Supplementary Information for:

Vaccination of household chickens results in a shift in young children’s diet and improves child growth in rural Kenya

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Supplementary Text 1: Participation, attrition analysis and probability weighting

Table S1 provides the distribution of visits by cumulative visit number (by child) and by quarter (3-month period). The Nth visit mode coincides with the Nth quarter, but there is variation due to missed intermediate visits.

Table S1.
Visit number by time in trial (by quarter)*

| Visit number | 1  | 2  | 3  | 4  | 5  | 6  | Row Sum (% Initial) |
|--------------|----|----|----|----|----|----|---------------------|
| 1            | 661|     |    |    |    |    | 661 (100%)          |
| 2            | 10 | 466| 91 | 26 | 5  | 1  | 599 (90.6)          |
| 3            | 2  | 3  | 381| 109| 24 | 9  | 528 (79.9)          |
| 4            | 2  | 286| 104| 24 |    |    | 416 (62.9)          |
| 5            | 244|    | 70 |    |    |    | 314 (47.5)          |
| 6            | 2  | 176|    |    |    |    | 178 (26.9)          |
| Col. Sum (% initial) | 666| 469| 474| 421| 379| 280| 2,696               |

*Quarter 1 begins at first visit and subsequent quarters begin 30 days apart.
All data is from households that were assessed at baseline and then continued in the study (i.e., households that did not continue beyond baseline were dropped). The mean number of successful visits with complete dietary and growth data was 4.24 and 4.32, respectively, for children in treatment and control households; 26.9% are represented by a full set of six visit records. There are therefore two types of missing records: those from missed intermediate visits, and those that did not participate at the final quarter, here designated as attrition. The most common reported reason for missed intermediate visits was that the caregiver or child was away from the household (84%) followed by either the caregiver or the child being ill (6.5%). For attrition, the recorded reasons were similar: caregiver or child away from the household (76%) and illness or death (10%).

Figure S1 shows the distribution of final recorded visits by time in trial (top panel), and the time in trial of all visits by visit number (bottom panel). The date for visit 1 is defined as T=0, so there is no variation in the timing of visit 1 in Figure S1. The distribution of visits tends to be later in the quarter with each successive visit as indicated by the position within the quarter (top panel). There are several peaks for intermediate responses because of missed intermediate survey delivery. For example, most third visits were recorded in quarter three, but due to missed survey response, some were in later quarters. NDV vaccination and parasite medication for chickens in treatment households and parasite medication alone in control households was carried out in each quarter regardless of whether an associated child diet and growth assessment was completed on that visit.
Fig. S1. Time in trial at final visit (top panel) and time in trial by visit number (bottom panel). The black vertical lines represent the number of successful data visits (individual child records) for a given date; the red vertical lines indicate the start of the first quarter (baseline); and the blue vertical lines demarcate each quarter. In the top panel, the y-axis (frequency) is the number of individual child records on a given visit day and the x-axis, the number of months that a child’s diet and growth assessment data had been collected at the time of the final successful visit. In the bottom panel, the visit number, 1-6, is indicated above each panel. The y-axis (frequency) is the number of individual child records on a given visit day and the x-axis indicates the quarters.
Based on the distribution of visits late in the trial as shown in Fig. S1 (top panel), we define attrition as a case where a child is not represented by a survey response in the 15th month or later (41.6%, Table S1). Attrition is thus 58.4% of children assessed at baseline and again at timepoints during the study (mean 4.24 timepoints for treatment; 4.32 for control) but not in the final quarter. We examine and address trial attrition between treatment and control households in several ways. First, Table S2 provides a test result for whether the last visit of a child occurred in the last quarter. Although the proportion completing the trial is slightly higher in the treatment group than the control group, there is no statistical difference in attrition between the two groups (p=0.311).

**Table S2.**

Proportions test for trial attrition differences across study arms.

|                          |               |
|--------------------------|---------------|
| Proportion completed (Control) | 0.394         |
| Proportion completed (Treatment) | 0.432        |
| Difference of proportions  | -0.038        |
| Two-sided p-value         | 0.311         |
| N (Control)               | 358           |
| N (Treatment)             | 324           |
The lack of statistical difference in attrition across groups based on the proportions test in Table S2 is supportive of no effect of attrition on trial outcomes. However, systematic differences across treatment and control in what drives attrition could still bias results. We therefore apply an inverse probability weighting approach for our regressions of interest presented in Tables 2, 3, and S4 to control for potential systematic differences in attrition (1-3).

The predicted probability of a child participating in the last quarter of the trial (15 months or more) are generated from this regression. The inverse of the predicted probability is used as a sampling weight to account for the relative under-representation of dropouts in the full sample. To generate predicted probabilities of trial completion, we estimated a Probit model using baseline factors for each child that may affect differential attrition. Variable definitions are constructed to be constant for each child because inverse probability sample weights represent a child’s propensity for remaining in the trial given the individual child’s characteristics. Variables 'Respondent's own child', 'Respondent=caregiver' and 'Respondent=compound head' are the mode response for each individual, and 'Caregiver age' is the median age of the reported caregiver in Table S3.

Table S3 shows the coefficient estimates from this regression, which are informative in their own right. The parameter associated with the Treatment Group indicator is not statistically different from zero. This is another indication that attrition does not differentially affect the two arms of the study conditional on the other explanatory variables, but again it does not necessarily preclude it; and because of the relatively large attrition rate and this remaining uncertainty over the effects of attrition on outcomes, we
apply inverse probability weighting as described in the main text (Materials and Methods). The negative parameter estimates associated with HAZ and WHZ at visit 1 suggest that those children who had higher HAZ and WHZ scores at the beginning of the trial were less likely to complete the trial through to the last quarter. However, controlling for this propensity, the results also show that children who diagnosed with MAM or SAM at some point during the trial were also less likely to complete the trial. Children who were older at the beginning of the trial were more likely to complete the trial. Children in households with higher income tended to have a lower completion rate. This could be that the opportunity cost of the time it takes respondents to participate is higher in households who are working more. Girls were not statistically more likely to drop out of the trial than boys. If the respondent was the caretaker of the child, trial completion was more likely, perhaps because the respondent was more invested in the child’s wellbeing, but if the respondent was the household head, trial completion was less likely.

Table S3.
Probit regression for full trial participation.

| Explanatory Variable                          | Coefficient |
|---------------------------------------------|-------------|
| Treatment Group                             | -0.022      |
| HAZ† @ visit 1                              | -0.232***   |
| WHZ‡ @ visit 1                              | -0.055*     |
| MAM§ [ever]                                 | -0.340***   |
| SAM¶ [ever]                                 | -0.945***   |
| Age @ visit 1                                | 0.107***    |
| Age @ visit 1 squared                       | -0.003***   |
| ln(Per capita income) @ visit 1             | -0.053***   |
| Female Child                                | -0.016      |
| Respondent’s Education Level                | -0.043      |
| Respondent’s Age                            | -0.016***   |
| Respondent’s Own Child                      | 0.182       |
| Respondent=Caregiver                        | 0.796***    |
| Respondent=Compound Head                    | -0.253***   |
| Intercept                                   | -0.984***   |
N=2599
Pseudo-$R^2=0.175$

- $^1$HAZ, Height-for-Age Z score
- $^2$WHZ, Weight-for-Height Z score
- $^3$MAM, Moderate Acute Malnutrition
- $^4$SAM, Severe Acute Malnutrition
- *statistically significant at $p<0.1$; ** statistically significant at $p<0.05$; *** statistically significant at $p<0.01$
Supplementary Text 2: Multinomial regression of food intake proportions

The fractional multinomial logit regression results (Table S4) focus on substitution between food groups in response to differences in explanatory variables. The dependent variables of this fractional multinomial logit model are the fraction or share of total servings represented by each food type in a given visit. The multinomial logit regression focuses more precisely on the substitution between food groups than the regression presented in Table 2, which focuses more broadly on how consumption levels change in response to covariates. The multinomial logit regressors are identical to those in Equations (1) (Material and Methods), except for the addition of the natural logarithm of total servings (the sum of the number of servings in all four food categories) because food category shares are conditional on the total number of servings. Because the dependent variables are shares of total food intake conditional on total food intake, changes in one share represent a substitution toward one food category and away from one or more of the other food categories.

In the food intake regressions in the main text (Table 2), the NDV treatment is associated with higher ASF consumption and (weakly) lower grains consumption. The fractional multinomial logit model results presented in Table S4 shed additional light on these effects. The multinomial logit results indicate that the share of ASF relative to grains increases at a significantly faster rate in the treatment group (0.13, p=0.081), supporting the conclusion that NDV vaccination is inducing or allowing households to substitute toward ASF and away from grains as the trial proceeds. In contrast, there are no significant changes in the shares of consumed fruits and vegetables between the treatment and control groups (p= 0.450 and p=0.645, respectively).
Second, the results show that as the number of food servings increases, the number of servings of ASF and vegetables decline relative to grains (e.g. -0.216 and -0.026 for ASF, for children >18 months of age and ≤18 months of age, respectively). The result is larger and statistically significant for older children for ASF and vegetables.

Third, breastfeeding status correlates with variation in food intake shares. The base case for comparison is children >18 months of age who are not breastfeeding. The share of ASF, fruit, and vegetables are consistently lower relative to grains for breastfed children than for children not breastfeeding for both younger and older children, suggesting a substitution effect in favor of breastmilk, although none of these differences are statistically significant at conventional levels. Younger children are fed significantly more ASF and fruit relative to grains than older children, regardless of whether they are breastfed (e.g. the coefficient on ≤18mo X Not breastfeeding is 2.540 (p=<0.001).

The fractional multinomial logit model results in Table S4 provide additional perspective on how income affects substitution between food groups. Consumption of ASF and vegetables are significantly higher relative to grains (p<0.068 and p<0.031, respectively) for household with higher incomes, with the increase in ASF consumption higher than that of vegetables (Table S4). This result is consistent with prior findings that ASF and vegetables tend to be more income-responsive than other food groups, while grains are less responsive to income or decline as a share of food expenditures (4,5).
**Table S4.**
Determinants of child consumption of animal source foods (ASF), fruits, and vegetables relative to grains.

| Independent Variable† | Share(A)  | Share(F)  | Share(V)  |
|------------------------|-----------|-----------|-----------|
| Treatment X Mo. in Trial | 0.013*    | 0.006     | 0.003     |
| Treatment              | -0.040    | -0.070    | -0.079    |
| Time in Trial (Months) | 0.005     | 0.031***  | -0.002    |
| MAM @ one or more visits | -0.079    | -0.302**  | -0.208*   |
| SAM @ one or more visits | 0.241     | 0.179     | 0.544***  |
| Time since MAM         | 0.002     | 0.002     | 0.012     |
| Time sinceSAM          | -0.041*   | -0.030    | -0.066*** |
| >18mo X ln(Total Servings) | -0.216*** | 1.114***  | -0.021    |
| ≤18mo X ln(Total Servings) | -0.026    | -0.357*** | -0.296*** |
| >18mo X Breastfeeding  | -0.076    | -0.024    | -0.051    |
| ≤18mo X Not breastfeeding | 2.450***  | 4.361***  | 0.255     |
| ≤18mo X Breastfeeding  | 2.203***  | 4.152***  | -0.005    |
| >18mo X Child Age      | 0.000     | 0.001     | 0.007     |
| ≤18mo X Child Age      | -0.524*** | -0.059    | -0.025    |
| >18mo X Child Age sq.  | 0.000     | 0.000     | 0.000     |
| ≤18mo X Child Age sq.  | 0.021***  | 0.004^    | 0.004*    |
| ln(Per capita income)  | 0.018*    | 0.012     | 0.015**   |
| Female Child           | 0.066     | 0.035     | 0.029     |
| Mother’s (Caregiver’s) Education Level | 0.115** | -0.032 | -0.004 |
| Mother’s (Caregiver’s) Age | -0.001 | -0.004** | 0.002 |
| Cos(month)             | -0.029    | 0.161***  | 0.069***  |
| Sin(month)             | -0.016    | -0.156*** | -0.097*** |
| Intercept              | -1.141*** | -4.864*** | -1.144*** |

- Number of observations for all equations=2,549.
- #Dependent variables are the share of servings for each respective food group consumption category: animal source foods (A), fruits (F), vegetables (V), and grains (the base category).
- †Independent variables include the treatment group (households receiving vaccination of chickens; the control group is the base case); whether ever diagnosed with Moderate Acute Malnutrition (MAM) or Severe Acute Malnutrition (SAM); time since first diagnosis of MAM and/or SAM; time in trial in months (T); child age and breast feeding status; logarithm of per capita income; gender of the child, mother’s (or caregiver’s) age and education level; and month of the year (to reflect seasonality). The use of 18 months as an age reference is based on our data that the transition from breastfeeding as the primary source of child nutrition through a period of increased intake of other food sources occurs up to month 18 (Figure 2). “X” represents the interaction between the two variables.
- ^statistically significant at p<0.15; *statistically significant at p<0.1; **statistically significant at p<0.05; ***statistically significant at p<0.01
- Estimation method: Fractional Multinomial Logit (Stata 17 mfnlogit routine), clustered by child.
Supplementary Text 3: Robustness of Z regressions across food intake measures

In the main text we maintain a hypothesis that given the length of our trial and frequency of data collection, HAZ is likely to exhibit a cumulative response to long-term food intake and breastfeeding and WHZ is likely to exhibit shorter term response to these forms of intake. We therefore include in HAZ the average intake up to visit date for food and an indicator for whether the child was ever breastfed, and for WHZ, recent food intake and current reported breastfeeding status. To examine the consequences of these maintained hypotheses, we present a table of results that includes either type of intake metrics in both the HAZ and WHZ regressions. These regressions are otherwise the same except for whether the hypothesized seasonal effects are included. Table S5 provides the results for three pairs of HAZ/WHZ regression, each based on full-model estimation with all food equations as well.

The results are quantitatively and qualitatively similar. For example, treatment effects (Treatment X Mo. in Trial) are all similar in magnitude and significance relative to conventional test sizes, as are MAM and SAM effects. Food and breastfeeding intake also vary little across models regardless of the use of recent or average intake measures. There are a few differences worth noting. First, note that the effect on HAZ of average ASF intake (lnAvgA) is almost twice as large as the effect of current ASF intake (lnA) for children 18 months and older (0.164 or 0.146 versus 0.92). This is consistent with our hypothesis that a short-term intake measure would likely not be as informative as a long-term measure for HAZ. The effects of average intake of the other food groups are also larger in absolute value in all but one case (≤18 mon X ln([Avg]F, neither parameter is statistically different from zero at conventional levels). However, the estimated effect of
long-term measures of intake on WHZ are also larger for some food groups, e.g. compare WHZ Model 1 and Model 2 in particular for vegetables (V) and grains (G). The perhaps unintuitive negative effects of food parameters on WHZ are persistent regardless of whether current or long-term metrics are used. For breastfeeding, the patterns are mixed (base case, 18 months and older, [never] breastfed). Despite some expected quantitative differences, the general implications of the model as described in the main text are maintained across these different model specifications.
Table S5.
Results of HAZ and WHZ for three different model specifications for comparison.

|                          | HAZ     | WHZ     |
|--------------------------|---------|---------|
|                          | Model 0† | Model 1† | Model 2† |
| AvgF, BE                 | F,B     | AvgF, BE | F,B     | AvgF, BE |
| Treatment X Mo. in Trial| 0.008   | 0.007   | 0.008   | 0.006   | 0.006   | 0.004   |
| Treatment                | -0.206  | *       | -0.199  | *       | -0.212  | *       |
| Mo. in Trial             | 0.022   | **      | 0.016   | **      | 0.024   | ***     |
| MAM^ @ one or more visits| -1.213  | ***     | -1.236  | ***     | -1.218  | ***     | -0.761  | ***     | -0.765  | ***     | -0.760  | ***     |
| SAM^ @ one or more visits| -0.604  | **      | -0.549  | *       | -0.643  | **      | -0.878  | ***     | -0.875  | ***     | -1.023  | ***     |
| Time since MAM^          | -0.010  |         | -0.021  |         | -0.009  |         | 0.018   |         | 0.019   |         | 0.018   |         |
| Time since SAM^          | -0.009  |         | -0.005  |         | -0.010  |         | 0.047   | *       | 0.047   | *       | 0.044   | *       |
| Child Age                | -0.067  | ***     | -0.077  | ***     | -0.065  | ***     | -0.020  | *       | -0.020  | **      | -0.010  |         |
| Child Age sq.            | 0.001   | **      | 0.001   | **      | 0.001   | **      | 0.000   | *       | 0.000   | *       | 0.000   |         |
| ln(Per capita income)    | 0.028   | **      | 0.028   | **      | 0.027   | **      | -0.007  |         | -0.008  |         | -0.009  |         |
| Female Child             | 0.152   |         | 0.166   |         | 0.155   |         | 0.084   |         | 0.085   |         | 0.102   |         |
| Mother’s (Caregiver’s) Age| 0.004   |         | 0.004   |         | 0.004   |         | 0.000   |         | 0.000   |         | 0.000   |         |
| Mother’s (Caregiver’s) Education Level | 0.100 | 0.123 | *       | 0.100   | 0.052   |         | 0.051   | *       | 0.054   | *       |         |

- >18mo X ln([Avg]A)      | 0.164   | **      | 0.092   | **      | 0.146   | **      | -0.021  |         | -0.024  |         | -0.075  |         |
- ≤18 mo X ln([Avg]A)     | -0.016  |         | -0.014  |         | -0.026  |         | -0.022  |         | -0.024  |         | -0.051  |         |
- >18mo X ln([Avg]F)      | 0.072   |         | 0.019   |         | 0.069   |         | -0.022  |         | -0.022  |         | -0.028  |         |
- ≤18 mo X ln([Avg]F)     | -0.003  |         | 0.004   |         | -0.001  |         | -0.030  |         | -0.030  |         | 0.014   |         |
- >18mo X ln([Avg]V)      | 0.097   |         | 0.023   |         | 0.078   |         | 0.035   |         | 0.033   |         | -0.046  |         |
- ≤18 mo X ln([Avg]V)     | -0.037  |         | -0.035  |         | -0.048  |         | -0.089  |         | -0.089  |         | -0.134  |         |
- >18mo X ln([Avg]G)      | -0.234  | *       | -0.107  | *       | -0.285  | **      | -0.001  |         | 0.001   |         | -0.182  | *       |
- ≤18 mo X ln([Avg]G)     | -0.074  |         | -0.070  |         | -0.089  |         | -0.108  |         | -0.107  |         | -0.172  | ***     |
- >18mo X [Has] breastfed | -0.341  | **      | -0.465  | ***     | -0.413  | ***     | -0.098  |         | -0.102  |         | -0.287  | ***     |
- ≤18 mo X [Never] breastfed | 0.665 | 0.387 | 0.551 | 0.357 | 0.359 | -0.146 |         |
- >18mo X [Has] breastfed | -0.656  |         | -0.574  |         | -0.815  | *       | 0.433   |         | 0.429   |         | -0.102  |         |
| Cos(month)                |         | 0.014   |         | 0.048   | ***     | 0.043   |         |         |         |         |         |
| Sin(month)                | 0.069   | **      | -0.045  |         | -0.045  | ***     |         |         |         |         |         |
| Intercept                | 0.119   |         | 0.018   |         | 0.287   |         | -0.226  |         | -0.219  |         | 0.300   |         |

- †Model 0 is the model presented in the main text. Included here for comparison. Model 1 includes recent food and breastfeeding variables (denoted in column heading F, B) in both Height-for-Age (HAZ) and Weight-for-Height (WHZ) regression. Model 2 includes average of previous food intake values and an indicator of whether a child had ever been breastfed to date (denoted AvgF, BE in column heading).
- ^MAM, Moderate Acute Malnutrition
- ^SAM, Severe Acute Malnutrition
- *statistically significant at p<0.1; ** statistically significant at p<0.05; *** statistically significant at p<0.01
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