Infant and Child health status ahead of implementation of an integrated intervention to improve nutrition and survival: A difference-in-difference quasi-experimental baseline assessment

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Abstract

Background Burundi has one of the poorest child health outcomes in the world. With an acute malnutrition rate of 5% and a chronic malnutrition rate of 56%, under five death is 78 per 1000 live births and 47 children in every 1000 children will not celebrate their first birthday. In response, Village Health Works, a Burundian-American organisation has invested in an integrated clinical and community intervention model. Ahead of implementation of this initiative, we conduct a baseline assessment using a difference-in-difference design in an effort to measure incremental effects.

Methods A quasi-experimental evaluation design (difference-in-difference) was employed. Adopting the methodology of the DHS, a sample of 952 and 990 households comprising of 2675 and 3311 birth histories respectively in the treatment and control areas were reached. Mortality data were analysed with R package for mortality computation, Complex Samples Module of IBM – SPSS for other outcomes and Emergency Nutrition Assessment software for nutrition data. Logistic regression was used to assess strength of associations and cox regression model for assessing risk of mortality

Results The incidence of low birth weight (LBW) was 5.7% at the program area compared to 7.2% at the controlled area with the strongest predictor being malnourished women (OR 1.4 95%CI 1.2 – 7.2 p=0.043). Fever incidence was higher in the program area (50.5%) in comparison to 48.4% in the control. Non-consumption of minimum acceptable diet was significantly associated with fever (OR 1.67 95%CI 1.07 – 2.61). Acute and chronic malnutrition was 7.6% and 45.8% respectively with non-receipt of Vitamin A was significantly associated with chronic malnutrition. Under-five mortality rate was 32.1 per 1000 live births in the program area and 33.6 in the control. Infant mortality rate was 25.7 in program area and 20.4 in the control. Risk of under-five mortality was higher in the neonatal period (HR 20.72 95% 8.64 – 49.65 p=0.001).

Conclusion Improving child health status is complex and therefore investing into an integrated intervention yields best results. Given that the risk of all under-five was higher at the neonatal period, strengthening the health system to provide quality care is crucial.

Background

Every year, the world experiences 5.4 million deaths of children under five, of which 46.3% occurs during the first month of life and 81.5% from preventable causes [1]. Whereas global under-five mortality rate has reduced from 93 per 1000 live births to just 39 per 1000 in 2017, that of sub-Saharan Africa stand at 76 per 1000, implying that 1 in 13 children will die before reaching the 5th birthday in this region [2]. According to a recent United Nations report, with the increasing child population in high mortality countries in the sub-Saharan Africa, it is estimated that the region will accommodate 60% of all childhood mortalities by 2050 [3]. Even within the region, the risk of childhood mortality depends on an array of socio-economic and cultural factors which is distinct among countries. Children in households of the poorest wealth quintile are two times likely to die compared to those in the richest quintile [4] and children in rural areas are 1.5 times at risk to die than their cohorts in urban areas [5]. The risk of all under-five deaths is 2.6 times more for children whose mothers have little than primary or no education in comparison to those with mothers who have a minimum of secondary education [1].

These complexities of the sociocultural factors influences child survival in sub-Saharan Africa is also mirrored by the inequity in nutritious food distribution resulting in differences in the rates of childhood malnutrition across the region [6—8]. International reports and several individual studies have established the link between all forms of childhood malnutrition and risk of death in the sub-region [9—11], directly accounting for 61% of all deaths [12]. Malnutrition is a combined effect of food access, frequency and quality which is deeply rooted in several socio-economic, cultural and environmental factors and often manifested in the form of increased poverty [13], household food insecurity, illiteracy, dwindling farmlands, poor sanitation and climate change along with several other background factors [14]. While most interventions have focused on increasing uptake of important nutrients and childhood supplements, little attention has been given to addressing these underlying issues in an integrated fashion [15, 16]. Nutrition specific and sensitive interventions have been mostly implemented parallel with little nexus in effectively tackling malnutrition, its root causes and all child mortalities. Integrating nutritional interventions does not only reduce the risk of childhood mortality [6], but also has long-term effect on overall child development and later life productivity and economic wellbeing [17]. Furthermore, emerging evidence has suggested that integrating these two components of nutrition programming can result in significant improvements in cost-effectiveness, impact, sustainability and efficiency [17].

With a wasting and stunting rate of 5% and 56% respectively, Burundi has one of highest malnutrition rates in the world [18]. Findings from the recent demographic and health survey [18] show that 78 children in every 1000 will not celebrate their 5th birthday and 47 children per 1000 will not go past the 1st year of birth. To tackle this, Village Health Works (VHW), a Burundian-American organisation has made significant investment in an integrated program that combines dignified clinical care with targeted food security, economic development, education and community health interlaced with gender and community engagement. Ahead of active implementation of components of this program, we conducted a baseline assessment to establish the major child health outcomes so to measure incremental progress towards set objectives during and after implementation. Also in an attempt to draw attributive impact of project activities, we employ a difference-in-difference quasi-experimental design. To provide useful programmatic information, child outcomes under this study were disaggregated by different geographic, cultural and socioeconomic variables and logistic regression was used to assess strength of association.

Methods

Study Design

A difference-in-difference (DID) quasi-experimental evaluation was adopted to compare changes in child health outcomes from this baseline over time in VHW catchment area (treatment) and other areas where it does not work (control). DID evaluations have been recognised as an effective evaluation method used to measure effectiveness and impact of complex interventions which are difficult to rigidly assign people or districts directly into treatments or controls using a randomised manner [19]. The determination changes in outcome will be determined by subtracting the difference in outcomes before and after program implementation in the treatment and controls. One key condition in the conduct of DID evaluations is that results in control zones should move in tandem [20] so assess whether this evaluation fulfilled this condition, the control sites will be segmented into two and results from subsequent evaluations will be compared.

Study Area

The evaluation was conducted at the Bururi and Rumonge provinces located in the south of Burundi (Figure 1). Predetermined collines (districts) of VHW's program area constituted the program target area and using a rigorous process, collines with similar characteristics as treatments were selected as controls. This resulted in selection of a mix of collines in highlands, lowlands and hinterlands. To avoid outliers in the results, the capital towns of both provinces were excluded ahead of colline selection. After applying these criteria, 18 and 24 collines with population of 142,953 and 113,847 were selected respectively in treatment and control zones.

Sampling Strategy

A two stage sampling strategy comprising of cluster and systematic sampling was employed for this evaluation. At the first stage, collines along with the respective population in the treatment and controls were received from the administrative province authorities. This constituted the sample frame for which a probability proportional to size (PPS) was applied to select a desired cluster size of 30 each for treatment and control. The second stage was conducted during field work. Enumerators received household list from the chief of collines (chef de colline) and depending on the total household size, either 2nd or 3rd consecutive household were selected after a random 'pen throw' to select the first household and direction of movement. Household selection were based on the following inclusion and exclusion criteria:

Inclusion Criteria

- Household with women aged 15 and 49 defined in this evaluation as women of reproductive age
- HHs with women 15–49 who were residents of the area for at least a year
- Head of household and caregiver in the right state of mind to actively respond to questions

Exclusion Criteria

- Households that did not meet the stated inclusion criteria

- Households that failed to grant consent via signing or thumb-printing of the form

Sample Size Calculation

The determination of an appropriate sample size was based on the methodology of the Demographic and Health Survey [18], an international program that conducts national representative surveys on major maternal, infant and child health indicators. Following the statistically robust predetermined conditions of the survey, 952 and 990 households were selected respectively for the treatment and control areas. These households then presented 2675 birth histories for treatment and 3311 for control divided equally into 30 clusters in each cluster. For collines (towns) with more than one cluster, the unit of segmentation was the ‘sous collines’ (sub-towns).

Survey Management and Data Collection

The entire survey was managed by the operational research, monitoring and evaluation department of VHW. Standard questionnaires were adopted from French version of the standard Demographic Health Surveys (DHS) [21] and United Nations Children’s Fund (UNICEF) multiple indicator cluster survey [22]. Questionnaires were segregated into three targeting women (the caregiver in most instances), men and other members of household. Questions about child outcomes were collected from the caregiver and childhood mortality collected via birth histories of women of reproductive age.

Data was collected by field teams comprising of a team lead (enumerator), measurer and a supervisor. Team leaders interviewed caregivers on child outcomes including taking birth histories and measurers were responsible for taking anthropometric measurements of children (height, weight and Mid-Upper Arm Circumference—MUAC). Supervisors ensured data quality and oversaw random selection of households.

Definition of Outcomes

Main outcomes for assessment in this study were: low birth weight, childhood morbidity (fever prevalence), and malnutrition as well as childhood mortality. To allow comparability of our results with national and province figures, we defined these outcomes according to set definitions by the Demographic Health Survey [18]

Low birth weight (LBW) was assessed from birth card of the last pregnancy of women within the reproductive age. We classified low birth weight as children who had a weight below 2500g at the first measurement after birth.

Fever incidence was defined as child with elevated temperature any level anytime within two weeks preceding the survey.

Malnutrition was classified under two main measures: acute malnutrition (wasting) and chronic malnutrition (stunting). Global Acute Malnutrition, a combination of moderate and severe wasting was defined as children with weight-for-height (WfH) z-score less than –2 according to the WHO growth standards and global Chronic Malnutrition on the other hand was defined as children with height-for-age z-score less than –2 according to the growth standards.

From birth histories acquired from women and using a synthetic cohort life table approach [24—26], the following five childhood mortality rates can be calculated:

- Neonatal mortality rate (NNMR): the probability of dying between birth and exact age 1 month;
- Post-neonatal mortality rate (PNMR): the probability of dying between exact ages 1 month and 1 year, usually calculated as the difference between IMR and NNMR;
- Infant mortality rate (IMR): the probability of dying between birth and exact age 1 year;
- Child mortality rate (CMR): the probability of dying between exact ages 1 and 5 years;
- Under–5 mortality rate (U5MR): the probability of dying between birth and exact age 5 years.

Data Analysis

Mortality rates were calculated by DHS.rates version 0.7.0 [24], an R package developed to calculate childhood mortality indicators according to the DHS methodology [25]. For each sample, control and treatment, childhood mortality rates calculated based on 60 months (5 years) preceding the survey, based on detailed birth and death histories provided by women.

All other indicators were calculated using IBM software—SPSS Statistic version 20 [23]. Chi-squares were used to assess relationships between outcomes and exposure variables. Binary or multinomial logistic regression were used to assess strength of association. Risk of mortality for selected background characteristics was calculated using a Cox proportional hazards model with the Complex Samples Module of IBM—SPSS. Significance of association was considered at 95% confidence interval $p<0.05$ (two-tailed).

Nutrition data was analysed with Emergency Nutrition Assessment (ENA) software and results exported to SPSS for further analysis [27].

Results

General Characteristics of Respondents and Households

Following a response rate of 95.4% for treatment and 98.5% for control, 2676 and 3311 live births were recorded for the mortality computation. Of this, 896 children under-five were identified and eligible for nutrition screening in the treatment (441 children) and control (455 children). Among women of reproductive age interviewed, 74.8% were married, 21.3% single, 1.1% divorced or separated and 2.0% widowed. Additionally, 0.8% children were identified as orphans and 3.3% reported to have lost either one parent. Overall, 74.2% women were involved in paid employment in farming or within the agricultural value chain. Functional literacy was higher among women (56.9%) and 73.8% of all women reported to have ever attended school.

On general characteristics of households where women and children resided, only 6.7% of households had access to electricity. Although 85.4% of households reported to have had access to improved sources of water, 36% reported to have inconsistencies in supply with longer travelling time for water access (22 minutes). Only 50.6% households had access to improved sanitation services which among those with unimproved sources, majority (50%) reported to using pit latrines with slabs. In determining overall socioeconomic status of households, we measured wealth classified households into wealth quintiles using principal component analysis. In the treatment area, the poorest (5^{th} quintile) comprised the highest quintile and was 5.5% greater than the poorest in the control areas. Combining the two poorest quintile shows that the treatment area accommodates 43% compared to only 35.5% in the control areas. In the control areas, the richest quintile constitutes the highest category (24.1%) compared to just 16.2% in the treatment areas (Table 1).

Indicator	**Control**	**Treatment**
Functional Literacy among women	55.4%	56.9%
Percentage of women ever attended school	72.4%	73.8%
Households with access to improved water sources	88.3%	85.4%
Households with access to improved sanitation sources	51.3%	50.6%
Wealth Distribution among Households		
Richest	24.1%	16.2%
Fourth	17.9%	21.7%
Middle	22.4%	19.2%
Second	18.3%	20.3%
Poorest	17.2%	22.7%

Table 1: Background characteristics among households in Treatment and Controls

Low Birth Weight (LBW)

Overall, the prevalence of low birth weight among eligible women of reproductive age was 31(6.4%) compared to the 10.5% at the national level and 5.8% and 6.8% respectively at Rumonge and Bururi provinces [18]. Disaggregating the prevalence rate by background information (Table 2), LBW was higher in the control (7.2%) than the treatment (5.7%).

Among age groups, LBW was most manifested among women aged between 30 and 34 years.

All five indicators were used to create a model to predict risk of low birth weight. The model showed that 81% (Nagelkerke R^2) of the variance in low birth weight and accurately classified 94.1% of all cases. Among the five variables, malnutrition among women were significantly associated with low birth weight (OR 1.4 95% CI 1.2 – 7.2 *p=0.*043). Increasing inclusion of cassava in household diet was associated with increased risk of low birth weight (OR 3.8 95%CI 1.5 – 9.5). Residing in treatment area and normal blood pressure were associated with a reduced risk of low birth weight but this was statistically insignificant (Table 2).

Variable Disaggregation	N (%)	Odds Ratio (OR)	Sig. Level (P-value)
LBW Prevalence by **Treatment Versus Control Zones**			
Treatment	14 (5.7%)	1.37	0.499
Control	17 (7.2%)		
LBW Prevalence by **BP status of woman**			
High/Low Blood Pressure	7(9.1%)	1.75	0.409
Normal Blood Pressure	21 (5.3%)		
LBW Prevalence by **Nutritional Status of woman**			
Normal Nutritional	20 (4.8%)	**1.40**	**0.043**
Malnourished	8 (12.5%)		
LBW Prevalence by **Household Hunger Scale**			
No hunger detected in household	17 (5.0%)	1.56	0.277
Moderate Hunger detected in household	13 (9.4%)		
Severe Hunger detected in household	1 (14.3%)		
LBW Prevalence by **Wealth Quintiles**			
Richest	2 (2.0%)	0.93	0.61
Fourth	5 (5.2%)		
Middle	9 (8.7%)		
Second	6 (6.5%)		
Poorest	9 (9.7%)		

Table 2: Low Birth Weight Prevalence disaggregated by background variables

Childhood Morbidity (Prevalence of Fever)

General fever prevalence among children under 5 was 49.5% in comparison to 34.3% and 35.3% respectively in Rumonge and Bururi province with 42% at the national level [18].

Child nutrition was associated with fever incidence and this was evident from an assessment of all indicators on food frequency, access and quality. Household Hunger Scale, an indicator that measures access and frequency of food shows that children in households with severe hunger were more predisposed to fever than those with moderate and no hunger (Table 3). Non-consumption of acceptable minimum diet, an indicator that measures food quality and diversity consumed by both breastfed and non-breastfed children showed a significant association with fever and was the highest predictor to fever (OR 1.67 95%CI 1.07 – 2.61 *p=0.028*).

Variable Disaggregation	**N (%)**	**Odds Ratio (OR)**	**Sig. Level (P-value)**
Prevalence by **Treatment Versus Control Zones**			
Treatment	139 (50.5%)	1.04	0.857
Control	135 (48.4%)		
Prevalence by S**tunting Status of Child**			
No Stunting	151 (50.0%)	1.11	0.661
Stunted	40 (48.4%)		
Prevalence by **Household Hunger Scale**			
No hunger detected in household	180 (47.5%)	1.20	0.438
Moderate Hunger detected in household	85 (51.8%)		
Severe Hunger detected in household	9 (81.8%)		
Prevalence by **Minimum Acceptable Diet Consumed**			
Minimum Acceptable diet consumed	72 (43.6%)	**1.67**	**0.028**
No Acceptable Minimum Diet Consumed	90 (54.9%)		
Prevalence by **Ownership and Sleeping in Mosquito Nets**			
Mosquito Net Present	62 (48.4%)	1.47	0.108
Mosquito Net Absent (Not Present)	133 (55.9%)		

Table 3: Prevalence of Fever disaggregated by background variables

Childhood Malnutrition (Acute and Chronic)

Global Acute Malnutrition (wasting) rate in general was 7.6% and this compares to 5% at the national level. Among the background variables disaggregated, month of child was significantly associated with risk of acute malnutrition (OR 1.16 95%CI 0.68 – 1.96 p=) with the 6 to 17 being the category with highest prevalence. Another interesting trend is how the risk of malnutrition reduces with increasing age of a child. Increased household wealth and reduced household size were associated with reduced risk of acute malnutrition (Table 4). Likewise, periodic household hunger was associated with increased risk of acute malnutrition.

Variable Disaggregation	N (%)	Odds Ratio (OR)	Sig. Level (P-value)
Prevalence of GAM by **Communes**			
Rumonge	7.80%	0.568	0.604
Vyanda	8.90%		
Prevalence of GAM by Age range in months			
6 to 17	12.70%	**1.16**	**0.04**
18 to 29	8.50%		
30 to 41	6.80%		
42 to 53	5.10%		
54 to 59	4.50%		
Prevalence of GAM by **Household Hunger Scale**			
No Hunger	6.90%	1.02	0.965
Moderate Hunger	10.90%		
Severe Hunger	10.50%		
Prevalence of GAM by **Wealth Quintiles**			
Highest	5.20%	**0.68**	**0.013**
Fourth	5.10%		
Middle	10.80%		
Second	8.90%		
Lowest	10.40%		
Prevalence of GAM by **Household size**			
1 to5	7.10%	0.45	0.152
6 to 10	8.60%		
more than 10	9.50%		

Table 4: Prevalence of Global Acute Malnutrition (GAM) by background variables

The Global Chronic Malnutrition (stunting) rate was 45.8% (95%CI 42.5 - 49.1) which compares to 55% at the national level. Prevalence was higher among boys 48.4% (95% CI

43.7 - 53.1) than girls 43.3% (95% CI 38.8 - 47.9). Non-receipt of Vitamin A six month before the survey was significantly associated with increased risk of childhood stunting (OR 1.76 95%CI 1.07 – 2.90). Households that cultivated less diversified crops were associated were 1.26 times more likely to be stunted than those with more diversified crops (Table 5).

Variable Disaggregation	N (%)	Odds Ratio (OR)	Sig. Level (P-value)
GCM by **Treatment Versus Control Zones**			
Treatment	138 (47.8%)	1.26	0.237
Control	121 (42.0%)		
GCM by **Nutritional Status of caregiver**			
Normal Nutritional	221 (44.9%)	1.18	0.554
Malnourished	35 (46.7%)		
GCM by **Household Hunger Scale**			
No hunger	163 (40.9%)	1.37	0.122
Moderate Hunger	90 (53.9%)		
Severe Hunger	6 (54.5%)		
GCM by **Wealth Quintiles**			
Richest	39 (33.9%)	0.92	0.222
Fourth	46 (40.0%)		
Middle	62 (51.7%)		
Second	47 (42.0%)		
Poorest	65 (56.5%)		
GCM rate by **Crop Harvest Diversity Index**			
Highest Crop Diversity Index	67 (41.1%)	1.26	0.213
Middle Crop Diversity Index	102 (45.7%)		
Lowest Crop Diversity Index	89 (47.3%)		
GCM rate by **Vitamin A supplementation for children U5**			
Yes Supplementation	195 (42.8%)	**1.76**	**0.027**
No Supplementation	53 (57.0%)		

Table 5: Prevalence of Global Chronic Malnutrition (GCM) by background variables

Childhood Mortality

In total, 5986 birth histories were collected in the treatment (2675) and control (3311) zones respectively from which childhood mortalities were computed. Neonatal mortality rate was 18.4 per 1000 live births compared to 9.4 in controlled communities and this compares to 23 deaths per 1000 live births at the national level.

Post Neonatal Mortality Rate (PNNR) was 7.4 and 11.1 respectively in the treatment and control. The national figure is 24 deaths per 1000 which is 123.3% more than the treatment figure. Infant mortality rate was 23.9% higher in the treatment area than the control. Also child mortality was lower in the catchment area and is in fact 127.5% lower than the national figure. Under-five mortality was slightly higher in the treatment area than control (0.6% percentage difference). Although statistically insignificant, there are differences in the rates of across the spectrum of childhood mortalities. For example, Neonatal mortality in the treatment is 64.7% higher than that of the control and is the highest contributor (53.7%) of all mortalities in the treatment (Figure 2).

In assessing the risk of childhood mortality, the risk of mortality is higher among children in control (HR 2.58 95%CI 1.28 – 5.21 *p=0.008*) than treatment. Also, the risk of a child to die within the first 28 days of life is significantly higher (HR 20.72 95% 8.64 – 49.65 *p=0.001*). On location, children in low land areas are 1.25 times (95%CI 0.68 – 2.29 *p=0.469*) more likely to die than those at the mountainous areas. Girls are at higher risk of childhood mortality than boys (HR 1.31 95%CI 0.76 – 2.29 *p=0.325*).

Discussion

Context matters in the delivery of child interventions as it is complex and therefore warrants a targeted an integrated response at least. This fundamental philosophy informed our program logic to implement an integrated intervention which its priorities will be further determined by areas which showed stronger associations or increased risks with the outcomes of measure. For example, the risk of death in the first 28 days is 20.7 times more than afterwards. This particular finding has been reinforced by several studies and global reports. The World Health Organisation estimates that 2.5 million die in the first month of life, amounting to 47% of all under-five deaths [28]. Lawn et al. [29] further highlight that of these numbers, 73% die within the first seven days and 36% on the first day of birth. Given that half of all these deaths occur within the first 48 hours [29], strengthening the health system to provide lifesaving integrated maternal and neonatal intrapartum care is critical. Our integrative intervention to be implemented takes account the incidence of low birth (who are at an increased risk of neonatal death) and will pay special focus to malnourished pregnant women who are even at increased risk. Additionally, inclusive in this integrated intervention is a USD 20 million capital investment made by VHW for a women pavilion hospital to provide compassionate and quality care for women and children. This ultramodern facility is expected to complement teaching and research capacity to improve clinical practice across the entire Burundi [30]. To improve access to this facility, a nexus of existing emergency referral systems will be strengthened along with an effective community health workers program.

Malnutrition emerged as one of the challenges to child health in the area and for acute malnutrition, the risk of acute malnutrition was significantly higher among children aged 6 to 17 months. Earlier studies have confirmed this finding [31, 32] and Gezahegn et al. [32] further suggests that children in this age group are 10 times more likely to be acutely malnourished than cohorts in other ages. From field observations during the study, we found that especially for young and first time mothers, there was an apparent difficulty in adhering to exclusive breastfeeding and appropriately introducing complementary foods after the initially six-month window. Both non-adherence to exclusive breastfeeding and inappropriate introduction of complementary foods have been directly linked to increased risk of acute malnutrition and mortality [33, 34]. Among the several community initiatives implemented to reduce incidence of acute malnutrition, our integrative model has a component of working with young and first time mothers via the ‘parenting journey’ program. This program will pair up first time mothers with selected experienced and older women who will provide mentorship and support under the supervision of VHW. Also, evidence points to increased risk of postpartum maternal depression among first time mothers [35], therefore, we hypothesize that this program will have improvements of maternal mental health as well.

Compared to an average of 33% in sub-Sahara Africa [36], chronic malnutrition manifested as stunted growth was high in our program area (47.8%) and was associated with low food diversity and food access. The mean food consumed out of eight food groups assessed was 2.5 with cassava being the most consumed food (87.0%). In most instances, cassava was consumed along with beans as the single most important source of protein (76.6%). This pattern puts children at risk of inadequate nutrient intake [37] which also is also associated with increased risk of stunted growth. From informal discussions with community members, the preference of cassava emanated from a myriad of problems: lack of farmable land viz a viz increased household size, its resistance to diseases, inadequate knowledge on diversified food cultivation and preparation. This complex situation will be tackled via creation of food security cooperatives and they will receive agricultural inputs and technical support for a year after which, they will transition into an independent group. We hypothesize that the formation of cooperatives will mitigate the problem with land access for vulnerable households who are often times at risk of chronic malnutrition.

Study Limitations

Three limitations of the study which should be noted. First, although some variables were statistically significant with the outcomes under study, we are in no way claiming causality at this baseline stage. Also, the assignment of intervention was not random as the original catchment area had been predetermined. To mitigate these challenges, data will be collected every two years in the treatment (catchment area) and control from which incremental impact will be calculated using appropriate difference-in-difference regression analysis. In the process of these analysis, possible cofounders will be controlled and a net effect of the integrated intervention can be estimated. Another limitation is that apart from malnutrition that children were assessed, results from all other indicators were acquired via verbal recall of caregivers. This could have resulted recall bias and either underestimated or overestimated findings, however, earlier studies have established the validity and reliability of this methodology [38, 39]. Moreover, we initially piloted and contextualised the survey instrument for relevance to the study setting.

Conclusion

Interventions to improve neonatal, infant and child health are complex and as such, its success will be dependent on the extent to which it is integrated to address underlying the cause of 'causes'. Lessons from VHW's initial phase of program implementation highlights the importance of active community engagement in building trust and solidarity to promote allopathic-based care offered by community health workers and the health facilities. This implies that community members and actors should play key role in every stage of health service planning, program implementation and evaluation.

Equally important in improving under-five health is health systems strengthening to provide quality and compassionate care for all. Especially in fragile settings, creating an optimal model of healthcare delivery and building sustainable systems to train the next generation of health workforce is a giant step. This process requires wide stakeholder engagement with government at the centre with a deep focus on sustainability post-intervention.

Abbreviations

Acronym	Meaning
CMR	Child mortality rate
DHS	Demographic Health Survey
DiD	Difference-in-Difference
ENA	Emergency Nutrition Assessment
HR	Hazard Ratio
IMR	Infant mortality rate
LBW	Low Birth Weight
MUAC	Mid-Upper Arm Circumference
NNMR	Neonatal mortality rate
OR	Odds Ratio
PNMR	Post-neonatal mortality rate
PPS	Probability Proportional to Size
SMART	Standardized Monitoring and Assessment of Relief and Transitions
SPSS	Statistical Package for the Social Sciences
U5MR	Under-5 mortality rate
UNICEF	United Nations Children’s Fund
VHW	Village Health Works
WHO	World Health Organisation

Declarations

Ethics approval and consent to participate

The study was approved by the Rumonge and Bururi local ethics under the National Burundian Ethics Committee which is under the Ministry of Health. The study was also internally commissioned and approved by senior management of VHW after review of the study protocol and questionnaires. Study participants signed a consent form ahead of interview. Parents signed the consent form on behalf of the children who underwent anthropometric assessment for malnutrition screening.

Consent for publication

Not Applicable

Availability of data and materials

The data used for analysis in this manuscript are available from the Research, Monitoring and Evaluation Department of VHW. Data is restricted but available from the authors upon reasonable request.

Competing interests

The authors declare no competing interests

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Authors' contributions

ENO, SH, GG, JBM, GI, HM, HM and ME conceptualised the study, ME conceptualised the mortality component and advised on the sampling strategy. ENO, SH, GG, JBM, GI, HM and HM supervised the data collection, cleaned, processed and created indices such as Wealth Distribution using principal component analysis, household hunger scale among others. . ENO, SH, GG, JBM, GI, HM, HM and ME analysed the data. Specifically, ENO, SH, JBM, GI, HM analysed data on low birth weight and fever, GG analysed data on acute and chronic malnutrition and ME used the R package to calculate the mortality rates. ENO created the logistic and cox regression model to assess risks. ENO wrote the first draft of the manuscript with inputs and reviews from ME, SH, GI, HM. All authors read and approved the final manuscript.

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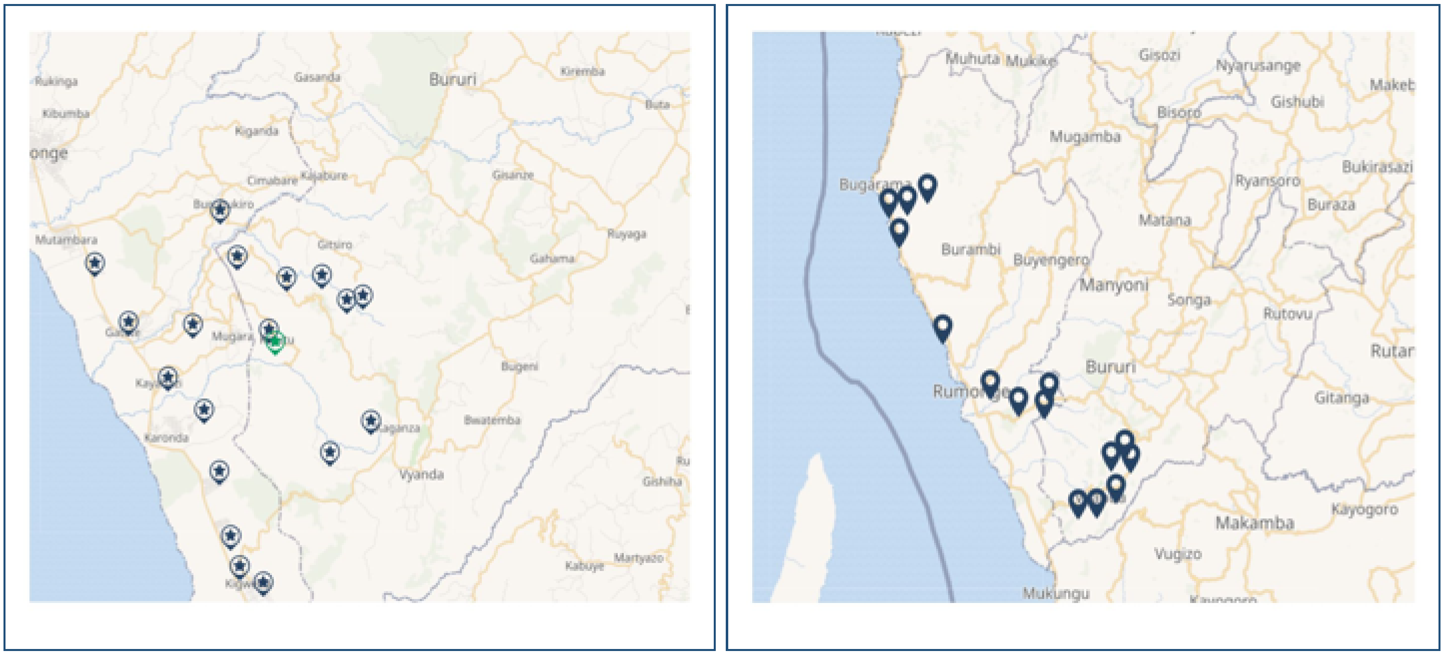
Figures



Map showing Treatment Areas

Map showing Control Areas

Figure 1

Map of Study Treatment and Control Areas

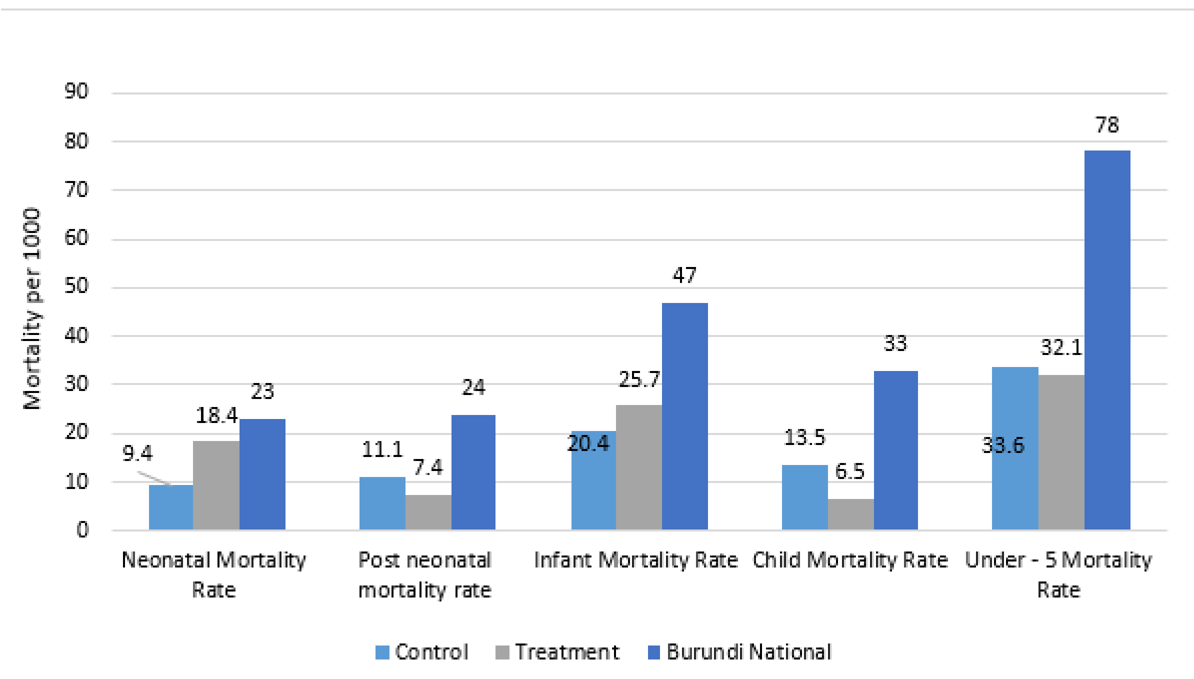


Figure 2

Comparative childhood mortality – Treatment, Control and National