Agricultural Intervention for Food Security and HIV Health Outcomes in Kenya

Study Protocol

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1. Title: Shamba Maisha: Agricultural intervention for food security and HIV health outcomes in Kenya

2. Investigators and Institutional Affiliations

Name	Organization	Role on Project
Craig R. Cohen, MD, MPH	Department of Obstetrics, Gynecology, and Reproductive Sciences, Bixby Center for Global Reproductive Health, University of California, San Francisco	Co-Principal Investigator
Sheri D. Weiser, MD, MPH	Division of HIV/AIDS, San Francisco General Hospital, University of California, San Francisco, Department of Medicine	Co-Principal Investigator
Elizabeth A. Bukusi, MBChB, MMed, MPH, PhD	Center for Microbiology Research, Kenya Medical Research Institute	KEMRI Principal Investigator
Shari Dworkin, PhD, MS	University of California, San Francisco, Dept. of Social & Behavioral Sciences	Co-Investigator
Edward A. Frongillo, Jr., PhD, MS	Department of Health Promotion, Education, and Behavior, Arnold School of Public Health, University of South Carolina	Co-Investigator/ Biostatistician
Lisa M. Butler, PhD, MPH, MA	Institute for Collaboration on Health, Intervention, and Policy, University of Connecticut	Co-Investigator
James G. Kahn, MD, MPH	Dept. of Epidemiology & Biostatistics, IHPS, and Global Health Sciences, University of California, San Francisco	Co-Investigator
Harsha Thirumurthy, PhD, MPhill	Perelman School of Medicine, University of Pennsylvania	Co-Investigator
Starley Shade, PhD, MPH	Department of Epidemiology & Biostatistics, Division of Prevention Science, University of California, San Francisco	Co-Investigator
Martin Fisher, PhD	Kickstart	Consultant

A. COLLABORATING INSTITUTIONS

UNIVERSITY OF CALIFORNIA SAN FRANCISCO (UCSF)

UCSF is the only University of California campus dedicated exclusively to the health sciences and is home to graduate professionals in medicine, nursing, pharmacy, and dentistry, and a graduate division for pre-doctoral and postdoctoral scientists. In addition to its main campus, where the Schools of Medicine, Nursing, Pharmacy, and Dentistry and the UCSF Medical Center are located, UCSF encompasses several major sites in San Francisco, including UCSF Mount Zion, the Comprehensive Cancer Center, and Mission Bay. UCSF is considered one of the United States' premier health sciences, training, and research centers and has a well-established reputation in biomedical research.

UCSF Department of Medicine The Department of Medicine has been the number one recipient of research dollars from the National Institutes of Health (NIH) among all departments of internal medicine in the nation. Eight of the adult specialty clinical programs are ranked in the

top 10 by the US News & World Report - AIDS, Diabetes & Endocrinology, Primary Care, Cancer, Kidney Disorders, Pulmonology, Geriatrics and Rheumatology. The department's continued success in this highly competitive arena attests to the quality and impact of the research performed by its basic and clinical scientists.

UCSF Department of Obstetrics/Gynecology and Reproductive Sciences: The Department boasts a diverse portfolio of research activities, from basic biological, translational, and clinical investigation to epidemiological inquiry and the development of public health policy. The Department is home to the University of California National Center of Excellence in Women's Health. The Department's exemplary academic reputation (consistently among the top three departments of obstetrics and gynecology in the nation to receive federal funding) derives from long-standing integrative and multidisciplinary partnerships within the UCSF community of nursing and medical scholars.

UCSF Department of Epidemiology and Biostatistics

The UCSF Department of Epidemiology & Biostatistics - the largest department of epidemiology in the University of California system in terms of full-time primary faculty and the number of affiliated faculty. It aims to carry out its educational, scientific, and clinical missions within the highly interdisciplinary culture of UCSF and to take a transdisciplinary approach to education and research.

UCSF AIDS Division: Positive Health Program (PHP)

Drs. Sheri Weiser is a faculty member in the PHP/HIV/AIDS Division at San Francisco General Hospital. The HIV/AIDS Division is part of the Department of Medicine at UCSF. PHP consists of a multidisciplinary HIV/AIDS clinic, an AIDS Inpatient Unit, and a strong clinical research program. The program has focused on clinical, research and educational issues of HIV and HIV-associated illnesses (e.g., sexually transmitted and blood borne infections) for over 25 years. Academically, PHP holds weekly clinical grand rounds, monthly research forums and periodic seminars, which provide ample opportunity for peer review as well as dissemination of study information. The Positive Health Program has become an internationally recognized center of clinical excellence and "standard-setter" for HIV care, pioneering a number of medical and scientific advances. The treatment model practiced at PHP has been widely adopted around the world. PHP has also had a major presence in the developing world, training local providers and leading global research. PHP's faculty is among the most cited in scientific publications and conducts work in all major areas of HIV science.

UCSF Center for AIDS Prevention Studies (CAPS)

Dr. Sheri Weiser holds a secondary appointment at CAPS. The mission of CAPS is to develop research focused on three long-term goals: preventing new HIV infections, behavioral approaches to optimizing health outcomes among HIV-infected people, and reducing disparities. These goals are advanced through multidisciplinary research supported by six cores. CAPS is located at 550 16th Street along with the AIDS Research Institute (ARI) administrative offices, the Pacific AIDS Education and Training Center (PAETC) and the UCSF program in Global Health Sciences (GHS). CAPS hosts a weekly town hall series, in which scientists from UCSF and around the world present findings from their ongoing and recent research. In addition, the UCSF Global Health Sciences program (co-located with CAPS) hosts a regular speaker series and offers a degree program with classes in epidemiology, biostatistics, and qualitative and quantitative behavioral research methods.

Both CAPS and PHP are programs of the AIDS Research Institute (ARI). The AIDS research program at UCSF constitutes an organized set of research activities aimed at all aspects of the

epidemic domestically and internationally. ARI is committed to harnessing the extraordinary resources of UCSF to advance scientific discovery in the service of fighting HIV/AIDS. UCSF faculty represent a mix of expertise in the basic, clinical, prevention, and policy sciences. The faculty is internationally renowned for their contributions to immunology, virology, vaccine research, pediatrics, genetics, behavioral science, and advanced treatment research. Further, UCSF scientists have the expertise in health economics, epidemiology, and health care delivery needed to determine how optimal treatments can be integrated into evolving health care systems to reach all HIV-affected populations. ARI brings together scientists from the four professional schools at UCSF (Medicine, Dentistry, Pharmacy, and Nursing), from the UCSF-affiliated laboratories (The Gladstone Institute of Virology and Immunology, Blood Centers of the Pacific, and the California State Labs), the San Francisco Department of Public Health, and the School of Public Health at UC Berkeley. Activities are conducted at all four hospital sites: Parnassus, San Francisco General, Mt. Zion, and the SF Veterans Affairs Medical Center.

UCSF Bixby Center for Global Reproductive Health: The Bixby Center was formed in 1999 to integrate research and training efforts in contraception and family planning with work in sexually transmitted infections (STIs) and HIV/AIDS. Projects and research range from primary prevention to treatment interventions and include epidemiologic and behavioral approaches, clinical and biomedical research, and public health and policy development, as well as leadership training programs. Faculty and staff from diverse disciplines, including medicine, epidemiology, public health, sociology and anthropology, use sound science to seek solutions to the reproductive health issues of most pressing concern to women, men and youth in the United States and internationally.

UCSF Department of Social & Behavioral Sciences, School of Nursing: The Department of Social and Behavioral Sciences (SBS) research mission is to advance knowledge through theory and research; to design and evaluate the organization, financing, and delivery of health care; and to examine one broad dynamics of health, healing, and the production of knowledge and its application in these domains.

UC GLOBAL HEALTH INSTITUTE (UGCHI)

UCGHI advances the mission of the 10-campus University of California system to improve the lives of people in California and around the world. By stimulating education, research, and partnerships, UCGHI leverages the diverse intellectual resources across the University to train the next generation of global health leaders and accelerate the discovery and implementation of transformative global health solutions. UCGHI includes three Centers of Expertise (COE), including the **COE in Women's Health & Empowerment (WHE)**. The COE in WHE believes that advances in women's health globally are impeded by poverty, limited access to educational and economic opportunities, gender bias and discrimination, unjust laws, and insufficient state accountability. By prioritizing women's health concerns, rights, and empowerment, this COE is uniquely poised to catalyze societal-level changes that will yield sustainable improvements in health and well-being for women on a global scale.

KENYA MEDICAL RESEARCH INSTITUTE (KEMRI)

The Kenya Medical Research Institute (KEMRI) is one of the leading health research institutes in Africa. KEMRI was established in 1979 under the Science and Technology (Amendment) Act of that year to represent the national body responsible for carrying out health science research in Kenya. KEMRI's mission is to conduct health research and generate research findings to be applied towards improvement of health in Kenya and the world over. Under the Amendment Act, KEMRI was charged with the responsibility of carrying out health research with the following mandates:

1. To carry out research in the field of biomedical sciences;
2. To co-operate with other organizations and other institutions of higher learning in training programs and on matters of relevant research;
3. To liaise with other research bodies within and outside Kenya carrying out similar research;
4. To disseminate research findings;

- To co-operate with the Ministry of Health, the Ministry responsible for research, the National Council for Science and Technology, and the Medical Science Advisory Committee on matters pertaining to research policies and priorities.

With health research and training expertise in infectious disease, parasitic disease, epidemiology, and biotechnology and non-communicable diseases, KEMRI has grown to become one of the leading centers of excellence in health research development and Africa's largest health research institute. KEMRI has trained cadres of professionals and maintains over 80 professors with PhD degrees or equivalent, over 148 with MA or equivalent, and nearly 400 highly trained and skilled technical staff. As a partner in global health initiatives, KEMRI collaborates with the World Health Organization (WHO), the Japan International Cooperation Agency (JICA), U.S. Center for Disease Control and Prevention (CDC), among others. KEMRI serves as the Collaborating Center for HIV/AIDS, Tropical Research, Polio Immunization, Viral Hemorrhagic Fevers, and Anti-Microbial Resistance.

Research, Training, and Care Program (RTCP), KEMRI

Drs. Bukusi and Cohen with others established the Research, Training, and Care Program (RTCP) with KEMRI and the University of Nairobi in 1994. Through this collaboration, Dr. Cohen and Dr. Elizabeth Bukusi (KEMRI) established the Research, Care, and Treatment Program (RCTP), a program with research projects in Nyanza Province and Nairobi, Kenya. In 2007, RCTP became registered as an NGO in Kenya and in 2013, the name of the NGO was changed to RCTP-FACES. In addition to facilitating collaborative research on STIs and HIV treatment and prevention between investigators from the US and Kenyan counterparts, the mission of RCTP-FACES is to provide administrative management of the biomedical research conducted by researchers from KEMRI, UCSF, and other collaborating institutions. The largest RCTP-FACES program is the PEPFAR/CDC-funded Family AIDS Care and Education Services (FACES) program, which works with the government of Kenya to strengthen comprehensive HIV prevention, care, and treatment service delivery and expand primary prevention efforts in Nyanza and Nairobi Provinces.

UNIVERSITY OF SOUTH CAROLINA (USC)

Established in 1801, USC is a full-service, state-supported research university that includes the 358-acre Columbia campus and seven regional campuses with a total full-time student body population of more than 39,500 and 2,100 full-time faculty members. USC offers a broad spectrum of educational opportunities with 14 colleges and schools that encompass 324 undergraduate and graduate degree-granting programs.

The Arnold School of Public Health (ASPH) Based at USC's main campus in Columbia, ASPH is one of 49 schools of public health fully accredited by the Council on Education for Public Health (CEPH), and is accredited through 2017. Dr. Edward Frongillo is a professor and chair of the *Department of Health Promotion, Education, and Behavior* (HPEB) at the USC. This department has as its focus understanding how policy, environmental, institutional, and individual actions can improve the public's health. This work, usually done in partnership with

organizations and communities, uses principles and methods from the social and behavioral sciences to promote health in diverse settings across South Carolina, the US, and the globe.

UNIVERSITY OF PENNSYLVANIA

Academic life at the University of Pennsylvania, Penn, is unparalleled, with 100 countries and every U.S. state represented in one of the Ivy League's most diverse student bodies. Consistently ranked among the top 10 universities in the country, Penn enrolls 10,000 undergraduate students and welcomes an additional 10,000 students to our world-renowned graduate and professional schools. Penn is one of the world's most powerful research and teaching institutions, with a research budget last year of nearly $1 billion and more than 4,000 active faculty members. The scale and interdisciplinary character of research and teaching sets Penn apart, and our highly ranked Perelman School of Medicine is one of the top recipients of NIH funding in the country.

Department of Medical Ethics and Health Policy at the Perelman School of Medicine

The Department is one of the premier institutions of research and education in medical ethics and health policy in the world. The Department's distinguished faculty produce and disseminate scholarship and lead three bioethics master's degree programs. In addition to their own projects, faculty members supervise research being carried out by undergraduates, graduate students, medical students, doctoral students and post-doctoral fellows. The Department's presence in the world of biomedical ethics education is ever-growing. In 2017, the department will launch the Master of Health Care Innovation, an online master's program aiming to training future leaders in health policy, administration, and ethics.

UNIVERSITY OF CONNECTICUT

The University of Connecticut is one of the top public research universities in the United States, with more than 30,000 students pursuing answers to critical questions in labs, lecture halls, and the community. Knowledge exploration throughout the University's network of campuses is united by a culture of innovation. An unprecedented commitment from the state of Connecticut ensures UConn attracts internationally renowned faculty and the world's brightest students. As a vibrant, progressive leader, UConn fosters a diverse and dynamic culture that meets the challenges of a changing global society.

The Institute for Collaboration on Health, Intervention, and Policy

The University of Connecticut's Institute for Collaboration on Health, Intervention, and Policy (InCHIP) is a multidisciplinary research institute dedicated to the creation and dissemination of new scientific knowledge and theoretical frameworks in the areas of health behavior, health behavior change, and health intervention and prevention at multiple levels of analysis (e.g., individual, environmental, social, and policy). InCHIP researchers lead novel, influential health behavior change initiatives at UConn, institutions across the United States, and globally in countries including Albania, Brazil, China, Kenya, Ethiopia, India, Mozambique, South Africa, Russia, Uganda, and Vietnam. Our investigators have expertise in the areas of HIV prevention and treatment adherence, diabetes management, cancer prevention and control, nutrition, pharmacology, substance abuse, obesity, autism, digital health technologies, school and child health, and complementary and alternative approaches to medicine, among other health domains.

KICKSTART

KickStart, an international NGO, developed a low-cost micro-irrigation pump which is purchased by local entrepreneurs and used to establish small agricultural businesses. These pumps enable farmers to irrigate their crops year-round avoiding dependence on seasonal rainfall thus capitalizing on higher crop prices in the marketplace. KickStart has been one of the leaders in micro-irrigation technologies since 1991, through the development and sales of manually operated “MoneyMaker” pumps, which are now widely available in Kenya.

3. ABSTRACT

Despite major advances in care and treatment for those living with HIV, morbidity and mortality among people living with HIV/AIDS (PLHIV) remain unacceptably high in sub-Saharan Africa (SSA), largely due to the parallel challenges of poverty and food insecurity. Food insecurity and poverty contribute to higher morbidity and mortality among PLHIV, and there has been increasing international recognition of the need to address these factors for a successful global response to the HIV epidemic. Yet, to date there have been few studies to systematically evaluate the impact and cost-effectiveness of promising food security interventions on health outcomes among PLHIV. To address these gaps, together with KickStart, a non-governmental organization based in SSA, we have developed a multisectoral intervention in Nyanza Region, Kenya that includes: a) a loan (~$175) for purchasing agricultural implements and commodities; b) agricultural implements to be purchased with the loan including a human-powered water pump, seeds, fertilizers and pesticides; and c) education in financial management and sustainable farming practices. We successfully completed a pilot intervention trial that showed that the intervention was feasible, acceptable and may improve HIV-related health. We now plan to conduct a cluster randomized controlled trial (RCT) of this intervention with the following specific aims: **Aim 1:** To determine the impact of a multisectoral agricultural intervention among HIV-infected farmers on ART on HIV clinical outcomes. We hypothesize that the intervention will lead to improved viral load suppression (primary outcome) and decreased HIV-related morbidity in the intervention arm compared to the control arm. **Aim 2:** To understand the pathways through which the multisectoral intervention may improve HIV health outcomes. Using our theoretical model, we hypothesize that the intervention will improve food security and household wealth, which in turn will contribute to improved outcomes through nutritional (improved diet quality, nutritional status), mental health (less depression, improved empowerment), and behavioral (improved ART adherence, and retention in care) pathways. **Aim 3:** To determine the cost-effectiveness of the intervention and obtain the information necessary to inform scale-up in Kenya and similar settings in SSA. We hypothesize that the intervention will be cost-effective, and that we will be able to translate lessons learned into successful scale up. To accomplish Aims 1 & 2, we will randomize 8 matched pairs of health facilities in the Nyanza Region in a 1:1 ratio to the intervention and control arms, and enroll up to 65 participants per facility (total up to n=1,040). All participants will be followed for 2 years. To accomplish Aim 3, we will: a) conduct a cost-effectiveness analysis; b) identify the characteristics of individuals most likely to benefit from the intervention (e.g., gender, education, family size, wealth, risk tolerance, etc.); and c) perform a mixed-methods process evaluation to guide future scale-up efforts of the intervention. Our ultimate goal is to develop and test an intervention to reverse the cycle of food insecurity and HIV/AIDS morbidity and mortality in SSA.

4. LAY SUMMARY

We plan to test the hypothesis that a multisectoral agricultural and finance intervention will improve food security, prevent antiretroviral treatment failure, and reduce co-morbidities among people living with HIV/AIDS.

5. BACKGROUND

HIV/AIDS and food insecurity are two of the leading causes of morbidity and mortality in sub-Saharan Africa (SSA).[1-6] There are an estimated 35.3 million people living with HIV/AIDS (PLHIV) worldwide, 70.8% of whom live in SSA.[7] Food insecurity, defined as ”the limited or uncertain availability of nutritionally adequate, safe foods or the inability to acquire personally acceptable foods in socially acceptable ways,”[8] is also highly prevalent in SSA. As of 2013, 223 million people were food insecure in SSA, an estimated 25% of the population.[9] Food insecurity

in the region stems from the combined effects of extreme poverty, infections, environmental change, insufficient agricultural output, rising food prices, and high rates of population growth.[10,11] While the agricultural sector accounts for 51% of Kenya's gross domestic product [12], crop productivity is low because of limited irrigation, unreliable rainfall patterns, and land that is highly depleted of nutrients.[13] At the same time, food prices have increased since 1995 due to globalization, economic shifts and human conflict.[11] The prevalence of Critical Food Poverty (pCFP) (the proportion of the population whose daily income is lower than the cost of a macronutrient-balanced food basket that meets minimum dietary needs) in the Nyanza Region of Kenya is 28%, exceeding the national average.[14] The prevalence of food insecurity is even higher among PLHIV in SSA. Studies from Kenya and Uganda have found that 70% or more of PLHIV are moderately or severely food-insecure.[15-17]

Food insecurity and HIV/AIDS are intertwined through biological, behavioral, and socio-economic pathways. Our novel evidence-based causal framework (Figure 1) builds upon our previously-published conceptual framework[18,19] adapted from existing theoretical models for understanding the linkages between HIV/AIDS, food security, and socio-economic well-being.[3,18,20-22] The bi-directional linkages between HIV/AIDS and food insecurity are embedded within a context of weak healthcare systems, poor agricultural infrastructure, and entrenched poverty. These structural determinants of health interact to create a vicious cycle of household poverty, food insecurity, and ill-health.[20,22] Each condition heightens the vulnerability to, and worsens the severity of the other. For example, if a household affected by HIV/AIDS has few agricultural skills, they may experience food insecurity and poverty (A1, A2) leading to malnutrition (A4a), decreased ART adherence (A4b), poor mental health (A4c), and disempowerment (A4d). These, in turn, can worsen immunologic and virologic responses, and lead to increased morbidity and mortality (A3). Likewise, when a household loses a family member to HIV-related illness or death, they are less able to produce agricultural outputs and may sell off household assets as a source of income. This further cements families into the cycle of poverty and food insecurity (A5, A6). In the sections that follow, we provide evidence for each linkage in our causal framework.

Food insecurity and poverty are key contributors to poor health outcomes among PLHIV receiving treatment. In studies by our group and others, food insecurity has been associated with a range of adverse clinical effects among PLHIV on ART, including declines in physical health status,[16,23,24] decreased viral suppression,[25-28] worse immunologic status,[23,25,29,30] increased incidence of serious illness,[16,31,32] and increased mortality. [33,34] In several longitudinal analyses, we found that after controlling for clinical and socioeconomic variables, HIV-infected people who were food insecure were 50%-95% more likely to die compared with individuals who were not food insecure.[33,34] Studies have also documented negative health impacts of other indicators of low socioeconomic status (SES) for HIV.[35] For example, in a prospective cohort study in Uganda, we found that lack of education, unemployment and lower wealth index were associated with mortality.[36] In Kenya, we have demonstrated an association between low SES and lower CD4 increase upon ART initiation.[37]

Food insecurity and poverty can impact HIV outcomes through four mediating pathways: nutritional, behavioral, mental health and empowerment (Figure 1).

1) Nutritional pathways: Food insecurity is associated with macronutrient and micronutrient malnutrition,[38,39] and malnutrition in turn has been shown to hasten progression to AIDS and death.[40-43] Among HIV-infected individuals, weight loss, low body mass index (BMI), and low albumin have been shown to predict opportunistic infections, immunologic decline, and shorter survival time in both untreated and ART treated individuals.[44-52] HIV increases metabolic requirements[50,53] and is associated with diarrhea and malabsorption of fat and carbohydrates,[53-56] which further compounds the links between malnutrition and disease progression. Also, lack

of food may impede optimal absorption of certain ARVs,[57-59] which may contribute to treatment failure. Additionally, oxidative stress caused by micronutrient deficiencies may cause HIV viral loads to increase.[60] Poverty and nutrition have also been closely linked in a number of studies conducted in developing countries. In Kenya we have shown that higher SES – achieved as a result of ART initiation – led to increased nutritional status.[61] Other studies have also shown that economic shocks, that make households fall below the poverty line, result in poorer nutrition.[62]

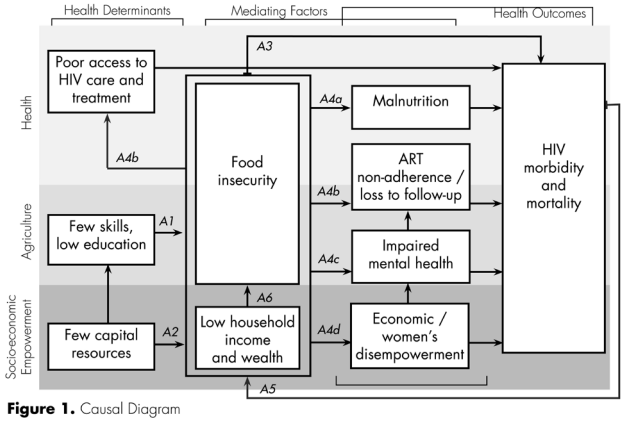

Figure 1. Causal Diagram

2) Behavioral pathways: Studies from our group and others have shown that food insecurity and poverty indicators are consistently associated with ART non-adherence and treatment interruptions,[63-72] which are both well-known determinants of HIV treatment outcomes. [73-80] Food insecurity and poverty contribute to non-adherence in SSA because of competing demands between costs of food, basic needs, and medical expenses, and because of worsened ART side effects in the absence of food,[65,67] In addition to ART non-adherence and treatment interruptions, individuals who struggle with food insecurity and poverty often miss scheduled clinic visits, and may have decreased uptake of ART.[16,81] In rural Uganda, we reported that severe food insecurity was associated with decreased outpatient clinic visits, [16] and our other work in Uganda provided support for the hypothesis that poverty contributes to lower retention in care.[82] In Uganda, participants in a cohort study reported foregoing food in order to obtain ART (83%), access outpatient care (76%) and access inpatient care (44%).[16] This suggests that the relatively high levels of adherence reported among ART-treated individuals in SSA[83-85] may not be sustainable unless reduction of food insecurity and poverty become essential components of comprehensive HIV care programs. Interventions aimed at improving food insecurity and economic status may contribute to better ART adherence and retention outcomes.

3. Mental health pathways: Food insecurity has been found to be associated with poor mental health status independent of other indicators of low socioeconomic status.[86,87] Specifically, it has been associated with anxiety,[88] depression,[86] and stress.[88,89] Among PLHIV, we have published several studies demonstrating that food insecurity is associated with depression and poor mental health status in SSA and elsewhere.[31,33,90] A number of studies have also documented that poverty has a negative, causal effect on mental health among PLHIV.[91-93] The mental health consequences of food insecurity and poverty can contribute to lower ART adherence and worse HIV clinical outcomes.[94-97] Even after adjusting for ART adherence, depression has been associated with worsened HIV treatment outcomes, including CD4+ T-lymphocyte count decline,[94] increased probability of AIDS-defining illness,[98] and AIDS-related mortality.[94] The role of depression in accelerating disease progression is strengthened by the fact that the treatment of depression has been demonstrated to improve ART adherence[99] and viral suppression.[99] Together, these data suggest that improving the food security and economic status of ART patients should result in better mental health outcomes, which in turn can contribute to better HIV clinical outcomes.

4. Empowerment pathways: Food insecurity and poverty also contribute to lower levels of empowerment, including women's empowerment, which can negatively impact health outcomes for HIV. Often dependence on male partners for food and other resources disempowers women by making it difficult to exercise control in household or sexual decision-making. In qualitative and quantitative studies from our group from Uganda, Botswana and Swaziland, we found that

lack of food impeded women's ability to refuse sex or to insist on condom use.[100,101] For example, in Botswana and Swaziland, we found that women who were food insecure reported lower control over sex, and experienced twice the odds of sexual victimization in the past year.[101,102] Research also suggests that low sexual relationship power is associated with adverse physical and mental health outcomes.[103-106] In Uganda, we have shown that, among HIV-infected women low sexual relationship power is associated with malnutrition, [103] depression,[107] and worse virologic outcomes.[106]

Morbidity and mortality from HIV/AIDS poses adverse social and economic consequences for households with HIV, perpetuating the vicious cycle of food insecurity, poverty and HIV/AIDS.[108,109] Households affected by HIV/AIDS lose income, assets, and skills when working-age adults fall ill, and the subsequent treatment and funeral costs can be doubly catastrophic.[110-119] National survey data from Kenya indicate that the net value of household crop production declines by 68% following the death of a male household head, and that affected households adopt short-term survival strategies (such as selling off productive assets and shifting from high-value to subsistence crops) that impair financial viability in the long term.[120] Furthermore, intergenerational transmission of poverty and food insecurity occurs when children are withdrawn from school to provide informal care or to compensate for lost labor.[61,121,122] Put differently, the epidemic represents a decade-long setback in human capital accumulation in Kenya.[123]

PLHIV may be particularly susceptible to food insecurity and poverty and are least able to rely on social support for assistance when faced with health and agricultural shocks. Borrowing and other transfers from kin and social networks serve as a source of informal insurance against shocks.[124-127] Due to higher poverty and greater stigma, however, HIV-affected households are generally less capable of drawing on these informal sources of support when faced with shocks.[128] As a result, HIV-affected households may be even more susceptible to worsening food insecurity.[129] Livelihood strategies are needed to improve both food security and HIV-related stigma, helping to interrupt the cycle of food insecurity and poor health.[130]

Given the evidence base, there is a critical need to develop cost-effective structural interventions that address food insecurity and poverty to reduce HIV morbidity and mortality for PLHIV receiving care. Although allocation of international resources towards HIV treatment and care programs in Africa has increased, food insecurity can significantly compromise the effectiveness of these programs.[131] As more individuals are initiated on treatment, the importance of addressing food insecurity and poverty for achieving good clinical outcomes will likely grow. As a result, the World Health Organization, UNAIDS and the World Food Programme have recommended integrating sustainable food production strategies into HIV/AIDS programming.[132-135] Specifically, UNAIDS calls for international partners *to "fund multisectoral HIV programming that incorporates effective food and nutrition interventions, in line with scale-up towards universal access to treatment, care and support."*[136] Yet, little research exists to test the effect of food security or sustainable agricultural interventions on HIV clinical outcomes among PLHIV in Africa or elsewhere. Furthermore, economic efficiency is increasingly important in the context of structural interventions to address food insecurity and HIV treatment. Today's strained global economic climate imposes practical constraints on goals for expanded use of ART.[137-139] The mismatch between global health goals and resources calls for close examination of promising means to obtain maximum health benefits using available funds.

Existing approaches to impacting HIV treatment outcomes via food security and poverty alleviation have numerous limitations. Economic, health and agricultural programs have historically been highly compartmentalized and poorly coordinated.[140-142] Several small studies using macronutrient supplementation have demonstrated that directly addressing food security

can improve health outcomes among PLHIV, including ART adherence and nutritional status.[131,143-150] Yet, a recent Cochrane review identified that there are no RCTs conducted in developing countries examining the impacts of either macronutrient supplementation or sustainable food production strategies on HIV morbidity and mortality.[151] Additionally, macronutrient supplementation is limited in scalability,[152] does not address all of the downstream health consequences of food insecurity, and perpetuates dependency on health and assistance programs.[147] Moreover, relying on clinics for food may be socially unacceptable and may contribute to ongoing anxiety about food supply. Livelihood interventions that address the root causes of food insecurity have a better chance of sustainably improving health outcomes by addressing the nutritional, mental health and behavioral pathways through which food insecurity negatively impacts HIV-related health. Likewise, while microcredit programs can improve health and prevent disease acquisition by helping to address poverty and gender inequality,[153-155] these have been criticized in terms of their effectiveness as a stand-alone strategy. As a result, experts have recommended an integration of finance and other livelihood approaches to maximize health and reduce poverty.[156,157] Income generating activities are well-suited to improving food security due to a strong empirical relationship between income and food consumption,[158,159] and to retaining patients in HIV care.[131,160] Agricultural interventions have significant potential to improve health since the sector is a primary source of income in many parts of SSA; in Kenya, agriculture accounts for >75% of the total workforce, and 51% of the GDP.[12] Randomized trials are urgently needed to test the impacts of combined livelihood and microcredit interventions on PLHIV health.

Preliminary data

A. In our *Shamba Maisha* feasibility study, we have shown that a similar intervention using agricultural training, microfinance and the KickStart pump was feasible and acceptable, and improved income and clinical outcomes. In 2007- 2008, FACES, in collaboration with KickStart, carried out a feasibility study with 30 HIV-positive patients in Kisumu, Kenya.[161] Mean annual income increased by $1,332 (range $1,187 - $2,518) over baseline, and mean CD4 count increased by 95.5 ± 139.2 cells/mcL.[161] At baseline, 27% of individuals had BMI<18.5 compared with 13% at follow-up.[161]

B. In our *Shamba Maisha* pilot intervention study (R34MH094215; Cohen/Weiser, PIs; Bukusi site PI; Dworkin co-I), *we have shown the current intervention to be feasible and acceptable*. In 2012-213, UCSF and FACES, in collaboration with KickStart, carried out a pilot study of the proposed intervention with 140 HIV-positive patients at two district hospitals in the Nyanza Region, one randomized to the intervention (n=72 participants) and one to the control arm (n=68 participants). Eligibility criteria and the intervention were the same as the current study (see C5a). Enrollment of the 140 participants took only four months, and the screening-to-enrollment ratio was similar between study arms. Thus enrollment into the control conditions did not appear to mitigate interest in study participation. Four participants withdrew from the study (98% retention). Only one of the 72 participants in the intervention arm failed to save the down payment for the loan and was withdrawn from the study. All intervention participants completed the agricultural and finance training, and found these trainings to be beneficial. Together, these findings have important implications concerning the feasibility for advancing the intervention into a definitive cluster randomized controlled trial.

C. In our *Shamba Maisha* pilot R34 study, the intervention *improved food security, HIV clinical outcomes, and child nutrition outcomes*. Using difference-in-difference mixed-effect models, when compared to the control arm, participants enrolled in the intervention arm had statistically significant improvements in food security (3.6 scale points higher, p<0.001), frequency of food consumption (9.4 times per week greater frequency, p=0.013) and self-confidence (p=0.004). Even though the study was not powered for HIV clinical outcomes, we

also found statistically significant improvements in CD4 cell counts (165 cells/mm^3, p<0.001) and proportion virologically suppressed in the intervention arm compared to the control arm (comparative improvement in proportion of 0.33 suppressed, (OR 7.6, 95% CI: 2.2-26.8). Children <5 years who resided in intervention-arm households (n=97) had significantly larger increases in height-for-age Z-scores compared to children in the control arm (n=100) (p=0.04). Weight-for-age Z-score declined in the control arm over time but not in the intervention arm (p=0.01). While these results are promising, with only two hospitals randomized to the intervention or control, it is difficult to definitely separate intervention effects from cluster-level variables, highlighting the need for the proposed RCT.

In a concurrent longitudinal qualitative study (n=60), participants in the intervention arm described notable improvements in food security, income and HIV-related health, including improved energy and fewer symptoms of illness compared to before initiating the intervention. Participants described improved health through nutritional, behavioral, mental health and empowerment pathways, in line with our theoretical framework (Figure 2, and Appendix 1). Nutritional pathway: Food quantity and diet quality improved and led to weight gain as a result of a) increased consumption of fresh fruits and vegetables from their farms; and b) increased income from selling produce, which was then used to purchase foods such as meat and grains. Behavioral pathway: Participants missed fewer clinic visits by using money earned from selling produce for transportation. Some reported better ART adherence because of an improved food supply resulting in fewer medication side effects. Mental health pathway: Participants reported improved mood and fewer symptoms of depression, as they became more active members of the community, were better able to financially support their family, and had less anxiety about household food supply. Participants also described more hope for the future.

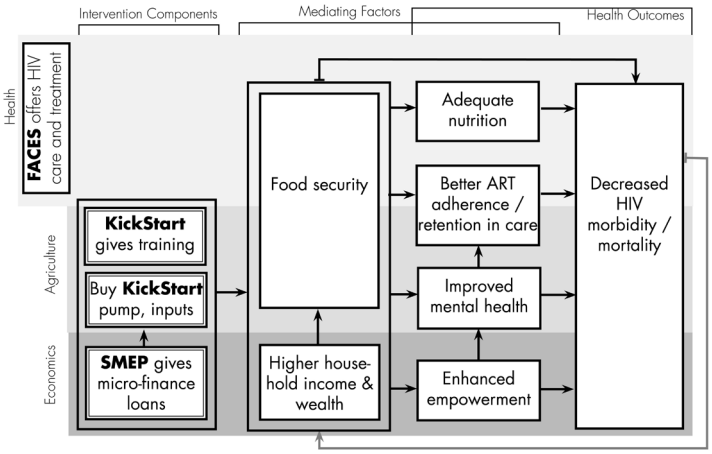

Figure 2. Intervention Theory of Change

Empowerment pathway: Due to improved health and work productivity, participants described a transformation in their identity from "patients living with HIV" to productive "farmers." Since joining Shamba Maisha, they were consulted by neighbors on farming techniques leading to increased visibility, influence, and engagement in community networks. Women's empowerment increased in several domains: a) improved equity over decision-making related to agricultural production, sales, and finances; b) improved control over intra-household resource distribution, and c) increased control over sexual relationships. These changes were most notable when women were responsible for bringing the intervention into the household.

Our team has extensive experience in conducting complex research and large clinical programs in the region, including recruiting and retaining intervention cohorts. FACES (CDC PS001913-01; PI C. Cohen; site PI E. Bukusi) is a PEPFAR-supported program that provides HIV care, treatment and prevention services and has enrolled more than 136,020 adults and children at 124 health facilities in Homa Bay, Migori, and Kisumu counties. The FACES program serves as the platform for over 12 clinical and implementation research studies conducted by teams from UCSF and the Kenya Medical Research Institute (KEMRI) including the *Shamba Maisha* pilot study and proposed cluster RCT. In one trial called "Sustainable East Africa Research for Community" (Site PIs: C. Cohen and E. Bukusi; co-Is Drs. Kahn and

Thirumurthy), our team is contributing to a multi-site community RCT (enrolled over 335,000 individuals) that will quantify the health and economic impact of early HIV diagnosis and immediate ART using a streamlined care delivery system in 32 rural communities in East Africa. Our team has also conducted a cluster RCT (PI: C. Cohen; Site PI: E. Bukusi) that showed that integrating family planning services into HIV care is associated with increased use of more effective contraceptive methods (sterilization, intrauterine device, implant, injectable or oral contraceptives).[162] We have also carried out two large HIV prevention trials among discordant couples in Kisumu (site-PIs, C. Cohen and E. Bukusi). Each study had at least 94% of participants retained after 24 months of follow-up.[163,164]

We have been leaders in research documenting negative health impacts of food insecurity on HIV health outcomes. Dr. Weiser (along with Drs. Frongillo, Cohen, and Butler) has published 30 manuscripts in peer- reviewed journals describing impacts of food insecurity on HIV health outcomes, mental illness, adherence, and women's empowerment (see sections A3, A4, A5 for details) in SSA and elsewhere. These include: a) longitudinal studies linking food insecurity with poor ART adherence and worse virologic and immunologic outcomes;[25,165] b) longitudinal studies showing that food insecurity is associated with increased measures of morbidity (opportunistic infections, physical health status), acute care utilization (hospitalizations, acute care visits) [16,32] and higher mortality among HIV-infected individuals.[34,166] One of Drs. Weiser's and Butler's articles published in PLoS Medicine won the NIH/Council of Science Editors Award for the Global Theme Issue on Poverty and Human Development and was chosen among more than 1000 articles published in 235 journals. [101] Based on the above work, Drs. Weiser, Frongillo, and Cohen published several review papers and a theoretical framework that forms the basis for our framework for the current study.[19,167] [18]

We have experience evaluating health impacts of food insecurity and economic interventions. In Kenya, Drs. Weiser, Cohen and Bukusi have demonstrated that patients enrolled in the food by prescription program achieved greater gains in BMI compared to those not enrolled.[15] Dr. Frongillo has been a leader in documenting impacts of food insecurity interventions on nutrition and health in Burkina Faso,[168] Bangladesh,[169-172] and the US.[173] The longitudinal studies in Burkina Faso and Bangladesh[174] had 99.2% and 90.4% retention rates, respectively, after two years. Dr. Thirumurthy has led studies of the effects of structural/economic interventions such as cash transfers on health outcomes in Kenya.[175] The novel intervention we are proposing here will build on the team's experience with these previous interventions as well our prior pilot study.

Our group has experience measuring empowerment, studying the linkages between gender empowerment, food insecurity and health outcomes, and studying microfinance interventions. Drs. Weiser and Dworkin developed a compendium of measures of empowerment for the UC Global Health Institute Center of Expertise on Women's Health & Empowerment. Drs. Weiser, Butler, and Dworkin have shown that food insecurity and poverty contributes to lower levels of empowerment for women,[100,176] and that low sexual relationship power is associated with malnutrition and depression.[107,177] In reviews of structural interventions for HIV prevention, Dr. Dworkin has shown how women's economic independence through microfinance contributes to improved sexual negotiation, safer sex and decreased gender-based violence.[178,179] In a rigorous meta-analysis examining the impacts of economic programs on women's empowerment, Dr. Dworkin and colleagues found that women's economic groups have a positive and statistically significant impact on women's economic and social empowerment. [180]

We are leaders in research on the intersection between economic variables and HIV/AIDS, and in evaluating cost-effectiveness. Dr. Thirumurthy has extensive experience in the measurement of poverty and economic status among rural households in Kenya and

Uganda. He has led analyses of the economic impact of HIV-associated health deterioration as well as ART-induced health improvements in individual productivity and on a broad array of socio-economic outcomes at the individual and household level.[25,37,181-185] Our team has also documented an association between the CD4 cell count of HIV-infected adults and their economic status.[186] Dr. Kahn has led the development of novel approaches to perform cost-effectiveness analysis in the context of HIV care, treatment and prevention, and has collaborated with Dr. Thirumurthy on cost-effectiveness analyses in East Africa related to HIV/AIDS. [61,186-189] In Tororo, Uganda, he assessed a safe water intervention ($1,252 dollars/disability-adjusted life year [DALY] averted)[190] and ART ($597 per DALY averted). In South Africa, he found that expanding ART to CD4 count <350 cells/μL would prevent 15% of new HIV infections, deaths, and DALYs, with savings of $4 billion over 40 years. He assessed the cost-effectiveness of ART across 45 clinics in Zambia, finding $833 per DALY averted compared to cotrimoxazole alone.[191] Recently, he assessed the cost-effectiveness of integrated community health campaigns in 70 countries, finding $49 per DALY averted for the 10 countries with the most favorable cost-effectiveness.[192]

6. JUSTIFICATION

The proposed cluster RCT will be the first definitive study to our knowledge to evaluate whether a multisectoral agricultural and finance intervention aimed to improve food insecurity and household economic indicators will lead to direct health benefits for HIV-infected persons. This will also be the first RCT to evaluate the impacts of an irrigation intervention on health for any condition including HIV. Finally, we will apply a novel theoretical framework to elucidate the mechanisms through which improvements in food security and economic indicators may impact HIV health outcomes. By demonstrating the role of sustainable agricultural and economic development in improving the health of HIV-positive individuals, the proposed investigation can have a major public health impact and has the potential to improve the ways in which development and HIV health care services are integrated and delivered throughout rural Africa.

Our work also provides an innovative approach to address the intersections between health, agricultural and socio-economic problems. This project brings together an interdisciplinary team of experts in agriculture, economics, epidemiology, biostatistics, behavioral science, HIV medicine, medical sociology, and gender studies. We will collaborate with an HIV care and treatment program (Family AIDS Care & Education Services, or FACES),[193] an international non-governmental organization (KickStart), a Kenyan finance organization, and the Kenyan Ministry of Health (MOH). Such collaborations are well positioned to contribute toward sustainable public health solutions that resolve the intersecting problems of food insecurity, poverty, and HIV/AIDS morbidity and mortality in SSA. By contributing to dialogue among those involved in international agricultural policy and ART delivery in SSA, the proposed study can impact both sectors, facilitating effective utilization of resources. Also, the intervention may play an important role in improving women's empowerment, and for child nutrition, as suggested by observational studies conducted in Kenya[194] and elsewhere.[195-201]

7. HYPOTHESIS

Hypothesis 1 (Aim 1): The intervention will lead to improved viral load suppression (primary outcome) and other measures of morbidity such as changes in CD4 cell count, physical health status, WHO stage III/IV disease, and hospitalizations (secondary outcomes) in the intervention arm compared to the control arm.

Hypothesis 2 (Aim 2): The intervention will improve food security and household income, which in turn will contribute to improved outcomes through nutritional (improved diet quality, nutritional status), behavioral (improved ART adherence and retention in care), mental health (improved mental health/less depression) and empowerment (gender role attitudes, household decision-making) pathways[18] (Figure 2).

8a. GENERAL OBJECTIVES

Our interdisciplinary team will conduct a randomized control trial in the Nyanza Region, Kenya to understand whether a multisectoral agricultural and finance intervention improves HIV clinical outcomes, and to elucidate the causal pathways (nutritional, mental health, and behavioral) through which the intervention may lead to these outcomes. We also aim to determine whether the intervention is cost-effective and sustainable.

8b. SPECIFIC OBJECTIVES

1. To determine the impact of a multisectoral agricultural intervention among HIV-infected farmers on ART on HIV clinical outcomes. The primary outcomes is improved viral load suppression secondary outcomes include changes in CD4 cell count, physical health status, WHO stage III/IV disease, and hospitalizations.
2. To understand the pathways through which the multisectoral intervention may improve HIV health outcomes. We will investigate nutritional, behavioral, mental health and empowerment pathways.
3. To determine the cost-effectiveness of the intervention and obtain the information necessary to inform scale-up in Kenya and similar settings in SSA. We will quantify the cost per disability-adjusted life year averted, and identify lessons to inform successful scale-up.

9. STUDY DESIGN AND METHODOLOGY

Overview

We plan to conduct a matched pair cluster RCT of a multisectoral agricultural intervention among HIV-infected farmers on ART to determine the impact of the intervention on HIV viral load suppression (primary outcome), and additional health outcomes including changes in CD4 cell counts, WHO Stage III/IV disease, hospitalizations, physical health status and mortality (secondary outcomes). We will also determine the impact of this intervention on mediating outcomes in the hypothesized causal framework. Proximal mediators include food security and household economic indicators. We will also look at nutritional (diet quality, anthropometry), behavioral (ART adherence, engagement and retention in care), mental health (depression, mental health status), and empowerment (gender role attitudes, household decision-making) mediators as per our causal framework (see Figure 2). We will randomize 8 matched pairs of health facilities in the Nyanza Region in a 1:1 ratio to the intervention and control arms, and enroll up to 65 participants per health facility (total up to n=1040). All participants will be followed for 2 years. Impacts of our intervention on primary health outcomes and mediators will be investigated to assess direct and indirect intervention effects. Control participants will be eligible for the intervention at the end of the 2-year follow-up period. Alongside the trial, we will conduct a cost-effectiveness analysis and a process evaluation, which includes interviews with study participants, staff and various stakeholders to understand strengths and pitfalls of the intervention and translate lessons learned to guide a possible scale-up of the intervention in similar settings in East Africa.

The *Shamba Maisha* intervention has three components. *Shamba Maisha* will be spearheaded by UCSF and KEMRI. The agricultural components of the intervention will be led by KickStart. The economic elements will be implemented by a Kenyan finance institution. Following our causal framework, the intervention diagram (Figure 2) illustrates the relationship between intervention components and hypothesized outcomes (Page 11). We hypothesize that the 3 intervention components will act synergistically to impact outcomes.

KickStart Irrigation pump: Recognizing the need for improved agricultural tools for poor farmers in Kenya, KickStart, an international NGO, developed a low-cost irrigation pump for use by local entrepreneurs seeking to establish small agricultural businesses. KickStart has been a leader in irrigation technologies since 1991 through their manually operated “MoneyMaker” pumps, which are widely available in Kenya (retail cost: ~$60). These portable, low-cost, human-powered

pumps can pull water from up to 23 feet (either surface water or a shallow well) and push water an additional 46 feet above the pump. These pumps enable farmers to irrigate larger amounts of land, harvest more crop cycles, and plant crops with less regard for the seasonality of rainfall, thus capitalizing on higher off-season crop prices in the marketplace. This technology has reduced food insecurity and poverty for 800,000 users in 22 countries in the subcontinent since 1991[202] Farmers using this irrigation pump enjoy up to a ten-fold increase in income.[203-206] Similarly successful models of irrigation in India and Nepal have been found to improve income and food insecurity by increasing crop yields by up to 200% and reducing water consumption by 40-70%.[207] As a result of its documented success in our previous studies and local availability, KickStart's irrigation pump, as part of an agricultural intervention, has the potential to improve food security, economic and health outcomes. As described below, participants receive a voucher for the pump at the time of receipt of their asset loan.

Agricultural training: Upon loan receipt, participants in the intervention arm will receive training on the use of the MoneyMaker irrigation pump. Participants will also attend approximately 8 separate 3-hour training modules over the agricultural season (didactic sessions and practical demonstrations) in sustainable farming techniques, including seed selection, soil and water conservation, fertilization and crop rotation, integrated pest and disease management (IPM), pre and post-handling and marketing, and identifying improved market access for selling horticultural products. Participants will be encouraged to grow locally available and environmentally sustainable crops, and to diversify crops to ensure a diverse diet and adequate markets for their produce. All trainings will be delivered by agricultural trainers, will take place on participant's farms or a nearby location, and will occur in the context of patient support groups. Agricultural trainers will also conduct 1-hour visits to individual farms as needed to support study participants. We developed initial field-based trainings based on a needs assessment conducted prior to launching the R34 pilot, and tested and refined the training course during the pilot. Trainings were further updated based on process evaluation findings from our R34 study, and will be tailored to the needs of farmers based on crop selection. Nearly all pilot intervention participants found the training to be extremely useful and reported rapid improvements in agricultural practices and yields.

Loan program and finance training: Participants will be given an asset loan (worth ~US $175) for the purchase of the irrigation pump and other agricultural implements. The loans will be managed by a Kenyan finance organization. In accordance with standard practice for individual loans, and as done in our pilot study, participants will be required to save no more than 2,000 KSH (~US $20) prior to receiving the loan. These savings will be placed in a bank account at one of the local branches. Each participant will receive the loan in the form of vouchers to purchase the irrigation pump, 50 feet of hosing, fertilizer, and government certified seeds. These materials will be made available at local farm stores ("agrovets") that are easily accessible in study communities. Loan repayment will follow the guidelines of the local MFI with payment expected within 16 months (starting with a 4-month grace period of no payment, followed by 12 months of monthly payments). The finance organization will document the loan payments made by each participant and will provide a quarterly financial report to the study coordinator and PIs. The finance organization will be solely responsible for collection of loan payments, following their usual standard protocol for participants who fail to repay their loan. Participants will not be asked to forfeit personal belongings to cover loan payments. Those who repay their loans may choose to take out additional loans (in accordance with standard policies), to allow for further investment and development. Our goal is to provide an enduring relationship between participants and the finance organization.

The intervention arm will receive training at baseline and at key intervals coordinated with harvesting seasons on financial management, group formation and management, record keeping, micro enterprise development, market planning and research, customer relations,

preparation of a business plan, and marketing skills. Trainings will be facilitated by the finance organization in collaboration with our study team. All trainings will take place on participants' farms or a nearby location.

a. Study site (geographical)

Residents of Nyanza Region including our target counties (Homa Bay, Kisumu, and Migori) have significant potential to benefit from the proposed intervention**:** The Nyanza Region has the highest prevalence of HIV in Kenya (15.1%),[208] and a very high prevalence of food insecurity.[14] Unlike more urban environments, there are few alternatives to agricultural production for income.[209] Farming and fishing are the primary means of income generation. Lack of irrigation and unpredictable rainfall lead to an inconsistent water supply and pose a central barrier to successful farming for many in the region.[210] Entrenched poverty and limited access to financial services means that few farmers are able to obtain quality agricultural inputs.

Eight matched pairs of facilities will be selected for inclusion in the study. Pair matching helps protect study credibility and validity with a limited numbers of clusters, and also can substantially improve power.[211,212] With newer matching algorithms/schemes, we can get close matches with multiple variables predictive of the outcome.[213-216] Therefore, we will match facilities on the following criteria: 1) size of facility (district, sub-district hospital, health center, dispensary) 2) geography defined by sub-county, 3) primary source of water for irrigation (lake, river, shallow wells), and 4) access to markets. We will select matched pairs that limit the chance of contamination between intervention and control health facilities based on geographic proximity and ethnographic mapping. Based on our pilot work, the minimum requirement for health facility inclusion in the study are: Ministry of Health facility that serves a minimum of 350 patients on ART, proximity to permanent water source/s (river, lake, and streams), suitable soil for farming, proximity to markets, and where farming is one of the a key economic activities in the community (i.e.: 50% of the population is involved in agriculture as the primary means of income, which will apply to most of the Ministry of Health facilities in Nyanza Region). Randomization, based on a computer-generated assignment, will occur after the 8 matched pairs have been selected.

b. Study populations

Participants will be recruited from the Kenyan Ministry of Health (MOH) facilities. As patients in the MOH facilities, all participants at intervention and control health facilities will receive HIV/AIDS care and treatment, including ART, in accordance with MOH standards.

i. Criteria for inclusion of subjects

At both intervention and control health facilities, we will enroll up to 65 persons currently enrolled in HIV care per health facility. Eligibility criteria will be similar to our pilot study.

1. HIV-infected adults
2. 18-60 years old
3. Currently receiving ART
4. Belong to a patient support group or demonstrate willingness to join one.
5. Have access to farming land and available surface water in the form of lakes, rivers, ponds and shallow wells.
6. Have evidence of moderate to severe food insecurity based on the Household Food Insecurity Access Scale (HFIAS), and/or malnutrition (BMI<18.5) based on medical records during the year preceding recruitment.
7. Participants must also agree to save the down payment (no more than 2,000 KSH) required for the loan

These criteria are likely to be met by the majority of HIV-infected patients on ART in Nyanza Region, as we saw in our pilot study.

ii. Criteria for exclusion of subjects

1. People who do not speak Dholuo, Swahili, or English
2. Inadequate cognitive and/or hearing capacity to complete planned study procedures, at the discretion of the research assistant

c. Sampling

i. Sample size determination

Data from the *Shamba Maisha* pilot R34 intervention study were used to estimate the sample size needed for this proposed study for the outcomes of changes from month 0 to month 24 in food insecurity score (key mediating variable), CD4 count, and viral load suppression (key outcome variable). The standard deviations (SD) seen in the proposed study likely will be similar to that in the pilot study because the two studies draw from a similarly geographically dispersed population. To be conservative, we assumed a coefficient of variation due to clustering of 0.150, ignoring the matched pairs.[217] Retention in the pilot study was 98%; to be conservative, retention in the proposed study was assumed to be 90%. For two-sided testing at α=0.05 in a longitudinal analysis, a sample of 8 health facilities per arm with up to 44 enrolled participants per health facility (total enrollment of up to 352 per arm) will provide power of 80% for an important clinical difference of 0.138 between the intervention and control arms in the proportion becoming virally suppressed from month 0 to month 24 (primary outcome).[217] We plan to over-enroll the number of participants by up to 65 per facility to account for participants that may not be able to save the down payment. That is, assuming as in our pilot study that 0.150 of the sample in the control arm becomes suppressed from baseline to month 24, there is 80% power to detect differences such that the proportion becoming suppressed from baseline to month 24 in the intervention arm is 0.288 or greater. In regards to two secondary outcomes, the within-arm SD for changes in food insecurity score and CD4 count were estimated from the pilot study as 2.95 and 208.9 cells/mm^3, respectively. The proposed sample size will provide power of 80% for differences of 1.2 for food insecurity (HFAIS score) and ≥57 cells/mm^3 for CD4 count.

ii. Recruitment procedures

Following the procedures from our pilot intervention study, participants will be recruited through organized meetings held at each health facility, publicized through announcements at patient support group sessions. At each meeting, research staff will present study details and eligibility guidelines. Among interested and potentially eligible individuals, home visits will be conducted to verify that the participant has access to agricultural land and surface water. Individuals that meet eligibility criteria but decline to participate in the study will be asked to discuss reasons for declining participation. Using female recruiters and promotional material geared towards recruiting women, we will enroll at least 40% of participants at each health facility from each gender. At intervention health facilities, participants will be enrolled in a savings program in anticipation of receiving the asset loan. In control health facilities, participants will be enrolled in the intervention at the end of 2 years follow-up.

iii. Enrollment procedures

Individuals who express interest in the study will be asked to consent to screening for the study in order to assess their eligibility. The screening procedures will involve a brief questionnaire (up to 10 minutes) on food security and access to farming land and surface water and a brief review of medical records. If they are eligible based on this information, a home visit will be conducted to confirm access to farming land and available surface water. If they are still eligible for the study and continue to be interested in participating, the individual will undergo the informed consent process for the study. Enrolled participants in the intervention arm are required to save a down payment of no more than 2,000 KSH for the asset loan by the end of the finance training. Control participants must also agree to save the down payment (~$20) required for the loan by the study end. At each data collection point conducted at the health

clinic, participants will receive up to 800 Kenyan Shillings (~$8.40) depending on the distance they have to travel, and at each data collection point conducted at their home or farm, they will receive up to 400 Kenyan Shillings (~$4.20).

d. Procedures

Conduct a cluster RCT of a multisectoral agricultural intervention among HIV-infected farmers on ART to determine the impact of the intervention on HIV clinical outcomes

After study enrollment, participants in Intervention health facilities will be immediately formed into a patient support group of 8-14 Shamba Maisha participants for delivery of the intervention. During the pilot study, we found that the patient support groups were a vital source of social and emotional support and strength for study participants. The groups provided an opportunity for sharing information, knowledge, ideas, and experiences in a confidential manner. Members also benefited from the coping skills gained, insight into the issues affecting others, and bonds made with others going through a similar experience. HIV positive people living positively and thriving also serve as role models and inspiration to others, and encourage care and treatment adherence. All agriculture and finance trainings will be conducted within the patient support group setting so that participants can learn from and support each other and help address any challenge that individuals may face on their farms (i.e. pest control) or in repayment of their asset loan. Participants will also be enrolled in a savings program in anticipation of receiving the asset loan. In control health facilities, HIV-infected patients between the ages of 18-60 receiving ART, have access to farm land and surface water, and have demonstrated evidence of food insecurity or malnutrition during the year preceding the study will be recruited as controls. Control participants must also agree to save the down payment of no more than 2,000 KSH (~$20) required for the loan by the study end. All intervention and control participants will be reimbursed for their transportation and time up to 800 Kenyan Shillings (~$11) for data collection that take place at the clinic and up to 400 Kenyan Shillings (~$5.5) for data collection that takes place at home.

Data collection

The research staff will administer surveys to both arms at baseline and at 6, 12, 18, and 24 months. Data will be collected within a window period around each data collection time point of +/- 2 months. For example, the six-month data collection period must take place 4 – 8 months after enrollment. The content of these interviews will cover demographic information; household economic indicators; detailed agricultural information; income, physical and mental health status; food and water insecurity and dietary diversity; healthcare utilization; social support and HIV-related stigma; ARV treatment status and adherence; intimate partner violence; risk tolerance and entrepreneurial ability; HIV risk behavior, including sexual activity and substance use; well-being, hope, relationship quality; and gender empowerment.

A section of the interview will be administered at the health facility (for either clinical or sensitive information), and another section will be administered at the participant's farm or household (see below). At the end of the home visit, we will also dfscapture the GPS coordinates of the home for data verification purposes. In addition to interview data, we will also abstract clinical data from the Comprehensive Care Clinic Patient Card, known as the blue card or green card (every 6-months for viral loads,CD4 T-cell counts, ART treatment interruptions and episodes of opportunistic infections). Clinicians or trained phlebotomist will collect additional blood for viral load and CD4 testing once per year. For those who miss their yearly blood draw , we will conduct an additional blood draw to ensure that we have these measures twice yearly on all participants. Phlebotomy will be performed using universal precautions, and specimens will be aliquoted, assigned an accession number, and stored at -70 C until shipment to the laboratory for processing. We will also perform mid upper arm circumference measurements to assess

nutritional status, body mass index measurements. Table 1 shows measures and health outcomes following our theoretical model.

Table 1. Measures

Nutritional Pathway	**Nutritional status**: We will use BMI and MUAC, commonly used to assess nutritional status.[218,219] The BMI reflects protein and fat reserves[220] and will be assessed using an established grading system.[221] For MUAC, we will use WHO sex-specific cut-offs of 22.0 cm for women and 23.0 cm for men with chronic energy deficiency.[222]
	Food frequency will be measured as the number of different foods or food groups consumed over a given period,[223] as used in the Kenya Demographic and Health Survey.
Behavioral Pathway	**ART adherence:** Participants will receive a Medical Electronic Monitoring System (MEMS) bottle to record bottle opening events providing a graphical printout of adherence. MEMS is one of the most extensively validated objective measures of ART adherence for use of studies in SSA, is closely correlated with undetectable viral loads, [224] and has been found to be feasible and acceptable to patients in the Nyanza Region by our study team.[225] [226] For self-report adherence, we used the visual analog scale,[227] which corresponds to the percentage of prescribed doses taken, and is correlated with unannounced pill count and MEMS.[228,229,226]
	Health care utilization and competing demands: We will collect data on urgent care visits and adherence to regular clinic visits using both self-report and abstraction of data from medical records comparing their scheduled visit date with their actual visit date. This method has used to assess clinic attendance in the literature.[230,231] Questions will be modified from Gelberg and Anderson's Behavioral Model for Vulnerable Populations[232,233] to assess how often lack of food interferes with ability to procure drugs or visit the clinic.
Mental Health Pathway	**Mental health status** will be measured using the MOS-HIV, a tool for assessing health-related quality of life[234] that has been validated among HIV-infected populations in resource-limited settings.[235,236] **Depression** will be screened using the Hopkins Symptom Check-list for Depression, a 15-item scale[237] which has been validated in sub-Saharan Africa.[238] **Alcohol use:** We will use the AUDIT-C indicators. The AUDIT-C is a 3-item alcohol screen that can help identify persons who are hazardous drinkers or have active alcohol use disorders.[239]
	Wellbeing, hope, and relationship quality. The 'Cantril ladder' was developed by Kilpatrick and Cantril (1960) and has since been used in several cross-national studies including Gallup's World Poll of more than 150 countries to measure general well-being. The relationship quality questions were adapted from the four item Couple Satisfaction Scale by Funk, J.L. & Rogge, R.D (2007).
	HIV-related stigma and disclosure: We will use the Earnshaw Stigma Scale, which has been extensively validated in sub-Saharan African settings.We will ask about disclosure of HIV status to partners, family members, and others using questions adapted from our previous studies in SSA.[101,240,241]

Empowerment Pathway	**Empowerment** indicators will be adapted from a large cluster-randomized trial of an intervention including: greater challenges to established gender roles, communication with relationship partner about sexual matters, measures of financial decision-making, measures of attitudes towards gender roles and gender-based violence, and experience of controlling behavior by relationship partner.[242] In addition, we will use the Sexual Relationship Power Scale (SRPS),[243] which conceptualizes sexual relationship power as a multi-dimensional construct assessing relative degrees of relationship control and decision making dominance. The SRPS has been used successfully in observational research conducted in South Africa[244,245] and Uganda.[246] We will also collect data on sexual victimization and perpetration in the prior 3 months.
Proximal Mediators	**Food insecurity:** The Household Food Insecurity Access Scale (HFIAS) has been validated in eight countries[168,247-249] and used successfully by our team in Kenya and rural Uganda.[24,246,250-254]
	Agricultural measures include questions about production, costs, harvesting and marketing, labor, irrigation, and post harvesting practices. Measures were designed to evaluate uptake and adoption of the intervention, and measure changes in agricultural practices including crop diversity, agricultural practices and production.
	Household economic indicators: *Household economic indicators* will be collected using a modified version of the World Bank Living Standards Measurement Study (LSMS) questionnaire.[255] Because the economic impact of the intervention likely will differ with where agricultural production is directed (e.g., market, household consumption, bartering produce for other goods) we will measure several economic outcomes: a) expenditures (food, health, education, and productive investments); b) consumption (food and non-food); c) income (from agriculture and all sources); d) savings and debt; and e) inter-household commodity and cash transfers. We have extensively used these questionnaires for prior studies in Kenya including in the ongoing SEARCH trial.
Health Outcomes	**HIV related mortality:** The 2012 WHO verbal autopsy instrument will be used to determine cause of death.[256] Information will also be gathered from the hospital record review and hospital discharge diagnosis.
	Viral load testing will be performed on venous blood on the COBAS TaqMan HIV viral load platform (Roche Molecular Diagnostics, Pleasanton, CA) with a lower limit of detection of <20 copies/mL.
	Absolute CD4 count testing on whole blood will use the BD FACSCount (BD Bioscience, San Jose, CA).
	HIV morbidity: We will abstract data on hospitalizations, opportunistic infections, and changes in WHO disease stage from medical records. We will also gather self-report data on opportunistic infections, hospitalizations and HIV symptoms during structured interviews.
	Physical health status will be measured using the MOS-HIV, a tool for assessing health-related quality of life[234] that has been validated in resource-limited settings.[235,236]
Covariates	**Demographics:** Age, religion, education, marital/partnership status, cost/time to reach the health facility, number of children, and household census will be collected at baseline. Changes to the household census will be captured every year.
	Social support: We will adapt the Functional Social Support Scale,[257] a modified version of the Duke University-University of North Carolina Functional Support Questionnaire[258] consisting of questions related to perceived emotional and instrumental support.
	Risk tolerance and entrepreneurial ability: We will adapt established questionnaires that have been used to measure individuals' attitudes towards risk as well questionnaires from microfinance studies that seek to measure individuals' entrepreneurial ability. [259,260]

Data quality and management: The Comprehensive Care Clinic Patient Card includes detailed information on health indicators (CD4 counts, WHO staging, OIs, drugs, etc.). Data from the blue card and those specifically conducted for this study (questionnaires, VL measurements, MUAC, weight and height) will be entered into a handheld computer tablet for data entry operating Open Data Kit (ODK) Collect. We successfully piloted the use of tablets and the ODK system during the pilot study. Procedures to promote data quality of these databases will include range and logical checks built into the data entry program, and running a series of additional error checks on the databases after data entry. We will investigate the patterns and types of missing data and non-response. Initial analyses also will involve inspection of the distributions of our mediating and outcome variables to identify outlying or unusual values and to assess distributional characteristics. We will also assess validity of scale constructs via exploratory and confirmatory factor analysis and perform internal consistency analyses to assess scales' reliabilities.

Facility Viral Load Checklist

From the award of the PEPFAR III program in 2016- FACES now offers technical support to Kisumu County and some of the sites are now under the Elizabeth Glazer Paediatric Foundation (EGPAF) and the University of Maryland (UMB).

The interpretation of the viral load results and the actual treatment changes made for participants in our study who are patients at these health facilities is determined by those given care at those health units. In order to appreciate differences in how study facilities interpret viral load data and make decisions on how to care for these patients, some of whom are our participants – we propose to use a Viral Load Readiness Check list to assess the protocols used at these facilities to guide their decisions making. And how they use this information to guide ART therapy, patient follow-up, and adherence counseling.

This will allow us to analyze the relationship between possible disparities in viral load readiness across sites and any disparities we observe in our primary outcome, viral load suppression at the time of our data analysis. This tool will be a program evaluation tool for the clinics and we also communicate information regarding any identified weaknesses in viral load interpretation practices to individual facilities in order to improve patient care for all facility patients.

The study staff will conduct the viral load readiness initiative at the sixteen Shamba Maisha study facilities in Kisumu, Homa Bay, and Migori counties. The purpose and procedures of the assessment will be explained to administrators and clinicians at each facility by a representative of Shamba Maisha during a face-to-face meeting prior to the assessment. Study staff will subsequently administer an approximately one-hour assessment at each site using the attached Viral Load Readiness Assessment form, a version of the International Center for AIDS Care and Treatment Program (ICAP) Viral Load Readiness assessment form's "Clinical Care Related Questions" section that has been adapted with input from FACES staff and clinicians for the context of our study. The form consists of a checklist of facility practices that comprise both self-report data and data verified by visual inspection, as indicated by an asterisk. Additional notes will be kept in the"Comments" section of each form. Assessments will be conducted with the primary ART clinician at each site in English. Assessments will not include any individually identifiable or personal data and will include clinic-level information only.

Immediately after administration of the form, study staff will score the form using the scoring template provided by ICAP. A "percentage readiness" will then be recorded on each

assessment form according to the total composite score. Results of the assessment will be used to aid Shamba Maisha investigators in interpreting viral load data across sites. All results will also be disseminated to facility administrators within one month of assessment completion.

We believe this assessment will provide us with critical information that will enhance our analysis of the study's primary outcome and contribute to long-term improvement of patient care at our study facilities.

Conduct a Process Evaluation to Inform Scale-up: We will assess implementation, feasibility and acceptability of intervention components to inform scale up. Using mixed methods, we will collect qualitative and quantitative data throughout the study. Staff will collect information on training attendance and participation levels (assessed on a 1-5 scaled rubric). Participant observation will be led by a researcher trained in ethnographic methods who will collect notes on observed delivery of key study and intervention components, community recruitment meetings, home visits to determine eligibility, agricultural training, business skills training and loan repayment procedures. Weekly meetings with detailed minutes including research staff and health care personnel will document challenges with recruitment and procedures in both the intervention and control arms, including reactions by participants, difficulties encountered, areas for improvement, and overall assessment of implementation. Twice monthly debriefings to review minutes will occur with the intervention team and study investigators. *Structured exit interviews* will be conducted with up to 350 intervention and up to 350 control participants to further assess intervention acceptability to inform scale-up. We will ask for detailed feedback on the key intervention components (microcredit loan, agricultural/finance training, use of the irrigation pump, patient support groups), and elicit suggestions for improvement. With control participants, we will ask if they participated in a farming training, received a loan, or own a pump to determine if there was study contamination. In-depth interviews with up to 124 intervention participants and up to 25 key informants (study coordinators, health care providers, and representatives from partner organizations) will assess challenges and facilitators of intervention components from the perspective of those who received and delivered the intervention. Interview themes will include: a) participation and attendance; b) securing loans; c) agricultural training topics, d) loan receipt and repayment; d) relationship between program participation and clinic attendance f) sense of empowerment and gender equity among participants; ~~and~~ g) perceptions of intervention efficacy based on land tenure and ownership; and h) perceptions of climate change, the impact of climate change on farming, food security, nutrition and health, changes participants are making to address climate change, and if Shamba Maisha is impacting how participant's deal with climate change. We will also ask pregnant women and women who were recently pregnant about the impact of Shamba Maisha on their health, antenatal care, family planning, diet, farming, income, and relationships. To gain diverse perspectives, we will interview both male and female participants and participants who completed the study as well as those who dropped out. These interviews will be conducted in either D'Luo or Kiswahili, last approximately 60 minutes and will be digitally recorded and transcribed.

As part of intervention refinement, we will conduct open-ended interviews with up to 25 key stakeholders to gather information to help us with adapting and improving the intervention. Key stakeholders to be contacted include leading experts in agriculture and finance in Kenya, relevant government officials, and health experts. Topics that may be covered will include: 1) Experiences, successes and challenges with loans, and specifically among individuals with chronic illness; 2) strategies to maximize loan repayment while minimizing stress and any risks to participants; 3) Recommendations for maximizing agricultural yields including seed selection,

and improving market access; 4) Experiences and suggestions on maximizing agricultural and finance trainings, and 5) Other topics related to the implementation of the intervention.

10. ETHICAL CONSIDERATIONS

The study protocol and forms will be submitted to the UCSF Committee on Human Research, as well as the Scientific and Ethical Review Unit (SERU) of the Kenya Medical Research Institute (KEMRI).

Human Subjects Involvement and Characteristics:

Involvement of human subjects:

All participants will be asked to consent to screening for the study in order to assess their eligibility. This will involve a brief questionnaire (up to 10 minutes) on food security and availability of surface water, a brief review of medical records, and a home visit to confirm access to surface water.

Individuals who meet eligibility criteria 1-6 (section 8.b.i) will be asked to provide informed consent and will be enrolled to participate in the study. We will ask these individuals to participate in interviews, have their blood drawn by a trained phlebotomist for measurement of HIV viral load and CD4 count, MEMS data collection, and also to have nutritional assessments done.

Participants will be asked to provide written informed consent for the following procedures for the 2 year study: a) Participation in the agriculture and finance training and the loan program, in order to purchase the Kickstart irrigation pump and other farm commodities, b) collection of data through clinic at baseline and 6-month intervals; c) collection of agricultural and economic data at baseline and approximately 5-7 times over the two year period; d) measurement of MUAC, height, and weight to assess their nutritional status at baseline and 6 month-intervals; e) MEMS data collection to measure ART adherence; f) collection of blood for testing of HIV viral load and CD4 count at baseline and 6 month intervals (note that the MoH program includes annual VL and CD4 testing, which the study will supplement with additional testing to ensure every 6-month VL and CD4 testing); and f) data abstraction from their medical records g) take and use photographs of them and their farms . Potentially vulnerable populations likely to be included in this study are those with limited household incomes, HIV and food insecurity. Our study staff and personnel are well-trained and experienced in working in a respectful, fair, and non-coercive manner with these populations. All study investigators and staff members with participant contact will have completed training on the protection of human subjects.

The lead investigators at the University of California, San Francisco (UCSF) and the Kenya Medical Research Institute (KEMRI) are well-respected research scientists who are experienced in human subjects research and trained in excellent clinical and/or laboratory practices. Drs. Cohen, Weiser, and Bukusi, with guidance from the co-investigators, will be responsible for seeking and maintaining the required IRB approvals.

j. *Study enrollment:*

Criteria for inclusion of subjects

1. HIV-infected
2. 18-60 years old
3. Currently receiving ART
4. Belong to a patient support group or demonstrate willingness to join a support group.
5. Have access to farming land and available surface water

6. Have evidence of food insecurity based on the Household Food Insecurity Access Scale (HFIAS), and/or malnutrition (BMI<18.5) based on medical records during the year preceding recruitment
7. Potential participants must also agree to save the down payment (no more than 2,000 KSH) required for the loan.

Criteria for exclusion of subjects

1. People who do not speak Dholuo, Swahili, or English
2. Inadequate cognitive and/or hearing capacity to complete planned study procedures, at the discretion of the research assistant

Recruitment procedures

Recruitment and retention plan: HIV-infected adult (18-60 years old) patients receiving ART will be recruited from the Ministry of Health (MoH) facilities. All participants at intervention and control health facilities will receive HIV/AIDS care and treatment, including ARV medications, in accordance with MoH standards.

A research staff person will approach eligible subjects selected for recruitment to introduce the study and gauge potential subjects' interest. Relevant study staff will be fluent in the local dialect to obviate the need for translators and, as such, optimize confidentiality. The study site has prior experience in obtaining informed consent for research and clinical trials within the cultural context of Kenya, and specifically among HIV-infected individuals. The informed consent procedure for this study has been designed to maximize understanding of potential risks. All consent forms will be translated into the local languages (Dholuo and Kiswahili) and back-translated into English to ensure correct use of language. Consent forms will be summarized aloud to participants by study interviewers. Potential participants will be informed of: (1) the purpose and methods of the study, (2) procedures to protect their confidentiality, (3) their rights to withdraw from the study at any time, (4) the fact that their participation or non-participation will not affect the care and services they receive at the Ministry of Health facility, and (5) persons to contact if they have any questions about the study after the completion of the interview, or to report any adverse events associated with study participation. Prior to seeking a signature, interviewers will ask participants to summarize the study and explain the reasons why they want to participate to the interviewers. The participant will also be given a copy of the consent form written in the local language to keep. The consent form will include names and phone numbers of persons to contact with any questions regarding the study. During the consent process, any misunderstandings regarding procedures, risks, or benefits can be clarified. Individuals will be provided with information on how to contact the study staff to report adverse events associated with study participation. Study staff will be trained extensively on how to assure that individuals provide voluntary informed consent. If a woman wishes to obtain the assent of her husband, father or chief, such assent may not substitute for her informed and voluntary consent. Individuals who cannot write will be invited to mark consent forms with a thumbprint (a standard practice for KEMRI clinical research), along with a co-signature by a witness otherwise not affiliated with the study. Each participant's signed informed consent form will be kept on file by the investigators for possible inspection by regulatory authorities.

Study retention will be monitored monthly by the research team. We plan to implement several proactive retention strategies successfully used during our pilot study and in our other studies in the region. These strategies include obtaining extensive contact information, building relationships with participants, calling participants to remind them of their up-coming study appointments, and field outreach to participant's homes. Participants will receive a copy of the scheduled visits to take home. If a participant misses his/her 6-monthly visit, a research assistant will make an attempt to communicate by phone, or when necessary will make a

"home" visit to the participant's previously agreed upon location (e.g. home, work, market, etc.). Research assistants will receive extensive training on procedures required for making "home" visits to maintain confidentiality and reduce the risk of inadvertent disclosure of the participant's HIV serostatus, other confidential information, and study participation to others.

Provision of HIV care and treatment will not be contingent upon participation in research, and participants will continue to receive standard of care at the same clinic should they decline enrollment or choose to leave the study at any point in time.

Enrollment procedures

At both intervention and control health facilities, we will enroll up to 65 persons currently enrolled in HIV care. Participants will be recruited through discussions about the study in the clinic patient waiting areas, and through organized meetings held at each health facility, publicized through posters and announcements at patient support group sessions. At each meeting, research staff, will present study details and eligibility guidelines. Among interested and potentially eligible individuals, home visits will be conducted to verify that the participant has access to farming land and surface water. Individuals that meet eligibility criteria, but decline to participate in the study, will be asked to discuss their reasons for declining participation. Through utilizing female recruiters and promotional material geared towards recruiting women, the study will plan to enroll at least 40% of participants at each health facility from each gender (which would include at least 18 women/men at each of the intervention health facilities and 18 women/men at each of the control health facilities). This will enable us to obtain data on whether the effects of our intervention on health outcomes differ by gender.

Collaborating Institutions

Much of the on-site research will be carried out in collaboration with the Centre for Microbiology Research at the Kenya Medical Research Institute (KEMRI). KEMRI will comply with all pertinent U.S. federal regulations and policies. Dr. Bukusi, as the local site Principal Investigator, serves an integral role in this proposal, as she will take responsibility for the scientific conduct of this project in Kenya. Specifically, she will supervise the implementation of this protocol, oversee the clinical and laboratory procedures, and be available as the primary point of contact in Kenya. She will represent the study to local regulatory and oversight agencies, and KEMRI. As Chief Research Officer at KEMRI, Dr. Bukusi will work closely with Drs. Weiser and Cohen to oversee the program's operations and ensure that all activities are within KEMRI and national Kenyan guidelines and policies. Kickstart will lead the agricultural components of the intervention. Kickstart is a prominent non-governmental organization (NGO) based in sub-Saharan Africa. It has been a leader in irrigation technologies since 1991 through the development and sales of a manually operated "MoneyMaker" irrigation pump, enabling farmers to grow high yield crops year-round. We have been collaborating with them since 2008. The economic elements of the intervention will be implemented by a Kenyan finance institution.

Drs. Weiser and Cohen as the study PIs will be responsible for registering and providing updated information about the clinical trial on ClinicalTrials.gov.

Sources of Materials

Structured and unstructured interviews: Quantitative data in the form of structured interviews and laboratory tests will be collected by trained research staff. Surveys will collect data on sociodemographics, food security and nutritional status, women's empowerment, health status, and measures along the nutritional, behavioral, and mental health pathways (see table 1, page 19-20). All of the proposed measures were used during the pilot study with the exception of the Medical Electronic Monitoring System (MEMS) caps, water insecurity, Intimate Partner

violence, Risk tolerance and entrepreneurial ability, and a verbal autopsy instrument. During our pilot study, we used an unannounced pill count and the visual analogue scale to measure ART adherence. However, based on some challenges conducting pill counts in this setting due to inconsistent dispensing practices by pharmacy staff and based on recent literature, we have chosen to use MEMS caps as our objective adherence measure. MEMS is one of the most extensively validated objective measures of ART adherence for use of studies in SSA, is closely correlated with undetectable viral loads,[224] and has been found to be feasible and acceptable to patients in the Nyanza region by our study team.[225,226] ***Qualitative data,*** including in-depth interviews and participant observation, will be collected by researchers trained in qualitative research methods. Interviews will be done with up to ~~5~~124 intervention participants and 10 key informants at study exit and will include questions about reasons for program adherence or non-adherence, positive and negative experiences with the intervention, suggestions for future implementation, sense of empowerment, capabilities and knowledge in the agricultural domain, impacts of the intervention on household decision-making, ~~and~~ perception of women in the family/community, and perceptions of climate change and the impact on farming, food security, nutrition and health. We hope to understand if Shamba Miasha mitigates the negative impacts of climate change on food security, nutrition, and health. We will also ask pregnant women and women who were recently pregnant about the impact of Shamba Maisha on their health, antenatal care, family planning, diet, farming, income, and relationships. The qualitative study will utilize a semi-structured guide which will be adapted, with additional probes and questions added, depending on needs and emergent data. The sample IDI guide, however, captures all the topics that will be explored during the interview. All in-depth interviews will be conducted in a private room designated for this purpose at the study health facilities or a nearby location. Audio-recordings, transcripts, and forms will be stored in a locked cabinet at the research office and on password protected computers only accessible by members of the research team.

Home visits will be conducted prior to enrolling in the research study and will be required to assess study eligibility. These visits will ascertain information on participant eligibility for study enrollment including access to agricultural land and a year-round water source. As mentioned above, the research assistants will be trained on the importance of confidentiality to avoid disclosure of a participants HIV serostatus and/or study participation. The “home” visits can either take place at home, or at another previously agreed upon location. Thus, any subject who is concerned about a potential breach of confidentiality related to a home visit can decline the home visit and select instead one of several alternatives, each of which avoids potential disclosure to family members or neighbors. We plan to use procedures similar to those we have successfully used in ongoing and past projects in Kenya, Uganda and San Francisco, in which some subjects have elected to meet the home visitor at our research site at the Ministry of Health clinic, or some other site of the subject’s choosing. Because home visiting is perceived as the most convenient method of contact, none of the participants in the pilot study declined them. If we have participants decline home visit, the clinic or an alternative location can be utilized.

Community health workers in Kenya have experience conducting home visits for a variety of conditions in addition to HIV, including maternal child health, malaria, tuberculosis, malnutrition, and diarrheal diseases. As such, conducting a home visit by a research assistant itself is not associated with HIV infection in the target communities. Nonetheless, confidentiality is their primary concern. We believe that a careful description the home visits during informed consent, the option to decline home visits at any time during follow-up, the convenience from the participant's perspective, and the low-impact of home visits themselves justifies their inclusion in this study.

Data from medical record: The Comprehensive Care Clinic Patient Card is filled out by health workers and will be entered into tablet computers on a regular basis by the Research

Assistants. Data will be entered on tablets operating Open Data Kit (ODK) Collect. We successfully piloted the use of tablets and the ODK system during the previous NIH-funded R34 pilot study. The medical record dataset will include detailed information on health indicators (ex: CD4 T-cell count, WHO staging, opportunistic infections, ARV drugs).

Data management and security:

These data will be subjected to a variety of quality control procedures. Data collected for this study (questionnaires, HIV viral load (VL) measurements, height, weight, MUAC) will be entered into the tablet computer operating ODK system adapted from the R34 pilot study. Procedures to promote data quality within these databases will include range and logical checks built into the data entry program, and running a series of additional error checks on the databases after data entry. The database will be protected by a separate password on password-protected tablets. Data from the tablets will be uploaded twice a week to a server located at UCSF. All Research Assistants will receive training on the requirements of strict confidentiality regarding patient identifying information, and security regarding tablet computers.

Study record keeping and access to participant identifying information will follow strict, written standard operating procedures. All records will be kept on password protected tablet computers at KEMRI and UCSF. Primarily, participants will be identified by their study number and/or their patient ID number. All participant record forms will be kept in individual files in a secured filing cabinet in an access-limited room at the health facility. Additional records will be kept in the clinical and laboratory record books, which will be stored in the local study laboratory. Participant names and addresses will be stripped from the database prior to analysis. No individual identifying information will be used in any reports or publications resulting from the study.

Potential Risks:

The primary risks associated with the study are loss of confidentiality and risks to reputation. There may also be risks associated with phlebotomy to obtain the additional VL specimens, including pain and/or bruising. There is also the risk of fatigue from interviewing. In addition, participants will be asked some sensitive questions regarding sexual practices and symptoms of depression, which may lead to personal discomfort or embarrassment. Finally, participants may experience discomfort in the case that they cannot make loan repayments. Research personnel are trained in strategies designed to minimize these risks and their potential impact on subjects'. All serious and unexpected adverse events will be reported to the Study PIs and to the relevant IRBs per local regulation.

Recruitment and informed consent

Research will be conducted according to Good Clinical Practice guidelines, the U.S. Code of Federal Regulations (CFR) Title 21 CFR (Part 50 – Protection of Human Subjects and Part 56 – Institutional Review Boards), and the Declaration of Helsinki. This protocol will be submitted to UCSF's Committee on Human Research for approval. The informed consent of each participant will be obtained before protocol-specified procedures are carried out.

Participants will be asked to provide written informed consent for the following procedures for the 2 year study: a) Participation in the agriculture and finance training and the loan program, in order to purchase the Kickstart irrigation pump and other farm commodities, b) collection of data through clinic at baseline and 6-month intervals; c) collection of agricultural and economic data at baseline and approximately 5-7 times over the two year period; d) measurement of MUAC, height, and weight to assess their nutritional status at baseline and 6 month-intervals; e) MEMS data collection to measure ART adherence; f) collection of blood for testing of HIV viral load and CD4 count at baseline and 6 month intervals (note that the MoH

program includes annual VL and CD4 testing, which the study will supplement with additional testing to ensure every 6-month VL and CD4 testing); and g) data abstraction from their medical records. Potentially vulnerable populations likely to be included in this study are those with limited household incomes, HIV and food insecurity. Our study staff and personnel are well-trained and experienced in working in a respectful, fair, and non-coercive manner with these populations. All study investigators and staff members with participant contact will have completed NIH-required training on the protection of human subjects. The lead investigators at UCSF and KEMRI are well-respected research scientists who are experienced in human subjects research and trained in excellent clinical and/or laboratory practices.

A research staff person will approach eligible subjects selected for recruitment to introduce the study and gauge potential subjects' interest. Relevant study staff will be fluent in the local dialect to obviate the need for translators and, as such, optimize confidentiality. The study site has prior experience in obtaining informed consent for research and clinical trials within the cultural context of Kenya, and specifically among HIV-infected individuals. The informed consent procedure for this study has been designed to maximize understanding of potential risks. All consent forms will be translated into the local languages (Dholuo and Kiswahili) and back-translated into English to ensure correct use of language. Consent forms will be summarized aloud to participants by study interviewers. Potential participants will be informed of: (1) the purpose and methods of the study, (2) procedures to protect their confidentiality, (3) their rights to withdraw from the study at any time, (4) the fact that their participation or non-participation will not affect the care and services they receive at Ministry of Health Facility, and (5) persons to contact if they have any questions about the study after the completion of the interview, or to report any adverse events associated with study participation. Prior to seeking a signature, interviewers will ask participants to summarize the study and explain the reasons why they want to participate to the interviewers. The participant will also be given a copy of the consent form written in the local language to keep. The consent form will include names and phone numbers of persons to contact with any questions regarding the study. During the consent process, any misunderstandings regarding procedures, risks, or benefits can be clarified. Individuals will be provided with information on how to contact the study staff to report adverse events associated with study participation. Study staff will be trained extensively on how to assure that individuals provide voluntary informed consent. If a woman wishes to obtain the assent of her husband, father or chief, such assent may not substitute for her informed and voluntary consent. Individuals who cannot write will be invited to mark consent forms with a thumbprint (a standard practice for KEMRI clinical research), along with a co-signature by a witness otherwise not affiliated with the study. Each participant's signed informed consent form will be kept on file by the investigators for possible inspection by regulatory authorities. Participants will also be asked to give consent for photography.

Protection against Risk:

Planned procedures for protecting against fatigue: Baseline and follow-up interviews will last 1-2 hours, including phlebotomy and weight, height, and MUAC measurements. Participants will be informed that they can take a break or stop at any time. Staff will be well-trained and supervised under the direction of experienced clinical researchers.

Planned procedures for protection of confidentiality or risks to reputation*:* To ensure confidentiality of participation, all data will be coded by a unique participant identifier number. Data will be kept in locked cabinets and will only be provided to a subject's clinician upon the written request of the subject. Research records will be kept confidential to the level allowed by law. The participant's name or other public identifiers will not be included with laboratory data, which will be identified only by a code number. For interview data collected as part of the study, subjects will be assigned a unique study identification number. Interviewers and support staff will be trained on procedures for maintaining privacy and will sign a pledge of confidentiality. All

transcripts and computer records will be password-protected to prohibit illicit access. All personal identifiers will be removed from any paper or electronic study forms, which will be coded only by numerical identifiers. When these procedures are followed, it is highly unlikely that any information revealed by participants during the course of the interviews or clinic visits will be disclosed to anyone outside the research team.

Planned procedure for protection of risks due to phlebotomy: Phlebotomists will be well-trained and experienced in the collection and handling of biological specimens. To minimize risks due to phlebotomy phlebotomists will collect all specimens using standard sterile procedures. This may cause momentary discomfort or soreness when blood is drawn as well as minimal bruising.

Planned procedure for protection of risks due to sensitive questions: Efforts will be made to minimize discomfort by assuring that interviewers are well trained and that they will inform participants beforehand about the nature of the questions and assure participants of privacy. The interviewer will be available after the interview to debrief the participant if s/he is in any way concerned by the nature of the questions. Routine demographic questions will be asked first, followed by more personal questions. Participants will be informed that they have the right to decline participation in the study, to refuse to answer any questions, or to withdraw at any time without adverse consequences. Since the Ministry of Health provides comprehensive AIDS education, counseling, and services, it will be possible for the interviewers to provide immediate referrals for research participants who are in emotional distress or exhibit any concerning physical signs or symptoms. As we will screen for depression, for participants who have suicidal thoughts, we will ask participants to speak with one of our study health providers who can further screen them for suicidal ideation. This may lead to some discomfort, but we hope will provide benefits for the participants if they are able to get access to appropriate mental health care.

Planned procedure for protection of risks due to loan defaults: Participants who fail to make loan repayments will under no circumstances be asked to forfeit personal or household belongings, other than the MoneyMaker irrigation pump, in order to repay the loans. Participants will also be assured that failure to repay the loans will in no way affect their access to medical care as well as any other benefits afforded by Ministry of Health facilities.

Planned procedure for reporting of adverse events: All serious adverse events associated with the procedures of this study will be reported within 10 days to the appropriate IRBs. Current guidance on adverse event reporting has focused on clinical trials of drugs or devices and has not provided clear guidance on behavioral prevention trials. The primary risk to subjects in this study is loss of confidentiality. If serious or unexpected adverse events occur, these will be filed with the appropriate IRBs within ten working days. We will ask study participants to return to the research field site in the case of ongoing adverse events. We will also provide participants with a palm card containing information on how to contact the local field staff to report such incidents as HIV-related disruption of families, acts of discrimination, physical harm, adverse events following phlebotomy, or personal distress. Field staff will be trained to complete descriptions of adverse events that will then be sent electronically to the study PIs.

Potential benefits of the proposed research to the subjects and others

Participants in the intervention group will receive basic training in sustainable farming techniques, including education about crop varieties that grow well in the area, pest control, fertilization and crop rotation, as well as improved market access for selling horticultural products. Participants in the intervention group will also receive a microcredit loan, a human-powered water pump, and other farming implements. This multisectoral agricultural and finance intervention has many potential benefits as evidenced in our pilot study and is likely to lead to increased agricultural output, which will in turn may contribute to increased household wealth

and improved food security for study participants. We also anticipate that improvements in household wealth and food security may in turn contribute to improved health benefits including improved ART adherence, mental health, nutritional status, clinical HIV treatment outcomes and decreased morbidity and mortality. Finally, the intervention may lead to improved gender empowerment for women. In addition to directly benefiting study participants, the proposed intervention has the potential to improve food security, nutrition and health outcomes of other family members. Control participants will be able to benefit from all aspects of intervention at the end of the 2-year pilot study when they will be eligible for the loan, water pump, agricultural implements and training. Ministry of Health facilities provide annual viral load and CD4 test results. Subjects and their clinicians in both the intervention and control group will be able to access an additional annual viral load result and CD4 count results in the study; thus, study participants will undergo twice per year VL and CD4 testing. The research findings have the potential to ultimately benefit other individuals in Kenya and elsewhere is sub-Saharan Africa who are struggling with the overlapping epidemics of food insecurity, poverty and HIV/AIDS. In view of the minimal risks to subjects, and the many actual and anticipated potential benefits to research subjects and others in their community, we believe that the benefits strongly outweigh the risks.

The qualitative research will not provide any direct benefits to the participants, other than possible psychological benefits associated with sharing their insights and stories. All participants making clinic-based research visits during the study will receive up to 800 Kenyan Shillings (equivalent to ~$11) and participants will receive up to 400 Kenyan Shillings (equivalent to ~$5.5) for home-based research visits.

Practitioners and policy makers need replicable models with which to tackle complex health and social challenges such as food insecurity and HIV/AIDS. Definitive trials, along with process measures, can offer conclusive lessons for what works in multisectoral development interventions.

Data and Safety Monitoring Plan

Primary responsibility for data and safety monitoring will fall on the PIs (Drs. Weiser, Cohen and Bukusi). In this research, the primary risk to subjects is social harm due to loss of confidentiality – disruption of family (e.g., breakup of couples following HIV detection), discrimination (e.g., a loss of employment or status in community), physical harm (e.g., acts of physical violence directed at people who have been disclosed as HIV-infected) and embarrassment (e.g., being questioned about sexual behavior). Risks to participants will be minimized through informed consent and strict confidentiality. In the case of any serious adverse events, we will ask subjects to return to the research field site. We will also provide subjects with an informed consent translated into the local language of their choice, so that they have the opportunity to contact the local field staff or one of the study investigators at any time. Study staff will be trained to complete descriptions of adverse events that will be sent electronically to the principal investigators (Drs. Weiser, Cohen and Bukusi). Serious or unexpected AEs will be reported to the appropriate IRBs within 10 working days of awareness of the incident.

11. DATA MANAGEMENT

a. Data Storage

These data will be subjected to a variety of quality control procedures. Data collected for this study (questionnaires, HIV viral load (VL) measurements, height, weight, MUAC) will be entered into the tablet computer operating ODK system adapted from the R34 pilot study. Data will be uploaded to a secure server.

b. Data Management

Data quality and management:
Procedures to promote data quality within these databases will include range and logical checks built into the data entry program, and running a series of additional error checks on the databases after data entry. The database will be protected by a separate password on password-protected tablets. Data from the tablets will be uploaded twice a week to a server located at UCSF. All Research Assistants will receive training on the requirements of strict confidentiality regarding patient identifying information, and security regarding tablet computers.

Study record keeping and access to participant identifying information will follow strict, written standard operating procedures. All records will be kept on password protected tablet computers at KEMRI and UCSF. Primarily, participants will be identified by their study number and/or their patient ID number. All participant record forms will be kept in individual files in a secured filing cabinet in an access-limited room at the health facility. Additional records will be kept in the clinical and laboratory record books, which will be stored in the local study laboratory. Participant names and addresses will be stripped from the database prior to analysis. No individual identifying information will be used in any reports or publications resulting from the study.

Data analysis

(Aims 1 and 2): Analysis of baseline data: We will describe the baseline characteristics of enrolled participants using frequency tables and provide descriptive statistics (e.g. means, standard deviations, medians, inter-quartile ranges, proportions) for scales and counts measuring the primary outcomes stratified by the intervention and control arms and by gender. From our pilot study, we expect missing data to be rare. Values for missing scale items will be imputed from other scale items using regression methods. If necessary, multiple imputation will be used to address incomplete data, with the mild assumption that missing data arise from a conditionally missing-at-random process.[261] Randomization should yield equivalence between arms on covariates, but if non-equivalence is found on baseline measures or from differential attrition, we will control for it using a propensity score.[262] Aim 1: Hypothesis 1: The intervention will lead to improved viral load suppression (primary outcome) and other measures of morbidity (secondary outcomes) in the intervention arm compared to the control arm. Intent-to-treat analyses using *Stata* procedures will assess whether the intervention will result in improved changes in primary outcomes with mixed (i.e., fixed and random) effects, maximum likelihood models that use all of the longitudinal data and account for variability among clusters and individuals (and for pair matching of facilities if there is sufficient observed variability among pairs to warrant it).[217,262] Aim 2: Hypothesis 2: The intervention will improve food security and household income, which in turn will contribute to improved outcomes through nutritional (improved diet quality, nutritional status), behavioral (improved ART adherence and retention in care), mental health (improved mental health/less depression) and empowerment (gender role attitudes, household decision-making) pathways[18] (Figure 2). We will assess direct and indirect intervention effects using structural equation modeling to examine pathways from the intervention through baseline-to-endline changes in mediating outcomes to changes in primary health outcomes.[263 264] Statistical mediation will be assessed in *Mplus* using the causal inference approach of Valeri and Vanderweele,[265] which yields optimal estimates of indirect effects in the presence of non-continuous outcomes, interactions, and clustered data.

Aim 3:

Cost-effectiveness analysis: Our intervention has potential to be sustainable because it relies on lending and repayment rather than cash transfers. Our cost-effectiveness assessment will have four major components: intervention cost; net cost; health effects; and the cost-

effectiveness ratio. We will measure ***intervention cost per participant*** including recruitment, training, support, and loan administration and monitoring (pumps and other commodities will be purchased by participants, thus not a direct program cost). Loans and their repayment will be tracked. We will measure costs using program expenditure records, explained as necessary by the program manager, and focused "time and motion" studies to allocate staff time across tasks within and outside the intervention. Costs will be classified by program activity and by standard resource categories (e.g., personnel, supplies, services). Costs will also be classified as experienced by the program (e.g., recruitment and training) and by partners (e.g., finance agency) that operate without program subsidy. Donated and subsidized resources will be appraised at market value. Because program implementation is standard across health facilities and centrally managed, cost data collection will be efficient. We will next quantify ***net costs*** – program costs adjusted for added or averted health care costs. We will base changes in short-term health care costs on household surveys (household expenditures for health care for illness episode and hospitalizations). Longer-term health care costs will be projected using clinical simulation modeling, based on observed changes in health status (e.g. HIV morbidity), combined with estimates from the trial and published studies of the costs of managing these conditions. Projections of HIV health care costs are imprecise but essential for a full cost portrayal. Uncertainty in this measure will be explored with sensitivity analyses. ***Health effects*** will be quantified in two ways. First, we will inventory major health-related events (deaths, detectable viral loads, hospitalizations, and opportunistic infections). Second, and following best practices in CEA, we will integrate the health impact of averted adverse events using **disability-adjusted life years (DALYs)**, including lost years of life and the collective disability effects of all the adverse events. DALY estimates will be for the short term (during the trial) and the long term (5, 10, and 20 years) using the clinical modeling. Finally, we will calculate ***cost-effectiveness ratios***: 1) net cost per death averted (if a significant difference is observed by study arm) and per major adverse health event averted and 2) net cost per DALY averted. Projected health and financial effects will be discounted at 3% per year. We will conduct extensive sensitivity analyses on these ratios. Importantly, if the intervention yields net savings (i.e., negative net costs) as well as health benefits, the intervention is classified as "dominant" and no CE ratio is calculated.

Identification of individuals most likely to benefit from the intervention: We will undertake regression analyses to provide guidance on targeting of finance interventions to subpopulations most likely to benefit. The benefits of microfinance are realized to a greater degree by individuals with entrepreneurial ability and risk-taking preferences, compared to individuals who use microfinance loans primarily for day-to-day expenses.[266,267] To learn which participants were most likely to benefit, we will use data collected at the time of enrollment to test for heterogeneous effects of the intervention on health outcomes, using interaction terms with individual characteristics including age, gender, baseline socio-economic status, household status, and novel measures of risk preferences[259] and entrepreneurial ability.[260]

Analysis of process evaluation data. Qualitative data will be translated from local languages to English and imported and managed using QSR Nvivo (QSR International Ltd, Doncaster, Australia). A start list of broad codes will be informed by Bonell's process evaluation framework,[268] with two researchers coding the transcripts in an effort to identify broad themes.[269] Transcripts will then be coded a second time to develop codes inductively from the data. In the tradition of grounded theory, close attention will paid to making 'constant comparisons' to challenge the analysis and develop insights that will inform the subsequent trial.[270] Our analysis will include both the 'top-down' structure of research questions and the 'grounded' voices of informants.[271] Data on intervention implementation will inform recommendations for modification and scale up.

12. TIME FRAME/DURATION OF THE PROJECT:

	Year 1		Year 2		Year 3		Year 4		Year 5	
Months	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12	0-6	7-12
Operationalize study procedures										
Site Selection										
Randomize facilities										
Hire & train researchers										
Recruit & enroll participants										
Implement study										
Process data for intervention scale up										
Analyze data/Prepare manuscripts										

13. EXPECTED APPLICATION OF RESULTS

The cluster RCT ultimately has the potential to improve the ways in which development and HIV health care and prevention services are conceptualized and delivered throughout rural Africa by demonstrating the role of sustainable agricultural and economic development in improving the health of HIV-positive individuals. As the proposed intervention will contribute to a dialogue between those involved in international agricultural policy and those involved in ART roll-out in sub-Saharan Africa, this approach, if effective, can help both sectors utilize their resources more effectively. Such collaborations are well positioned to contribute towards sustainable solutions that resolve the intersecting problems of food insecurity, poverty, HIV/AIDS and morbidity and mortality in sub-Saharan Africa. This intervention may also play an important role in improving women's household bargaining power and relationship power.

14. REFERENCES

1. Gillespie S, Greener R, Whiteside A, Whitworth J. Investigating the empirical evidence for understanding vulnerability and the associations between poverty, HIV infection and AIDS impact. *AIDS.* Nov 2007;21 Suppl 7:S1-4.
2. Gupta GR, Parkhurst JO, Ogden JA, Aggleton P, Mahal A. Structural approaches to HIV prevention. *Lancet.* Aug 30 2008;372(9640):764-775.
3. Hawkes C, Ruel M. The links between agriculture and health: an intersectoral opportunity to improve the health and livelihoods of the poor. *Bull World Health Organ.* 2006;84(12):984-990.
4. Holzemer WL, Marefat S. Poverty, development, and PEPFAR: a US strategy for combating the global HIV/AIDS epidemic. *Nurs Outlook.* Sep-Oct 2007;55(5):215-217.
5. Hyder A, Maman S, Nyoni J, et al. The pervasive triad of food security ,gender inequity and women's health: exploratory research from sub-Saharan Africa. *African Health Sciences.* 2005;5(4):328-334.
6. Masanjala W. The poverty-HIV/AIDS nexus in Africa: a livelihood approach. *Soc Sci Med.* Mar 2007;64(5):1032-1041.
7. *Global report: UNAIDS report on the global AIDS epidemic 2013*: Joint United Nations Programme on HIV/AIDS.
8. Normen L, Chan K, Braitstein P, et al. Food insecurity and hunger are prevalent among HIV-positive individuals in British Columbia, Canada. *J Nutr.* Apr 2005;135(4):820-825.
9. FAO, IFAD, WFP. *The State of Food Insecurity in the World 2013. The multiple dimensions of food security.* Rome: Food and Agriculture Organization of the United Nations 2013.
10. de Onis M, Frongillo EA, Blossner M. Is malnutrition declining? An analysis of changes in levels of child malnutrition since 1980. *Bull World Health Organ.* 2000;78(10):1222-1233.
11. The Kenya Food Security Steering Group. *The impact of rising food prices on disparate livelihoods groups in Kenya.* Nairobi, Kenya: World Food Programme (WFP);2008.
12. USAID. Feed the Future Program, country profile for Kenya. http://www.feedthefuture.gov/country/kenya. Accessed August 4, 2014.
13. Place F, Adato M, Hebinck P. Understanding rural poverty and investment in agriculture: an assessment of integrated quantitative and qualitative research in western Kenya. *World Dev.* 2007;35(2):312-325.
14. Kenya National Bureau of Statistics. *Food Insecurity Assessment in Kenya.* Nairobi: Government of Kenya;2008.
15. Nagata JM, Cohen CR, Young SL, et al. Descriptive characteristics and health outcomes of the food by prescription nutrition supplementation program for adults living with HIV in Nyanza Province, Kenya. *PLoS One.* 2014;9(3):e91403.
16. Weiser SD, Tsai AC, Gupta R, et al. Food insecurity is associated with morbidity and patterns of healthcare utilization among HIV-infected individuals in a resource-poor setting. *AIDS.* Jan 2 2012;26(1):67-75.
17. Nagata JM, Magerenge RO, Young SL, Oguta JO, Weiser SD, Cohen CR. Social determinants, lived experiences, and consequences of household food insecurity among persons living with HIV/AIDS on the shore of Lake Victoria, Kenya. *AIDS Care.* 2012;24(6):728-736.
18. Weiser SD, Young SL, Cohen CR, et al. Conceptual framework for understanding the bidirectional links between food insecurity and HIV/AIDS. *Am J Clin Nutr.* 2011;94(suppl):1729S–1739S.
19. Weiser S, Palar K, Hatcher A, S. Y, Frongillo EA, Laraia BA. Food insecurity and health: A Conceptual Framework. In: Ivers L, ed. *Food Insecurity and Public Health*. Boston, MA: CRC Press; 2014.

20. Barnett T, Whiteside A. *AIDS in the Twenty-First Century: Disease and Globalization*. New York: Palgrave Macmillan; 2006.

21. Lemke S. Nutrition security, livelihoods and HIV/AIDS: implications for research among farm worker households in South Africa. *Public Health Nutr.* Oct 2005;8(7):844-852.

22. Seager J, Ganyaza-Twalo T, Tamasane T. *Development of a conceptual framework to help understand the interactions between poverty and HIV/AIDS at the household level.* Cape Town, South Africa: Human Sciences Research Council;2007.

23. Weiser SD, Bangsberg DR, Kegeles S, Ragland K, Kushel MB, Frongillo EA. Food insecurity among homeless and marginally housed individuals living with HIV/AIDS in San Francisco. *AIDS Behav.* Oct 2009;13(5):841-848.

24. Weiser S, Tsai A, Senkungu J, et al. Food Insecurity and Morbidity among HIV-Infected Persons Accessing Antiretroviral Therapy (ART) in Rural Uganda. *XVIII International AIDS Conference*. Vienna, Austria2010.

25. Weiser SD, Palar K, Frongillo EA, et al. Longitudinal assessment of associations between food insecurity, antiretroviral adherence and HIV treatment outcomes in rural Uganda. *AIDS.* Jan 2 2014;28(1):115-120.

26. Kalichman SC, Cherry C, Amaral C, et al. Health and treatment implications of food insufficiency among people living with HIV/AIDS, Atlanta, Georgia. *J Urban Health.* Jul 2010;87(4):631-641.

27. Weiser SD, Frongillo EA, Ragland K, Hogg RS, Riley ED, Bangsberg DR. Food insecurity is associated with incomplete HIV RNA suppression among homeless and marginally housed HIV-infected individuals in San Francisco. *J Gen Intern Med.* Jan 2009;24(1):14-20.

28. Wang EA, McGinnis KA, Fiellin DA, et al. Food insecurity is associated with poor virologic response among HIV-infected patients receiving antiretroviral medications. *J Gen Intern Med.* Sep 2011;26(9):1012-1018.

29. Kalichman SC, Cherry C, Amaral CM, et al. Adherence to antiretroviral therapy and HIV transmission risks: implications for test-and-treat approaches to HIV prevention. *AIDS Patient Care STDS.* May 2010;24(5):271-277.

30. McMahon JH, Wanke CA, Elliott JH, Skinner S, Tang AM. Repeated assessments of food security predict CD4 change in the setting of antiretroviral therapy. *J Acquir Immune Defic Syndr.* Sep 1 2011;58(1):60-63.

31. Weiser SD, Bangsberg DR, Kegeles S, Ragland K, Kushel MB, Frongillo EA. Food insecurity among homeless and marginally housed individuals living with HIV/AIDS in San Francisco. *AIDS Behav.* Oct 2009;13(5):841-848.

32. Weiser SD, Hatcher A, Frongillo EA, et al. Food insecurity is associated with greater acute care utilization among HIV-infected homeless and marginally housed individuals in San Francisco. *J Gen Intern Med.* Jan 2013;28(1):91-98.

33. Anema A, Weiser SD, Fernandes KA, et al. High prevalence of food insecurity among HIV-infected individuals receiving HAART in a resource-rich setting. *AIDS Care.* Feb 2011;23(2):221-230.

34. Weiser SD, Fernandes KA, Brandson EK, et al. The association between food insecurity and mortality among HIV-infected individuals on HAART. *J Acquir Immune Defic Syndr.* Nov 1 2009;52(3):342-349.

35. Strauss J, Thomas D. Health, nutrition, and economic development. . *Journal of Economic Literature.* 1998;36(2):766-817.

36. Burkey MD, Weiser SD, Fehmie D, et al. Socioeconomic determinants of mortality in HIV: evidence from a clinical cohort in Uganda. *J Acquir Immune Defic Syndr.* May 1 2014;66(1):41-47.

37. Thirumurthy H, Zivin JG, Goldstein M. The Economic Impact of AIDS Treatment: Labor Supply in Western Kenya. *J Hum Resour.* Summer 2008;43(3):511-552.

38. Rose D, Oliveira V. Nutrient intakes of individuals from food-insufficient households in the United States. *American journal of public health.* Dec 1997;87(12):1956-1961.

39. Lee JS, Frongillo EA, Jr. Nutritional and health consequences are associated with food insecurity among U.S. elderly persons. *J Nutr.* May 2001;131(5):1503-1509.

40. Stringer JS, Zulu I, Levy J, et al. Rapid scale-up of antiretroviral therapy at primary care sites in Zambia: feasibility and early outcomes. *Jama.* Aug 16 2006;296(7):782-793.

41. Zachariah R, Fitzgerald M, Massaquoi M, et al. Risk factors for high early mortality in patients on antiretroviral treatment in a rural district of Malawi. *Aids.* Nov 28 2006;20(18):2355-2360.

42. Johannessen A, Naman E, Ngowi BJ, et al. Predictors of mortality in HIV-infected patients starting antiretroviral therapy in a rural hospital in Tanzania. *BMC Infect Dis.* 2008;8:52.

43. Friis H. *Micronutrients and HIV infection: a review of current evidence*: World Health Organization;2005.

44. Kotler DP, Tierney AR, Wang J, Pierson RN, Jr. Magnitude of body-cell-mass depletion and the timing of death from wasting in AIDS. *The American journal of clinical nutrition.* Sep 1989;50(3):444-447.

45. van der Sande MA, van der Loeff MF, Aveika AA, et al. Body mass index at time of HIV diagnosis: a strong and independent predictor of survival. *J Acquir Immune Defic Syndr.* Oct 1 2004;37(2):1288-1294.

46. Wheeler DA, Gibert CL, Launer CA, et al. Weight loss as a predictor of survival and disease progression in HIV infection. Terry Beirn Community Programs for Clinical Research on AIDS. *J Acquir Immune Defic Syndr Hum Retrovirol.* May 1 1998;18(1):80-85.

47. Guenter P, Muurahainen N, Simons G, et al. Relationships among nutritional status, disease progression, and survival in HIV infection. *J Acquir Immune Defic Syndr.* Oct 1993;6(10):1130-1138.

48. Chlebowski RT, Grosvenor MB, Bernhard NH, Morales LS, Bulcavage LM. Nutritional status, gastrointestinal dysfunction, and survival in patients with AIDS. *Am J Gastroenterol.* Oct 1989;84(10):1288-1293.

49. Chlebowski RT, Grosvenor M, Lillington L, Sayre J, Beall G. Dietary intake and counseling, weight maintenance, and the course of HIV infection. *Journal of the American Dietetic Association.* Apr 1995;95(4):428-432; quiz 433-425.

50. Macallan DC, Noble C, Baldwin C, et al. Energy expenditure and wasting in human immunodeficiency virus infection. *N Engl J Med.* Jul 13 1995;333(2):83-88.

51. Jones CY, Hogan JW, Snyder B, et al. Overweight and human immunodeficiency virus (HIV) progression in women: associations HIV disease progression and changes in body mass index in women in the HIV epidemiology research study cohort. *Clin Infect Dis.* 2003;37 Suppl 2:S69-80.

52. Tang AM, Forrester J, Spiegelman D, Knox TA, Tchetgen E, Gorbach SL. Weight loss and survival in HIV-positive patients in the era of highly active antiretroviral therapy. *J Acquir Immune Defic Syndr.* Oct 1 2002;31(2):230-236.

53. Babameto G, Kotler DP. Malnutrition in HIV infection. *Gastroenterol Clin North Am.* Jun 1997;26(2):393-415.

54. Kotler DP, Tierney AR, Brenner SK, Couture S, Wang J, Pierson RN, Jr. Preservation of short-term energy balance in clinically stable patients with AIDS. *The American journal of clinical nutrition.* Jan 1990;51(1):7-13.

55. Stack JA, Bell SJ, Burke PA, Forse RA. High-energy, high-protein, oral, liquid, nutrition supplementation in patients with HIV infection: effect on weight status in relation to incidence of secondary infection. *Journal of the American Dietetic Association.* Apr 1996;96(4):337-341.

56. Fields-Gardner C, Fergusson P. Position of the American Dietetic Association and Dietitians of Canada: nutrition intervention in the care of persons with human immunodeficiency virus infection. *Journal of the American Dietetic Association.* Sep 2004;104(9):1425-1441.

57. Gustavson L, Lam W, Bertz R, et al. Assessment of the bioequivalence and food effects for liquid and soft gelatin capsule co-formulations of ABT-378/ritonavir (ABT-378/r) in healthy subjects. Paper presented at: 40th Interscience Conference on Antimicrobial Agents and Chemotherapy2000; Toronto, Canada.

58. Bardsley-Elliot A, Plosker GL. Nelfinavir: an update on its use in HIV infection. *Drugs.* Mar 2000;59(3):581-620.

59. Colin A, Reggers J, Castronovo V, Ansseau M. [Lipids, depression and suicide]. *Encephale.* Jan-Feb 2003;29(1):49-58.

60. Schreck R, Rieber P, Baeuerle PA. Reactive oxygen intermediates as apparently widely used messengers in the activation of the NF-kappa B transcription factor and HIV-1. *EMBO J.* Aug 1991;10(8):2247-2258.

61. Zivin JG, Thirumurthy H, Goldstein M. AIDS Treatment and Intrahousehold Resource Allocation: Children's Nutrition and Schooling in Kenya. *J Public Econ.* Aug 1 2009;93(7-8):1008-1015.

62. Ferreira F, Schady N. *Aggregate Economic Shocks, Child Schooling And Child Health.* Washington: The World Bank;2008.

63. Tuller DM, Bangsberg DR, Senkungu J, Ware NC, Emenyonu N, Weiser SD. Transportation costs impede sustained adherence and access to HAART in a clinic population in southwestern Uganda: a qualitative study. *AIDS Behav.* Aug 2010;14(4):778-784.

64. Anema A, Vogenthaler N, Frongillo EA, Kadiyala S, Weiser SD. Food insecurity and HIV/AIDS: current knowledge, gaps, and research priorities. *Curr HIV/AIDS Rep.* Nov 2009;6(4):224-231.

65. Weiser SD, Tuller DM, Frongillo EA, Senkungu J, Mukiibi N, Bangsberg DR. Food insecurity as a barrier to sustained antiretroviral therapy adherence in Uganda. *PLoS One.* 2010;5(4):e10340.

66. Weiser S, Fernandes K, Anema A, et al. Food insecurity as a barrier to antiretroviral therapy (ART) adherence among HIV-infected individuals in British Columbia. *5th IAS Conference on HIV Pathogenesis, Treatment and Prevention*. Cape Town, South Africa2009.

67. Physicians for Human Rights. *Epidemic of Inequality: Women's Rights and HIV/AIDS in Botswana & Swaziland: An Evidence-Based Report on the Effects of Gender Inequity, Stigma and Discrimination.* Cambridge, MA2007.

68. Kalichman SC, Cherry C, Amaral C, et al. Health and treatment implications of food insufficiency among people living with HIV/AIDS, Atlanta, Georgia. *J Urban Health.* Jul 2010;87(4):631-641.

69. Kalichman SC, Hernandez D, Cherry C, Kalichman MO, Washington C, Grebler T. Food Insecurity and Other Poverty Indicators Among People Living with HIV/AIDS: Effects on Treatment and Health Outcomes. *J Community Health.* Apr 5 2014.

70. Young S, Wheeler AC, McCoy SI, Weiser SD. A Review of the Role of Food Insecurity in Adherence to Care and Treatment Among Adult and Pediatric Populations Living with HIV and AIDS. *AIDS Behav.* Jul 11 2013.

71. Musumari PM, Feldman MD, Techasrivichien T, Wouters E, Ono-Kihara M, Kihara M. "If I have nothing to eat, I get angry and push the pills bottle away from me": A qualitative study of patient determinants of adherence to antiretroviral therapy in the Democratic Republic of Congo. *AIDS Care.* 2013;25(10):1271-1277.

72. Musumari PM, Wouters E, Kayembe PK, et al. Food insecurity is associated with increased risk of non-adherence to antiretroviral therapy among HIV-infected adults in the Democratic Republic of Congo: a cross-sectional study. *PLoS One.* 2014;9(1).
73. Parienti JJ, Massari V, Descamps D, et al. Predictors of virologic failure and resistance in HIV-infected patients treated with nevirapine- or efavirenz-based antiretroviral therapy. *Clin Infect Dis.* May 1 2004;38(9):1311-1316.
74. Parienti JJ, Das-Douglas M, Massari V, et al. Not all missed doses are the same: sustained NNRTI treatment interruptions predict HIV rebound at low-to-moderate adherence levels. *PLoS One.* 2008;3(7):e2783.
75. Oyugi JH, Byakika-Tusiime J, Ragland K, et al. Treatment interruptions predict resistance in HIV-positive individuals purchasing fixed-dose combination antiretroviral therapy in Kampala, Uganda. *Aids.* May 11 2007;21(8):965-971.
76. Paterson DL, Swindells S, Mohr J, et al. Adherence to protease inhibitor therapy and outcomes in patients with HIV infection. *Ann Intern Med.* Jul 4 2000;133(1):21-30.
77. Liu H, Miller LG, Hays RD, et al. Repeated measures longitudinal analyses of HIV virologic response as a function of percent adherence, dose timing, genotypic sensitivity, and other factors. *J Acquir Immune Defic Syndr.* Mar 2006;41(3):315-322.
78. Bangsberg DR, Perry S, Charlebois ED, et al. Non-adherence to highly active antiretroviral therapy predicts progression to AIDS. *AIDS.* Jun 15 2001;15(9):1181-1183.
79. Peltzer K, Pengpid S. Socioeconomic factors in adherence to HIV therapy in low- and middle-income countries. *J Health Popul Nutr.* Jun 2013;31(2):150-170.
80. Mani A, Mullainathan S, Shafir E, Zhao J. Poverty impedes cognitive function. *Science.* Aug 30 2013;341(6149):976-980.
81. Cunningham WE, Andersen RM, Katz MH, et al. The impact of competing subsistence needs and barriers on access to medical care for persons with human immunodeficiency virus receiving care in the United States. *Med Care.* Dec 1999;37(12):1270-1281.
82. Emenyonu N, I., , Muyindike W, Habyarimana J, et al. Cash Transfers to Cover Clinic Transportation Costs Improve Adherence and Retention in Care in a HIV Treatment Program in Rural Uganda. Paper presented at: 17th Conference on Retroviruses and Opportunistic Infections 2010; San Francisco, CA.
83. Weiser S, Wolfe W, Bangsberg D, et al. Barriers to antiretroviral adherence for patients living with HIV infection and AIDS in Botswana. *J Acquir Immune Defic Syndr.* Nov 1 2003;34(3):281-288.
84. Laurent C, Ngom Gueye NF, Ndour CT, et al. Long-term benefits of highly active antiretroviral therapy in Senegalese HIV-1-infected adults. *J Acquir Immune Defic Syndr.* Jan 1 2005;38(1):14-17.
85. Mills EJ, Nachega JB, Buchan I, et al. Adherence to antiretroviral therapy in sub-Saharan Africa and North America: a meta-analysis. *Jama.* Aug 9 2006;296(6):679-690.
86. Alaimo K, Olson CM, Frongillo EA. Family food insufficiency, but not low family income, is positively associated with dysthymia and suicide symptoms in adolescents. *J Nutr.* 2002;132(4):719-725.
87. Cole SM, Tembo G. The effect of food insecurity on mental health: panel evidence from rural Zambia. *Soc Sci Med.* 2011;73(7):1071-1079.
88. Hadley C, Tegegn A, Tessema F, Cowan J, Asefa M, Galea S. Food insecurity, stressful life events and symptoms of anxiety and depression in east Africa: evidence from the Gilgel Gibe growth and development study. *Journal of epidemiology and community health.* 2008;62(11):980-986.
89. Belle Doucet D. Poverty, inequality, and discrimination as sources of depression among US women. *Psychology of Women Quarterly.* 2003;27(2):101-113.

90. Tsai AC, Bangsberg DR, Frongillo EA, et al. Food insecurity, depression and the modifying role of social support among people living with HIV/AIDS in rural Uganda. *Soc Sci Med.* Jun 2012;74(12):2012-2019.

91. Burgess R, Campbell C. Contextualising women's mental distress and coping strategies in the time of AIDS: A rural South African case study. *Transcult Psychiatry.* Mar 26 2014.

92. Boyes ME, Cluver LD. Relationships Between Familial HIV/AIDS and Symptoms of Anxiety and Depression: The Mediating Effect of Bullying Victimization in a Prospective Sample of South African Children and Adolescents. *J Youth Adolesc.* Jul 5 2014.

93. Cluver L, Gardner F, Operario D. Poverty and psychological health among AIDS-orphaned children in Cape Town, South Africa. *AIDS Care.* Jun 2009;21(6):732-741.

94. Ickovics JR, Hamburger ME, Vlahov D, et al. Mortality, CD4 cell count decline, and depressive symptoms among HIV-seropositive women: longitudinal analysis from the HIV Epidemiology Research Study. *Jama.* Mar 21 2001;285(11):1466-1474.

95. Tucker JS, Burnam MA, Sherbourne CD, Kung FY, Gifford AL. Substance use and mental health correlates of nonadherence to antiretroviral medications in a sample of patients with human immunodeficiency virus infection. *The American journal of medicine.* May 2003;114(7):573-580.

96. Evans DL, Ten Have TR, Douglas SD, et al. Association of depression with viral load, CD8 T lymphocytes, and natural killer cells in women with HIV infection. *Am J Psychiatry.* Oct 2002;159(10):1752-1759.

97. Weiser SD, Wolfe WR, Bangsberg DR. The HIV epidemic among individuals with mental illness in the United States. *Curr HIV/AIDS Rep.* Dec 2004;1(4):186-192.

98. Anastos K, Schneider MF, Gange SJ, et al. The association of race, sociodemographic, and behavioral characteristics with response to highly active antiretroviral therapy in women. *J Acquir Immune Defic Syndr.* Aug 15 2005;39(5):537-544.

99. Tsai AC, Weiser SD, Petersen ML, Ragland K, Kushel MB, Bangsberg DR. A marginal structural model to estimate the causal effect of antidepressant medication treatment on viral suppression among homeless and marginally housed persons with HIV. *Archives of general psychiatry.* 2010;67(12):1282.

100. Miller CL, Bangsberg DR, Tuller DM, et al. Food insecurity and sexual risk in an HIV endemic community in Uganda. *AIDS Behav.* Oct 2011;15(7):1512-1519.

101. Weiser SD, Leiter K, Bangsberg DR, et al. Food insufficiency is associated with high-risk sexual behavior among women in Botswana and Swaziland. *PLoS Med.* Oct 2007;4(10):1589-1597; discussion 1598.

102. Aad G, Abajyan T, Abbott B, et al. Search for quantum black hole production in high-invariant-mass lepton+jet final states using pp collisions at radicals=8 TeV and the ATLAS detector. *Physical review letters.* Mar 7 2014;112(9):091804.

103. Siedner MJ, Tsai AC, Dworkin S, et al. Sexual relationship power and malnutrition among HIV-positive women in rural Uganda. *AIDS Behav.* Aug 2012;16(6):1542-1548.

104. Filson J, Ulloa E, Runfola C, Hokoda A. Does powerlessness explain the relationship between intimate partner violence and depression? *J Interpers Violence.* Mar 2010;25(3):400-415.

105. Volpe EM, Hardie TL, Cerulli C. Associations among depressive symptoms, dating violence, and relationship power in urban, adolescent girls. *J Obstet Gynecol Neonatal Nurs.* Jul-Aug 2012;41(4):506-518.

106. Weiser SD, Tsai A, Senkungu J, et al. Effect of Low Sexual-Relationship Power on Viral Load Suppression among Women Receiving ART in Mbarara, Uganda. *17th Conference on Retroviruses and Opportunistic Infections*. San Francisco, CA2010.

107. Hatcher AM, Tsai AC, Kumbakumba E, et al. Sexual relationship power and depression among HIV-infected women in Rural Uganda. *PLoS One.* 2012;7(12):e49821.

108. Negin J. Assessing the impact of HIV/AIDS on economic growth and rural agriculture in Africa. *J Int Affairs.* 2005;58(2):267-281.

109. de Waal A, Whiteside A. New variant famine: AIDS and food crisis in southern Africa. *Lancet.* Oct 11 2003;362(9391):1234-1237.

110. Parker DC, Jacobsen KH, Komwa MK. A qualitative study of the impact of HIV/AIDS on agricultural households in southeastern Uganda. *Int J Environ Res Public Health.* 2009;6(8):2113-2138.

111. Baylies C. The impact of AIDS on rural households in Africa: a shock like any other? *Development and Change.* 2002;33(4):611-632.

112. Rugalema G. Coping or struggling? A journal into the impact of HIV/AIDS in southern Africa. *Rev Afr Pol Econ.* 2000;27(86):537-545.

113. Nabyonga-Orem J, Bazeyo W, Okema A, Karamagi H, Walker O. Effect of HIV/AIDS on household welfare in Uganda rural communities: a review. *East Afr Med J.* Apr 2008;85(4):187-196.

114. Gregson S, Mushati P, Nyamukapa C. Adult mortality and erosion of household viability in AIDS-afflicted towns, estates, and villages in eastern Zimbabwe. *J Acquir Immune Defic Syndr.* Feb 1 2007;44(2):188-195.

115. Brown LR, Webb P, Haddad L. The role of labour in household food security: implications of AIDS in Africa. *Food Policy.* 1994;19(6):568-573.

116. Chapoto A, Jayne TS. *Impact of HIV/AIDS-related deaths on rural farm households' welfare in Zambia: implications for poverty reduction strategies.* Lusaka: Food Security Research Project;2005.

117. Chapoto A, Jayne TS. Impact of AIDS-related mortality on farm household welfare in Zambia. *Econ Dev Cultural Change.* 2008;56(2):327-374.

118. Beegle K, de Weerdt J, Dercon S. Adult mortality and consumption growth in the age of HIV/AIDS. *Econ Dev Cultural Change.* 2008;56(2):299-326.

119. Donovan C, Massingue J. Illness, death, and macronutrients: adequacy of rural Mozambican household production of macronutrients in the face of HIV/AIDS. *Food and nutrition bulletin.* Jun 2007;28(2 Suppl):S331-338.

120. Yamano T, Jayne TS. Measuring the impact of working-age adult mortality on small-scale farm households in Kenya. *World Dev.* 2004;32(1):91-119.

121. Yamano T, Jayne TS. Working-age adult mortality and primary school attendance in rural Kenya. *Econ Dev Cultural Change.* 2005;53(3):619-654.

122. Evans DK, Miguel E. Orphans and schooling in Africa: a longitudinal analysis. *Demography.* 2007;44(1):35-57.

123. Bell C, Bruhns R, Gersbach H. *Economics growth, education, and AIDS in Kenya: a long-run analysis.* Washington, D.C.: The World Bank;2006.

124. Fafchamps M, Lund S. Risk-sharing networks in rural Philippines. *J Dev Econ.* 2003;71(2):261-287.

125. de Weerdt J, Dercon S. Risk-sharing networks and insurance against illness. *J Dev Econ.* 2006;81(2):337-356.

126. Fafchamps M. Solidarity networks in preindustrial societies: rational peasants with a moral economy. *Econ Dev Cultural Change.* 1992;41(1):147-174.

127. la Ferrara E. Kin groups and reciprocity: a model of credit transactions in Ghana. *Am Econ Rev.* 2003;93(5):1730-1751.

128. Danziger R. The social impact of HIV/AIDS in developing countries. *Soc Sci Med.* Oct 1994;39(7):905-917.

129. Ndirangu M, Wariero JO, Sachs SE, Masibo P, Deckelbaum RJ. Nutritional status of under-five children in HIV-affected households in western Kenya. *Food Nutr Bull.* Jun 2011;32(2):159-167.

130. Tsai AC, Bangsberg DR, Weiser SD. Harnessing poverty alleviation to reduce the stigma of HIV in Sub-Saharan Africa. *PLoS Med.* Nov 2013;10(11):e1001557.

131. Mamlin J, Kimaiyo S, Lewis S, et al. Integrating nutrition support for food-insecure patients and their dependents into an HIV care and treatment program in Western Kenya. *American journal of public health.* Feb 2009;99(2):215-221.

132. Seume-Fosso E, Rajabiun S, Cogill B, Elder L, Castleman T, Sheckler A. Food and Nutrition Technical Assistance. HIV/AIDS: A Guide For Nutritional Care and Support. 2004; http://www.fantaproject.org/publications/HIVguide.shtml. Accessed September 23, 2008.

133. *Nutrition and HIV/AIDS. Statement by the Administrative Committee on Coordination, Sub-Committee on Nutrition at its 28th Session.* Nairobe, Kenya: United Nations Administrative Committee on Coordination, Sub-Committee on Nutrition;2001.

134. Blumberg SJ, Dickey WC. Prevalence of HIV risk behaviors, risk perceptions, and testing among US adults with mental disorders. *J Acquir Immune Defic Syndr.* Jan 1 2003;32(1):77-79.

135. Programming in the Era of AIDS: WPF's Response to HIV/AIDS. 2003; http://reliefweb.int/rw/lib.nsf/db900sid/PANA-7DSFKW/$file/wfp_jan2003.pdf?openelement. Accessed September 23, 2008.

136. World Food Program, World Health Organization, UNAIDS. HIV, food security, and nutrition. *Policy Brief* 2008; http://data.unaids.org/pub/Manual/2008/jc1515a_policybrief_nutrition_en.pdf. Accessed January 18, 2010.

137. Leeper SC, Reddi A. United States global health policy: HIV/AIDS, maternal and child health, and The President's Emergency Plan for AIDS Relief (PEPFAR). *AIDS.* Sep 10 2010;24(14):2145-2149.

138. Bristol N. Slow going for the global health initiative. *Health Aff (Millwood).* Jun 2011;30(6):1007-1009.

139. Moszynski P. Global Fund suspends new projects until 2014 because of lack of funding. *BMJ.* 2011;343:d7755.

140. Weigers E. The role of the agricultural sector in mitigating the impact of HIV/AIDS in sub-Saharan Africa. *NJAS Wageningen Journal of Life Sciences.* 2008;56(3):155-166.

141. Economic Commission for Africa. *Mitigating the impact of HIV/AIDS on smallholder agriculture, food security and rural livelihoods in Southern Africa: Challenges and Action Plan.* Addis Ababa: Economic Commission for Africa;2006.

142. UNAIDS. *Report on the global AIDS epidemic.* Geneva: Joint United Nations Programme on HIV/AIDS;2008.

143. Cantrell RA, Sinkala M, Megazinni K, et al. A pilot study of food supplementation to improve adherence to antiretroviral therapy among food-insecure adults in Lusaka, Zambia. *J Acquir Immune Defic Syndr.* Oct 1 2008;49(2):190-195.

144. Partners in Health. Agricultural initiatives for health in Haiti, Rwanda, and Lesotho. 2009; http://model.pih.org/food/agriculture. Accessed January 13, 2010.

145. Ochai R. HIV, livelihoods, nutrition and health research. Paper presented at: Global Ministerial Forum on Research for Health2008; Bamako, Mali.

146. Njenga M, Karanja N, Gathuru K, Mbugua S, Fedha N, Ngoda B. The role of women-led micro-farming activities in combating HIV/AIDS in Nakuru, Kenya. In: Hovorka A, de Zeeuw H, Njenga M, eds. *Women feeding cities: mainstreaming gender in urban agriculture and food security*. Warwickshire, UK: Practical Action Publishing; 2009.

147. Byron E, Gillespie S, Nangami M. Integrating nutrition security with treatment of people living with HIV: lessons from Kenya. *Food and nutrition bulletin.* 2008;29(2):87-97.

148. Koethe J, Chi B, Megazzini K, Heimburger D, Stringer J. Macronutrient supplementation for malnourished HIV-infected adults: a review of the evidence in resource-adequate and resource-constrained settings. *Clinical infectious diseases.* Sep 2009;49(5):787-798.
149. Ivers LC, Chang Y, Gregory Jerome J, Freedberg KA. Food assistance is associated with improved body mass index, food security and attendance at clinic in an HIV program in central Haiti: a prospective observational cohort study. *AIDS Res Ther.* 2010;7:33.
150. de Pee S, Grede N, Mehra D, Bloem MW. The Enabling Effect of Food Assistance in Improving Adherence and/or Treatment Completion for Antiretroviral Therapy and Tuberculosis Treatment: A Literature Review. *AIDS Behav.* Mar 12 2014.
151. Mahlungulu S, Grobler LA, Visser ME, Volmink J. Nutritional interventions for reducing morbidity and mortality in people with HIV. *Cochrane Database Syst Rev.* 2007(3):CD004536.
152. Sztam KA, Fawzi WW, Duggan C. Macronutrient supplementation and food prices in HIV treatment. *J Nutr.* Jan 2010;140(1):213S-223S.
153. Ashburn K, Kerrigan D, Sweat M. Micro-credit, women's groups, control of own money: HIV-Related negotiation among partnered Dominican women. *AIDS Behav.* May 2008;12(3):396-403.
154. Kim J, Pronyk P, Barnett T, Watts C. Exploring the role of economic empowerment in HIV prevention. *Aids.* Dec 2008;22:S57-S71.
155. Schuler SR, Hashemi SM. CREDIT PROGRAMS, WOMENS EMPOWERMENT, AND CONTRACEPTIVE USE IN RURAL BANGLADESH. *Studies in Family Planning.* Mar-Apr 1994;25(2):65-76.
156. Dworkin SL, Blankenship K. Microfinance and HIV/AIDS prevention: assessing its promise and limitations. *AIDS Behav.* Jun 2009;13(3):462-469.
157. Weinhardt LS, Galvao LW, Stevens PE, Masanjala WH, Bryant C, Ng'ombe T. Broadening research on microfinance and related strategies for HIV prevention: commentary on Dworkin and Blankenship (2009). *AIDS Behav.* Jun 2009;13(3):470-473.
158. Diagne A. *Impact of Access to Credit on Income and Food Security in Malawi.* Washington: IFPRI;1998.
159. Doocy S, Teferra S, Norell D, Burnham G. Credit program outcomes: coping capacity and nutritional status in the food insecure context of Ethiopia. *Soc Sci Med.* May 2005;60(10):2371-2382.
160. Gomez B, Lister A, Wiese M. Micro-credit: giving life through work to PLWHA. Paper presented at: International AIDS Conference2004; Bangkok, Thailand.
161. Pandit JA, Sirotin N, Tittle R, Onjolo E, Bukusi EA, Cohen CR. Shamba Maisha: a pilot study assessing impacts of a micro-irrigation intervention on the health and economic wellbeing of HIV patients. *BMC Pub Health.* 2010;10:245.
162. Grossman D, Onono M, Newmann SJ, et al. Integration of family planning services into HIV care and treatment in Kenya: a cluster-randomized trial. *AIDS.* Oct 2013;27 Suppl 1:S77-85.
163. Celum C, Wald A, Lingappa JR, et al. Acyclovir and transmission of HIV-1 from persons infected with HIV-1 and HSV-2. *N Engl J Med.* Feb 4 2010;362(5):427-439.
164. Baeten JM, Donnell D, Ndase P, et al. Antiretroviral prophylaxis for HIV prevention in heterosexual men and women. *N Engl J Med.* Aug 2 2012;367(5):399-410.
165. Weiser SD, Yuan C, Guzman D, et al. Food insecurity and HIV clinical outcomes in a longitudinal study of urban homeless and marginally housed HIV-infected individuals. *AIDS.* Nov 28 2013;27(18):2953-2958.
166. Anema A, Chan K, Chen Y, Weiser S, Montaner JS, Hogg RS. Relationship between food insecurity and mortality among HIV-positive injection drug users receiving antiretroviral therapy in British Columbia, Canada. *PLoS One.* 2013;8(5):e61277.

167. Young S, Cohen C, Kushel M, et al. Conceptual framework for understanding the bidirectional links between food insecurity and HIV/AIDS. *In press, American Journal of Clinical Nutrition.* July 2011.
168. Frongillo EA, Nanama S. Development and validation of an experience-based measure of household food insecurity within and across seasons in northern Burkina Faso. *J Nutr.* May 2006;136(5):1409S-1419S.
169. Frith AL, Naved RT, Ekstrom EC, Rasmussen KM, Frongillo EA. Micronutrient supplementation affects maternal-infant feeding interactions and maternal distress in Bangladesh. *Am J Clin Nutr.* Jul 2009;90(1):141-148.
170. Frith AL, Naved RT, Persson LA, Rasmussen KM, Frongillo EA. Early participation in a prenatal food supplementation program ameliorates the negative association of food insecurity with quality of maternal-infant interaction. *J Nutr.* Jun 2012;142(6):1095-1101.
171. Persson LA, Arifeen S, Ekstrom EC, Rasmussen KM, Frongillo EA, Yunus M. Effects of prenatal micronutrient and early food supplementation on maternal hemoglobin, birth weight, and infant mortality among children in Bangladesh: the MINIMat randomized trial. *Jama.* May 16 2012;307(19):2050-2059.
172. Frith AL, Naved RT, Persson LA, Frongillo EA. Early prenatal food supplementation ameliorates the negative association of maternal stress with birth size in a randomised trial. *Matern Child Nutr.* Apr 5 2013.
173. Frongillo EA, Jyoti DF, Jones SJ. Food Stamp Program participation is associated with better academic learning among school children. *J Nutr.* 2006;136(4):1077-1080.
174. Khan AI, Kabir I, Ekstrom EC, et al. Effects of prenatal food and micronutrient supplementation on child growth from birth to 54 months of age: a randomized trial in Bangladesh. *Nutr J.* 2011;10:134.
175. Handa S, Halpern CT, Pettifor A, Thirumurthy H. The government of Kenya's cash transfer program reduces the risk of sexual debut among young people age 15-25. *PLoS One.* 2014;9(1):e85473.
176. Weiser SD, Leiter K, Bangsberg DR, et al. Food insufficiency is associated with high-risk sexual behavior among women in Botswana and Swaziland. *PLoS Med.* Oct 2007;4(10):1589-1597; discussion 1598.
177. Siedner MJ, Tsai AC, Dworkin S, et al. Sexual Relationship Power and Malnutrition Among HIV-Positive Women in Rural Uganda. *AIDS and behavior.* Mar 2 2012.
178. Blankenship KM, Friedman SR, Dworkin S, Mantell JE. Structural interventions: concepts, challenges and opportunities for research. *J Urban Health.* Jan 2006;83(1):59-72.
179. Dworkin SL, Kambou SD, Sutherland C, Moalla K, Kapoor A. Gendered empowerment and HIV prevention: policy and programmatic pathways to success in the MENA region. *J Acquir Immune Defic Syndr.* Jul 1 2009;51 Suppl 3:S111-118.
180. Brody C, Hoop Td, Voitkova M, Dunbar M, Mrthy P, Dworkin S. The effects of economic group programs on women's empowerment: A systematic review. *Journal of Development Effectiveness.* 2015, In Press.
181. Venkataramani AS, Thirumurthy H, Haberer JE, et al. CD4+ cell count at antiretroviral therapy initiation and economic restoration in rural Uganda. *AIDS.* Jan 8 2014.
182. Thirumurthy H, Galarraga O, Larson B, Rosen S. HIV treatment produces economic returns through increased work and education, and warrants continued US support. *Health Aff (Millwood).* Jul 2012;31(7):1470-1477.
183. Thirumurthy H, Jafri A, Srinivas G, et al. Two-year impacts on employment and income among adults receiving antiretroviral therapy in Tamil Nadu, India: a cohort study. *AIDS.* Jan 14 2011;25(2):239-246.

184. Cui RR, Lee R, Thirumurthy H, Muessig KE, Tucker JD. Microenterprise development interventions for sexual risk reduction: a systematic review. *AIDS Behav.* Nov 2013;17(9):2864-2877.

185. d'Adda G, Goldstein M, Zivin JG, Nangami M, Thirumurthy H. ARV Treatment and Time Allocation to Household Tasks: Evidence from Kenya. *Afr Dev Rev.* Apr 1 2009;21(1):180-208.

186. Thirumurthy H, Chamie G, Jain V, et al. Improved employment and education outcomes in households of HIV-infected adults with high CD4 cell counts: evidence from a community health campaign in Uganda. *AIDS.* Feb 20 2013;27(4):627-634.

187. Marseille E, Kahn JG, Saba J. Cost-effectiveness of antiviral drug therapy to reduce mother-to-child HIV transmission in sub-Saharan Africa. *AIDS.* May 28 1998;12(8):939-948.

188. Marseille E, Kahn JG, Pitter C, et al. The cost effectiveness of home-based provision of antiretroviral therapy in rural Uganda. *Appl Health Econ Health Policy.* 2009;7(4):229-243.

189. Kahn JG, Marseille EA, Bennett R, Williams BG, Granich R. Cost-effectiveness of antiretroviral therapy for prevention. *Curr HIV Res.* Sep 2011;9(6):405-415.

190. Shrestha RK, Marseille E, Kahn JG, et al. Cost-effectiveness of home-based chlorination and safe water storage in reducing diarrhea among HIV-affected households in rural Uganda. *Am J Trop Med Hyg.* May 2006;74(5):884-890.

191. Marseille E, Giganti MJ, Mwango A, et al. Taking ART to scale: determinants of the cost and cost-effectiveness of antiretroviral therapy in 45 clinical sites in Zambia. *PLoS One.* 2012;7(12):20.

192. Marseille E, Jiwani A, Raut A, Verguet S, Walson J, Kahn JG. Scaling up integrated prevention campaigns for global health: costs and cost-effectiveness in 70 countries. *BMJ Open.* 2014;4(6):e003987.

193. Kulzer JK, Penner JA, Marima R, et al. Family model of HIV care and treatment: a retrospective study in Kenya. *Journal of the International AIDS Society.* 2012;15(8).

194. Kennedy E, Peters P. Household food security and child nutrition: the interaction of income and gender of household head. *World Dev.* 1992;20(8):1077-1085.

195. Quisumbing AR, de la Briere B. *Women's assets and intrahousehold allocation in rural Bangladesh: testing measures of bargaining power.* Washington, D.C.: International Food Policy Research Institute;2000.

196. Thomas D. Intra-household resource allocation: an inferential approach. *J Hum Resources.* 1990;25(4):635-664.

197. Thomas D. The distribution of income and expenditure within the household. *Ann d'Econ Stat.* 1993;29(1):109-135.

198. Buvinic M, Gupta GR. Female-headed households and female-maintained families: are they worth targeting to reduce poverty in developing countries. *Econ Dev Cultural Change.* 1997;45(2):259-280.

199. Smith LC, Ramakrishnan U, Ndiaye A, Haddad L, Martorell R. *The importance of women's status for child nutrition in developing countries.* Washington, D.C.: International Food Policy Research Institute;2003.

200. Quisumbing AR, ed *Household decisions, gender, and development: a synthesis of recent research*. Washington, D.C.: International Food Policy Research Institute; 2004.

201. Duflo E, Udry C. *Intrahousehold resource allocation in Cote d'Ivoire: social norms, separate accounts and consumption choices.* Cambridge: National Bureau of Economic Research;2004. NBER Working Paper No. 10498.

202. KickStart. KickStart Impact. http://www.kickstart.org/what-we-do/impact/. Accessed July 11, 2014.

203. Brandsma T. Waterworks: Kenyan Farmers Are Getting A Big Boost From A Simple Piece Of Equipment. *Newsweek*2003.
204. Kihia JK, Kamau RN. *Super-Money Maker pressure pedal pump impact assessment in utilisation, job creation and income generation.* Nairobi: ApproTEC, Inc.;1999.
205. Stevens JE. Martin makes a middle class: Stanford grad Martin Fisher has gone low-tech in search of solutions for Kenyan farmers. *SF Chronicle Magazine*2002;CM: 18.
206. Bank W. *Yes, Africa can: success stories from a dynamic continent*. Washington, D.C.: The World Bank; 2010.
207. Shah T, Keller K. Micro-irrigation and the poor: A marketing challenge in smallholder irrigation development. In: Sally HA, C.L., ed. *Private Irrigation in Sub-Saharan Africa: regional Seminar on Private Sector Participation and Irrigation Expansion in Sub-Saharan Africa*. Columbo: ACP-EU Technical Centre for Agricultural and Rural Cooperation; 2002:165-183.
208. *National AIDS and STI Control Programme, Ministry of Health, Kenya. September 2013. Kenya AIDS Indicator Survey 2012: Preliminary Report. Nairobi, Kenya.*
209. Lay J, Mahmoud TO, M'Mukaria GM. Few opportunities, much desperation: the dichotomy of non-agricultural activities and inequality in western Kenya. *World Dev.* 2008;36(12):2713-2732.
210. Government of Kenya. *District Development Plan: Migori.* Migori, Kenya: District Commissioner's Office, GoK;2008.
211. van der Laan MJ, Balzer LB, Petersen ML. ADAPTIVE MATCHING IN RANDOMIZED TRIALS AND OBSERVATIONAL STUDIES. *J Stat Res.* Dec 1 2012;46(2):113-156.
212. Imai K, King G, Nall C. The Essential Role of Pair Matching in Cluster-Randomized Experiments, with Application to the Mexican Universal Health Insurance Evaluation. *Statistical Science.* 2009;24(1):29-53.
213. Greevy R, Lu B, Silber JH, Rosenbaum P. Optimal multivariate matching before randomization. *Biostatistics.* Apr 2004;5(2):263-275.
214. Lu B, Greevy R, Xu X, Beck C. Optimal Nonbipartite Matching and Its Statistical Applications. *Am Stat.* 2011;65(1):21-30.
215. Greevy RA, Jr., Grijalva CG, Roumie CL, et al. Reweighted Mahalanobis distance matching for cluster-randomized trials with missing data. *Pharmacoepidemiol Drug Saf.* May 2012;21 Suppl 2:148-154.
216. King G, Gakidou E, Ravishankar N, et al. A "politically robust" experimental design for public policy evaluation, with application to the Mexican universal health insurance program. *J Policy Anal Manage.* Summer 2007;26(3):479-506.
217. Hayes RJ, Moulton LH. *Cluster Randomized Trials*. Boca Raton: Chapman & Hall/CRC Press; 2009.
218. *Physical Status: The Use and Interpretation of Anthropometry. Report of a WHO Expert Committee. WHO Technical Report Series 854.* Geneva, Switzerland: World Health Organization;1995.
219. Collins C, Duffield A, Myatt M. *Adults Assessment of Nutritional Status in Emergency-Affected Populations* Geneva, Switzerland: United Nations, Administrative Committee on Coordination, Sub-committee on Nutrition;2000.
220. James WP, Ferro-Luzzi A, Waterlow JC. Definition of chronic energy deficiency in adults. Report of a working party of the International Dietary Energy Consultative Group. *Eur J Clin Nutr.* Dec 1988;42(12):969-981.
221. Ferro-Luzzi A, Sette S, Franklin M, James WP. A simplified approach of assessing adult chronic energy deficiency. *Eur J Clin Nutr.* Mar 1992;46(3):173-186.
222. Doocy S, Teferra S, Norell D, Burnham G. Credit program outcomes: coping capacity and nutritional status in the food insecure context of Ethiopia. *Soc Sci Med.* May 2005;60(10):2371-2382.

223. Hoddinott J, Yohannes Y. *Dietary diversity as a household food security indicator.* Washington, D.C.: Food and Nutrition Technical Assistance Project, Academy for Educational Development.; May 2002.
224. Farley J, Hines S, Musk A, Ferrus S, Tepper V. Assessment of adherence to antiviral therapy in HIV-infected children using the Medication Event Monitoring System, pharmacy refill, provider assessment, caregiver self-report, and appointment keeping. *J Acquir Immune Defic Syndr.* Jun 1 2003;33(2):211-218.
225. Lyimo RA, van den Boogaard J, Msoka E, et al. Measuring adherence to antiretroviral therapy in northern Tanzania: feasibility and acceptability of the Medication Event Monitoring System. *BMC Public Health.* 2011;11:92.
226. Thirumurthy H, Siripong N, Vreeman RC, et al. Differences between self-reported and electronically monitored adherence among patients receiving antiretroviral therapy in a resource-limited setting. *AIDS.* Nov 28 2012;26(18):2399-2403.
227. Oyugi J, Byakika-Tusiime J, Charlebois E, et al. Multiple validated measures of adherence indicate high levels of adherence to generic HIV antiretroviral therapy in a resource-limited setting. *J Acquir Immune Defic Syndr.* Aug 15 2004;36(5):1100-1102.
228. Giordano TP, Guzman D, Clark R, Charlebois ED, Bangsberg DR. Measuring adherence to antiretroviral therapy in a diverse population using a visual analogue scale. *HIV Clin Trials.* Mar-Apr 2004;5(2):74-79.
229. Kelly JD, Hubenthal EA, Lurton G, et al. Multiple self-report measures of antiretroviral adherence correlated in Sierra Leone, but did they agree? *Int J STD AIDS.* Dec 2013;24(12):931-937.
230. Evans D, Menezes C, Mahomed K, et al. Treatment outcomes of HIV-infected adolescents attending public-sector HIV clinics across Gauteng and Mpumalanga, South Africa. *AIDS Res Hum Retroviruses.* Jun 2013;29(6):892-900.
231. Hassan AS, Fielding KL, Thuo NM, Nabwera HM, Sanders EJ, Berkley JA. Early loss to follow-up of recently diagnosed HIV-infected adults from routine pre-ART care in a rural district hospital in Kenya: a cohort study. *Trop Med Int Health.* Jan 2012;17(1):82-93.
232. Gelberg L, Andersen RM, Leake BD. The Behavioral Model for Vulnerable Populations: application to medical care use and outcomes for homeless people. *Health Serv Res.* Feb 2000;34(6):1273-1302.
233. Gelberg L, Gallagher TC, Andersen RM, Koegel P. Competing priorities as a barrier to medical care among homeless adults in Los Angeles. *Am J Public Health.* Feb 1997;87(2):217-220.
234. Wu AW, Rubin HR, Mathews WC, et al. A health status questionnaire using 30 items from the Medical Outcomes Study. Preliminary validation in persons with early HIV infection. *Med Care.* Aug 1991;29(8):786-798.
235. Chatterton ML, Scott-Lennox J, Wu AW, Scott J. Quality of life and treatment satisfaction after the addition of lamivudine or lamivudine plus loviride to zidovudine-containing regimens in treatment-experienced patients with HIV infection. *Pharmacoeconomics.* 1999;15 Suppl 1:67-74.
236. Mast TC, Kigozi G, Wabwire-Mangen F, et al. Measuring quality of life among HIV-infected women using a culturally adapted questionnaire in Rakai district, Uganda. *AIDS Care.* Jan 2004;16(1):81-94.
237. Derogatis LR, Lipman RS, Rickels K, Uhlenhuth EH, Covi L. The Hopkins Symptom Checklist (HSCL). A measure of primary symptom dimensions. *Mod Probl Pharmacopsychiatry.* 1974;7(0):79-110.
238. Bolton P, Wilk CM, Ndogoni L. Assessment of depression prevalence in rural Uganda using symptom and function criteria. *Soc Psychiatry Psychiatr Epidemiol.* Jun 2004;39(6):442-447.

239. Bradley KA, DeBenedetti AF, Volk RJ, Williams EC, Frank D, Kivlahan DR. AUDIT-C as a brief screen for alcohol misuse in primary care. *Alcohol Clin Exp Res.* 2007;31(7):1208-1217.
240. Wolfe WR, Weiser SD, Leiter K, et al. The impact of universal access to antiretroviral therapy on HIV stigma in Botswana. *Am J Public Health.* Oct 2008;98(10):1865-1871.
241. Tsai A, Bangsberg D, Kegeles S, et al. Internalized stigma, disease progression, and serostatus disclosure among people living with HIV/AIDS in rural Uganda. *Annals of Behavioral Medicine.*May 21, 2013 [Epub ahead of print].
242. Pronyk PM, Hargreaves JR, Kim JC, et al. Effect of a structural intervention for the prevention of intimate-partner violence and HIV in rural South Africa: a cluster randomised trial. *Lancet.* Dec 2 2006;368(9551):1973-1983.
243. Pulerwitz J, Gortmaker SL, DeJong W. Measuring sexual relationship power in HIV/STD research. *Sex Roles.* 2000;42(7-8):637-660.
244. Dunkle KL, Jewkes RK, Brown HC, Gray GE, McIntryre JA, Harlow SD. Gender-based violence, relationship power, and risk of HIV infection in women attending antenatal clinics in South Africa. *Lancet.* May 1 2004;363(9419):1415-1421.
245. Jewkes RK, Dunkle K, Nduna M, Shai N. Intimate partner violence, relationship power inequity, and incidence of HIV infection in young women in South Africa: a cohort study. *Lancet.* Jul 3 2010;376(9734):41-48.
246. Weiser S, Tsai A, Senkungu J, et al. The impact of low sexual relationship power on viral load suppression among women receiving antiretroviral therapy in Mbarara, Uganda. *17th Conference on Retroviruses and Opportunistic Infections*. San Francisco2010.
247. Coates J, Swindale A, Bilinsky P. *Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide.* Washington, D.C.: Food and Nutrition Technical Assistance. Academy for Educational Development.; January 2006.
248. Swindale A, Bilinsky P. Development of a universally applicable household food insecurity measurement tool: process, current status, and outstanding issues. *J Nutr.* May 2006;136(5):1449S-1452S.
249. Coates J, Frongillo EA, Rogers BL, Webb P, Wilde PE, Houser R. Commonalities in the experience of household food insecurity across cultures: what are measures missing? *J Nutr.* May 2006;136(5):1438S-1448S.
250. Miller CL, Bangsberg DR, Tuller DM, et al. Food insecurity and sexual risk in an HIV endemic community in Uganda. *AIDS Behav.* April 20 2010.
251. Tsai A, Bangsberg D, Frongillo E, et al. Gendered Effects of Food Insecurity on Depression among HIV-Infected Persons Accessing Antiretroviral Therapy (ART) in Rural Uganda. *17th Conference on Retroviruses and Opportunistic Infections*. San Francisco2010.
252. Tsai AC, Bangsberg DR, Senkungu J, et al. Food insecurity, competing demands, and health care utilization among HIV-infected persons accessing antiretroviral therapy (ART) in rural Uganda. Paper presented at: 17th Conference on Retroviruses and Opportunistic Infections; Feb 16-19, 2010, 2010; San Francisco, California.
253. Tsai AC, Bangsberg DR, Frongillo EA, et al. HIV-related stigma and food insecurity among men and women accessing ART in rural Uganda. *XVIII International AIDS Conference*. Vienna, Austria2010.
254. Tsai A, Gupta R, Frongillo E, et al. Food insecurity is associated with morbidity and patterns of healthcare utilization among HIV-infected individuals in rural Uganda. *Aids.* September 2011;In press.
255. Grosh M, Glewwe P. Data Watch: the World Bank's Living Standard Measurement Study household surveys. *Journal of Economic Perspectives.* 1998;12(1):187-196.
256. World Health Organization. Verbal autopsy standards: ascertaining and attributing causes of death. 2012;

http://www.who.int/healthinfo/statistics/WHO_VA_2012_RC1_Instrument.pdf?ua=1. Accessed July 21, 2014.

257. Antelman G, Smith Fawzi MC, Kaaya S, et al. Predictors of HIV-1 serostatus disclosure: a prospective study among HIV-infected pregnant women in Dar es Salaam, Tanzania. *AIDS.* Sep 28 2001;15(14):1865-1874.

258. Broadhead WE, Gehlbach SH, de Gruy FV, Kaplan BH. The Duke-UNC Functional Social Support Questionnaire. Measurement of social support in family medicine patients. *Med Care.* Jul 1988;26(7):709-723.

259. Eckel CC, Grossman PJ. Forecasting risk attitudes: An experimental study using actual and forecast gamble choices. *Journal of Economic Behavior & Organization.* 2008;68:1-17.

260. de Mel S, McKenzie D, Woodruff C. Returns to Capital in Microenterprises: Evidence from a Field Experiment. . *Quarterly Journal of Economics.* 2008;123(4):1329-1372.

261. Little RJA, Rubin DB. *Statistical Analysis with Missing Data*. New York: John Wiley and Sons; 2002.

262. Paul J. Gertler, Sebastian Martinez, Patrick Premand, Laura B. Rawlings, Vermeersch. CMJ. Impact Evaluation in Practice. Washington DC: The International Bank for Reconstruction and Development / The World Bank; 2011. Accessed June 6, 2014.

263. Bollen KA. *Structural Equations with Latent Variables*: John Wiley & Sons, Inc; 1989.

264. Petersen ML, Sinisi SE, van der Laan MJ. Estimation of direct causal effects. *Epidemiology.* May 2006;17(3):276-284.

265. Valeri L, Vanderweele TJ. Mediation analysis allowing for exposure-mediator interactions and causal interpretation: theoretical assumptions and implementation with SAS and SPSS macros. *Psychol Methods.* Jun 2013;18(2):137-150.

266. Morduch J. The microfinancne promise. *Journal of Economic Literature.* 1999;37(4):1569 - 1614.

267. Morduch J, Karlan D. “Access to finance” In Dani Rodrik and Mark Rosenzweig, eds Handbook of Development Economics. Vol Volume 5. Amsterdam: Elsevier; 2009.

268. Bonell C, Oakley A, Hargreaves J, Strange V, Rees R. Assessment of generalisability in trials of health interventions: suggested framework and systematic review. *British Medical Journal.* Aug 12 2006;333(7563):346-349.

269. Miles M, Huberman A. *Qualitative Data Analysis: An expanded sourcebook*. Thousand Oaks, California: Sage; 1994.

270. Glaser B, Strauss A. *The discovery of grounded theory: strategies for qualitative research*. Chicago: Aldine; 1967.

271. Lofland J, Lofland L. *Analyzing social settings: a guide to qualitative observation and analysis*. 3rd ed. Belmont, California: Wadsworth; 1995.