	0.30	(0.46)
Animals owned (all respondents)	8.60	(9.66)	9.05	(10.56)
Assets owned	21.15	(11.96)	20.22	(11.42)
Days without food (0-7)	0.77	(1.35)	0.79	(1.35)

Note: Data are mean (SD) or n (%). See the Supplementary Material (Appendix B) for variable definitions. Data from baseline survey and pooled across respondent types (randomly selected and large animal owners). For responses that are not continuous, the response type is indicated in parentheses.

Table 3. Primary and Intermediary Outcomes

	Control	Program	T-C	95% CI	N
Human Health Index	**0.000**	**-0.009**	**-0.008**	**[-0.148,0.133]**	**1,819**
U5 deaths community	0.176	0.198	0.000	[-0.103,0.103]	1,631
U5 deaths household	0.015	0.035	0.018	[-0.001,0.037]	1,812
Diarrhea adult† (0/1)	0.058	0.055	-0.002	[-0.033,0.030]	1,901
Cough adult† (0/1)	0.064	0.054	-0.01	[-0.043,0.023]	1,901
Fever adult† (0/1)	0.161	0.157	-0.001	[-0.053,0.051]	1,897
Diarrhea children (0/1)	0.029	0.028	-0.003	[-0.022,0.017]	1,901
Cough children (0/1)	0.059	0.038	-0.02	[-0.049,0.009]	1,898
Fever children (0/1)	0.208	0.226	0.018	[-0.030,0.067]	1,895
Animal Health Index (for those with at least one animal at baseline)	**0.000**	**0.172**	**0.164**	**[0.017,0.311]**	**1,722**
PPR incidence (for those with goats and/or sheep at baseline)	1.493	1.019	-0.497	[-1.010,0.017]	1,157
Newcastle incidence (for those with chickens and/or ducks at baseline)	1.950	1.540	-0.321	[-0.882,0.241]	1,410
Animals died (for those with at least one animal at baseline)	3.717	2.547	-1.056	[-2.495,0.382]	1,718
Stillborn (for those with at least one animal at baseline)	0.543	0.421	-0.085	[-0.231,0.061]	1,718
Animal Husbandry Practices Index	**0.000**	**0.242**	**0.255**	**[0.087,0.424]**	**1,921**
Response Rabies† (0-6)	0.234	0.275	0.034	[-0.028,0.097]	1,867
Response Newcastle† (0-6)	0.613	0.497	-0.113	[-0.195,-0.030]	1,881
Response PPR† (0-6)	0.686	0.976	0.285	[0.192,0.377]	1,883
Good animal practices† (0-5)	0.734	1.008	0.272	[0.130,0.414]	1,905
Knows about zoonotic diseases† (0/1)	0.336	0.382	0.053	[-0.011,0.116]	1,903
Zoonotic diseases mentioned† (0-6)	0.433	0.523	0.098	[-0.029,0.225]	1,903
Knows about swineflu† (0/1)	0.102	0.089	-0.011	[-0.049,0.027]	1,904
Symptoms of swineflu† (0-3)	0.070	0.078	0.011	[-0.026,0.048]	1,904
Knows about F&M† (0/1)	0.513	0.527	0.025	[-0.059,0.109]	1,903
Symptoms of F&M† (0-3)	0.839	0.888	0.065	[-0.081,0.211]	1,903
Actions to prevent F&M† (0-7)	0.507	0.627	0.128	[-0.010,0.266]	1,903
Stillbirth safe practice mother (0/1)	0.798	0.877	0.082	[0.020,0.143]	1,872
Stillbirth safe practice fetus (0/1)	0.650	0.663	0.002	[-0.059,0.064]	1,872
Stillbirth handle fetus (0/1)	0.751	0.777	0.016	[-0.039,0.072]	1,921
Stillbirth use gloves (0/1)	0.149	0.146	-0.005	[-0.055,0.045]	1,579
Animals sleep in house (0/1)	0.340	0.328	-0.018	[-0.085,0.048]	1,892
Human Health Behaviour Index	**0.000**	**0.152**	**0.187**	**[0.025,0.348]**	**1,906**
Visit PHU when sick (1= “definitely not” to 5= “definitely”)	4.132	4.105	-0.028	[-0.145,0.090]	1,895
Recent visit PHU (1= “never” to 6= “within last week”)	4.515	4.486	0.012	[-0.258,0.282]	1,808
Visit PHU when healthy (1= “never” to 6= “more than once a week”)	1.752	1.997	0.250	[0.027,0.473]	1,845
Children vaccinated†	0.800	0.867	0.065	[0.019,0.112]	1,887
Diarrhea trust western medicine (1= “not effective” to 4= “very effective”)	3.800	3.807	0.008	[-0.074,0.091]	1,871
Diarrhea trust traditional medicine (1= “not effective” to 4= “very effective”)	1.997	1.989	-0.039	[-0.206,0.128]	1,725
Diarrhea trust religious body (1= “not effective” to 4= “very effective”)	2.012	1.860	-0.185	[-0.366,-0.004]	1,668
High quality water source (0/1)	0.426	0.386	-0.005	[-0.094,0.083]	1,890
Any action to clean water (0/1)	0.199	0.255	0.056	[0.001,0.112]	1,857
Hand washing with disinfectant (0/1)	0.911	0.926	0.019	[-0.020,0.059]	1,830
Integration into Public Services Index	**0.000**	**0.342**	**0.339**	**[0.137,0.541]**	**1,903**
MoHS visited village† (0/1)	0.289	0.388	0.097	[0.022,0.171]	1,901
MoHS project in community† (0/1)	0.357	0.411	0.05	[-0.032,0.133]	1,902
MoHS supervisor visited† (0/1)	0.278	0.325	0.049	[-0.035,0.132]	1,902
MAF visited village† (0/1)	0.149	0.251	0.100	[0.046,0.155]	1,902

Recent development project† (0/1)	0.105	0.189	0.086	[0.022,0.150]	1,903
Wealth Index	**0.000**	**0.181**	**0.163**	**[0.053,0.273]**	**1,922**
Days without food (0-7)	0.503	0.394	-0.104	[-0.239,0.032]	1,903
Bushels planted on swamp farm	2.445	2.563	-0.005	[-0.311,0.302]	1,898
Bushels planted on upland farm	1.623	1.619	0.061	[-0.243,0.366]	1,896
Animals owned	7.319	9.618	2.158	[1.086,3.230]	1,922
Assets owned	22.125	23.134	1.652	[0.146,3.157]	1,922

Note: "T-C" contains ITT estimates based on two tailed regressions with randomization strata fixed effects (at the Chiefdom level) and robust errors clustered at village level. Individual measures without baseline information are indicated with an asterisk (†). Data are pooled across respondent types (randomly selected and large animal owners). See Appendix G for results by subgroup. Data from panel individuals: i.e., respondents interviewed both before and after the program. For the family index, variables are rescaled so that higher values imply better outcomes. Variables are control-group normalized at endline (z-scored). Family level effects thus represent Standard Deviation unit differences relative to the control group. For responses that are not continuous, the response type is indicated in parentheses.

METHODS

Study Design and Participants

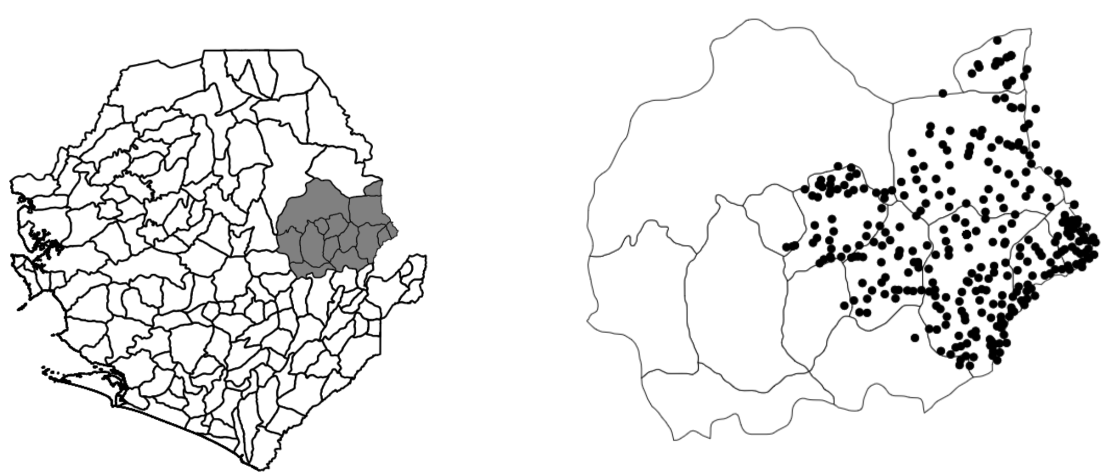
We identify the effects of a One Health program using a randomized trial in which a random set of villages received a Community and Animal Health Worker (CAHW). The Government of Sierra Leone identified rural villages with a trained Community Health Worker (CHW) in seven Chiefdoms in Kono District, a border region at high risk of zoonotic diseases (**Figure 3**). CHWs are health workers responsible for human health in the community, including human health surveillance. In total, 382 villages were listed from 424 villages. Of these, five villages functioned as pilot villages, and 14 villages no longer existed. The final sample included 363 villages (see consort diagram in **Figure 1**).

Before the onset of the program, formal approval was obtained from local authorities. We obtained verbal informed consent from all study participants. Ethics approval was obtained from the Office of the Sierra Leone Ethics and Scientific Review Committee (SLERC 16102017) and Columbia University (AAAR5175).

Randomisation and Masking

Within each of the seven Chiefdoms, villages were randomised 1:5 to receive the One Health program. In total, 300 villages were assigned to treatment, blocked by Chiefdom, and 63 villages to the control condition using the randomizr package in R. In the Supplementary Material (Appendix I), we provide an overview of the number of villages per treatment arm across Chiefdoms. Due to the nature of the intervention, field workers and participants were aware of a village's treatment assignment.

Figure 3. Map of Study Villages



(a) Kono District, Sierra Leone (b) Kono District and study villages

Note: Authors rendering. Panel (a) shows Kono District in Sierra Leone. Panel (b) shows the Chiefdoms and study villages in Kono District. Village GPS coordinates are jittered to ensure study site anonymity.

Procedures

In each treatment village, eligible individuals were recruited to become a CAHW. Before program onset, few animal health workers operated in Sierra Leone. Recruitment took place with the involvement of local leaders and community members. Eligibility criteria included literacy, numeracy, animal rearing experience, residence in the community, good health and availability to participate in a multi-week training session. CAHWs participated in a 21-day training, which was implemented by livestock officers under the supervision of MAF and qualified veterinarians. The training included skills development on the basics of animal husbandry, disease prevention and treatment, and focused on disease surveillance. CAHWs were subsequently tasked to report to MAF supervisors on suspected animal disease symptoms. Furthermore, a three-day training on community One Health took place for both the CAHW and CHW, stressing the need for a joint human and animal-oriented approach to disease prevention.

CAHWs received a starter kit with tools and drugs for treatment of basic animal diseases. During a village ceremony, the CAHWs were officially installed and the One Health program was introduced to the wider community, specifying the roles and responsibilities of the CAHW. Furthermore, the community was invited to create a One Health platform consisting of all actors responsible for health in the community: CHW, CAHW, and the traditional health worker.

As part of the program, CAHWs provided basic animal health services, demonstrated and provided information on best practices for animal husbandry and reported suspected disease symptoms to MAF supervisors. Surveillance activities included symptom disease reporting for large ruminants (cows, bulls), small ruminants (sheep, goats), pigs, birds (chicken, ducks, fowls), and dogs. An example of a reporting form can be found in the Supplementary Material (Appendix J).

These features were provided in the same way for all CAHWs. However, the intervention also randomly varied some features of the program across CAHWs, including selection and incentive schemes. These are the subject of separate analyses with the current analysis focused on comparing the average effect of these variations in scheme.

Outcomes

Our primary outcome was human health. In addition, we explored the impact of the program on five intermediary outcomes: animal health, animal husbandry practices, human health behaviours, integration into public services, and household wealth. **Figure 2** gives a simplified causal diagram. A large household survey collected multiple individual indicators for each outcome to capture a full set of relevant dimensions. Variable definitions and summary information for each individual measure are included in the Supplementary Material (Appendix B).

To measure human health, we recorded under-five mortality in the village and household in the previous year. In addition, we asked about the incidence of diarrhea, cough and fever in the prior three months for adults and children under five.

To measure animal health, we recorded the incidence of Newcastle diseases and rinderpest (PPR), and the number of stillborn and animal deaths during the preceding year.

For animal husbandry practices, we collected information about whether animals slept inside the house, and knowledge about practices for suspected cases of rabies and PPR. We also recorded household knowledge about zoonotic diseases, swine flu and foot and mouth disease, and foot and mouth disease prevention.

For human health behaviours, we recorded health-seeking behavior (clinic visits, child vaccinations, and attitudes towards modern or traditional medicine to treat diarrhea). We also recorded household access to safe water sources, and behaviors related to hand washing and making water safer to drink.

For integration into public services, we recorded whether somebody from MoHS or MAF had visited the community in the preceding six months (thus after program end) to provide health services (vaccinations) or sensitization campaigns, and whether there had been a development project (other than the OH program) in the community during the prior year.

We also assessed impacts on household wealth, including food security, farm size, animal ownership, and assets.

Statistical Analysis

We conducted a power simulation to calculate the minimum detectable effect size, with 300 of the 363 villages assigned to the treatment. We achieved 90% power for an effect size of about 0.3 standard deviation units (with an alpha of 0.05).

To assess the impact of the OH program, we use Intention-To-Treat (ITT) analyses to test for differences in outcome measures between the assigned treatment and control group. We report treatment effects for all individual outcome measures, and calculate a summary index for each outcome family to reduce Type I errors due to multiple inference. To generate a summary index, we rescale each outcome so that higher values imply better outcomes, and take the average of standardized values relative to the endline control group (as per Kling et al 2007). We estimate treatment effects as the difference in the summary index between treatment and control groups; treatment effects are thus expressed in standard deviation units (SDU) relative to the control group. We estimated effects using least squares models with randomization fixed effects (Chiefdoms). Where available, regressions include baseline outcomes. Robust standard errors are used with clustering at the village level.

All analyses were done in Stata (Version 18.0). The study was pre-registered at the International Clinical Trials Registry Platform (ICTRP) via the Dutch Trial Register (# 21660). An updated version can be found at https://osf.io/9xfv3. See Supplementary Material (Appendix K) for any deviations.

Role of the Funding Source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of this study. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Ethics and Inclusion Statement

The study received Institutional Review Board (IRB) approval from the Sierra Leone Ethics and Scientific Review Committee (SLERC 16102017), and Columbia University (AAAR5175).The research protocol was pre-registered at the National Trail Registry (#21660), which is part of the International Clinical Trials Registry Platform, and at OSF (https://osf.io/9xfv3). All study participants completed informed consent.

The study was designed and implemented in close collaboration between the researchers and the Ministry of Health and Sanitation (MoHS) and the Ministry of Agriculture and Forestry (MAF) of the Government of Sierra Leone in response to the 2014-2016 Ebola virus epidemic. Throughout the study, a cross section of MoHS and MAF were regularly engaged throughout the project through individual and group discussions, as well as participation in workshops and technical working groups. This included the director and deputy director of the livestock division, district livestock officers, and district agricultural officers for MAF. For MoHS, the conversations included the Directorate of Health, Security and Emergencies, the District Health Management Team and District Medical officers. Training materials were developed in collaboration with the Livestock Division at the Ministry of Agriculture and Forestry and its technical partners.

Data Availability Statement

All data collected as part of this study will be available in a public repository. These data are de-identified to protect individual participants' privacy. There are no restrictions on sharing these data. Related documents such as the survey instruments and the code to produce the tables and figures in the manuscript will also be available in a public repository.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Appendix.pdf
- vanderWindtFlatEPC.pdf
- vanderWindtFlatRS.pdf