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Using Agriculture to Improve Child Health: Promoting Orange Sweet Potatoes Reduces Diarrhea

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Summary. — Vitamin A deficiency (VAD) is prevalent throughout the developing world, and causes night blindness and increases child morbidity and mortality. We studied the health benefits of biofortification in reducing VAD, using a cluster-randomized impact evaluation in 36 villages in northern Mozambique. Based on a sample of 1,321 observations of children under the age 5, biofortification reduced diarrhea prevalence by 11.4 percentage points (95% CI 2.0–20.8), and by 18.9 percentage points in children under the age three (95% CI 6.6–68.3). Diarrhea duration was also reduced. This is promising evidence that child health can be improved through agricultural interventions such as biofortification.

Key words — nutrition, child health, morbidity, micronutrients, vitamin A, diarrhea

1. INTRODUCTION

Vitamin A deficiency (VAD) is prevalent in young children throughout the developing world, afflicting 190 million children under the age five worldwide (WHO, 2009). VAD is rated as a severe public health problem in 73 countries, many located in Sub-Saharan Africa (WHO, 2009). The impacts of VAD in early childhood include not only night blindness, but increased risk of other morbidity, as well as mortality. In a systematic review covering 43 randomized controlled trials (RCT) or cluster-RCTs, Mayo-Wilson, Imdad, Herzer, Yakoob, and Bhutta (2011) found that vitamin A supplementation (VAS) reduced diarrhea incidence by 15% (based on 13 studies) and measles incidence by 50% (six studies) in children aged six months to five years. Further, they found that VAS reduced all-cause mortality for these children by 24% (43 studies); evidence that the authors rate as high quality. [1]

According to Villamor and Fawzi (2005), the impact of vitamin A on measles is due to increased lymphocyte proliferation, which increases short-term antibody production. In contrast, the reduction in severe diarrhea is likely due to the role of vitamin A in restoring and maintaining gut mucosal integrity, though there may be other immunological pathways. These impacts are believed to be the strongest among children who are undernourished or suffering from severe infection. While reductions in these morbidities contribute to the impact of vitamin A on all-cause mortality, that impact is likely also bolstered by the ability of vitamin A to increase T-cell counts, particularly of the CD4 population, in children infected with HIV.

Akachi and Canning (2010) argue that improving nutrition and reducing morbidity should be a key focus for development interventions, as child morbidity is a strong predictor of later-life outcomes. Indeed, individuals experiencing high levels of childhood morbidity have been shown to have reduced cognition, impaired adult stature, and be at increased risk of later-life morbidity and mortality. [2] In Sub-Saharan Africa in particular, achievements in reducing child mortality may have outpaced reductions in childhood morbidity. This hypothesis is based on the fact that, despite advances in reducing child mortality in Africa, today's adult Africans are shorter than their predecessors, which may be an indicator of increased childhood morbidity (Akachi & Canning, 2010). Reducing childhood morbidity may prove an effective and sustainable option for improving the productivity and longevity of the next generation of Africans.

However, indefinitely continuing high-frequency supplementation can be costly. Edejer *et al.* (2005) estimated that VAS costs \$2.71 per recipient per dose. Relying on VAS alone, at least quarterly dosing is required for maximum impact, at a cost of \$10.84/child/year. This implies that alleviating VAD worldwide through supplementation alone would cost at least \$2.8 billion per year, implying a net present value of nearly \$40 billion to alleviate VAD for the next 20 years. If other interventions can effectively complement VAS, these may be useful not only for reducing the cost of addressing VAD now, but also as more sustainable future alternatives to VAS, once the prevalence of VAD has been sufficiently reduced.

One complementary approach to reducing VAD and other micronutrient deficiencies is to encourage shifts toward more micronutrient-dense diets (Ruel, Alderman, & Maternal Child Nutrition Study Group, 2013). In rural areas, where diets often include a great deal of own-produced food, such interventions must occur through agriculture. Potential interventions include home gardening, various types of animal husbandry, aquaculture, and biofortification of staple crops (Masset, Haddad, Cornelius, & Isaza-Castro, 2012). Yet many of these strategies are still unproven in improving nutrition or health (Bhutta *et al.*, 2008; Ruel *et al.*, 2013). The primary goal of these programs is generally to improve dietary diversity, yet there is little existing evidence that such interventions actually affect dietary diversity, not to mention health. Bhutta *et al.* (2008) suggest that lack of evidence is partially due to a general paucity of rigorous evaluations of agricultural interventions to deal with micronutrient deficiencies.

One recent exception is the biofortification of staple crops (Bouis, Hotz, McClafferty, Meenakshi, & Pfieffer, 2011). Biofortification involves the breeding of micronutrients into staple

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crops using conventional breeding practices to control vitamin A, iron, and zinc deficiencies (Nestel, Bouis, Meenakshi, & Pfieffer, 2006). Since biofortification works through improving the nutritional quality of the variety of staple crops that households are already consuming, it is a promising, potentially cost-effective way to reduce VAD or other micronutrient deficiencies (Gilligan, 2012). This approach is currently recommended as a complement to ongoing efforts of VAS, with the potential to act as a longer-term replacement once the prevalence and severity of VAD in Africa has been significantly reduced.

In this work we examined the impact on child health of a targeted biofortification intervention for improving vitamin A intakes among young children in northern Mozambique. At the time of the intervention, 69% of children under the age five in Mozambique were vitamin A deficient (Aguayo, Kahn, Ismael, & Meershoek, 2005). The intervention, called the HarvestPlus Reaching End Users (REU) program, promoted the cultivation of orange sweet potatoes (OSP) in home gardens, rather than the traditionally grown white or yellow varieties. The intervention was designed as a scaled up version of the prior Toward Sustainable Nutrition Improvement (TSNI) intervention that distributed OSP at a much higher cost per beneficiary (Low *et al.*, 2007). The intervention included modules on production, consumption, and exchange of OSP. The REU was successful in promoting OSP adoption, increasing dietary intake of vitamin A, and decreasing VAD prevalence among both women of child bearing age and children (Hotz, Loechl, de Brauw *et al.*, 2012; Hotz, Loechl, Lubowa *et al.*, 2012). In this paper, we study the impacts of the REU on childhood morbidity. Primary outcome indicators include prevalence and duration of diarrhea within the two weeks prior to the interview.

2. METHODS

(a) *Intervention*

The HarvestPlus REU project aimed to promote and distribute provitamin A-rich OSP in Mozambique with the goal of reducing vitamin A deficiency among children under the age five and women of childbearing age. The REU included three components: seed systems, demand creation, and marketing. In the seed systems component, vines for growing OSP were distributed to households in treatment villages and households were trained in planting OSP, how to disinfect vines, and vine preservation.[3] In the demand creation component, mothers in treatment households were offered training on the benefits of consuming OSP, methods of preparing OSP, and other general health messages. Finally, the project included a marketing component to increase visibility of and demand for OSP in local markets.[4] The project worked in Zambézia with 144 farmer groups, approximately corresponding to villages, and reached over 10,000 farmers in total. Villages were chosen for the study based on their agricultural potential for growing sweet potatoes and maintaining sweet potato vines over the dry season.

The impact evaluation included 36 villages spread over three strata; two strata were in the north of Zambézia (Milange district and Gurué district) and a third stratum in the south (combining Mopeia and Nicoadala districts). Within strata, 2/3 of villages were randomly selected to receive the program and 1/3 were reserved as controls, in which the program would be implemented following endline data collection.[5] Villages included in the impact evaluation sample were chosen to ensure that no other health or agriculture-health interventions were taking place simultaneously in those villages. The program, as described, was implemented in 2007, 2008, and early 2009 with baseline data collection in 2006 (October to December) and endline data collection in June 2009 for dietary intakes, nutrition, and morbidity, and in August and September of 2009 for socioeconomics and OSP production. Within study villages, households were selected for inclusion in the study based on the presence of a child under age three within the household.

We first compiled a list of households in the village with children under 36 months, and then took a random sample of 12 households from the list for the main nutrition study. We then added four households from the list to those twelve for measuring anthropometry, morbidity (diarrhea), and food frequency.

(b) *Data*

Information regarding health and the frequency of consumption of different food items was collected at the baseline for one child each from 553 households. At the endline, this information was collected for the same children, plus additional children within these households who were born since the baseline, as well as children in newly recruited households from the same study villages. In total at the endline, 866 children were included in this component from 673 households.

For this paper, OSP consumption is measured through the food frequency questionnaire. The food frequency questionnaire gathered information on patterns of consumption of a variety of foods and food groups, with an emphasis on vitamin A-rich foods. Respondent guardians were asked about the number of times children had consumed 26 specific foods during the past seven days. Diarrhea and other health conditions were measured using a set of relatively standard recall questions asked to a guardian regarding all children under the age 5 resident in targeted households who were included in the sample frame. The pertinent questions in this survey were whether or not the child had diarrhea in the past 14 days, and if so, how many days the diarrhea spell lasted.

Table 1 shows the sample size by age. The baseline recruitment for this study yielded a sample of 540 children observed in 2006 when under the age 3. In addition to following-up these children in 2009, new children under the age three in the same households were also enrolled at that time.[6] The 2009 sample included children aged zero to 5, so the mean age for the 2009 sample was significantly higher than in the 2006 sample. The final row of Table 1 indicates that when restricting the sample to those under the age of 36 months

Table 1. *Sample size by child age*

Age in years	2006	2009	Total
0	93	45	138
1	212	137	349
2	218	112	330
3	14	175	189
4	3	193	196
5	0	119	119
Total	540	781	1,321
Mean age	1.30	2.88	2.24
Total U3	523	294	817
Mean age of U3	1.24	1.23	1.24