Community-Based Impact-Oriented Child Survival
in Huehuetenango, Guatemala

USAID Child Survival and Health Grants Program
October 1, 2011 – September 30, 2015
Cooperative Agreement No: AID-OAA-A-11-00041

Analysis of Project Vital Events

Ira Stollak MA MPH, Lic. Juan Antonio Diaz, Mario Valdez MD MPH, and Henry Perry MD MPH PhD

November 2015

Curamericas Global, Inc.
318 West Millbrook Road, Suite 105, Raleigh, NC 27609
Tel: 919-510-8787; Fax: 919-510-8611

The Community-Based Impact-Oriented Child Survival in Huehuetenango, Guatemala Project in Huehuetenango, Guatemala is supported by the American people through the United States Agency for International Development (USAID) through its Child Survival and Health Grants Program. The Project is managed by Curamericas Global, Inc. under Cooperative Agreement No. AID-OAA-A-11-00041. The views expressed in this material do not necessarily reflect the views of USAID or the United States Government. For more information about *The Community-Based Impact-Oriented Child Survival in Huehuetenango, Guatemala Project*, visit: http://www.curamericas.org/

TABLE OF CONTENTS

GLOSSARY

AMTSL- Active Management of the Third Stage of Labor

ARI- Acute respiratory infection

Care Group - Group of mother peer educators (Care Group Volunteers)

Casa Materna – Community-owned and –operated maternal birthing center

CBIO – Community-Based Impact-Oriented Methodology (project service platform)

CBIO+CG – Combined methodologies of CBIO and Care Groups

CCM – Community Case Management

CF- Community Facilitator

CGV - *Care* Group Volunteer

Comunicadora - Care Group Volunteer

Community Facilitator- Volunteer community health worker who trains *Comunicadoras*

Curandero – Traditional healer

Educadora –Curamericas Guatemala staff Health Educator

IF- Institutional facilitator (RN who maintains vital events registers and performs verbal autopsies)

IM- Infant mortality (deaths in children under 1 year of age)

IMR- Infant Mortality Rate (deaths in under-1 children per 1,000 live births)

IRDS – Infant respiratory distress syndrome

Micro-region – Catchment of the partner communities that construct and operate their Casa Materna

MMR- Maternal Mortality Ratio (maternal deaths per every 100,000 live births)

MSPAS – Guatemalan Ministry of Health and Social Assistance

NNM- Neonatal Mortality (deaths in children 1-28 days of age)

NNMR – Neonatal Mortality Rate (neonatal deaths per every 1,000 live births)

Partner Community – A community in a micro-region that builds and operates its Casa Materna

PEC- Extension of Coverage Program

PNNM- Post-neonatal Mortality (deaths in children 29 days to <1 year of age)

PNNMR – Post-neonatal Mortality Rate (post-neonatal deaths per every 1,000 live births)

PY – Project year (October 1 through September 30)

OR- Operational Research

SIDS – Sudden infant death syndrome

SIGSA – Guatemalan national health management information system (Sistema de información gerencial de salud)

U-5M – Under-five Mortality

U-5 MR- Under-five Mortality Rate (deaths in under-five children per 1,000 live births)

Analysis of Project Vital Events

Executive Summary

Background and rationale: A hallmark of the Community-based, Impact- Oriented (CBIO) methodology is its use of community surveillance of vital events to 1) determine the actual epidemiological priorities of the communities it is serving, 2) engage the community by having them participate in this activity and sharing the findings with them, and 3) track the impact of the project's interventions on the health status of the population (and in our case, on maternal and child mortality specifically). This allows 1) precision and efficiency in the targeting of interventions to exactly match local epidemiological needs and 2) the rare ability to demonstrate actual reductions in mortality, rather than depend on less precise or indirect estimates from instruments such as the Lives Saved Tool (LiST) or external national mortality studies. By wedding Care Groups to CBIO and using the Care Group Volunteers as the project's "eyes and ears" to detect and report vital events, this community-based surveillance of births and deaths is further strengthened. As with all CBIO+CG projects, this Child Survival project created and maintained Vital Events Registers that record every live birth and maternal and child death in the communities served by the project. All deaths were followed up by a verbal autopsy with the family of the deceased woman or child. These were conducted by a qualified project staff member to determine the cause of death and contributing factors.

Our Operational Research to demonstrate the effectiveness of the combined CBIO+Care Group methodology included the following research questions:

- *What are the community health priorities and the epidemiological priorities in the project area?*
- *Does the CBIO+Care Group methodology produce significant improvements in maternal and under-five mortality compared to a control/comparison area (project Phase 2 communities) and compared to selected municipalities of Huehuetenango department and/or the rural population of Huehuetenango department (after four years of project implementation)?*

We capitalized on the need to implement the project in two phases to create the OR design, to see if there was a dose-response effect that produced superior results in intervention coverage and mortality in the 91 Phase 1 communities (where project implementation began in Year 1) by end of project compared to the coverage and mortality reductions (if any) achieved during the much briefer intervention period in the 89 Phase 2 communities (where project implementation began in Year 3). We also compared our results with the Ministry of Health and Social Assistance (MSPAS) mortality data for three comparable municipalities outside the project area to see if CBIO+Care Groups yielded mortality reductions superior to the standard MSPAS interventions in those comparison municipalities.

Methodology: The source of the data analyzed was the project's Vital Events Registers. These are Excel files maintained by project staff known as Institutional Facilitators (IFs), who are all RNs intensively trained in the CBIO+CG methodology, in the registration of vital events and in the execution of verbal autopsies. There are two Vital Events Registers for each of the three municipalities, one Register for the Phase 1 communities and one for the Phase 2 communities. There are spreadsheets in each Register containing for each event: 1) all pregnancies and pregnancy outcome (whether the pregnancy resulted in a live births or a stillbirth); 2) under-5 deaths (including data from the verbal autopsy); and 3) deaths in reproductive age women, including data from the verbal autopsy.

The vital events data is collected monthly utilizing the Care Group infrastructure. Care Group Volunteers (CGVS) are each assigned 8-12 households with reproductive age women and collectively they cover every such household in their community, allowing comprehensive vital events surveillance of every household served by the project. New pregnancies, deliveries, and maternal/under-5 child deaths are detected and reported by the CGVs, with this data flowing upwards through the Care Group supervisory infrastructure to the project monitoring and evaluation (M & E) staff. The IF follows up within two weeks with a verbal autopsy with the family of every reported deceased woman or child. The most salient information from the verbal

autopsy is added to the maternal and under-5 death register of the Vital Events Register, including cause of death.

Prior to data analysis the Registers underwent extensive data cleaning. Every entry of each Register was reviewed for completion, internal consistency, and accuracy. Corrections were made as needed. A list was generated of under-5 and maternal deaths needing further verification, and the primary Focused Strategic Assessment author, Dr. Ramiro Llanque, reviewed all the original verbal autopsies of these deaths at the project site and based on this review made the necessary corrections in the death registers.

Two separate Excel data sets, one for each Phase, were created from the cleaned Vital Events Registries and analyzed. Data were organized by project year (PY), which runs from October 1 through September 30, rather than calendar year.

In addition, to understand the effect of the Casa Maternas on maternal and neonatal mortality, data sets were created for the 26 partner communities of the three Casa Materna micro-regions. These data for these communities were compared to the data for the remaining 154 communities served by the project.

The operational research also called for comparison of end-of-project mortality with MSPAS mortality data for three comparable municipalities in Huehuetenango Department. The three comparison municipalities chosen were: San Mateo, San Rafael de Independencia, and Barillas, each comparable to one of the three municipalities in our own project area (see below). We obtained from the MSPAS office in the city of Huehuetenango Excel data sets for the morbidity and mortality for each Department municipality for each calendar year 2011 through 2014, including the above three municipalities and the three municipalities in our own project area. We re-calculated our mortality data for the calendar year 2014 for the three project municipalities using combined Phase 1 and Phase 2 data. Before comparing this data to the three comparison municipalities, we compared our 2014 data with the MSPAS 2014 data for the project's three municipalities in order to quantify the difference in capture of vital events to factor into the comparison. We then compared our 2014 calendar year mortality data for San Sebastián Coatán with the MSPAS 2014 data for San Mateo; our mortality 2014 data for San Miguel Acatán with the 2014 MSPAS data for San Rafael de Independencia; and our 2014 data for Santa Eulalia with the 2014 MSPAS data for Barillas.

Findings: Comparing end-of-project mortality for Year 4 of the project (October 2014-September 2015) in Phase 1 communities with that in Phase 2 communities, we see lower maternal and 12-59 month mortality in Phase 1, and lower neonatal, post-neonatal, infant, and U5 mortality in Phase 2:

Table 1. Mortality Rates during the final year of project operations
(October 2014-September 2015) in Phase 1 and Phase 2 communities

Mortality Indicator	**Phase 1 communities**	**Phase 2 communities**
Maternal mortality ratio	221	624
Neonatal mortality rate	*38*	*21*
Post-neonatal mortality rate	*23*	*15*
Infant mortality rate	*61*	*35*
12-59-month mortality rate	2	6
Under-5 mortality rate	*63*	*42*

Our hypothesis that we would see lower mortality across the board in the Phase 1 communities, due to the longer exposure to the project and its interventions, was not borne out. This is primarily due to a spike observed in neonatal mortality – and to a lesser degree, in post-neonatal mortality- in PY4 in the Phase 1 communities.

Table 2. Annual mortality ratios/rates in Phase 1 and Phase 2 communities and in all communities by project year

Mortality Indicator	Phase 1 communities				Phase 2 communities		Phase 1 and Phase 2 communities combined	
	PY1	PY2	PY3	PY4	PY3	PY4	PY3	PY4
Maternal mortality ratio	524	740	281	221	435	624	350	428
Neonatal mortality rate	16	20	12	38	16	21	14	29
Post-neonatal mortality rate	12	24	12	23	19	15	16	19
Infant mortality rate	28	44	25	61	35	35	30	48
12-59-month mortality rate	8	10	9	2	6	6	8	4
Under-5 mortality rate	37	53	34	63	41	42	37	52

PY= Project year

Maternal Mortality: In the Phase 1 communities, there was a large decrease in the maternal mortality ratio (MMR), from 524 in PY1 and 740 in PY2 to 281 in PY3 and a further decline to 221 in PY4, a 70% decline from PY2 (Table 2). In the Phase 2 communities, the MMR increased 43% from 435 in PY3 to 624 in PY4. All but two of the 34 maternal deaths for the combined set of communities in Phases 1 and 2 (n=32, 94%) were home deliveries. A very high percentage of maternal deaths occurred en route to a health facility: 26% (n=9). The large majority (62%, n=21) died at home, where there was no time for transport or the family was unable/ unwilling to transport the woman to a health facility. Post-partum hemorrhage accounted for 82% (n=28) of maternal deaths, followed by pre-eclampsia/eclampsia (9%, n=3), sepsis (6%, n=2) and complications of cesarean section (3%, n=1). Retained placenta was the most common underlying cause of death from hemorrhage (75%, n=21), followed by uterine atony (18%, n=5) and uterine rupture (7%, n=2). The second delay (recognizing danger but not responding or responding too late)accounted for 29% (n=10) of maternal mortality; the most frequently reason cited was lack of money for transportation. An equally large percentage were third delays (delay in transportation), 29% (n=10), which correlates with the high percentage who died en route to a health facility.

The Casa Maternas contributed greatly to the reduction of maternal mortality in their micro-regions and in the lowering of maternal mortality in Phase 1. In the combined Calhuitz/Santo Domingo micro-regions, the MMR declined from 508 in PY1 to 0 in PY4, and for the Tuzlaj-Coya micro-region, from 1,124 in PY3 to 0 in PY4. For the three micro-regions combined, the MMR declined from 366 in PY3 to 0 in PY4. *There were no maternal deaths in the 26 partner communities of the three Casa Materna micro-regions in PY4.*

Neonatal mortality: In Phase 1, the neonatal mortality rate (NNMR), after declining 40% from 20 in PY2 to 12 in PY3, spiked sharply to 38 in PY4, an increase of 215% (Table 2). In Phase 2, the NNMR increased 33% from 16 in PY3 to 21 in PY4. End of project PY4 NNMR for both Phases combined was 29, rising sharply over 100% from only 14 in PY3. For the combined Phases, 95% (n=131) of neonatal deaths were home deliveries. Similarly, 88% (n=121) of neonatal deaths occurred in the home, mostly commonly on the day of delivery from birth asphyxia. Very few neonates in distress were taken to a health facility, or they died quickly before the family could respond. Birth asphyxia was the largest cause of neonatal mortality (52%, n=72), followed by complications of prematurity (18%, n=25), pneumonia/ARI (17%, n=24), and sepsis 6% (n=9). These four causes accounted for 94% (n=130) of neonatal mortality for both Phases combined. With birth asphyxia as the leading cause, we see 61% (n=84) of neonatal deaths occurring on the first day of life. A full 81% (n=112) of neonatal deaths occurred during the first week of life, accounting for 36% of all under-5 deaths. After the first week, deaths were fairly evenly distributed over the remaining 21 days of the neonatal period.

Post-neonatal mortality: In the Phase 1 communities, the post-neonatal mortality rate (PNNMR) decreased dramatically from PY2 to PY3 from 24 to 13, and then spiked by 74% to 23 in PY4 (Table 2). In contrast, in the Phase 2 communities, the PNNMR dropped 21% from 19 in PY3 to 15 in PY4. Due to the spike in PNNMR in the Phase 1 communities, the combined project PNNMR (for Phase 1 and Phase 2 communities combined) increased from 16 in PY3 to 19 in PY4. The main cause, by far, of post-neonatal death in the Phase

1 and Phase 2 communities and in the combined set of communities was pneumonia/ARI. For the combined set of communities, it was the cause of 63% (n=78) of the 124 deaths among this age group. Next was diarrheal disease (18% of the deaths in this age group in the combined set of communities, n=23). Pneumonia/ARI and diarrhea combined accounted for 81% of the PNN deaths for the combined set of communities. Sepsis/infection accounted for 3% (n=4), and complications of prematurity another 2% (n=3). Other miscellaneous causes accounted for 14% of PNN deaths; the causes in this group included hepatitis and other causes of liver failure; sudden infant death syndrome (SIDS); aspiration of regurgitation; food poisoning; organ deformities; spina bifida; and accidents.

12-59-month mortality: Unlike neonatal and post-neonatal mortality, 12-59-month mortality in Phase 1 communities declined from 10 in PY2 and 9 in PY3 to 2 in PY4, a decline of 77%, with only 2 deaths in this age group in PY4: *in PY4, 12-59 month deaths were almost eliminated in the Phase 1* communities (Table 2). In the Phase 2 communities, the 12-59 month mortality rate was unchanged from PY3 to PY4 at 6. For the combined set of Phase 1 and Phase 2 communities, the 12-59-month mortality rate declined 50%, from 8 in PY3 to 4 in PY4. The two main causes of 12-59-month mortality for the combined set of communities were pneumonia/ARI (52%, n=27) and diarrhea (31%, n=16). These two causes together accounted for 83% of the deaths among 12-59-month olds. Miscellaneous causes accounted for 17% of mortality. Among these causes were accidents, epilepsy/convulsions, acute malnutrition/wasting, meningitis, aspiration, and intravascular coagulation.

Under-5 mortality: In the Phase 1 communities we see a marked decline in the under-5 mortality rate (U5MR) from PY2 to PY3, from 53 to 34, and then a spike in PY4 to 63 (Table 2). In the Phase 2 communities, the U5MR remained virtually unchanged, from 41 in PY3 to 42 in PY4. For the combined set of communities, the U5MR increased sharply from 37 in PY3 to 52 in PY4, due to the marked increase in neonatal and post-neonatal mortality in PY4 in the Phase 1 communities, as noted above. Pneumonia/ARI was the leading cause, with 41% (n=129) of all under-5 deaths for the combined set of communities, followed by birth asphyxia (23%, n=72), diarrhea (13%, n=40), complications of prematurity (10%, n=31), and sepsis (3%, n=10). These five causes accounted for 90% of all under-5 mortality. The vast majority of under-5 deaths occurred at home (85%, n=268); 6% (n=18) occurred en route to a health facility; and only 9% (n=28) occurred at a health facility. For all deaths among children younger than 5 years of age, the Institutional Facilitators assigned one of "four delays" that made the greatest contribution to the child's death. The second delay – recognizing but not responding to the danger signs, or responding too late – was the most common, accounting for 43% of U5 deaths. Reasons cited by families include: 1) using a traditional healer (*curandero)* or home herbal remedies; 2) not taking the child to a health facility because of the poor/rude treatment anticipated; 3) lack of money to pay for transportation to a clinic or to a hospital referral; and 4) fatalistic attitudes towards child death, such as "God's will," or that the child's *nahual* [spirit] dictates the death. Also, despite the educational efforts of the Care Groups, the percentage of families still not recognizing and responding to danger signs (first delay), especially of pneumonia/ARI, declined only slightly from 35% in PY1 in Phase 1 communities to 29% in PY4 for the combined set of communities.

Comparison with MSPAS data: We compared our mortality data for the calendar year 2014 for the project's three municipalities (containing the combined set of communities) with the 2014 MSPAS mortality data for those same municipalities and saw moderate differences in the number of live births registered but very large differences in the number of child deaths registered, with the project capturing 115 child deaths in the three municipalities vs. only 69 captured by MSPAS. The MSPAS vital events registration system did capture 5 maternal deaths in 2014 that the project did not capture. Comparing our project data for each of the three municipalities in our project area with the vital events data collected by the MSPAS in the three municipalities outside the project area that had been paired with our project municipalities, we observe higher 2014 child mortality rates in the project municipalities for nearly all age groups due to superior capture of child deaths; and comparable levels of maternal mortality.

Discussion: The project's achievements included 1) a marked reduction in maternal mortality in the Phase 1 communities, from 740 to 221, with the Casa Maternas appearing to contribute significantly to this decline; and 2) near elimination of 12-59 mortality in the Phase 1 communities, with only 2 deaths in the 12-59 month age group reported there in PY4. Unfortunately, neonatal and post-neonatal mortality appears to have increased from PY3 to PY4 in the Phase 1 communities and, as a result, the end-of-project neonatal, post-neonatal, and U5 mortality were all higher in the Phase 1 communities than in the Phase 2 communities during PY4. The reasons for this increase cannot be definitively determined from our available data. Possible reasons include: 1) better differentiation of stillbirths from neonatal deaths in PY4, with a higher proportion of perinatal deaths being classified as neonatal deaths whereas previously similar deaths were registered as stillbirth; 2) improved capture of neonatal deaths; 3) loss of the curative and preventive services of the MSPAS Extension of Coverage Program, which MSPAS closed at the beginning of PY4; 4) increase in the local cost of transportation combined with increased poverty due to loss of remittances from men working in the US; and 5) the local effects of the current Guatemalan socio-political crisis, which has caused local health services to deteriorate.

Pneumonia/ARI remains the main killer of children younger than 5 year of age, and the persistent reluctance of families to bring children to health facilities for treatment due to distance, cost and/or fear of disrespectful or poor technical quality of treatment further strengthens the need for the introduction of Community Case Management of pneumonia/ARI by appropriately trained community health workers. With respect to maternal mortality, the high percentage of maternal deaths that occurred at home at the time of a home delivery, the high number of women dying in transit, and the elimination of maternal mortality in the Casa Materna micro-regions in PY4 all strengthen the case for health facility deliveries and for the Casas Maternas in particular. The barriers to transporting puerperal women and sick children to health facilities, including the economic barriers, also must be addressed. Successful local emergency transportation insurance schemes, such as those currently utilized by the Casas Maternas and the project community of Chenen can provide models on which to build.

Limitations: There may have been inconsistencies in classifying of cause of death, the assigning the correct delay, and in differentiating stillbirths from neonatal deaths. Verbal autopsies are inherently limited tools since families are often unreliable witnesses during verbal autopsies, affected by guilt, shame, and recall error, thus impeding the ability to accurately determine cause of death and contributing factors.

Recommendations: 1) Develop written algorithms for attributing the correct "delay" and for distinguishing stillbirths from neonatal deaths to achieve year-to-year consistency of data; 2) further improve the classification system for causes of death utilizing the recently published WHO guidelines for classification of maternal deaths; 3) petition the new administration of MSPAS to permit Curamericas/Guatemala to pilot CCM of pneumonia/ARI in the micro-regions of the operating Casa Maternas; 4) extend and adapt the Casa Materna emergency transport scheme to all communities to cover transportation of sick children (as well as mothers with obstetric complications) to a referral health facility; and 5) procure MSPAS financial and logistical support to maintain and improve the project's vital events surveillance system so that it may serve as a national sentinel site. This can involve incorporating data management software, m-Health cloud-based data transmission and storage, and integration of the project vital events HIS into the national HMIS system (SIGSA).

1. Background

A hallmark of the Community-based, Impact- Oriented (CBIO) methodology is its utilization of community surveillance of vital events to 1) determine the actual epidemiological priorities of the communities it is serving ; 2) engage the community by having them participate in this activity and sharing the findings with them, and 3) track the impact of the project's interventions on the health status of the population (and in our case, on maternal and child mortality specifically). CBIO projects are therefore not dependent on data or estimates from external sources, such as DHS surveys and national maternal mortality surveys. This allows 1) precision and efficiency in the targeting of interventions to exactly match local epidemiological needs and 2) the rare ability to assess whether or not declines in mortality are occurring, rather than depend on indirect estimates such as the Lives Saved Tool (LiST). By wedding Care Groups to CBIO and using the Care Group Volunteers (CGVs) as the project's "eyes and ears" to detect and report vital events as well as to provide health education and build trust with the community, this community-based surveillance of births and deaths is further strengthened.

As with all CBIO+CG projects, this Child Survival Project created and maintained Vital Events Registers that attempt to record every pregnancy, stillbirth, live birth, maternal death, and child death in the communities served by the project. All deaths were followed up by a verbal autopsy with the family of the deceased woman or child conducted by a qualified project staff member to determine the cause of death and contributing factors, such as which of the "four delays" contributed to the mortality. These Registers provide data that is analyzed on an ongoing basis to determine (1) what are the current causes of maternal and child mortality and, therefore, the local epidemiological priorities to be addressed with appropriate interventions and 2) if a CBIO+CG project is having an impact on maternal and child mortality with these interventions. Consequently, our Operational Research to demonstrate the effectiveness of the CBIO+CG methodology included the following questions:

- *What are the community health priorities and the epidemiological priorities in the project area?*
- *Does the CBIO+CG methodology produce significant improvements in maternal and under-5 mortality compared to a control/comparison area (Phase 2 communities) and compared to selected municipalities of Huehuetenango department and/or the rural population of Huehuetenango Department (after four years of project implementation)?*

The 91 Phase 1 communities (population 42,755) received the project interventions all four years of the project lifetime, from October 2011 through the project's effective end May, 2015. The 89 Phase 2 communities (population 54,867) received project interventions only during the last 20 months of the project years, from October 2013 through May 2015. The need to implement the project in phases made it possible to create a quasi-comparison area to assess for a dose-response effect that produced superior results in the Phase 1 communities in terms of population coverage and mortality impact compared to the coverage and mortality reductions (if any) achieved during the much briefer intervention period in the Phase 2 communities. We also compared our results with MSPAS mortality data for three comparable municipalities outside the project area to see if CBIO+CG yielded superior mortality reduction to the standard MSPAS interventions in those comparison municipalities

2. Methodology

The source of the data analyzed was the project's Vital Events Registers. These are Excel files maintained by the project's Institutional Facilitators (IFs), all of whom are RNs intensively trained in the CBIO+CG methodology and in the conduct of verbal autopsies. There are two Vital Events Registers for each of the three municipalities, one with the vital events data from the municipalities' Phase 1 communities and

another with the data from its Phase 2 communities. Thus, there are six Registers in all, each in its own Excel file. There are four spreadsheets in each Register, each containing a specific data set: 1) pregnancies and pregnancy outcomes (stillbirths and live births); 2) under-5 deaths (including data from the verbal autopsy); 3) deaths among reproductive age women, indicating if it was a maternal death (related to pregnancy, delivery, or post-partum) and also including data from the verbal autopsy; and 4) a general mortality registry including data for deaths of older children who died, men, and non-reproductive age women. Every pregnancy/live birth/stillbirth and maternal and child death has a unique 12-digit identifying number that prevents duplication of data and enables location of specific vital events in the Register utilizing the data sorting/filtering capacity of Excel. The ID number is constructed using a standardized method that utilizes code numbers that capture which Phase the community is in, as well as the municipality, community, name of Supervisor, name of *Educadora,* and ID number of the pregnancy (later assigned to the live delivery or stillbirth as well as the ID number for a death).

The vital events data are collected by a Community Facilitator (CF) in each community every two weeks at a meeting with the Care Group Volunteers (CGVs) she trains and supervises. These volunteers keep track of 8 to 15 of their reproductive age women neighbors, with whom they meet every two weeks to teach lessons on proper health behaviors and to collect vital events. Collectively, the CGVs keep track of the vital events of every family in which there is a woman of reproductive age (defined as 15 to 49 years of age) in every project village (or urban/peri-urban neighborhood). The Community Facilitator in turn reports this information to the staff *Educadora* who meets with the CF twice a month for training on how to teach the CGVs how to teach their lessons and to collect the vital events data the CF have gathered from the CGVs. The *Educadora* collects these data from the 5 to 8 FCs she supports in her assigned communities, and in turn passes the collated data to her municipal Supervisor (*Supervisora Educadora)* who collates the municipality's vital events data she receives from the 5 to 10 *Educadoras* she supervises. Once collated, the municipal data is passed on to the municipality's Institutional Facilitator (IF) who records the data in the Vital Events Register. If there is a maternal or child death reported, the IF follows up within two weeks by performing a verbal autopsy with the family of the deceased woman or child. The Register contains all the information he/she will need to locate the family with the aid of the FC (name of the deceased, date of death, name of community, and the names of the CGV, FC, *Educadora,* and Supervisor so the path of the data flow can be tracked to facilitate contact tracing and data cleaning).

Verbal autopsy data forms are completed by hand by the IF using the notes taken in the field at the interview using the MSPAS standard verbal autopsy form (to align the project data with the Ministry's) and the most salient information from the verbal autopsy is added to the maternal and under-5 death registers of the Vital Events Register: date of death, birth date of child (for under-5 deaths); age group for under-5 deaths – neonatal, post-neonatal, or 11-59 months; age at death (in days for neonates, in months for post-neonates); classification of the cause of death (see next paragraph); location of death; location of delivery (for maternal and neonatal deaths); which of the "four delays" contributed to the death (see below); and notes that include a brief narrative of the circumstances of the death, including whether treatment was sought, and if treatment was obtained, with whom, when, and how the treatment was obtained; and if no treatment was sought or if there was a delay in seeking treatment, the family's stated reason for this. The information obtained in the verbal autopsy also enables the IF to distinguish still births from neonatal deaths, and maternal deaths from non-maternal deaths among reproductive age women.

The project utilized a system of "primary" and "secondary" classifications of cause of death. Primary classifications of the cause of maternal deaths were hemorrhage, pre-eclampsia/eclampsia, sepsis, other direct causes, and indirect causes. Primary classifications for child deaths included birth asphyxia, complications of prematurity, pneumonia/ARI, diarrhea, sepsis/other infections, and other/miscellaneous causes. A "secondary" classification elucidated the primary attributable cause, such as retained placenta,

uterine rupture, or uterine atony for hemorrhage; or aspiration of meconium for birth asphyxia or infant respiratory distress syndrome for complications of prematurity.

"Delays" refers to critical junctures which can delay the receipt of appropriate treatment at a health facility, and is generally applicable to maternal deaths. The usual analysis is based on the "three delays" mode of Maine which involves (1) delay in recognition, (2) delay in transport to a referral facility, and (3) delay in receiving appropriate care once the patient arrives at the facility.[1] Rather than this system, the project elected to use a "four delay" mode. [2] The first delay involves the family not recognizing danger and therefore not responding by bringing the woman to a health facility or summoning help. The second delay involves recognition of the danger, but either choosing to not take the woman to a health facility, or hesitating too long to do so, until it is too late to prevent maternal or neonatal mortality. The third delay involves transportation – delay in procuring it, or the length of the journey, in our case, on unpaved treacherous mountain roads. The fourth delay involves delay in treatment once arrived at the facility and/or receiving inadequate treatment. [Note that in some maternal deaths that occurred in health facilities the delay involved is the second rather than the fourth– had the family acted in time the woman may have lived]. This "four-delay" classification was utilized because key project indicators included the family's ability to recognize and react to danger signs in pregnancy, delivery, and post-partum, as well as in children ill with pneumonia/ARI and diarrhea. Evaluating how many deaths are attributable to the first delay helps assess the penetration of the health education the project provided (mostly through the Care Groups). Also, being able to evaluate "second delays" helps understand the factors that impede proper care-seeking by the family despite their recognition of the danger. Attribution of the delay is done by the IF based on the information gathered during the verbal autopsy. If the family indicates that they recognized the danger but did not respond with prompt care-seeking at a health facility, the IF inquired why not and recorded the responses. Though the "delays" are generally applied to maternal deaths, the project elected to apply them to deaths in under-5 children as well to help understand the factors that contributed to these deaths.

Therefore, it should be noted that the verbal autopsies provide key qualitative data through the IF's analysis of the "story" of the death related by the family, which helps understand the various geographical, socio-economic, cultural, and gender-based factors that contribute to maternal and child mortality.

Prior to data analysis the Registries underwent data cleaning. These investigators and the project's M&E Technician reviewed every entry of every Register for completion, internal consistency, and accuracy. Missing data were collected (by returning back to the household if necessary) and corrections were made. In addition, the verbal autopsy notes in the Registers were all reviewed and compared to the stated primary and secondary classifications of death (as well as location of death and which of the "four delays" was present) and a list was generated of child and maternal deaths needing further verification. Dr. Ramiro Llanque, a physician who directed the project's final evaluation, reviewed all the original verbal autopsies for the deaths of these under-fives and mothers and made additional corrections in the Registers.

The Operations Research called for comparing the vital events data for the communities of Phase 1 vs. the data for those of Phase 2, and so two separate Excel data sets, one for each Phase, were created and analyzed from the cleaned Vital Events Registers of the two Phases. Data were analyzed by project years, which ran from October 1 through September 30, rather than calendar year. Phase 1 communities received project services for the full four years of the project; Phase 2 communities received project services only

[1] Thaddeus S[1], Maine D. Too far to walk: maternal mortality in context..Soc Sci Med. 1994 Apr;38(8):1091-110.

[2] M. Ghebrehiwet and RH Morrow. Delay in Seeking and Receiving Emergency Obstetric Care in Eritrea. Journal of Eritrean Medical Association. Vol. 2 No..1 (2007).

during the final 20 months of project functioning (October 2013-May 2015). Thus, the following sets of vital events data were compiled and analyzed:

For Phase 1 communities:

- PY1 (October 1, 2011 through September 30, 2012)
- PY2 (October 1, 2012 through September 30, 2013
- PY3 (October 1, 2013 through September 30, 2014)
- PY4 (October 1, 2014 through May 31, 2015)

For Phase 2 communities:

- PY3 (October 1, 2013 through September 30, 2014)
- PY4 (October 1, 2014 through May 31, 2015).

[Note: The IFs recorded all vital events that occurred only through May 31, 2015 because the project was winding down and there would not be sufficient staff to maintain the Registers for all 180 Phase 1 and 2 communities after that date. In June 2015, the project went into a transition phase with reduced staff and reduced project services- including the maintenance of vital events registration. In June 2015 the project reduced its activities to the 26 partner communities of the three operating Casas Maternas (community-built maternal birthing centers) and the 12 communities of a fourth Casa Materna soon to be operational. After June 1, the Registers included data only from these 38 Casa Materna partner communities. None of the vital events data recorded beginning on 1 June 2015 are included in this analysis.]

The analysis utilized the data sorting and filtering capacities of Excel to extract the following data by program year, by Phase, and by municipality (and also for the Casa Materna partner communities):

1) Number of live births
2) Number of stillbirths
3) Number of maternal deaths (defined as deaths directly related to pregnancy, delivery, or the post-partum period)
4) Number of neonatal deaths (defined as deaths occurring in a live birth within 28 days of delivery)
5) Number of post-neonatal deaths (defined as deaths in children aged 29 days (1 month) through 11 months of age (up to one year of age)
6) Number of infant deaths (combining neonatal and post-neonatal deaths)
7) Number of deaths in children 12-59 months of age (among children aged one year up to but not including 5 years of age)
8) Age (in days) of death of neonatal deaths
9) Location of death
10) Location of delivery (for maternal and neonatal deaths)
11) Primary classification of cause of death
12) Secondary classification of cause of death, If known (e.g., cause of post-partum hemorrhage; identification of the specific complication of prematurity; cause of birth asphyxia; etc.)
13) Which of the "four delays" most contributed to the mortality

Data sets for each municipality by type of Phase community and project year were created utilizing Excel spreadsheets. The municipal data were aggregated into data sets for each project year for each of the two sets of Phase communities. The analysis utilized these tables, as well as graphs created in Excel from the tables. In addition, we wanted to understand the effect of the Casas Maternas on maternal and neonatal mortality. Therefore, tables were constructed from the data sets for maternal and neonatal mortality for the partner communities of each of the three Casa Materna micro-regions, which are listed in Table 1.

Table 1. Casa Materna Partner Communities

Casa Materna Micro-region	Partner Communities	Population
For Casa Materna located in the town of Calhuitz (Phase 1 communities)	Calhuitz	990
	Loblatzan	385
	Jolombojop	185
	Ucachoj	206
	Timacap	117
	Jolomtenam I	228
	Jolomtenam II	194
	Biltaq	328
	Total Population	2,633
For Casa Materna located in the town of Santo Domingo (Phase 1 communities)	Jajhuitz	402
	Yalankululuz I	208
	Yotzcojoltaj	211
	Nuevo San Juan	326
	Ulna	427
	Santo Domingo	282
	Nuevo Progresso	195
	Cajbaquil	461
	Plan Quenchucul	217
	Sactenam	182
	Cojom	128
	Total Population	**5,672**
For Casa Materna located in the town of Tuzlaj Coya (Phase 2 communities)	Santa Cruz	200
	Akal Coya	194
	Tuzlaj Coya	503
	Taquina	396
	Coya	1,143
	Poza	351
	Loma Bonita	384
	Total Population	**3,171**

The data for these 26 partner communities were analyzed by project year and by Phase and compared to the corresponding data sets for the remaining 154 communities served by the project.

The Operations Research also called for comparison of end-of-project mortality with MSPAS mortality data for three comparable municipalities outside the project area in Huehuetenango Department. The three municipalities chosen were:

1) San Mateo (to compare with San Sebastián Coatán): They are both inhabited principally by people of the Chuj ethnic/linguistic group, they are contiguous, and they have a similar socio-economic and geographic profile.
2) San Rafael de Independencia (to compare with San Miguel Acatán): They are both inhabited principally by people of the Akateko ethnic/linguistic group, they are contiguous, and they have a similar socioeconomic and geographic profile.

3) Barillas (to compare with Santa Eulalia): They are both inhabited principally by people of the Q'anjobal ethnic/linguistic group, they are contiguous, and they have a similar socioeconomic and geographic profile.

To accomplish this, we obtained from the Area (Huehuetenango Department) MSPAS office in the city of Huehuetenango Excel data sets for each municipality in the Department for each calendar year 2011 through 2014. This data includes live births, maternal and child deaths, child mortality rates and maternal mortality ratios, attributable causes of death, as well as extensive data on maternal, child, and adult morbidity. MSPAS collects this data from RENAP (*Registro Nacional de Personas*), the national vital events registry, which receives its data when families register the births and deaths of family members. In addition, mortality and morbidity data are also collected from the municipal MSPAS offices through the national HMIS called SIGSA (*Sistema de Información Gerencial de Salud*). The municipal MSPAS offices collect this SIGSA data from MSPAS clinics and health posts, and from the Extension of Coverage Program (when it was still operational).

The municipal mortality data for MSPAS are organized by calendar year and include data for the entire municipality. As noted above, our data are organized by project year (October through September) and include data for the entire municipalities – both Phase 1 and Phase 2 communities– only for PY3 and PY4, from October 2013 through May 2015. Therefore, the only calendar year of data we could compare with MSPAS data was 2014. We therefore re-calculated our mortality data for calendar year 2014 for the three municipalities using combined Phase 1 community and Phase 2 community data. Before comparing these data to the three comparison municipalities, we had to take into account the difference in the capture of vital events between our project and the system of MSPAS.

We expected that our project would have a more complete capture of vital events (and especially deaths), which would lead to the calculation of higher mortality rates in the Curamericas project communities. We therefore compared the number of births and deaths in our 2014 data with the MSPAS 2014 data for the project's three municipalities in order to quantify the difference in capture of vital events to factor into the comparison. We then compared our 2014 calendar year mortality data for San Sebastián Coatán with the MSPAS 2014 data for San Mateo; our 2014 mortality data for San Miguel Acatán with the 2014 MSPAS data for San Rafael de Independencia; and our 2014 data for Santa Eulalia with the 2014 MSPAS data for Barillas.

3. Findings

3a. Maternal Mortality

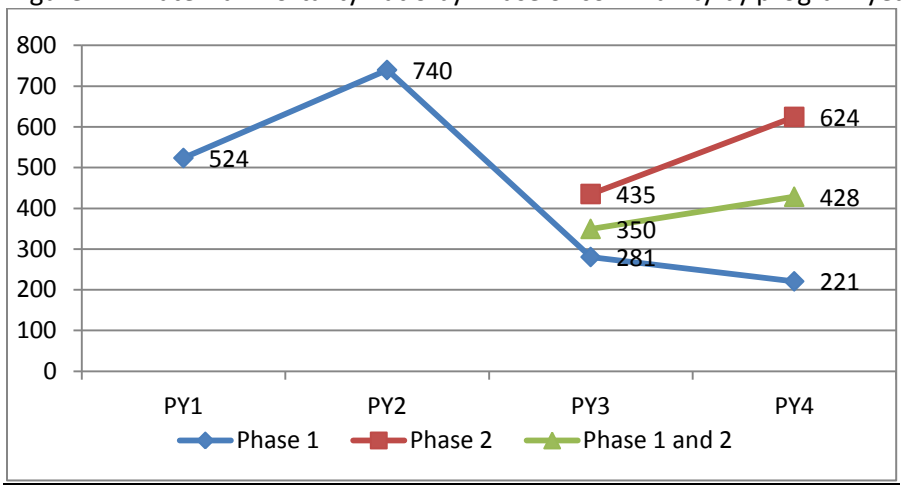
In the Phase 1 communities, there was a large decrease in the maternal mortality ratio (MMR), from 524 in PY1 and 740 in PY2 to 281 in PY3 and a further decline to 221 in PY4 (Table 2). This decline from PY2 to PY4 was 70%. In Phase 2 communities, the MMR increased 43% from 435 in PY3 to 624 in PY4, an end-of-project ratio much higher than Phase 1's 221 (Figure 1). Annualizing the PY4 data, there would have been 3 maternal deaths in PY4 in Phase 1, and 9 in Phase 2. For both Phases combined, end of project MMR was 428, up from 350 in PY3.

Table 2. Maternal mortality in Phase 1 and Phase 2 communities by project year

Project Year*		Phase 1 Communities			Phase 2 Communities			Phase 1 and 2 Communities Combined		
		No. of live births	No. of maternal deaths	MMR	No. of live births	No. of maternal deaths	MMR	No. of live births	No. of maternal deaths	MMR
PY1	OCT 2011 - SEP 2012	1,337	7	524						
PY2	OCT 2012 - SEP 2013	1,352	10	740						
PY3	OCT. 2013 - SEP. 2014	1,426	4	281	1,149	5	435	2,575	9	350
PY4	OCT 2014 - MAY 2015	906	2	221	961	6	624	1,867	8	428
PY1-4	Oct 2011- May 2015	5,021	23	458	2,110	11	521	4,442	17	383

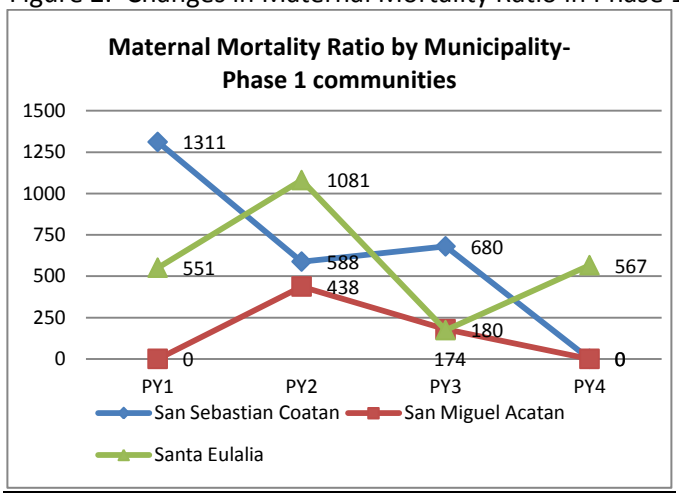
* PY=Project Year

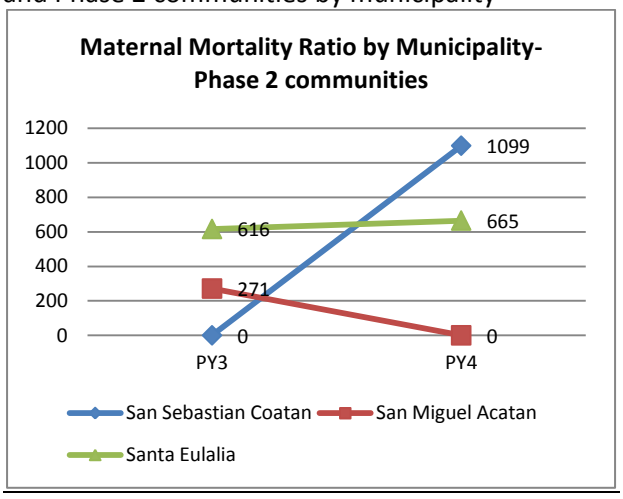
Figure 1. Maternal Mortality Ratio by Phase of community by program year (PY)



When the maternal mortality data for Phase 1 communities are analyzed by municipality, we see a decline in the MMR in all three municipalities (Figure 2). In Phase 2 communities, the results were heterogeneous, rising sharply in San Sebastian Coatán, declining in San Miguel Acatán, and remaining stable in Santa Eulalia. End of project MMRs for the communities of both Phases combined were 504 for San Sebastian Coatán, 0 for San Miguel Acatán, and 622 for Santa Eulalia.

Figure 2. Changes in Maternal Mortality Ratio in Phase 1 and Phase 2 communities by municipality





All but two of the 34 maternal deaths registered in the project's vital events system during the life of the project were home deliveries (Tables 3 and 4, Figure 3). One Phase 2 woman died while delivering en route to the facility. A second died during a cesarean section at the hospital in Huehuetenango.

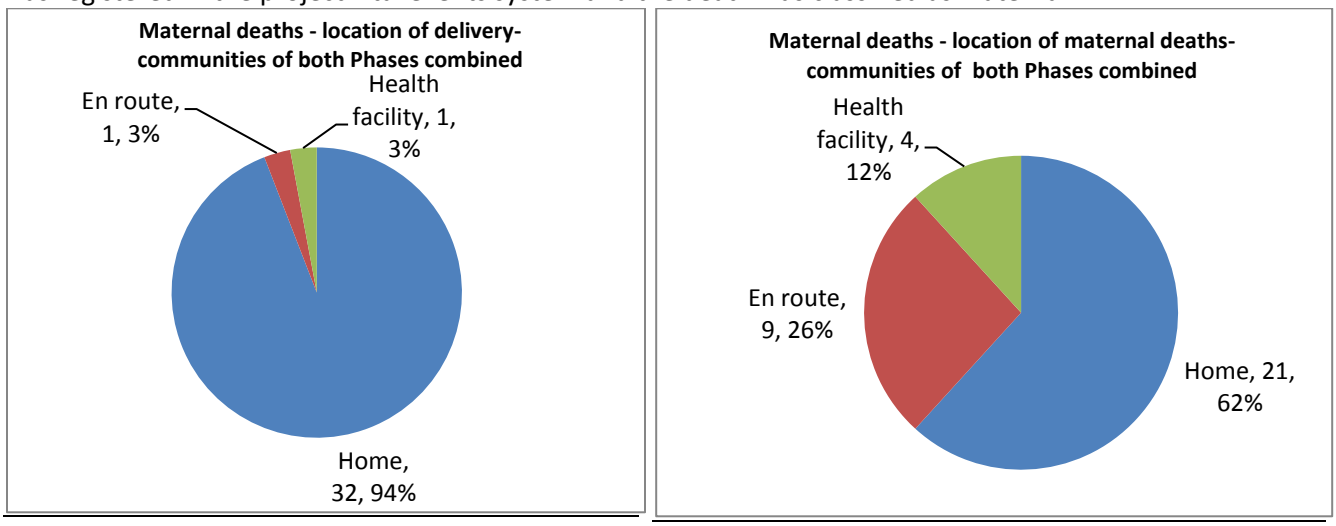
Table 3. Location of delivery and death for women in Phase 1 communities whose deaths were classified as maternal

Project Year (PY)	Location of delivery			Location of maternal death		
	Home	En route	Health facility	Home	En route	Health facility
PY1	7	0	0	4	2	1
PY2	10	0	0	8	1	1
PY3	4	0	0	1	3	0
PY4	2	0	0	1	0	1
Total	23	0	0	14	6	3
Pctg	100%	0%	0%	61%	26%	13%

Table 4. Location of delivery and death for women in Phase 2 communities whose deaths were classified as maternal

Project Year (PY)	Location of delivery			Location of maternal death		
	Home	En route	Health facility	Home	En route	Health facility
PY3	3	1	1	3	1	1
PY4	6	0	0	4	2	0
Total	9	1	1	7	3	1
Pctg	82%	9%	9%	64%	27%	9%

Figure 3. Location of delivery and of death for women in Phase 1 and 2 communities combined whose death was registered in the project vital events system and the death was classified as maternal



What is striking is the high percentage of maternal deaths that occurred en route to a health facility: 26% (n=6) in Phase 1, 27% (n=3) for Phase 2, and 26% (n=9) for both Phases (Figure 3). In all 9 cases the woman died of post-partum hemorrhage. Another 12% (n=4) died after reaching a health facility. The large majority

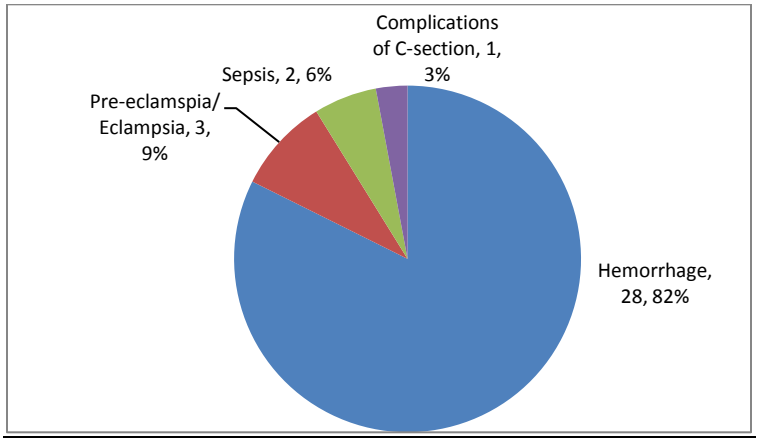
(62%, n=21) died at home, possibly because there was no time to arrange for transport or because the family was unable or unwilling to transport the woman to a health facility.

Post-partum hemorrhage was far and away the most common cause of maternal death, accounting for 82% (n=28) of deaths, followed by eclampsia/preeclampsia (9%, n=3), sepsis (6%, n=2) and complications of cesarean section (3%, n=1) (Table 5, Figure 4).

Table 5. Causes of maternal mortality in Phase 1 and Phase 2 communities

Phase 1 Communities (Oct 2011-May 2015)			Phase 2 Communities (Oct 2013-May 2015)		
Causes of maternal mortality	**No. Deaths**	**Pctg**	**Causes of maternal mortality**	**No. Deaths**	**Pctg**
Hemorrhage	19	83%	Hemorrhage	9	82%
Preeclampsia/eclampsia	3	13%	Sepsis	1	9%
Sepsis	1	4%	Complications of C-section	1	9%
TOTAL	23	100%	TOTAL	11	100%

Figure 4. Causes of maternal mortality, communities of both Phases combined

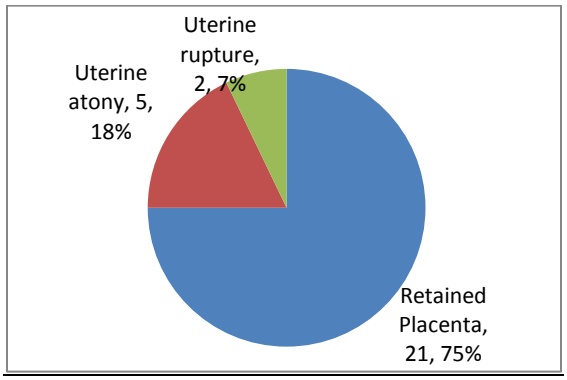


The most common cause of post-partum hemorrhage was retained placenta, which was the underlying factor for 75% (n=21) of all deaths from hemorrhage, followed by uterine atony (18%, n=5) and uterine rupture (7%, n=2) (Table 6, Figure 5).

Table 6. Causes of post-partum hemorrhage

Phase 1 communities (Oct 2011-May 2015)			Phase 2 communities (Oct 2013-May 2015)		
Cause of hemorrhage	**No. Deaths**	**Pctg**	**Cause of hemorrhage**	**No. Deaths**	**Pctg**
Retained Placenta	14	74%	Retained Placenta	7	78%
Uterine Atony	4	21%	Uterine Atony	1	11%
Uterine Rupture	1	5%	Uterine Rupture	1	11%
TOTAL	19	100%	TOTAL	9	100%

Figure 5. Causes of post-partum hemorrhage, communities of both Phases combined

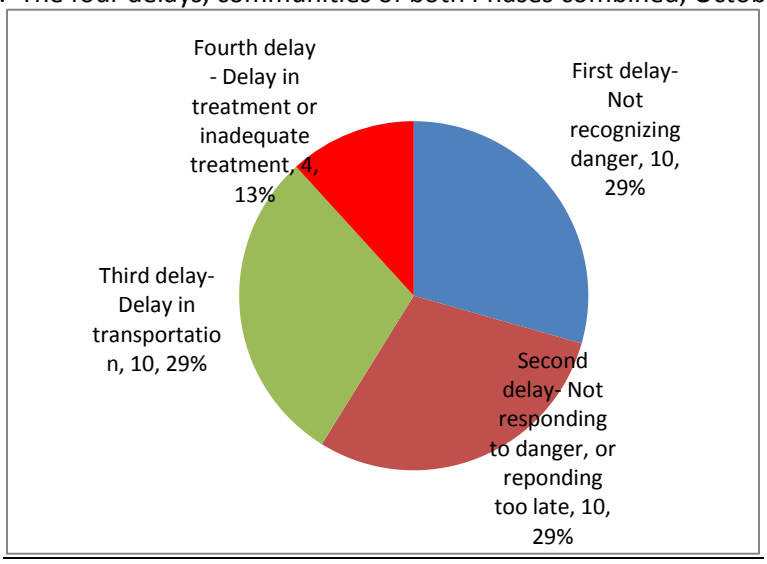


In nearly all maternal deaths, time is a critical factor, especially in the case of hemorrhage, as a woman can bleed to death very quickly. Of the four delays (see Methodology, above) the first delay accounted for 29% (n=10) of the delays, with the family not even recognizing that the woman was in danger (generally in cases where there was no overt bleeding) (Figure 6). Another 29% (n=10) recognized the danger but either chose not to transport the woman to a health facility, or waited too long to arrange transportation. The verbal autopsies did not always capture the reason given for not transporting the woman, but the most frequently cited reason was lack of money for transportation. Other causes cited were "it is God's will that she die", and in one instance, inter-community conflict which impeded arranging transportation.

Table 7 The Four Delays by Phase of communities

Delay	Phase 1 communities (Oct 2011-May 2015)		Phase 2 communities (Oct 2013-May 2015)	
	No.	Pctg	No.	Pctg
First- Not recognizing danger	8	35%	2	18%
Second- Not responding to danger or responding too late	7	30%	3	27%
Third- Delay in transportation	5	22%	5	45%
Fourth - Delay in treatment or inadequate treatment	3	13%	1	9%
TOTAL	23	100%	11	100%

Figure 6. The four delays, communities of both Phases combined, October 2011 – May 2015.



A large percentage are third delays (29%, n=10). It was already noted the large percentage of maternal deaths that occurred en route to the facility (26%, n=9) and this is correlates with the large percentage of third delays. It should be noted that the closest referral hospital is in the city of Huehuetenango, a four-hour drive with most of it over difficult unpaved mountain roads, contributing to this delay and to finding that 26% of the maternal deaths registered by the project occurred en route to the hospital.

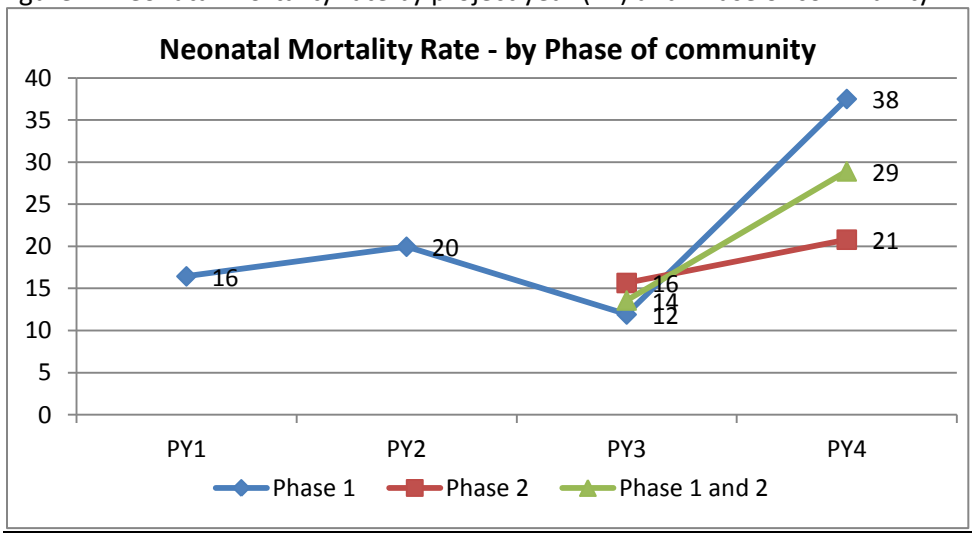
3b. Neonatal Mortality (days during the first 28 days of life)

In the Phase 1 communities, the neonatal mortality rate (NNMR), after declining 40% from 20 in PY2 to 12 in PY3, appeared to spike sharply to 38 in PY4, an increase of 215% (Table 8). In the Phase 2 communities, the NNMR increased 33% from 16 in PY3 to 21 in PY4. Thus, the end-of-project NNMR was lower in the Phase 2 communities (21) than in the Phase 1 communities (38). Annualizing the PY4 data (since we have data for only 9 months of PY4), in the Phase 1 communities there would have been 51 neonatal deaths for the 12 months ending Sept 30, 2015, an increase from 17 in PY3. Annualizing the number of deaths in PY4 for Phase 2 communities would give 30 deaths, up from 18 in PY3. End of project PY4 NNMR for the communities of both Phases combined was 29, rising sharply over 100% from only 14 in PY3 (Figure 7).

Table 8. Number of births and neonatal deaths, and neonatal mortality rates by project year and community category

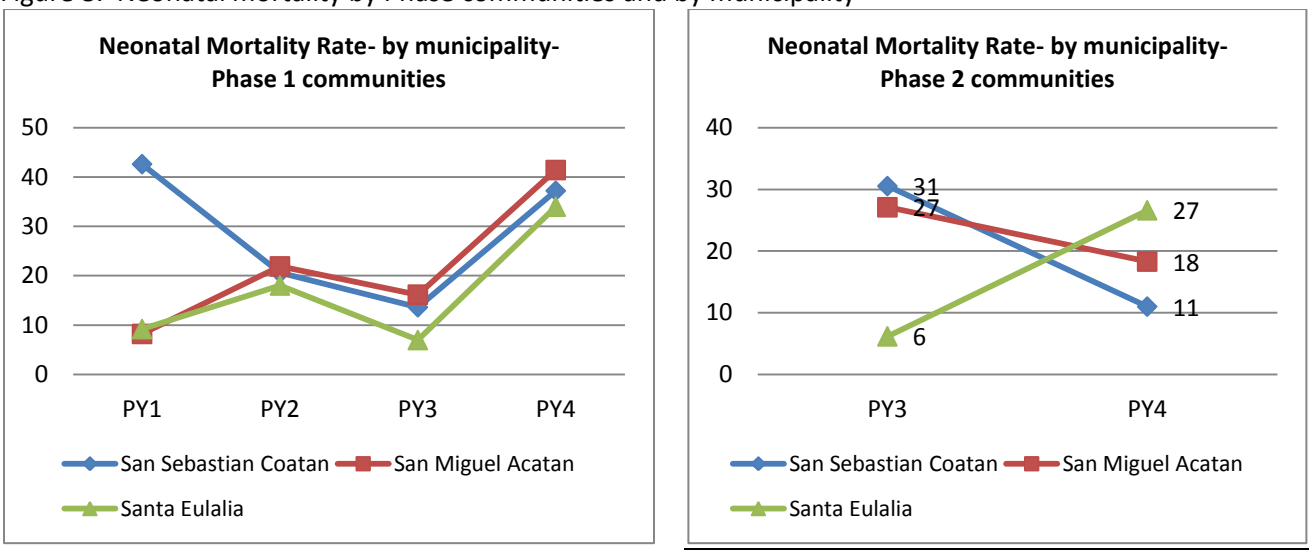
Project Year (PY)		Phase 1 communities			Phase 2 communities			Phase 1 and 2 communities combined		
		No. of live births	No. of neonatal deaths	NNMR	No. of live births	No. of neonatal deaths	NNMR	No. of live births	No. of neonatal deaths	NNMR
PY1	OCT. 2011 - SEP. 2012	1,337	22	16						
PY2	OCT. 2012 - SEP. 2013	1,352	27	20						
PY3	OCT. 2013 - SEP. 2014	1,426	17	12	1,149	18	16	2,575	35	14
PY4	OCT 2014 - MAY 2015	906	34	38	961	20	21	1,867	54	29
PY1-4	Oct 2011- May 2015	5,021	100	20	2,110	38	18	4,442	89	20

Figure 7. Neonatal mortality rate by project year (PY) and Phase of community



Disaggregating by municipality, in Phase 1 communities we see the same sharp spike in NNMR from PY3 to PY4 in all three municipalities (Figure 8). In contrast, in Phase 2 communities, we see year-on-year declines for San Sebastian Coatán and San Miguel Acatán, but a sharp spike for Santa Eulalia, from 6 to 27.

Figure 8. Neonatal mortality by Phase communities and by municipality



The reasons for this apparent spike in NNMR in PY4 remain to be determined and will be addressed in the Discussion. Factored into the analysis will be year-to-year changes in the proportion of deaths classified as stillbirths vs. neonatal deaths (Table 9). There was a notable decrease in the proportion of deaths classified as stillbirths in Phase 1 communities, from 73% in PY3 to 51% in PY4, which can account for much of this apparent increase in neonatal mortality in the Phase 1 communities.

Table 9. Stillbirths vs. Neonatal deaths

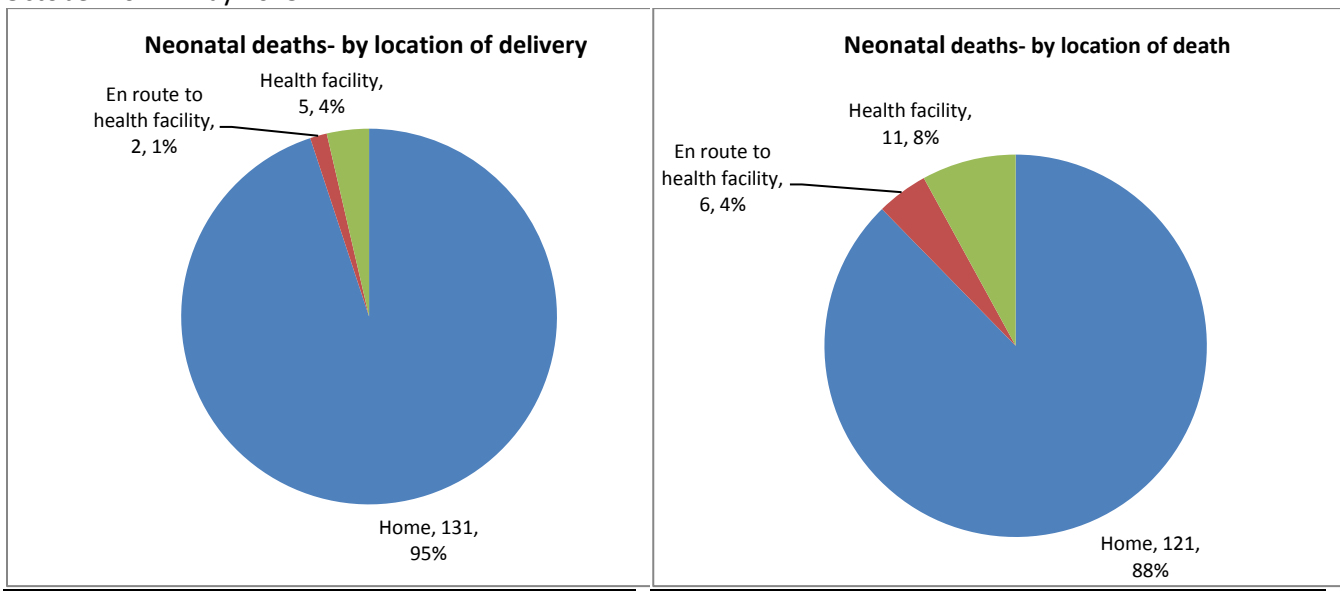
Project Year		Phase 1 communities			Phase 2 communities		
		No. Stillbirths	No. Neonatal Deaths	Pctg Stillbirths	No. Stillbirths	No. Neonatal Deaths	Pctg Stillbirths
PY1	OCT. 2011- SEP. 2012	21	22	49%			
PY2	OCT. 2012 - SEP. 2013	58	27	68%			
PY3	OCT. 2013- SEP. 2014	46	17	73%	21	18	54%
PY4	OCT. 2014 - MAY 2015	36	34	51%	38	20	66%
OCT 2011- May 2015		161	100	62%	59	38	61%

The overwhelming majority of neonatal deaths were among newborns who were born at home – 95% (n=131) of the neonatal death in the combined set of communities and 95% in the communities of both Phases (Table 10, Figure 9). Only 5 (4%) of neonatal deaths occurred to newborns who were born in a health facility, where aspiration of meconium and complications of prematurity were unable to be resolved. Similarly, 88% (n=121) of neonatal deaths occurred in the home, most commonly on the day of delivery from birth asphyxia (see causes of NNM, below). Very few the neonates who died at home and were in distress prior to death were taken to a health facility, or they died quickly before the family could respond.

Table 10. Location of delivery and death for neonatal deaths

Location	Phase 1 communities (Oct 2011-May 2015)				Phase 2 communities (Oct 2013-May 2015)			
	Location of delivery		Location of death		Location of delivery		Location of death	
	No.	Pctg	No.	Pctg	No.	Pctg	No.	Pctg
Home	95	95%	88	88%	36	95%	33	87%
En route to health facility	1	1%	4	4%	1	3%	2	5%
Health facility	4	4%	8	8%	1	3%	3	8%
Total	100	100%	100	100%	38	100%	38	100%

Figure 9. Location of delivery and death for neonatal deaths – communities of both Phases combined- October 2011- May 2015

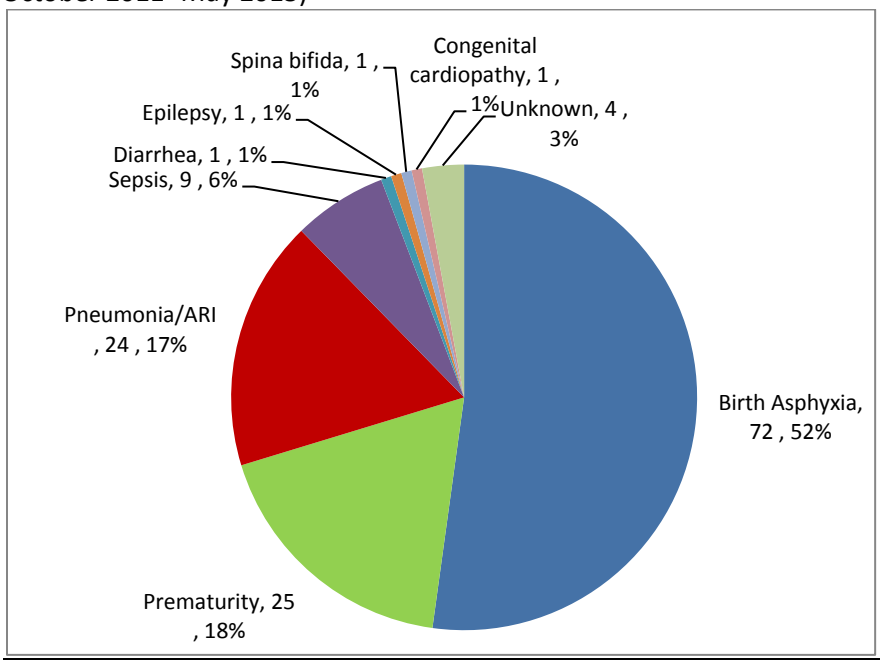


Birth asphyxia was by far the main cause of neonatal mortality (52%, n=72), followed by complications of prematurity (18%, n=25), pneumonia/ARI (17%, n=24), and sepsis 6% (n=9) as the major causes (Figure 10). These four causes accounted for 93% (n=135) of neonatal mortality for the communities of both Phases combined. However, the communities of the two Phases differed widely in their respective distribution of causes (Table 11). While the communities of Phase 1 matched the overall project pattern, for those in Phase 2, pneumonia/ARI was the number one cause (29%, n=11), complications of prematurity second (24%, n=9), birth asphyxia third, with only 24% (n=9) of deaths, and with proportionally more deaths from sepsis than in Phase 1 communities (13% vs. 4% Phase 1). The reasons for these differences remain to be determined.

Table 11. Causes of neonatal mortality by community Phase category

Phase 1 communities (Oct 2011- May 2015)			Phase 2 communities (Oct 2013-May 2015)		
Cause	No.	Pctg.	Cause	No.	Pctg.
Birth Asphyxia	63	63.0%	Pneumonia/ARI	11	28.9%
Complications of prematurity	16	16.0%	Complications of prematurity	9	23.7%
Pneumonia/ARI	13	13.0%	Birth asphyxia	9	23.7%
Sepsis	4	4.0%	Sepsis	5	13.2%
Diarrhea	1	1.0%	Congenital cardiopathy	1	2.6%
Epilepsy/Convulsions	1	1.0%	Spina bifida	1	2.6%
Unknown	2	2.0%	Unknown	2	5.3%
TOTAL	100	100%	TOTAL	38	100%

Figure 10. Causes of Neonatal Mortality – communities of both Phases combined (October 2011- May 2015)

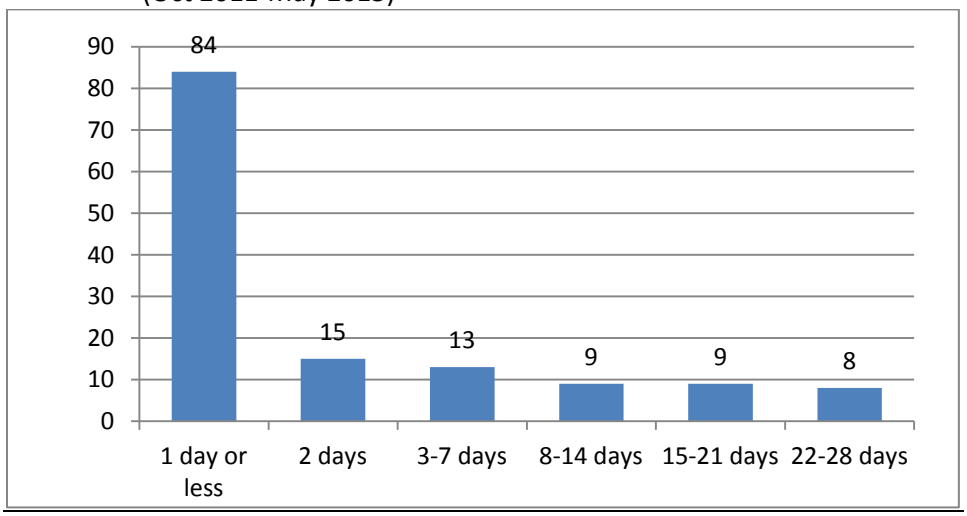


Analyzing age at neonatal death by cause, since birth asphyxia is the leading cause of neonatal death, it is no surprise that 61% (n=84) of neonatal deaths occurred in the first day of life (Table 12, Figure 11). But since birth asphyxia represents a much lower percentage of deaths in the Phase 2 communities than in the Phase 1 communities, we see a lower percentage of neonatal deaths, 42%, occurring on the first day in the Phase 2 communities. A full 81% (n=112) of neonatal deaths occurred during the first week of life, varying from 86% (n=86) for Phase 1 communities to 69% (n=26) for Phase 2 communities. After the first week, deaths were fairly evenly distributed over the remaining 21 days of the neonatal period in both groups of communities.

Table 12. Age (in days) at death, neonatal deaths- communities of both Phases, Oct 2011-May 2015

Age (in days) at neonatal death	Phase 1 communities		Phase 2 communities		Phase 1 & 2 communities combined	
	No.	Pctg	No.	Pctg	No.	Pctg
1 day or less	68	68%	16	42%	84	61%
2 days	11	11%	4	11%	15	11%
3-7 days	7	7%	6	16%	13	9%
8-14 days	6	6%	3	8%	9	7%
15-21 days	4	4%	5	13%	9	7%
22-28 days	4	4%	4	11%	8	6%
TOTAL	100	100%	38	100%	138	100%

Figure 11. Age (days) of neonatal death, communities of both Phases combined (Oct 2011-May 2015)



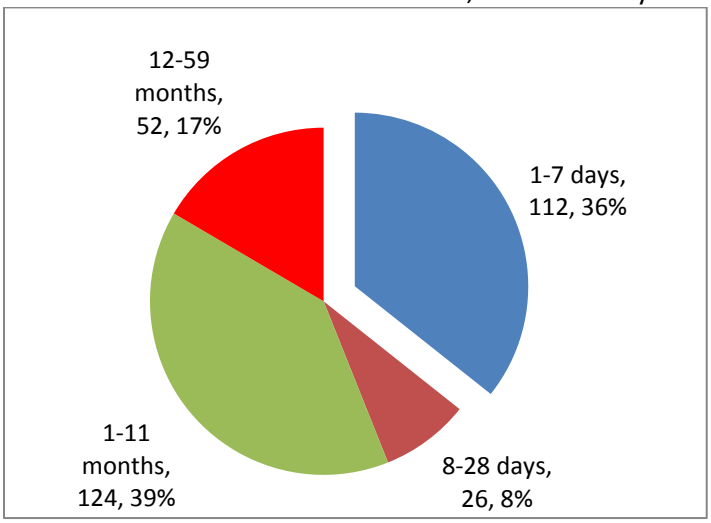
Looking at causes of death for each time period, we see 66 of 72 birth asphyxia deaths (92%) occurring on the first day of life; and also nearly half of deaths due to complications of prematurity (48%, n=12) also occurring on the first day of life (Table 13).

Table 13. Cause of neonatal death by age (days) at death, communities of both Phases combined (Oct 2011-May 2015)

Age at death	Birth asphyxia	Complication of Prematurity	Sepsis	Pneumonia/ ARI	Diarrhea	Other/ Unknown	TOTAL
1 day	66	12	1	3	0	2	84
2 days	6	3	1	4	0	1	15
3-7 days	0	3	4	5	0	1	13
8-14 days	0	5	1	2	0	1	9
15-21 days	0	0	1	7	0	1	9
22-28 days	0	2	1	3	1	1	8
TOTAL	72	25	9	24	1	7	138

Verbal autopsies, unfortunately, could not always identify the specific complication of prematurity, but it appears nearly all of the premature infants who died on the first day of life suffered from infant respiratory distress syndrome (IRDS). After this first day, deaths attributable to prematurity were fairly evenly distributed over the neonatal period. Pneumonia/ARI deaths were also evenly distributed over the neonatal period, and deaths from sepsis were concentrated during the 3-7 day period, which is a typical timeframe for umbilical infection, the most common infectious cause reported, to take its toll. The one diarrhea death identified did not appear until the final week of the neonatal period. It should be noted that deaths during the first week of life (n=112) represented 36% of all under-5 mortality in the communities of both Phases combined (Figure 12). The 84 deaths on day 1 of life represent 27% of all under-5 deaths. All neonatal deaths represented 44% (n=138) of all under-5 deaths in the communities of both Phases combined (see Under-5 Mortality, below).

Figure 12. Deaths during first week of life as a percentage of all under-5 deaths communities of both Phases combined, Oct 2011-May 2015



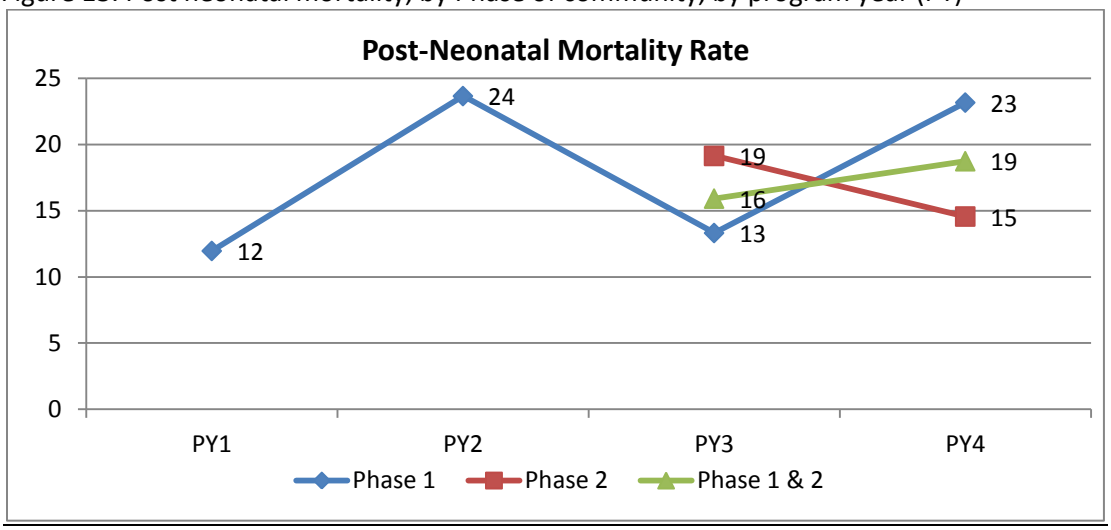
3c. Post-Neonatal Mortality (deaths among infants 1-<12 months at age)

As with neonatal mortality, in Phase 1 communities we see the post-neonatal mortality rate (PNNMR) decreasing by half from PY2 to PY3 (from 24 to 13), and then increasing back to 23 in PY4 (Table 14, Figure 13). The PNNMR in Phase 1 communities was thus effectively unchanged from PY2 to PY4. In contrast, in Phase 2 communities, PNNMR dropped from 19 in PY3 to 15 in PY4. As with neonatal deaths, the end of project PY4 post-neonatal mortality rate was lower in Phase 2 communities (15) than in Phase 1 communities (23). Due to the spike in PNNMR in Phase 1 communities, the combined Phase 1 and 2 end of project PNNMR increased from 16 in PY3 to 19 in PY4. The reasons for the apparent spike in the PNNMR of Phase 1 communities in PY4 remain to be determined (see Discussion).

Table 14. Numbers of live births and post-neonatal deaths, and post-neonatal mortality rates by project year and Phase area

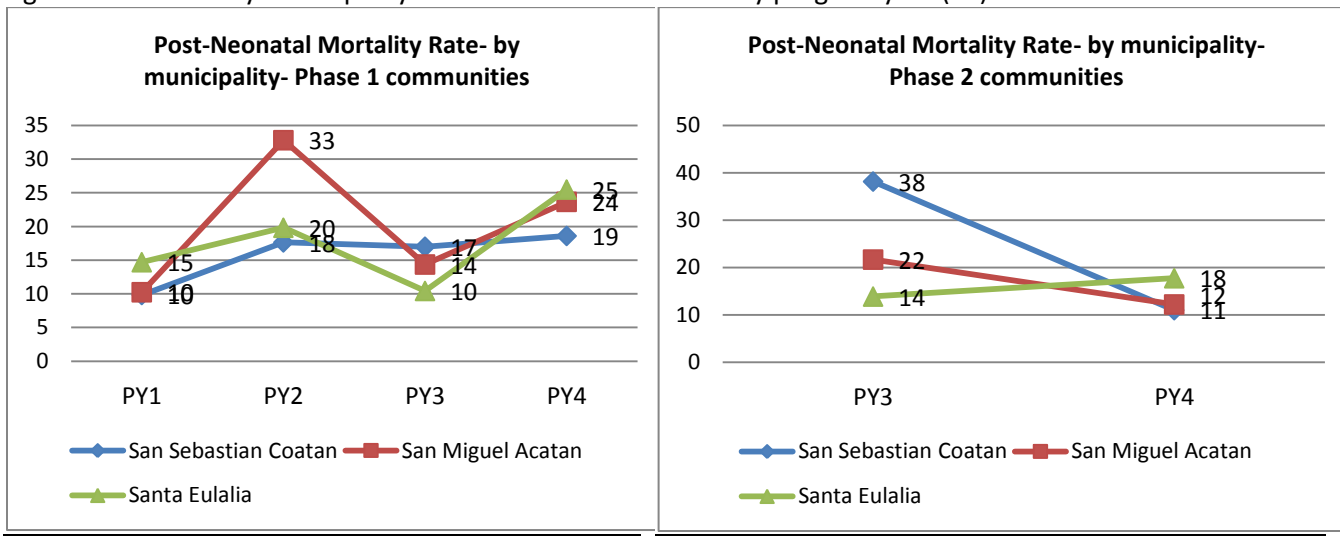
Project Year (PY)		Phase 1 communities			Phase 2 communities			Phase 1 and 2 communities combined		
		No. of live births	No. of PNN deaths	PNNMR	No. of live births	No. of PNN deaths	PNNMR	No. of live births	No. of PNN deaths	PNNMR
PY1	OCT. 2011 - SEP. 2012	1,337	16	12						
PY2	OCT. 2012 - SEP. 2013	1,352	32	24						
PY3	OCT. 2013 - SEP. 2014	1,426	19	13	1,149	22	19	2,575	41	16
PY4	OCT 2014 - MAY 2015	906	21	23	961	14	15	1,867	35	19
PY1-4	Oct 2011- May 2015	5,021	88	18	2,110	36	17	4,442	76	17

Figure 13. Post neonatal mortality, by Phase of community, by program year (PY)



Disaggregating by municipality (Figure 14), we see that in the Phase 1 communities the PNNMR rose from PY3 to PY4 in all three municipalities, though only slightly in San Sebastian Coatán (from 17 to 19). In Phase 2 communities, the PNNMR fell from PY3 to PY4 in both San Sebastian Coatán (from 38 to 18) and San Miguel Acatán (from 22 to 12), but rose slightly in Santa Eulalia, from 14 to 18.

Figure 14. PNNMR by municipality and Phase of communities by program year (PY)



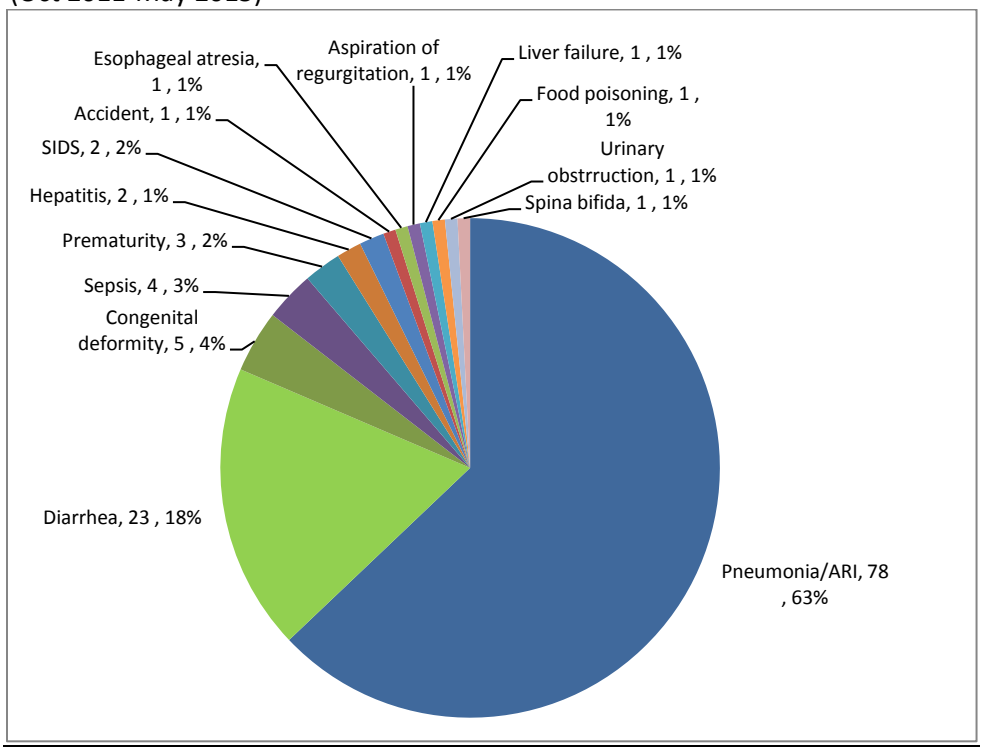
The main cause, by far, of post-neonatal (PNN) death in the communities of both Phases and for the Phases combined was pneumonia/ARI (Phase 1 communities: 63%, n=55; Phase 2 communities: 64%, n=23; both Phases combined: 63%, n=78) (Table 15, Figure 14). Next was diarrheal disease (18% for the combined Phases, n=23), though diarrhea was the cause of only 8% (n=3) of the PNN deaths in Phase 2 communities as compared to 23% among the Phase 1 communities. Pneumonia/ARI and diarrhea combined accounted for 85% of PNN deaths in Phase 1 communities, 72% in Phase 2 communities, and 85% in the communities for the combined Phases. Sepsis/infection (i.e., infection other than pneumonia/ARI) accounted for only 3% in the communities of both Phases combined. Phase 2 communities differed from those of Phase 1 with 8% (n=3) of PNN deaths from complications of prematurity vs. none for Phase 1. Other miscellaneous causes included hepatitis and other causes of liver failure; sudden infant death syndrome (SIDS); aspiration of

regurgitation; food poisoning; organ deformities; spina bifida; and accident. Together these accounted for 13% of all PNN deaths, though no one cause accounted for more than 2%.

Table 15. Causes of Post-Neonatal Mortality

Phase 1 communities (Oct 2011-May 2015)			Phase 2 communities (Oct 2013- May 2015)		
Cause	**No.**	**Pctg.**	**Cause**	**No.**	**Pctg.**
Pneumonia/ARI	55	62.5%	Pneumonia/ARI	23	63.9%
Diarrhea	20	22.7%	Diarrhea	3	8.3%
Congenital deformity	4	4.5%	Prematurity	3	8.3%
Sepsis	3	3.4%	Sepsis	1	2.8%
Hepatitis	2	2.3%	Aspiration of regurgitation	1	2.8%
Liver failure	1	1.1%	Congenital cardiopathy	1	2.8%
Sudden Infant Death Syndrome (SIDS)	1	1.1%	Spina bifida	1	2.8%
Food poisoning	1	1.1%	Esophageal atresia	1	2.8%
Urinary obstruction	1	1.1%	Sudden Infant Death Syndrome (SIDS)	1	2.8%
			Accident	1	2.8%
TOTAL	88	100%	TOTAL	36	100.0%

Figure 14. Causes of Post-neonatal death, communities of Phase 1 & 2 combined (Oct 2011-May 2015)



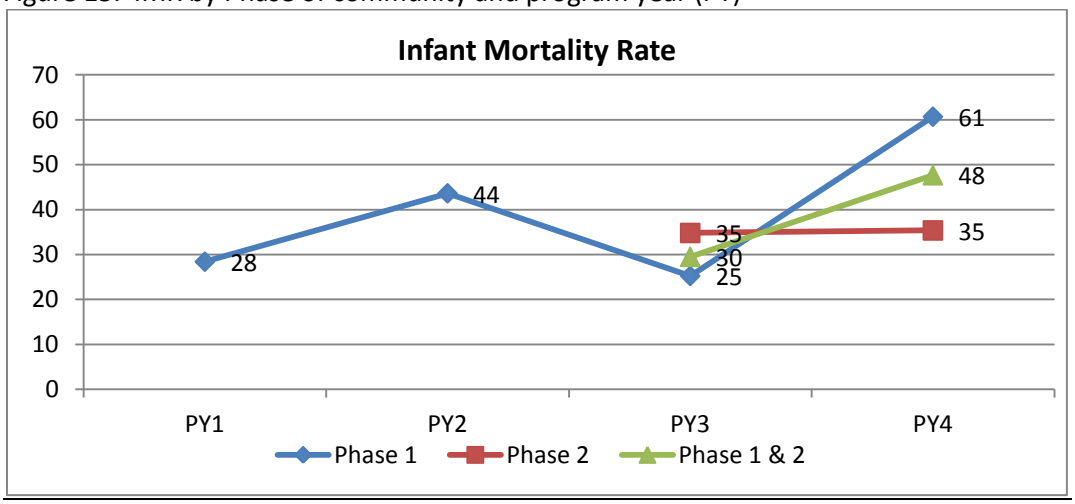
3d. Infant Mortality (deaths during the first 12 months of life)

Infant mortality combines neonatal and post-neonatal mortality. Due to the patterns noted above in neonatal and post-neonatal mortality, we also observe in Phase 1 communities the infant mortality rate (IMR) drop from 44 to 25 from PY2 to PY3, and then surge to 61 in PY4, mostly due to the already noted increase in neonatal mortality (Table 16, Figure 15). For Phase 2 communities, IMR remained unchanged from PY3 to PY4 at 35. As with NNM and PNNM, the end of project PY4 IMR rate was lower for Phase 2 communities than for Phase 1 communities (35 vs. 61). IMR for the combined Phase 1 and 2 communities rose from 30 in PY3 to 48 in PY4.

Table 16. Number of births and infant deaths, and infant mortality rate by project year and project area

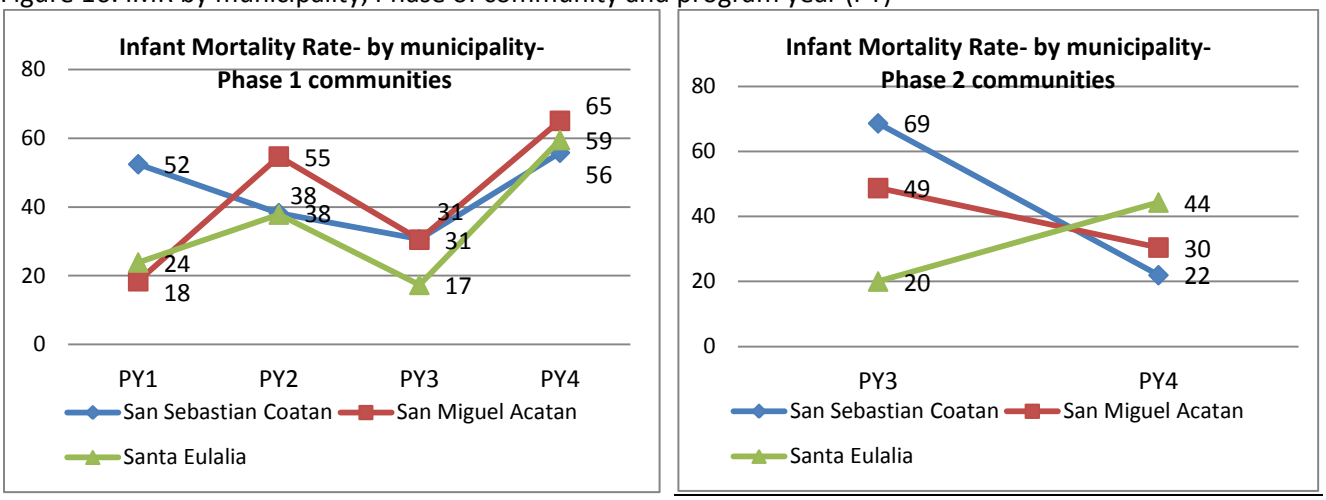
Project Year (PY)		Phase 1 communities			Phase 2 communities			Phase 1 and 2 communities combined		
		No. of live births	No. of Infant deaths	IMR	No. of live births	No. of Infant deaths	IMR	No. of live births	No. of Infant deaths	IMR
PY1	OCT. 2011 - SEP. 2012	1,337	38	28						
PY2	OCT. 2012 - SEP. 2013	1,352	59	44						
PY3	OCT. 2013 - SEP. 2014	1,426	36	25	1,149	40	35	2,575	76	30
PY4	OCT 2014 - MAY 2015	906	55	61	961	34	35	1,867	89	48
PY1-4	Oct 2011- May 2015	5,021	188	37	2,110	74	35	4,442	165	37

Figure 15. IMR by Phase of community and program year (PY)



Disaggregating by municipality, in Phase 1 communities we see IMR increasing from PY3 to PY4 in all three municipalities (Figure 16). In Phase 2 communities, IMR declined from PY3 to PY4 in both San Sebastián Coatán (from 69 to 22) and San Miguel Acatán (from 49 to 30), but rose sharply from 20 to 44 in Santa Eulalia. Possible causes of the increased IMR in Phase 1 communities and in the Santa Eulalia Phase 2 communities will be reviewed in the Discussion section.

Figure 16. IMR by municipality, Phase of community and program year (PY)

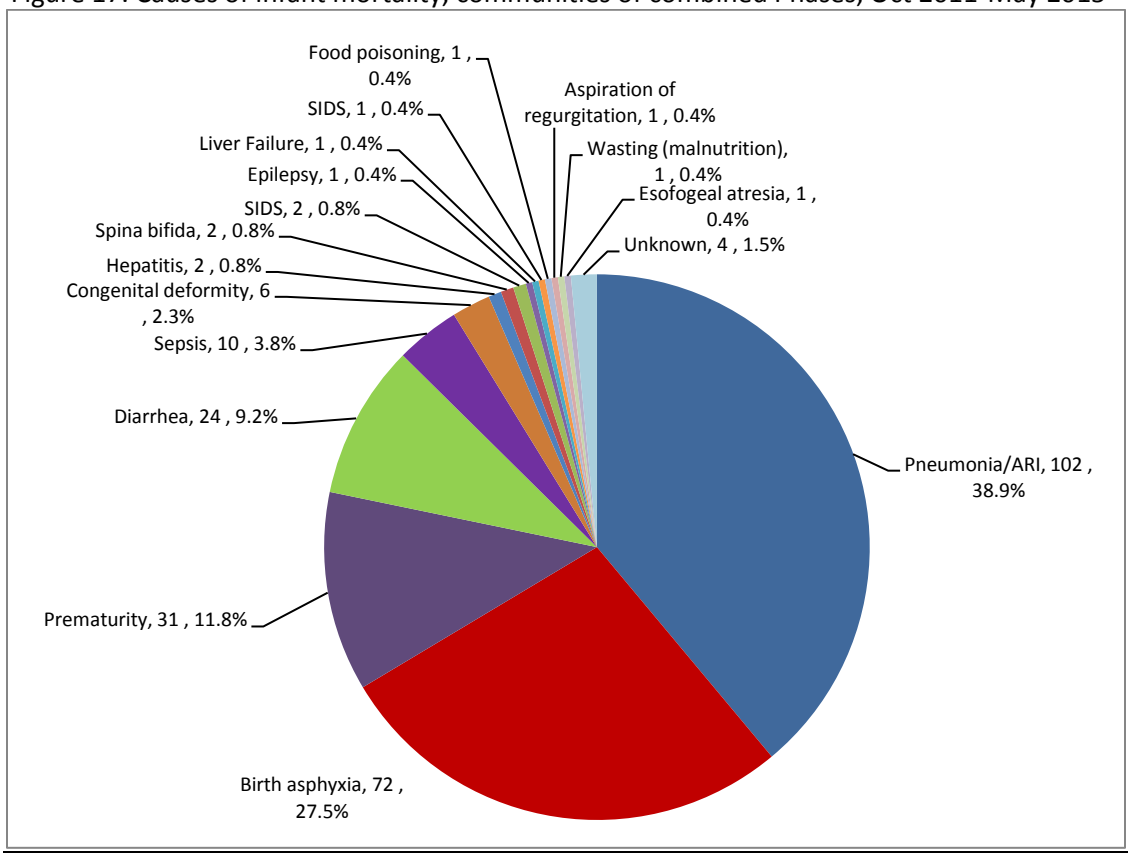


The main causes of infant mortality for the communities of the combined Phases were pneumonia/ARI (39%, n=102), birth asphyxia (28%, n=72), complications of prematurity (12%, n=31), diarrhea (9%, n=24), and sepsis/other infections (4%, n=10) (Figure 17). These five accounted for 91% (n=239) of all infant mortality.

Table 17. Causes of infant mortality by Phase of community

Phase 1 communities (Oct 2011-May 2015)			Phase 2 communities (Oct 2013-May 2015)		
Cause	**No.**	**Pctg.**	**Cause**	**No.**	**Pctg.**
Pneumonia/ARI	68	36.2%	Pneumonia/ARI	34	45.9%
Birth asphyxia	63	33.5%	Prematurity	12	16.2%
Diarrhea	21	11.2%	Birth asphyxia	9	12.2%
Prematurity	19	10.1%	Sepsis	6	8.1%
Sepsis	4	2.1%	Diarrhea	3	4.1%
Congenital deformity	4	2.1%	Inhalation of regurgitation	1	1.4%
Hepatitis	2	1.1%	Congenital deformity	2	2.7%
Urinary obstruction	1	0.5%	Spina bifida	2	2.7%
Epilepsy/convulsions	1	0.5%	Wasting (Acute malnutrition)	1	1.4%
Liver Failure	1	0.5%	Esophageal atresia	1	1.4%
SIDS	1	0.5%	SIDS	1	1.4%
Food poisoning	1	0.5%	Unknown	2	2.7%
Unknown	2	1.1%			
TOTAL	188	100%	TOTAL	74	100%

Figure 17. Causes of infant mortality, communities of combined Phases, Oct 2011-May 2015



Comparing Phases, we note important differences: birth asphyxia was the cause of only 12% of the infant deaths in Phase 2 communities compared to 35% of deaths in Phase 1 communities, and diarrhea was only 4% of Phase 2 communities vs. 11% for Phase 1 communities (Table 17). On the other hand, complications of prematurity were 16% of Phase 2 community infant deaths, vs. only 10% for Phase 1 communities, and sepsis was 8% vs. only 2% for Phase 1 communities.

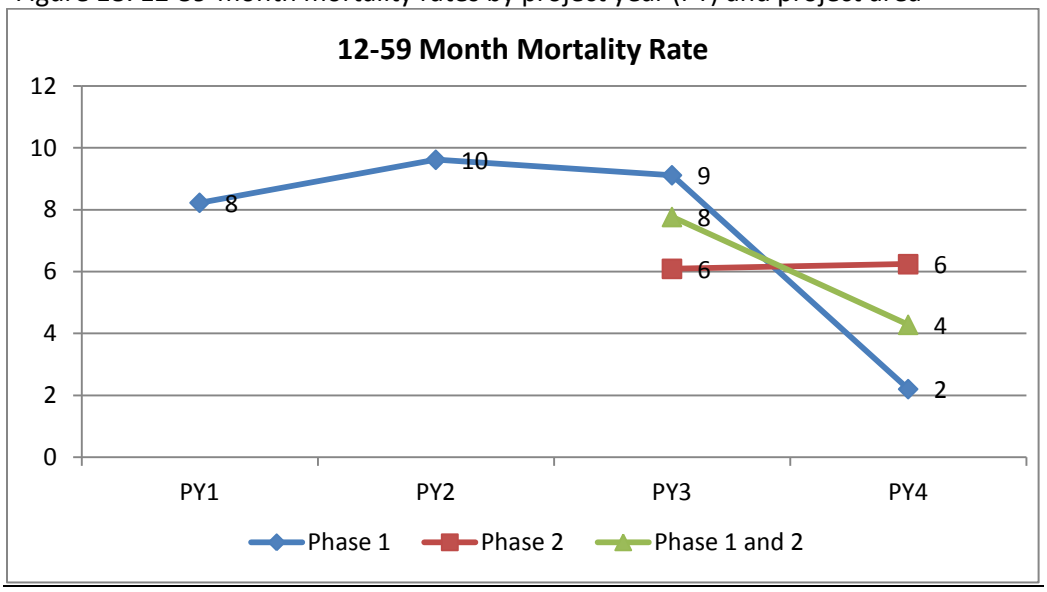
3e. 12-59 Month Mortality

Unlike neonatal and post-neonatal mortality, in the Phase 1 communities the 12-59 month mortality rate (expressed as number of deaths per 1,000 live births) dropped dramatically from 10 in PY2 and 9 in PY3 to only 2 in PY4, a decline of 77%, with only 2 PY4 deaths in this age group: *in PY4, 12-59-month deaths were almost eliminated in the Phase 1 communities* (Table 18, Figure 18). In Phase 2 communities, the 12-59 month mortality rate was unchanged from PY3 to PY4 at 6 deaths per 1,000 live births. Thus, at the end of project in PY4, the 12-59-month mortality rate was lower in the Phase 1 communities than in the Phase 2 communities (2 vs. 6). The 12-59 month mortality rate for the combined Phases declined 50%, from 8 in PY3 to 4 in PY4. Number of deaths decreased from 20 in PY3 to 12 in PY4 (when PY4 findings are annualized).

Table 18. Births, 12-59-month deaths, and 12-59-month mortality rates by project year and project area

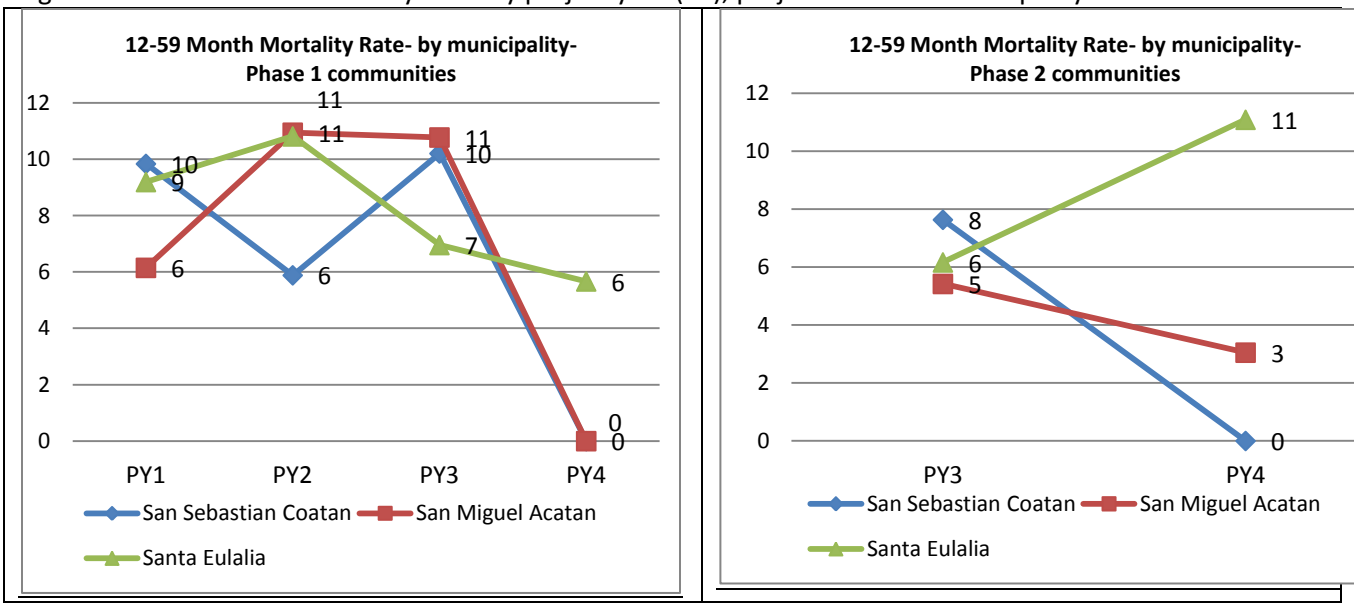
Project Year		Phase 1 communities			Phase 2 communities			Phase 1 and 2 communities combined		
		No. of live births	No. 12-59 month deaths	12-59 month MR	No. of live births	No. 12-59 month deaths	12-59 month MR	No. of live births	No. 12-59 month deaths	12-59 month MR
PY1	OCT. 2011 - SEP. 2012	1,337	11	8						
PY2	OCT. 2012 - SEP. 2013	1,352	13	10						
PY3	OCT. 2013 - SEP. 2014	1,426	13	9	1,149	7	6	2,575	20	8
PY4	OCT 2014 - MAY 2015	906	2	2	961	6	6	1,867	8	4
PY1-4	Oct 2011- May 2015	5,021	39	8	2,110	13	6	4,442	28	6

Figure 18. 12-59-month mortality rates by project year (PY) and project area



Disaggregating by municipality, among the Phase 1 communities we see sharp declines in 12-59 month mortality from PY3 to PY4 in all three municipalities, with no 12-59 month deaths recorded in San Sebastián Coatán and San Miguel Acatán in PY4 (Figure 19). Among the Phase 2 communities, the 12-59 mortality rate also sharply declined from PY3 to PY4 in San Sebastian Coatán (from 8 to 0) and San Miguel Acatán (from 5 to 3) but rose sharply in Santa Eulalia from 6 to 11. The Phase 2 communities of Santa Eulalia is the only project area where 12-59 month mortality increased in PY4.

Figure 19. 12-59-month mortality rates by project year (PY), project area and municipality

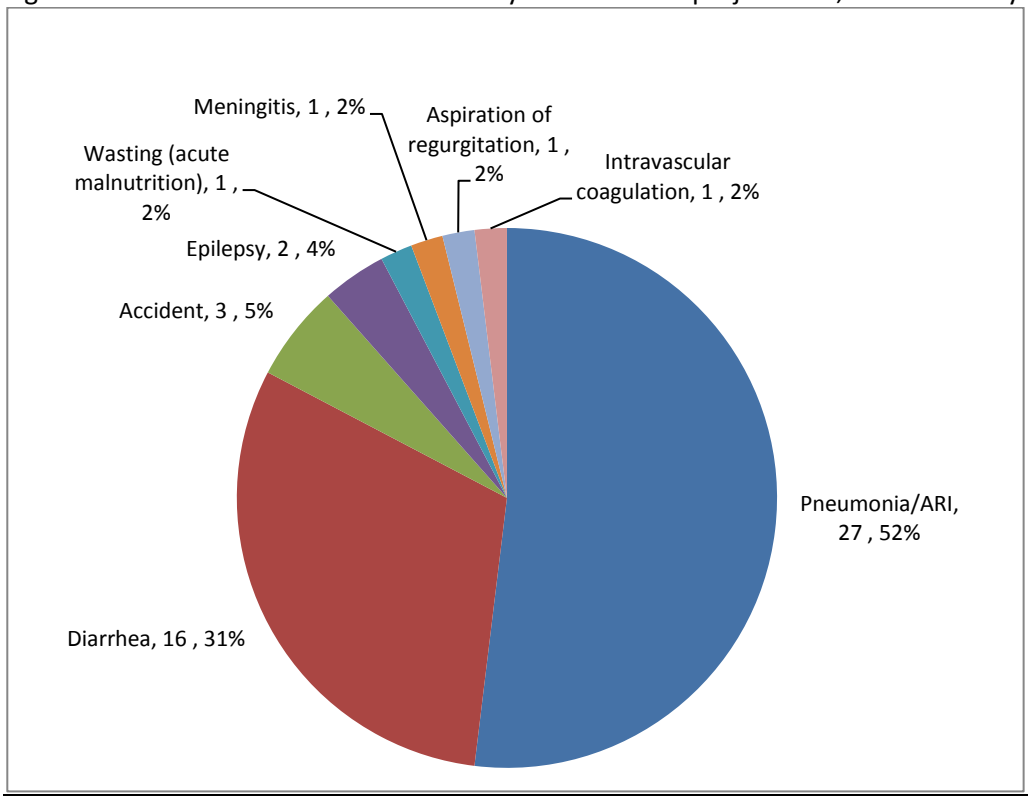


The two main causes of 12-59-month mortality in the communities of both Phases and for the combined Phases were pneumonia/ARI (54% for Phase 1 communities, 46% of Phase 2 communities, and 52% for the combined Phases) and diarrhea (33% for Phase 1 communities, 23% of Phase 2 communities, and 31% for the combined Phases) (Table 19, Figure 20). Diarrhea is a more important cause of death in this 12-59 month age group than in the 0-11 month age group (31% versus 9% of deaths in their respective age categories). Pneumonia/ARI and diarrhea combined accounted for 83% of 12-59 month mortality for the communities of the combined Phases. Miscellaneous causes accounted for 17% of the mortality, and included accidents (3%), epilepsy/convulsions (2%), acute malnutrition/wasting (2%), meningitis (2%), aspiration of regurgitation (2%), and intravascular coagulation (2%).

Table 19. Causes of 12-59 month mortality by project area

Phase 1 communities (Oct 2011- May 2015)			**Phase 2 communities (Oct 2013-May 2015)**		
Cause	**No.**	**Pctg.**	**Cause**	**No.**	**Pctg.**
Pneumonia/ARI	21	53.8%	Pneumonia/ARI	6	46.2%
Diarrhea	13	33.3%	Diarrhea	3	23.1%
Accident	3	7.7%	Meningitis	1	7.7%
Wasting (acute malnutrition)	1	2.6%	Aspiration of regurgitation	1	7.7%
Epilepsy	1	2.6%	Epilepsy	1	7.7%
			Intravascular coagulation	1	7.7%
TOTAL	39	100%	TOTAL	13	100%

Figure 20. Causes of 12-59 month mortality for the entire project area, Oct 2011-May 2015



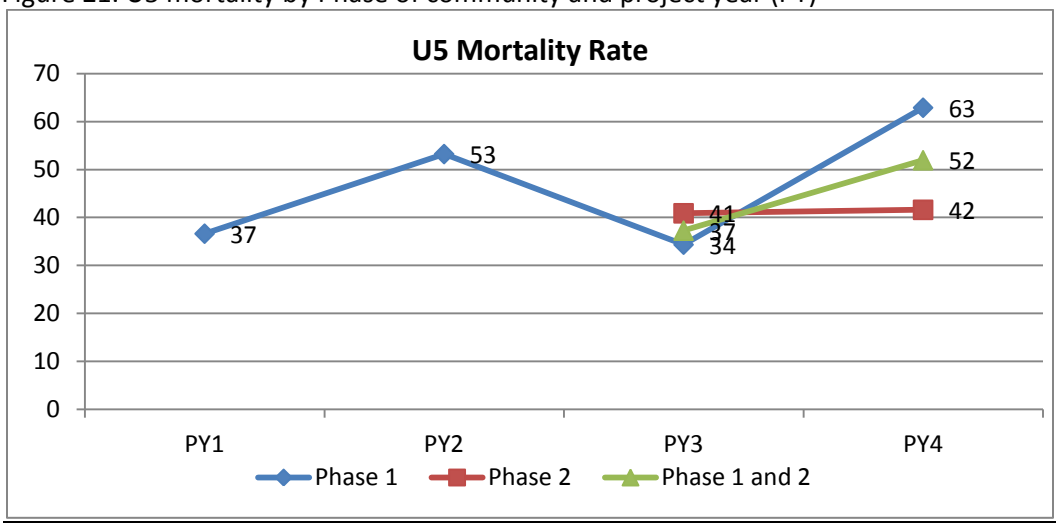
3f. Under-5 Mortality

With so few deaths in the 12-59 month age group, the pattern of under-5 mortality mirrors that of infant mortality. As with infant mortality, in Phase 1 communities we see a dramatic decline in the under-5 mortality rate (U5MR) from PY2 to PY3, from 53 to 34, and then an increase in PY4 to 63 (Table 20, Figure 21). The U5MR in Phase 2 communities remained virtually unchanged, from 41 in PY3 to 42 in PY4. The end-of-project U5MR was thus higher in Phase 1 communities (63) than in Phase 2 communities (42). For the communities of the combined Phases, the U5MR increased sharply from 37 in PY3 to 52 in PY4, due to the increased infant mortality in PY4 in Phase 1 communities, already noted above.

Table 20. Number of births, under-5 deaths, and under-5 mortality rates by project year (PY) and project area

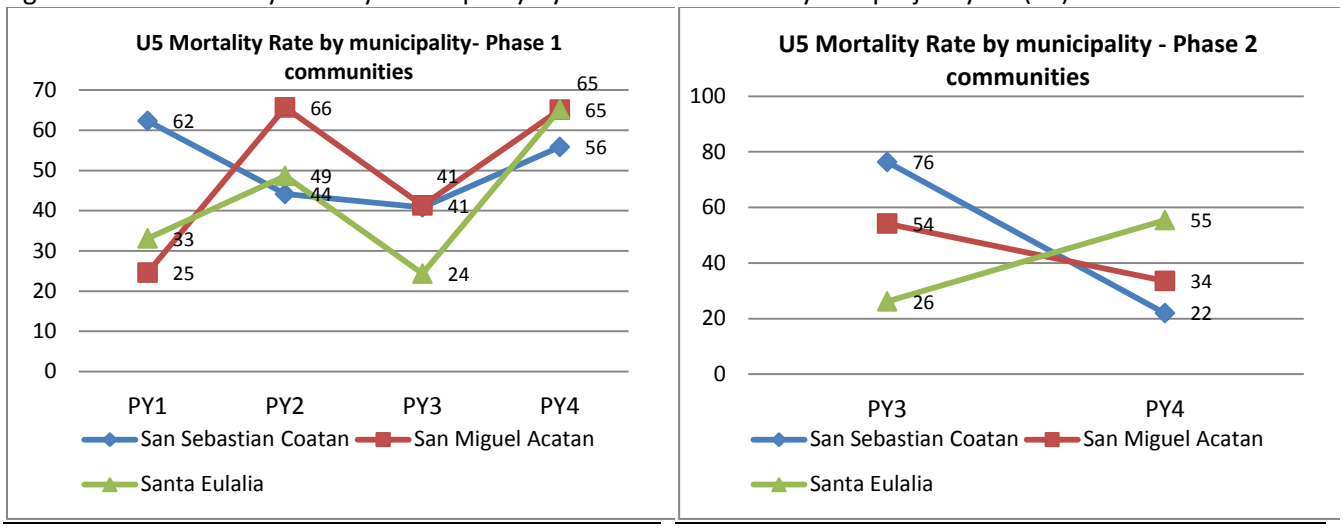
Project Year (PY)		Phase 1 communities			Phase 2 communities			Phase 1 and 2 communities combined		
		No. of live births	No. U5 deaths	U5 MR	No. of live births	No. U5 deaths	U5 MR	No. of live births	No. U5 deaths	U5 MR
PY1	OCT. 2011 - SEP. 2012	1,337	49	37						
PY2	OCT. 2012 - SEP. 2013	1,352	72	53						
PY3	OCT. 2013 - SEP. 2014	1,426	49	34	1,149	47	41	2,575	96	37
PY4	OCT 2014 - MAY 2015	906	57	63	961	40	42	1,867	97	52
PY1-4	Oct 2011- May 2015	5,021	227	45	2,110	87	41	4,442	193	43

Figure 21. U5 mortality by Phase of community and project year (PY)



Disaggregating by municipality, we see the same pattern as we saw for infant mortality, with the U5MR increasing in all three municipalities among the Phase 1 communities, though the net change from PY1 to PY4 for San Sebastian Coatán was a slight decrease from 62 in PY1 to 56 in PY4 (Figure 22). The U5MR increased in Santa Eulalia, while in San Miguel Acatán it remained virtually unchanged from PY2. Among the Phase 2 communities, the U5MR decreased markedly from PY3 to PY4 in San Sebastián Coatán (from 76 to 22) and in San Miguel Acatán (from 54 to 34), but increased in Santa Eulalia (from 26 to 55).

Figure 22. U5 Mortality Rate by municipality by Phase of community and project year (PY)

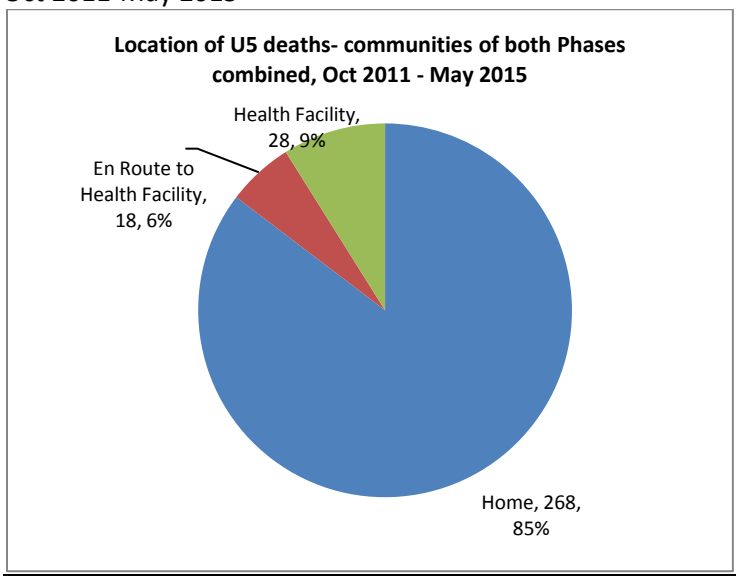


Examining the location of under-5 deaths, we see in each of the two project areas and in the entire project area that the vast majority of under-5 deaths (85%) occurred at home (Table 21, Figure 23). A smaller proportion of under-5 deaths occurred en route to a health facility (7%) than for maternal deaths (26%), as the latter were all cases of hemorrhage where time was a more critical factor. It should be noted that many children who died at home (n=27, or 10.1% of the total of 268 under-5 children who died at home) had been taken to a health facility where they were treated, but the child later died at home. In many of these cases the family had waited too long after noticing danger signs (see "four delays", below). In 12 (or 44.4% of the 27 cases) of the cases that we know of, the health facility referred the child to the hospital in Huehuetenango but the family did not take the child and the child soon died at home.

Table 21. Location of deaths of 0-59-month-old children by project year (PY) and project area

Location of death - U5 Deaths- Phase 1 communities (Oct 2011-May 2015)					Location of death - U5 Deaths- Phase 2 communities (Oct 2013-May 2015)			
Project Year	Home	En Route to Health Facility	Health Facility	Total	Home	En Route to Health Facility	Health Facility	Total
PY1	46	1	2	49				
PY2	61	6	5	72				
PY3	41	2	6	49	39	3	5	47
PY4	46	3	8	57	35	3	2	40
Total	194	12	21	227	74	6	7	87
Pctg.	85%	5%	9%	100%	85%	7%	8%	100%

Figure 23. Location of U5 death, communities of both Phases combined, Oct 2011-May 2015



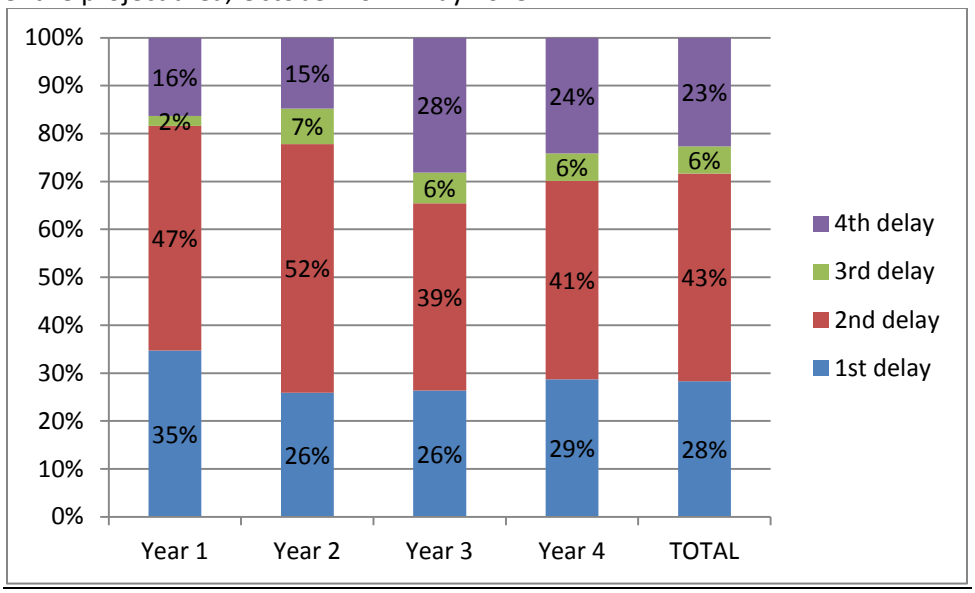
As they did with maternal deaths, the Institutional Facilitators, when possible from the verbal autopsy findings, attributed to every U5 death which of the "four delays" most contributed to the child's death. In Table 22 and Figure 24 we see that the second delay – recognizing but not responding to the danger signs, or responding too late – was by far the most common, accounting for 43% of U5 deaths in the communities of both Phases combined. The verbal autopsies did not always capture the reason for this delay, but the most common reasons cited include: 1) taking the child instead to a traditional healer (*curandero)* and/or attempting home herbal remedies; 2) deciding not to take the child to a clinic or to a hospital referral because of the poor/rude treatment anticipated; 3) lack of money to pay for transportation to the clinic or for the treatment at the hospital; and 4) traditional fatalistic attitudes towards child death , such as "God's will", or that the child's *nahual* [spirit]dictated that the child die.

Table 22. The "Four Delays", all U5 deaths, communities of both Phases combined (Oct 2011-May 2015)

Project Year	First Delay	Second Delay	Third Delay	Fourth Delay	Total*
PY 1	17	23	1	8	49
PY 2	14	28	4	8	54
PY 3	29	43	7	31	110
PY 4	25	36	5	21	87
Total	85	130	17	68	300*
	28%	43%	6%	23%	100%

*There were 14 U-5 deaths for which the delay could not be determined

Figure 24. Distribution of the "four delays" for all deaths of children 0-59 months of age for the entire project area, October 2011-May 2015



We do note, however, a decrease in the percentage of deaths attributed to the second delay, from 47% and 52% in PY1 and PY2 to 39% and 41% in PY3 and PY4; and a corresponding increase in the percentage of fourth delays (from 16% and 15% to 28% and 24%), suggesting that a greater proportion of sick children were being taken to health facilities (Figure 24). Also, despite the educational efforts of the project through its Care Groups, the percentage of families still not recognizing and responding to danger signs (1st delay), especially signs of pneumonia/ARI and diarrhea/dehydration, remained fairly constant from PY1 to PY4, with only a slight decline from 35% in PY1 to 29% in PY4.

Table 23. Causes of under-5 mortality by project area

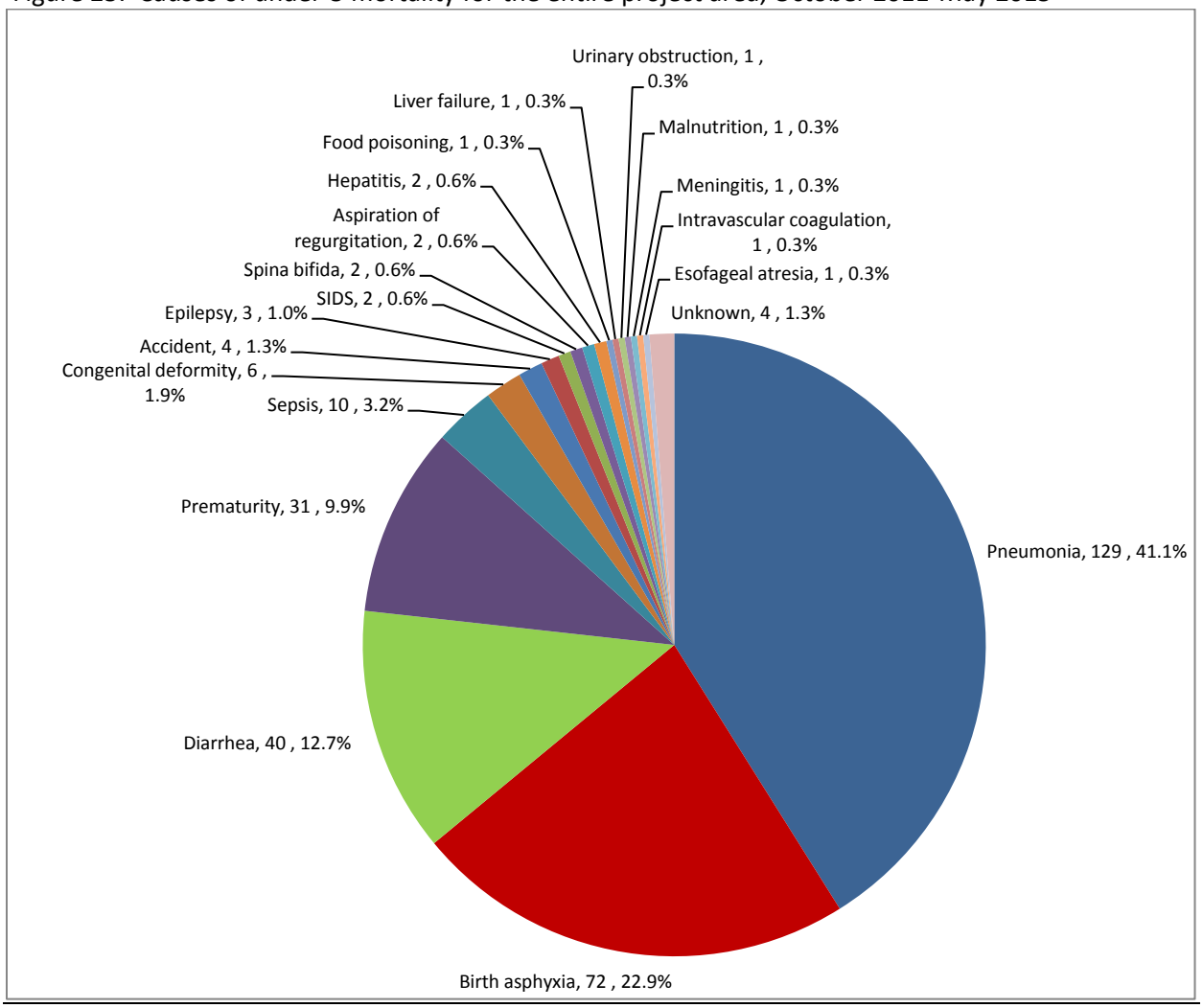
Phase 1 communities (Oct 2011- May 2015)			Phase 2 communities (Oct 2013-May 2015)		
Cause	**No.**	**Pctg.**	**Cause**	**No.**	**Pctg.**
Pneumonia/ARI	89	39.2%	Pneumonia/ARI	40	46.0%
Birth asphyxia	63	27.8%	Prematurity	12	13.8%
Diarrhea	34	15.0%	Birth asphyxia	9	10.3%
Prematurity	19	8.4%	Diarrhea	6	6.9%
Sepsis/other infection	4	1.8%	Sepsis/other infection	6	6.9%
Congenital deformity	4	1.8%	Aspiration of regurgitation	2	2.3%
Accidents	3	1.3%	Congenital deformity	2	2.3%
Epilepsy/convulsions	2	0.9%	Spina bifida	2	2.3%
Hepatitis	2	0.9%	Accident	1	1.1%
Urinary obstruction	1	0.4%	Esophageal atresia	1	1.1%
Liver failure	1	0.4%	SIDS	1	1.1%
SIDS	1	0.4%	Epilepsy/convulsions	1	1.1%
Food poisoning	1	0.4%	Intravascular coagulation	1	1.1%
Acute malnutrition	1	0.4%	Meningitis	1	1.1%
Unknown	2	0.9%	Unknown	2	2.3%
TOTAL	227	100%	TOTAL	87	100%

Table 24. Causes of U5 mortality, communities of Phase 1 and 2 combined

Cause	No.	Pctg.	Cum Pctg
Pneumonia/ARI	129	41.1%	41.1%
Birth asphyxia	72	22.9%	64.0%
Diarrhea	40	12.7%	76.8%
Complications of Prematurity	31	9.9%	86.6%
Sepsis/other infection	10	3.2%	89.8%
Congenital deformity	6	1.9%	91.7%
Accident	4	1.3%	93.0%
Epilepsy/Convulsions	3	1.0%	93.9%
Sudden Infant Death Syndrome (SIDS)	2	0.6%	94.6%
Spina bifida	2	0.6%	95.2%
Aspiration of regurgitation	2	0.6%	95.9%
Hepatitis	2	0.6%	96.5%
Food poisoning	1	0.3%	96.8%
Liver failure	1	0.3%	97.1%
Urinary obstruction	1	0.3%	97.5%
Acute Malnutrition	1	0.3%	97.8%
Meningitis	1	0.3%	98.1%
Intravascular coagulation	1	0.3%	98.4%
Esophageal atresia	1	0.3%	98.7%
Unknown	4	1.3%	100.0%
TOTAL	314	100.0%	

Looking at the causes of U5 mortality, we note the same pattern we saw for infant mortality – pneumonia/ARI was the leading cause, with 41% (n=129) of all U5 deaths (communities of both Phases combined), followed by birth asphyxia (23%, n=72), diarrhea (13%, n=40), complications of prematurity (10%, n=31), and sepsis (3%, n=10) (Table 23 and 24, Figure 25). These five causes accounted for 90% of all U5 mortality. The more common miscellaneous causes included congenital deformities (2%), accidents (1%), epilepsy/convulsions (1%), SIDS (1%), spina bifida (1%), aspiration of regurgitation (1%), and hepatitis (1%).

Figure 25. Causes of under-5 mortality for the entire project area, October 2011-May 2015



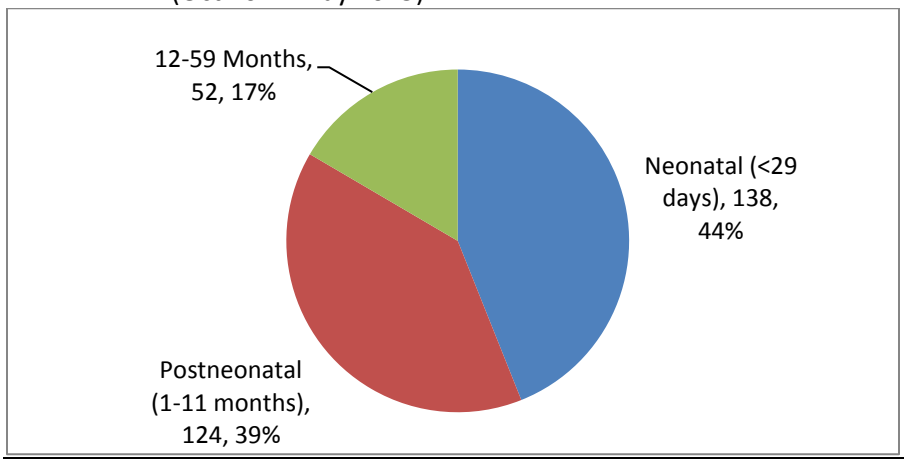
Comparing the two project areas, we see the same differences noted previously for infant mortality – a greater proportion of deaths from birth asphyxia and diarrhea in the Phase 1 communities, and a greater percentage of deaths from pneumonia/ARI, complications of prematurity, and sepsis in the Phase 2 communities (Table 23).

Looking at the distribution of the number of deaths by age group, we notice similar percentages in the two project areas. For the communities of the combined Phases, 44% of the deaths occurred during the neonatal period, 39% occurred during the post-neonatal period (yielding 83% of the under-5 deaths occurring during the first 12 months of life), and 17% were among children 12-59 months of age (Table 25, Figure 26).

Table 25. Number and percentage of under-5 deaths occurring by age group

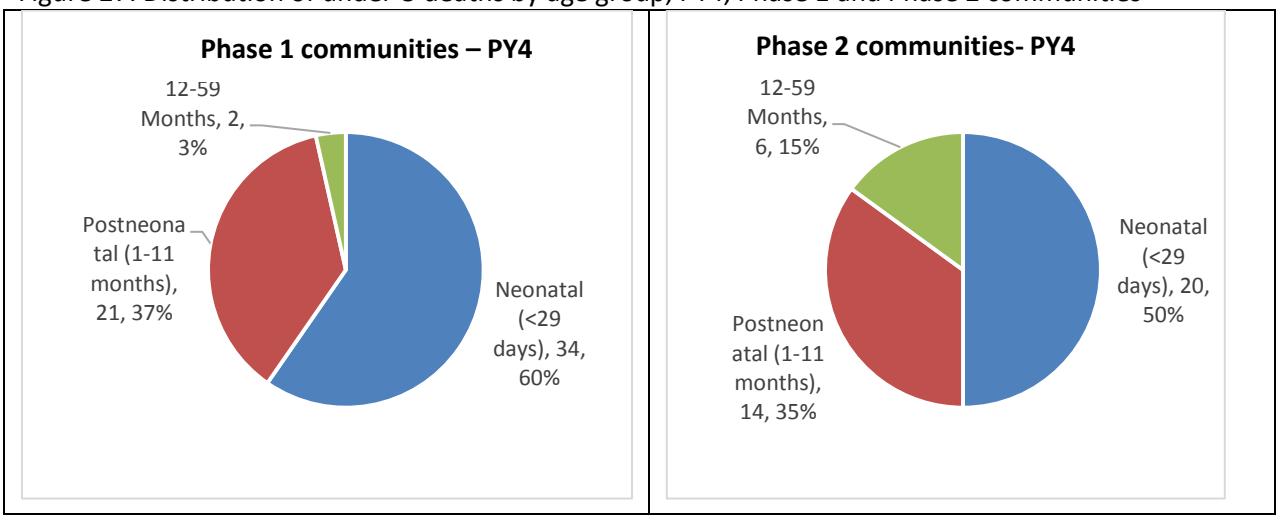
Age Group	Phase 1 communities (Oct 2011-May 2015)		Phase 2 communities (Oct 2013-May 2015)		Communities of both Phases combined (Oct 2011-May 2015)	
	No.	Pctg	No.	Pctg	No.	Pctg
Neonatal (0-28 days)	100	44.1%	38	43.7%	138	43.9%
Post-neonatal (1-11 months)	88	38.8%	36	41.4%	124	39.5%
12-59 Months	39	17.2%	13	14.9%	52	16.6%
Total	227	100%	87	100%	314	100%

Figure 26. Distribution of U5 death by age group, communities of both Phases combined (Oct 2011-May 2015)



However, given the great decline in 11-59 month mortality in the Phase 1 communities in PY4, we observe a very different age group distribution in PY4 when comparing the communities of the two Phases, with only 3% of Phase 1 community PY4 deaths in the 11-59 month age group compared to 15% of the 11-59-month deaths in the Phase 2 communities in PY4 (Figure 27). This and the increase already noted in neonatal deaths yielded a much higher percentage of neonatal deaths in the Phase 1 communities for PY4, 60% vs. only 50% for the Phase 2 communities. The percentage of post-neonatal deaths, on the other hand, was similar in both project areas.

Figure 27. Distribution of under-5 deaths by age group, PY4, Phase 1 and Phase 2 communities



3g. Casa Materna Partner Communities

We noted above a decline in the Maternal Mortality Ratio (MMR) in the Phase 1 communities from 524 in PY1 and 740 in PY2 to 221 in PY4 (Table 2). In the Phase 1 communities of San Sebastián Coatán, the Phase 1 MMR decline was the most dramatic of all the three municipalities, from 1,311 in PY1 to 0 in PY4, accounting for the greater part of the overall decline in the MMR achieved in the Phase 1 communities (Figure 2). Two of the project's three Casas Maternas were operating in the Phase 1 communities of San Sebastian Coatán during this period: the Calhuitz Casa Materna in San Sebastian Coatán was operating over all 4 years of the project; the Santo Domingo Casa Materna, also in San Sebastián Coatán, began operations in April 2013 (halfway through PY2). A third Casa Materna, in Tuzlaj Coya, began operations in May 2014, halfway through PY3) n the Phase 2 communities of San Miguel Acatán.

Each Casa Materna has a service catchment called a micro-region, with 7 to 10 communities that build and operate the Casa Materna: these are known as "partner communities." In the three micro-regions of the three Casa Maternas, there are a total of 26 partner communities (Table 1). The 19 partner communities of the Calhuitz and Santo Domingo Casa Maternas are all Phase 1 communities; the 7 partner communities of the Tuxlaj Coya Casa Materna are all Phase 2 communities.

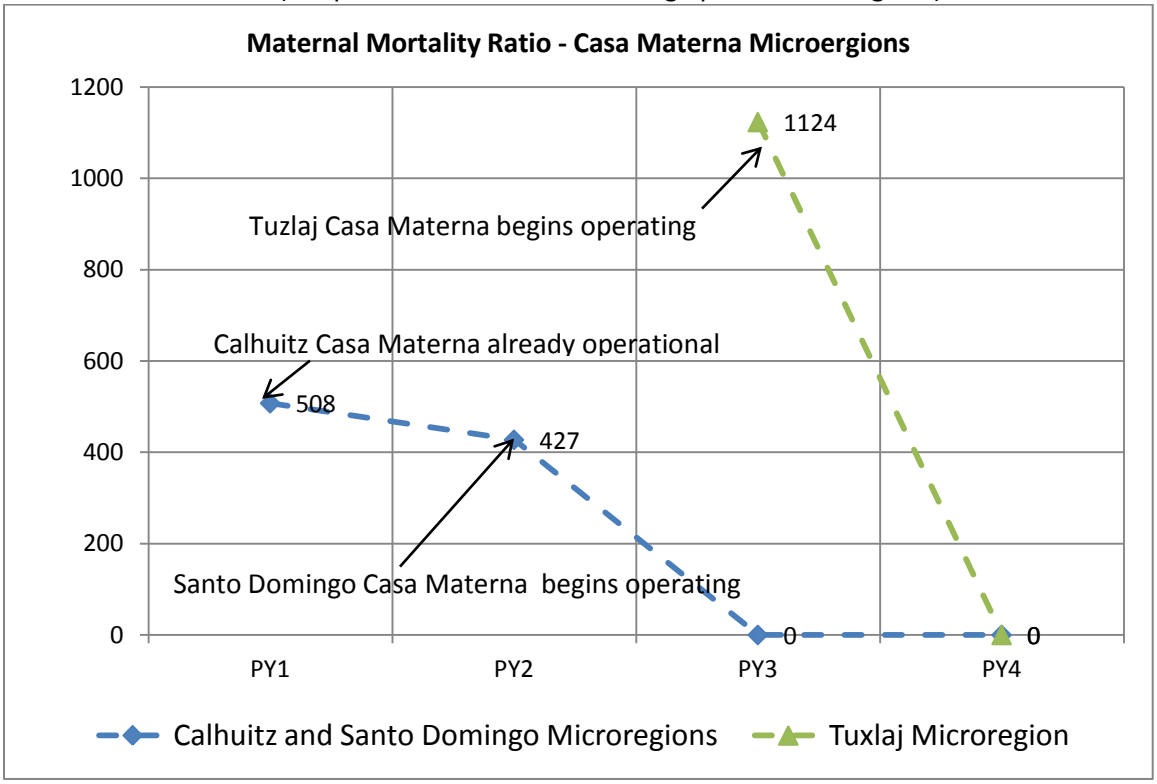
To estimate the contribution of the Casas Maternas to the reduction of maternal mortality, we disaggregated the maternal mortality data for the 26 partner communities of the three micro-regions of the three Casas Maternas and compared this data to the mortality data for the 154 other communities in the project area who are not Casa Materna partner communities (Table 26 and 27, Figure 27).

Table 26. Number of births and maternal deaths, and Maternal Mortality Ratios (MMR) in Casa Materna partner communities by project year (PY)

Project Year		Communities of Calhuitz and Santo Domingo Micro-regions (19 Phase 1 communities)			Communities of Tuxlaj Coya Micro-region (7 Phase 2 communities)			Communities of the 3 Micro-regions combined (26 communities from both Phases)		
		No. of live births	No. of maternal deaths	MMR	No. of live births	No. of maternal deaths	MMR	No. of live births	No. of maternal deaths	MMR
PY1	OCT. 2011 - SEP. 2012	197	1	508						
PY2	OCT. 2012 - SEP. 2013	234	1	427						
PY3	OCT. 2013 - SEP. 2014	184	0	0	89	1	1,124	273	1	366
PY4	OCT 2014 - MAY 2015	141	0	0	97	0	0	238	0	0
PY1-4	Oct 2011- May 2015	756	2	265	186	1	538	942	3	318

We see a marked decline in the MMR for the 19 communities of the two Phase 1 micro-regions supporting the Casas Maternas for Calhuitz and Santo Domingo, from 508 in PY1 to 0 in PY4, and for the 7 Phase 2 communities of the Tuzlaj-Coya micro-region, from 1,124 in PY3 to 0 in PY4 (Table 26, Figure 27). For the 26 communities of the three micro-regions combined, the MMR declined from 366 in PY3 to 0 in PY4.

Figure 27. Maternal Mortality Ratios by project year (PY) for communities that are supporting Casas Maternas (the partner communities making up the micro-regions)



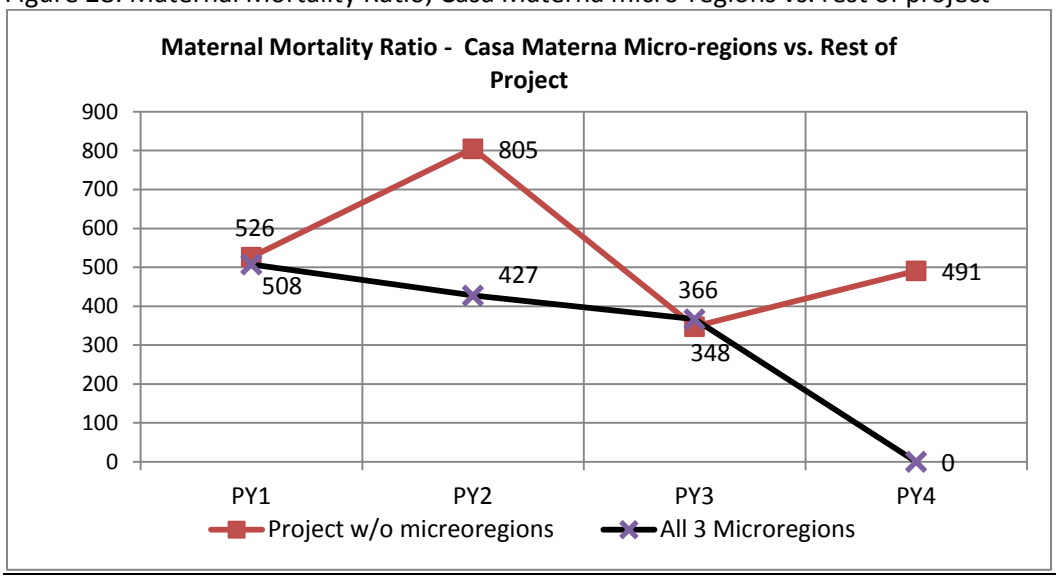
Comparing the data for the 26 communities of the combined three micro-regions with the data for the remaining 154 communities in the project area, we see that the MMR in the partner communities declined from 508 in PY1 to 0 in PY4, while for the rest of the project, the MMR rose from 526 to 805 from PY1 to PY2, declined to 348 in PY3, and rose to 491 in PY4 (Table 27, Figure 28). Thus, at end of project, the MMR in the 26 Casa Materna partner communities was 0 compared to 491 for the rest of the project's 154 communities.

Table 27. Number of live births, maternal deaths, and Maternal Mortality Ratios by project year and type of community (located in a micro-region supporting a Casa Materna, referred to as a partner community) or not)

Project Year		26 Casa Materna partner communities			154 non-partner communities		
		No. of live births	No. of maternal deaths	MMR	No. of live births	No. of maternal deaths	MMR
PY1*	OCT. 2011 - SEP. 2012*	197	1	508	1,140	6	526
PY2*	OCT. 2012 - SEP. 2013*	234	1	427	1,118	9	805
PY3**	OCT. 2013 - SEP. 2014 **	273	1	366	2,302	8	348
PY4**	OCT 2014 - MAY 2015 **	238	0	0	1,629	8	491
PY1-4**	Oct 2011- May 2015**	942	3	318	6,189	31	501

*- Phase 1 only; ** - combined Phase 1 and Phase 2

Figure 28. Maternal Mortality Ratio, Casa Materna micro-regions vs. rest of project



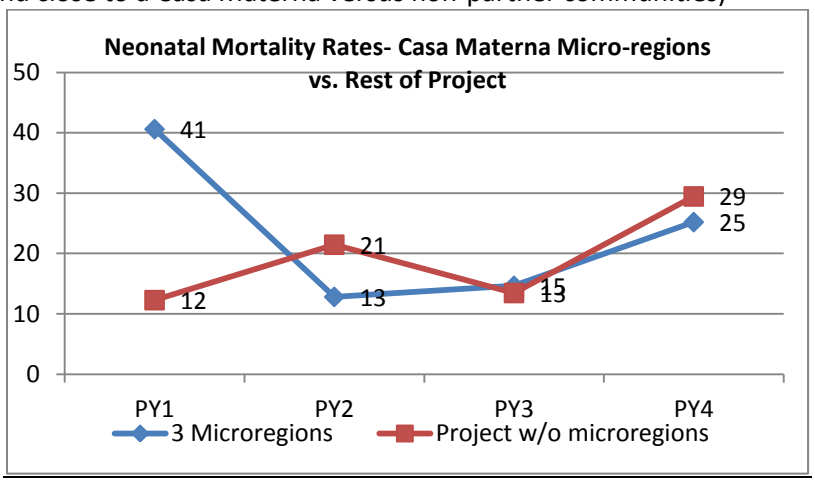
The differences in neonatal mortality, however, were minimal when comparing these same two groups of communities (Table 28, Figure 29). When looking at the data for PY3 and PY4 for the entire project area, including all three micro-regions, we see the same spike in neonatal mortality from PY3 to PY4 that we saw for the overall project. In the 3 micro-regions, the NNMR rose from 15 to 25 and in the other 154 non-partner communities, it rose from 13 to 29. Thus, the end-of-project NNMR was only slightly lower in the Casa Materna partner communities (25) than in the rest of the project's communities (29). However, we must note that of the 21 neonatal deaths recorded in the 26 partner communities, 17 (81%) were among neonates who were born at home rather than in the Casa Materna or other health facility, and only 4 (19%) were among newborns born in a health facility (3 were among births in a Casa Materna and 1 in a government health facility). *Thus, the increase in neonatal mortality seen throughout the project area in PY4 was almost exclusively among infants delivered at home*. The causes of death for the 4 neonates born at a health facility were birth asphyxia/aspiration of meconium (n=2), complications of prematurity/ Infant Respiratory Distress Syndrome (n=1), and pneumonia (n=1).

Table 28. Number of live births and neonatal deaths, and neonatal mortality rates in partner communities (supporting and close to Casas Maternas) and non-partner communities by project year

Project Year		26 Casa Materna partner communities (from both Phases)			154 non-partner communities (from both Phases)		
		No. of live births	No. of neonatal deaths	NNMR	No. of live births	No. of neonatal deaths	NNMR
PY1*	OCT. 2011 - SEP. 2012*	197	8	41	1140	14	12
PY2*	OCT. 2012 - SEP. 2013*	234	3	13	1118	24	21
PY3**	OCT. 2013 - SEP. 2014**	273	4	15	2302	31	13
PY4**	OCT 2014 - MAY 2015 **	238	6	25	1629	48	29
PY1-4**	Oct 2011- May 2015**	942	21	22	6189	117	19

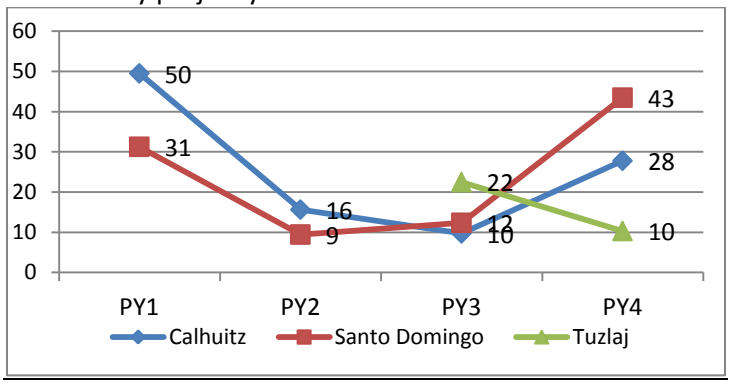
*- Phase 1 only; **- Phases 1 and 2 combined

Figure 29. Neonatal mortality rates by type of community (participating in and close to a Casa Materna versus non-partner communities)



Disaggregating the neonatal mortality data by micro-regions, however, we observe that the NNMR increased only in the Calhuitz and Santo Domingo micro-regions, which were comprised exclusively of Phase 1 communities (Figure 30). This mirrored the increase in NNMR seen for all Phase 1 communities in PY4. In contrast, the NNMR declined dramatically in the 7 Phase 2 communities of the Tuzlaj-Coya micro-region, from 22 to 10, mirroring a similar decline for all the Phase 2 communities of San Miguel Acatán, from 27 in PY3 to 18 in PY4 and contributing to this decline. Thus the NNM in the Casa Maternity partner communities reflected the neonatal mortality trends of their Phase.

Figure 30. Neonatal mortality rates in partner communities supporting Casas Maternas by project year



3h. Comparison of Project Mortality Data with Ministry of Health Data for the Department of Huehuetenango

The operational research protocol called for two sets of comparisons to assess the effectiveness of the CBIO + Care Group methodology in reducing maternal and child mortality. The first set involved comparisons of changes over time in mortality in the Phase 1 and Phase 2 communities as well as differences in the end-of-project mortality in the Phase 1 communities with the Phase 2 communities (as we reported in sections 3a-3f, above), and comparison of the project mortality data for its 3 municipalities with Ministry of Health (MSPAS) mortality data for three comparable municipalities outside the project area in Huehuetenango Department. The three comparison municipalities chosen were: 1) San Mateo, to compare with San Sebastián Coatán, which is also Chuj and contiguous with San Mateo); San Rafael de Independencia , to compare with San Miguel Acatán, which is also Akateko and contiguous with San Rafael; and 3) Barillas, to compare with Santa

Eulalia, which is also Q'anjobal and contiguous with Barillas. Since MSPAS data are available by calendar year only and are for the entire municipalities, we are able only to compare our data for the only calendar year for which we had complete (Phase 1 and Phase 2) vital events data for the entire three municipalities, 2014.

We first compared our vital events data for the calendar year 2014 from the project's three municipalities with the 2014 MSPAS data for the same municipalities in order to assess any differences in the capture of vital events (Table 29). We see moderate differences in the number of live births registered (primarily in San Sebastián Coatán). In all cases, the MSPAS data contain more live births than the Project data. However, the project's vital events system registered twice as many under-5 deaths as did the MSPAS system (115 versus 69 for the three municipalities combined). The relative under-registration of child deaths in the MSPAS system was particularly marked in San Miguel Acatán (14 compared to 53 in the Project's system) and virtually identical in San Sebastián Coatán. The MSPAS vital events system did register 5 maternal deaths in 2014 that the project did not identify (1 in San Miguel Acatán and 4 in Santa Eulalia).

Table 29. Comparison of the number of live births, deaths and mortality rates for mothers and children based on the Project's vital events with Ministry of Health (MSPAS) data for the calendar year 2014, by municipality

Mortality Indicator	Project- Jan - Dec 2014			MSPAS - Jan - Dec 2014			Difference - no. of live births	Pctg difference - live births	Difference no. of deaths	Pctg difference deaths
	No. of live births	No. of deaths	Mortality Ratio/ Rate	No. of live births	No. of deaths	Mortality Ratio/ Rate				
San Sebastian Coatán										
Maternal Mortality	497	2	402.4	613	2	326.3	-116	-19%	0	0%
Neonatal Mortality		11	22.1		6	9.8			5	45%
Post-neonatal Mortality		7	14.1		7	11.4			0	0%
Infant Mortality		18	36.2		13	21.2			5	28%
12-59 Month Mortality		2	4.0		3	4.9			-1	-50%
U5 Mortality		20	40.2		16	26.1			4	20%
San Miguel Acatán										
Maternal Mortality	941	1	106.3	1,013	2	197.4	-72	-7%	-1	-100%
Neonatal Mortality		25	26.6		0	0.0			25	100%
Post-neonatal Mortality		20	21.3		7	6.9			13	65%
Infant Mortality		45	47.8		7	6.9			38	84%
12-59 Month Mortality		8	8.5		7	6.9			1	13%
U5 Mortality		53	56.3		14	13.8			39	74%
Santa Eulalia										
Maternal Mortality	1,210	3	247.9	1,234	7	567.3	-24	-2%	-4	-133%
Neonatal Mortality		12	9.8		1	0.8			11	92%
Post-neonatal Mortality		20	16.5		15	12.2			5	25%
Infant Mortality		32	26.4		16	13.0			16	50%
12-59 Month Mortality		10	8.3		13	10.5			-3	-30%
U5 Mortality		42	34.7		29	23.5			13	31%

Table 30 compares the project's vital events data for its three municipalities with the MSPAS vital events data for the three comparison municipalities.

Table 30. Numbers of live births, deaths, and mortality ratios/rates for mothers andunder-5 children in the Projects three municipalities and in comparison municipalities, 2014.

Mortality Indicator	MSPAS Data Jan-Dec 2014			Project Data Jan-Dec 2014		
	No. of live births	No. of deaths	Mortality Rate	No. of live births	No. of deaths	Mortality Rate
	San Mateo			San Sebastian Coatán		
Maternal Mortality	1,477	3	203.1	497	2	402.4
Neonatal Mortality		1	0.7		11	22.1
Post-neonatal Mortality		5	3.4		7	14.1
Infant Mortality		6	4.1		18	36.2
12-59 Month Mortality		3	2.0		2	4.0
U5 Mortality		9	6.1		20	40.2
	San Rafael la Independencia			San Miguel Acatán		
Maternal Mortality	494	1	202.4	941	1	106.3
Neonatal Mortality		0	0.0		25	26.6
Post-neonatal Mortality		9	18.2		20	21.3
Infant Mortality		9	18.2		45	47.8
12-59 Month Mortality		5	10.1		8	8.5
U5 Mortality		14	28.3		53	56.3
	Barillas			Santa Eulalia		
Maternal Mortality	2,497	7	280.3	1,210	3	247.9
Neonatal Mortality		2	0.8		12	9.9
Post-neonatal Mortality		20	8.0		20	16.5
Infant Mortality		22	8.8		32	26.4
12-59 Month Mortality		29	11.6		10	8.3
U5 Mortality		51	20.4		42	34.7

The main finding arising from this comparison is that the maternal mortality ratios in the comparison municipalities and project municipalities appear to be generally comparable. On the other hand, the under-5 mortality rates (and the rates for sub-categories in the age group) are much higher in the Project's municipalities than in the comparison municipalities. Given the far better capture of under-5 deaths by the project noted above, it is likely that this difference is due to differences in capture of under-5 deaths and not due to inferior outcomes of the CBIO+Care Group methodology.

4. Discussion

The vital events data reveal three key project accomplishments:

1) A marked reduction in the Maternal Mortality Ratio (MMR) in the Phase 1 communities, from 740 deaths per 100,000 births in PY2 to 221 at end of project in May 2015.

2) The Casa Maternas appeared to have contributed significantly to this decline in the MMR in the Phase 1 communities. There were 0 maternal deaths in the 19 Phase 1 Casa Materna partner communities in both PY3 and PY4, a MMR of 0 for both project years.

3) The near elimination of 12-59 mortality in the Phase 1 communities, with only 2 deaths in the 12-59 month age group reported for PY4, a 12-59 month mortality rate of only 2.

Unfortunately, neonatal and post-neonatal mortality appears to have increased sharply from PY3 to PY4 in the Phase 1 communities and, as a result, the end-of-project neonatal, post-neonatal, and U5 mortality calculated were higher in the Phase 1 communities at end of project than they were in PY1.

Comparing end-of-project mortality ratios and rates in Phase 1 communities with those of Phase 2 communities, in the Phase 1 communities we see lower maternal mortality ratio and 12-59 month mortality rate, but higher neonatal, post-neonatal, infant, and under-5 mortality rates (Table 31).

Table 31. PY4 Mortality indicators, Phase 1 communities vs. Phase 2 communities

Mortality Indicator	Phase 1 communities PY4	Phase 2 communities PY4
Maternal Mortality Ratio	221	624
Neonatal Mortality Rate	*38*	*21*
Post-Neonatal Mortality Rate	*23*	*15*
Infant Mortality Rate	*61*	*35*
12-59 Month Mortality Rate	2	6
Under-5 Mortality Rate	*63*	*42*

Our hypothesis that we would see lower mortality ratios/rates across the board at end of project in the Phase 1 communities, due to the longer dose-response exposure to the project and its interventions, was not borne out. This is primarily due to the already-noted increase in neonatal mortality – and to a lesser degree, increased post-neonatal mortality – in the Phase 1 communities during PY4.

The reason for the observed spike in neonatal and post-neonatal mortality in Phase 1 communities (and in Santa Eulalia's Phase 2 communities) remains to be explained. We postulate several possible contributing factors:

1) Improved differentiation of stillbirths and neonatal deaths. The Institutional Facilitators (IFs) improved their verbal autopsy skills, especially in being able to distinguish stillbirths from neonatal deaths. In PY3 in the Phase 1 communities, stillbirths were 73% of combined stillbirths and neonatal deaths. But in PY4, that proportion dropped to only 53%, with a corollary increase in number of deaths classified as neonatal, and thus contributing to a sizeable increase in the calculated neonatal mortality rate.

2) Improved capture of child deaths. The project was continuously improving its vital events surveillance, particularly in PY4, when cell phone communication between project staff and community volunteers was systemized for more timely and efficient detection and response to vital events. In addition, the project had

been steadily building trust among the beneficiaries. All of this may have resulted in further improved capture of child deaths. As one IF commented, "This [PY4 neonatal mortality data] is our real baseline."

3) Loss of preventive and curative health services. The closure in the fall of 2014 of MSPAS's Extension of Coverage Program (PEC), implemented by Curamericas Guatemala and another Guatemalan NGO, ADIVES, over most of the project area, may have contributed to higher child mortality in PY4. The PEC program's ambulatory nurses make monthly visits to the villages, where they operate out of MSPAS health posts, and where they provide key services such as treatment and follow-up for sick children (including for pneumonia/ARI and diarrheal disease), childhood immunizations, Vitamin A supplementation, and antenatal and post-natal care for pregnant and puerperal women and neonates. When MSPAS closed the PEC program across all of Guatemala in October 2014, it meant the loss of these critical curative and preventive services provided by PEC's ambulatory nurses in the villages during all of PY4, which may have contributed to higher neonatal and post-neonatal mortality. Supporting this hypothesis is the project's June 2015 final KPC Survey, which revealed that several indicators of services provided by PEC had declined in Phase 1 communities from the January 2012 baseline KPC survey: Vitamin A supplementation for children declined from 79.1% to 74.3% ($p=0.216$), measles vaccination coverage from 79.3% to 64.8% ($p<.01$); and complete vaccination regimen coverage from 73.6% to 56.6% ($p<.01$).

4) Worsening poverty and increased cost of transportation. The most common reason given during the verbal autopsies for not transporting a sick child or woman with complications in pregnancy, labor or post-partum to a health facility was the cost of transportation. Data from an earlier survey shows that only 15% of families have access to a vehicle and rely on local private vans and buses. According to the Project's Director Dr. Mario Valdez, the cost of local transportation in the project area has risen sharply over the past year, impacting families' ability to afford transportation. In addition, the project area, one of extreme poverty, has long depended heavily on remittances from male heads of households working in the United States. Since the financial crisis in 2008, many men have returned home, unable to find work in the US. Remittances have dropped and there has been a corresponding increase in poverty. This, combined with higher transportation costs, may have combined with increased food insecurity to create a "perfect storm" resulting in higher neonatal and post-neonatal mortality. The verbal autopsies confirmed many instances when a sick child was taken to a local clinic but the family then declined the referral of the child to the hospital in Huehuetenango due to the high cost of that long-distance transportation (along with a fear of high hospital expenses as well).

5) Local effects of the Guatemalan political crisis. Guatemala is in the throes of a political crisis, with a disintegrating government riven by corruption unable to provide basic human services, particularly health services, as exemplified by the closure of PEC. This crisis is being felt down to the level of even the remote mountain villages of our project area, where local MSPAS health services have been crippled. During PY4, local MSPAS clinics in the project's municipalities were forced to close at times because staff had not been paid for months. This state of national crisis likely has had repercussions on health that our improved vital events surveillance may have detected.

We will need to further explore these possibilities to determine 1) if indeed there was an actual increase in neonatal and post-neonatal mortality or if it was purely a product of improved capture of child deaths; and, 2) if there was a real increase, the contributing causes.

The vital events data also shed light on the locally important epidemiological priorities, fulfilling the potential of a CBIO+CG project to act as a sentinel site. Pneumonia/ARI remains by far the primary killer of under-5 children, accounting for 41% of all under-5 deaths. Despite the marked increase detected during the life of the project (from the baseline and end-of-project KPC surveys) in the percentage of mothers who stated that they took a child ill with symptoms of pneumonia/ARI in the two weeks prior to the interview to a health

professional for treatment (from 26% at baseline to 52% at final, $p<0.01$), the number and proportion of pneumonia/ARI deaths in under-5 children changed little over the course of the project. A key reason for this detected by the verbal autopsies is that families continue to resist taking severely ill children to health facilities (second delay) due to 1) the cost of transportation; 2) anticipated poor treatment by clinic staff; 3) traditional fatalistic attitudes towards child death and 4) attachment to traditional medicine and healers.

This all combines to reinforce the case for Community Case Management (CCM) of pneumonia/ARI provided by community health workers as recommended by the World Health Organization. Through CCM, a community health worker is trained and equipped to promptly detect, treat, and follow-up most cases of pneumonia/ARI in the community, referring only the most critically ill children. Official MSPAS policy currently forbids CCM, with the rationale that it will lead to abuse of antibiotic use and lead to antibiotic-resistant strains of pneumococcal pathogens. The Project's vital events data – including the qualitative data from the verbal autopsies – provide strong evidence to justify MSPAS authorizing Curamericas to pilot a CCM project in this area in the near future. As the Casas Maternas now possess community pharmacies and trained personnel who speak the local languages, they can readily serve as the foundation of a CCM program.

The project maternal and neonatal mortality data also strongly reinforce the case for health facility deliveries, and particularly for deliveries in the Casas Maternas. *Virtually all (94%) maternal deaths and virtually all (95%) of neonatal deaths occurred when the mother delivered at home*. We also saw that in PY3, there were 0 maternal deaths in the 19 partner communities of the two Casas Maternas in operation at the time in Calhuitz and Santo Domingo, and that in PY4 there were again 0 maternal deaths in the combined 26 partner communities of the three then-operating Casa Maternas in Calhuitz, Santo Domingo, and Tuzlaj Coya. This can be attributed not only to the provision of clean, safe, high-quality deliveries characterized by active management of the third stage of labor (AMTSL), including the administration of uterotonic drugs, but also, during PY3 and PY4, the three Casas Maternas successfully made 51 referrals of women with obstetrical complications to the hospital in Huehuetenango, with only 1 maternal death (due to complications of anesthesia during a cesarean-section). Like CCM, Casas Maternas bring the vitally needed culturally-adapted health services provided in the Mayan language within proximity of families who are unable or unwilling to make expensive and arduous trips to health facilities where expensive and undignified treatment is expected in a language that Project inhabitants often do not well understand. Also, 80% of all maternal deaths over the course of the project were due to post-partum hemorrhage among women who delivered at home. This supports the case for the WHO-recommended strategy of having trained community health workers provide misoprostol to women who insist on delivering at home.

The vital events data also underline the challenge of geography and transportation in the Project area. Not only are families resisting transporting sick children to a referral facility due to cost, but we also observed that 26% of maternal deaths – all from post-partum hemorrhage - occurred en route to a health facility. The success story of the Casa Materna referrals is due in large part to the early recognition of complications and an emergency transport insurance scheme, whereby families of a pregnant woman pay Q80 (around US$10) early during the pregnancy to have 50% of the cost of emergency transportation covered, a potential savings of around $75, a huge sum for these families. Emergency transportation is coordinated with local on-call drivers and emergency medical technicians (EMTs) with an ambulance in San Antonio Huistia, located at the foot of the mountain. Due to this insurance scheme, there has been little resistance by the families to Casa Materna referrals of women with complications to the hospital in Huehuetenango. The vital events data clearly show the need to extend such a scheme to sick children and include transportation to local clinics and to the Casas Maternas as well as to the hospital in Huehuetenango. The project community of Chenen has implemented its own very successful community emergency transportation insurance scheme for women in labor that can serve as a model on which to build.

5. Limitations

Comparison of 2014 project data with 2014 MSPAS data for Santa Eulalia suggests that the project was not capturing all maternal deaths, thus underestimating maternal mortality in that municipality. However, we have not had the capacity to confirm the maternal deaths registered in the MSPAS system. The comparisons of the findings from the two vital events system are at best very rough. Both systems need strong quality of control systems and confirmation of births and deaths by a higher-level supervisor – neither of which is feasible at present because of lack of staff.

Attributing causes of death via verbal autopsies is an inherently challenging method due to issues of lack of trust, recall error, and the unreliability of witnesses and family members affected by shame and guilt. This also makes attributing one of the four delays for a maternal or under-5 death a difficult process as well. Ideally, there is a clear written methodology/algorithm for attributing the delay, which the project lacked. The Institutional Facilitators (IFs) thus may not have all used the same criteria for assigning cause of death and reasons for delays in referral. In addition, the families interviewed may have been unreliable witnesses, claiming to not have recognized danger signs to absolve themselves of guilt.

The comparisons of the project vital events data with the MSPAS vital events data for the three comparison municipalities likely is not a meaningful comparison, given 1) the large discrepancies noted in vital events capture, particularly the MSPAS under-reporting of child mortality; and 2) the difficulty of finding three truly comparable municipalities, similar in ethnicity, terrain, and agricultural productivity/socio-economic indicators, and quality of vital events registration. The three comparison municipalities – San Mateo, San Rafael, and Barillas – while contiguous with their comparison municipality and of the same ethnicity, all contain extensive portions which are lower in altitude (and hence warmer) with longer growing seasons that our three municipalities lack, allowing the comparison areas to have greater agricultural production and hence less extreme poverty, with presumably favorable effects on maternal and under-5 mortality.

Due to the small numbers involved, confidence intervals for the mortality ratios/rates calculated are very large and therefore none of the differences noted are statistically significant. We would need to be working with a far larger population to detect significant differences. Future vital events analyses may require much larger service catchment, and/or longer time frames and comparing the consolidated vital events data for two or even three year periods.

6. Recommendations

1) Develop a clear written questionnaire/algorithm for determining which of the “four delays” is applicable to a cause of death. There is now a “social” verbal autopsy being developed by WHO which may address these issues.

2) Further improve the classification system for causes of death to reduce inconsistent classifications and the need for data cleaning. We suggest, for maternal deaths, utilizing the recently published WHO guidelines for classification of maternal deaths.

4) Develop and implement a clear algorithm/questionnaire for distinguishing stillbirths from neonatal deaths soon after birth to improve the quality of classification.

5) Petition the new administration of MSPAS to permit Curamericas to implement a pilot CCM project for pneumonia/ARI in the micro-regions of the four operating Casa Maternas, using the existing vital events data to support our case, with the Casa Maternas as the base for the CCM services and the vital events system to monitor progress.

6) Petition the new administration of MSPAS to permit Curamericas to implement a pilot project for the distribution of misoprostol by Community Facilitators to women who insist on delivering at home in the micro-regions of the four operating Casa Maternas, using the existing vital events data to support our case.

7) Extend and adapt the Casa Materna emergency transport scheme to all communities to cover transportation of sick children to local health facilities – including to Casa Maternas – as well as to the referral hospital in Huehuetenango. Also consider adapting the model piloted by the community of Chenen.

8) Procure MSPAS financial and logistical support to maintain and improve the project's vital events surveillance system so that it may serve as a national sentinel site as well as a national model for an improved national vital events registration system. This can involve incorporating data management software, m-Health cloud-based data transmission and storage, and integration of the project vital events HIS into the national health information system, the Sistema de información gerencial de salud (SIGSA).