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Impact of a Community-based Comprehensive Primary Healthcare Programme on Infant and Child Mortality in Bolivia

Henry B. Perry[1], David S. Shanklin[2], and Dirk G. Schroeder[3]

[1]Future Generations, Franklin, WV 26807, USA, [2]PRIME II/IntraHealth International, Chapel Hill, NC, USA, and [3]Rollins School of Public Health, Emory University, Atlanta, GA 30322, USA

ABSTRACT

Community-based comprehensive primary healthcare programmes are a widely-promoted strategy for improving child survival in less-developed countries, but limited documentation exists concerning their effectiveness in actually reducing child mortality. This study examined the impact of a community-based comprehensive primary healthcare programme on child survival in Bolivia. Mortality rates from two intervention areas where Andean Rural Health Care (ARHC) had been conducting child-survival activities for 5-9 years were compared with those from two geographically-adjacent comparison areas that lacked such activities and that were virtually identical to the intervention areas in socioeconomic characteristics. Vital events were registered at the time of regular visit to all homes. In the comparison areas, limited services were available which reached only a small percentage of the population, while in the intervention areas, prenatal care, immunizations, growth monitoring, nutrition rehabilitation, and acute curative services were readily available to the entire population. In 1992-1993, the annual rates of mortality of children, aged less than five years, were 205.5 per 1,000 and 98.5 per 1,000 in the comparison and intervention areas respectively. The absolute difference in mortality of 107.0 deaths per 1,000 (95% confidence interval [CI], 72.7-141.3 per 1,000) represented 52.1% (95% CI, 35.2-68.8%) lower mortality of children aged less than five years in the intervention areas compared to the control communities. These results suggest that the provision of community-based, integrated health services can significantly improve child survival in poor countries. Better-designed and larger field trials of community-based comprehensive primary healthcare programmes in multiple regions of the world are needed to provide a stronger scientific basis for developing this approach further in developing countries.

***Key words*:** Infant mortality; Child mortality; Child survival; Primary healthcare; Impact studies; Community programmes; Bolivia

INTRODUCTION

Approximately, 10.5 million children aged less than five years die each year in less-developed countries, mostly from readily-preventable or treatable conditions (1). Child-survival programmes that emphasize immunizations, prevention and treatment of acute respiratory infection and diarrhoea, growth monitoring, and appropriate infant-feeding continue to be recommended strategies for reducing the number of these deaths (2). Although such child-survival programmes usually undergo periodic review, these evaluations are rarely published in the scientific literature, and they usually focus on process and coverage indicators rather than on impact mortality.

Results of the few published evaluations of primary healthcare programmes that assessed the impact of mortality suggest that substantial improvements can be achieved. Reductions in infant or child (<5 years) mortality ranging

Correspondence and reprint requests should be addressed to: Dr. Henry B. Perry
Future Generations
HC 73 Box 100
Franklin, WV 26807
USA
Email: hperry3@earthlink.net
Fax : 304-358-3008

from 10% to 78% have been documented within 5-20 years after implementation (3-18). Many of these published evaluations are retrospective in nature, lack comparison or control groups, or lack a full description of the methodology used (19,20). Given the global importance of the problem of infant and child mortality and the growing level of resources being directed at this problem, additional well-conducted impact evaluations of child-survival efforts are needed (19).

The present study examined the impact on infant and child mortality of a community-based comprehensive primary healthcare programme carried out in two rural regions of Bolivia, South America. We use the term 'comprehensive' to emphasize the fact that these primary healthcare programmes provided more than child-survival interventions. In fact, these programmes provided a broad range of preventive and curative care services for all age groups in the entire population that they served, with an emphasis on maternal and child health.

The programme was implemented by two Bolivian non-governmental organizations: Consejo de Salud Rural Andino (CSRA) and Asociaciòn de Programas de Salud del Area Rural (APSAR). Andean Rural Health Care (ARHC), a U.S.-based private voluntary organization (PVO) receiving support from PVO Child Survival Program of the U.S. Agency for International Development, provided financial and technical assistance. For the sake of simplicity, we will refer to ARHC as the overall implementing organization. Since the time of this study, ARHC changed its name to Curamericas.

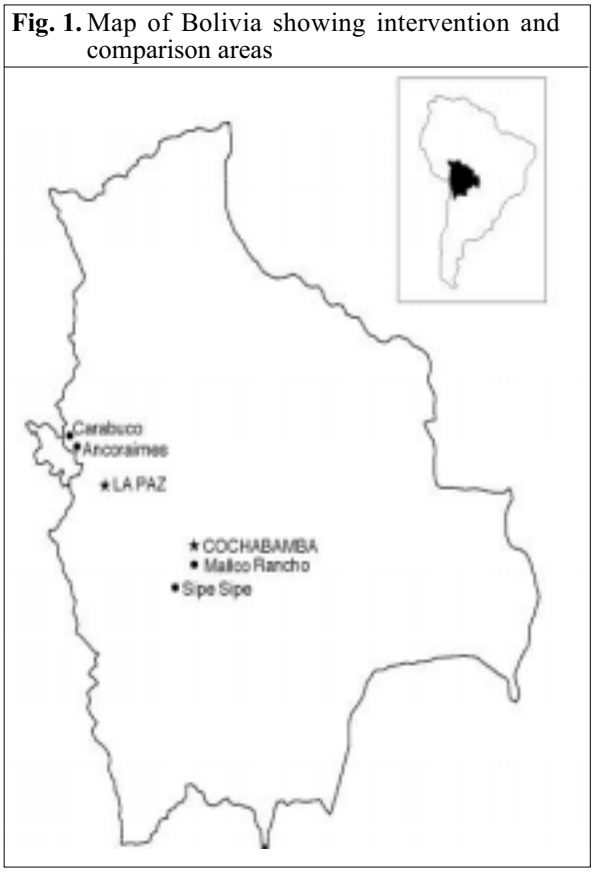
MATERIALS AND METHODS

Study areas

Data from four health service areas were compared in this paper (Fig. 1). In two areas—Carabuco and Mallco Rancho—ARHC had been coordinating health services since 1983 and 1987 respectively and are, therefore, referred to as intervention areas. Data gathered from January 1992 to December 1993 in these two intervention areas were compared with those from two geographically-adjacent areas—Ancoraimes and Sipe-Sipe. In April 1992, ARHC began the initial stages of establishing health services in Ancoraimes and Sipe-Sipe. During that time, ARHC worked with a sub-sample of the communities in these areas to carry out censuses and prospectively gather vital statistics.

Carabuco and Ancoraimes are located on the Bolivian *altiplano* (high plain) and are inhabited by Aymara Native Americans living in small isolated rural villages. In addition to being geographically adjacent to one another, Carabuco and Ancoraimes are very similar in socioeconomic terms (Table 1). Mallco Rancho and Sipe-Sipe are also contiguous and very similar in socioeconomic terms (Fig. 1 and Table 1). These are located in the mountainous valley region of Bolivia and are inhabited by Quechua Native Americans living in small, semi-rural villages. Inhabitants of all four health service areas maintain a subsistence life-style based primarily on agriculture and domestic livestock production.

Fig. 1. Map of Bolivia showing intervention and comparison areas



Censuses and assessment of mortality

Village maps were prepared in collaboration with local residents, houses were numbered, and each resident was enrolled in a census. During the census process, basic socioeconomic data were collected for each household. The health workers registered vital events (births, deaths, and migrations) during their subsequent home visits, and the programme staff recorded the vital events centrally. Vital events were confirmed by the programme supervisors and reviewed by both programme physicians and two of us (HBP and DSS) during periodic site visits.

The methods for collecting vital events data were equivalent in the intervention and comparison areas. In the comparison areas, data on vital events were collected from April 1992 to March 1993 for a selected subset of communities. Health data, including mortality rates, were not available for comparison communities prior to this time, and the selection of these comparison communities was based solely on factors relating to project start-up, namely ease of access and willingness to participate. In Ancoraimes, eight comparison communities with a total population of 2,008 and in Sipe-Sipe, eight comparison communities with a total population of 2,064 were included. Figure 2 shows the timeline of programme implementation and registration of vital events in the two intervention and two comparison sites.

Trained health staff conducted an unstructured interview with a family member to determine the cause(s) of death. In most cases, a local health worker talked to the mother within one month of the death. These workers had received training in the signs and symptoms of serious childhood illnesses. A programme physician, in discussion with the health staff, usually determined the final cause.

Activities in the intervention areas

In the two intervention areas, ARHC was the primary provider of health services. In accordance with written terms of the agreement between ARHC and the Bolivian Ministry of Health (MoH), MoH facilities, staff, and supplies in the intervention areas were coordinated with ARHC programmes to maximize efficiency. ARHC programme services were provided by full-time, paid auxiliary nurses and unpaid, part-time community health volunteers. When possible, paid staff members were recruited from local communities, thus increasing community acceptance and participation. These community staff members were supported by one mid-level health professional and one physician for approximately 5,000 inhabitants each (Table 2). These higher-level staff members were based in centrally-located health facilities within the intervention areas.

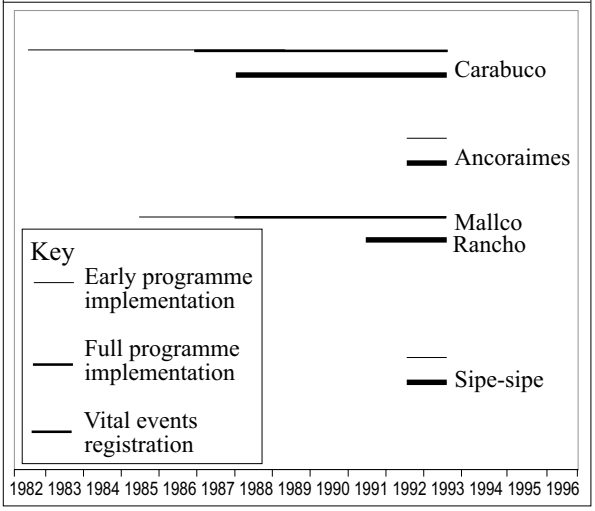
Community-perceived priorities for health services were ascertained on entry into each new community. These, together with epidemiological data gathered at the time of the initial village censuses, were used for designing initial programme activities. Programme priorities were re-assessed on an annual basis. This methodology is referred to as the census-based, impact-oriented (CBIO) approach (21,22).

Table 1. Basic demographic and socioeconomic characteristics for intervention and comparison areas of ARHC, Bolivia, 1992-1993

Characteristics	Altiplano area		Mountainous valley area	
	Carabuco (intervention)	Ancoraimes (comparison)	Mallco Rancho (intervention)	Sipe-Sipe (comparison)
Total population (1993)	9,000	14,500	6,400	9,900
Total number of communities	31	52	11	17
Population under surveillance (1993)	9,000	2,008*	6,400	2,064*
Number of communities under surveillance (1993)	31	8	11	8
Illiteracy rate (%)				
Male	17	19	12	10
Female	46	56	27	27
Households with no electricity (%)	80	80	23	26
Households with no piped water (%)	88	69	43	40
Households with no toilet or latrine (%)	94	89	57	60

* Vital events registration commenced in only a portion of the Ancoraimes and Sipe-sipe comparison areas during 1992-1993

Fig. 2. Dates of implementation of ARHC programme and vital events registration, by service area



Programme staff visited all homes in the ARHC intervention and comparison areas at least once a year. Additional visits were scheduled according to the risk profile of the individual households. Households with children aged less than two years and those with children aged 3-5 years were visited every two and four months respectively. Households with women of child-bearing age were visited at least every four months. Families with sick individuals were visited more frequently, as needed.

Table 2. Comparison of primary healthcare programme staffing levels in intervention and comparison areas, 1992

Type of staff	Actual no. of staff				No. of staff per 10,000 population	
	Intervention area		Comparison area			
	Carabuco (population 9,000)	Mallco Rancho (population 6,400)	Ancoraimes (population 14,500)	Sipe-Sipe (population 9,900)	Intervention area (Carabuco and Mallco Rancho)	Comparison area (Ancoraimes and Sipe-Sipe
Physician	2	1	1	1	1.9	0.8
Mid-level health staff (health technician, graduate nurse)	2	2	1	1	2.6	0.8
Lower-level health staff (auxiliary nurse)	12	2	1	1	9.0	0.8
Ancillary staff (driver, maintenance staff)	2	4	1	1	3.9	0.8
Administrative staff	3.5	4	0	0	4.9	0.0

ARHC provided community-based comprehensive primary healthcare services in the intervention communities. These included: provision of immunizations and vitamin A capsules in accordance with MoH policies, growth monitoring, prenatal healthcare, health education (particularly relating to the prevention and treatment of diarrhoea, the early warning signs of childhood pneumonia, and the promotion of appropriate infant feeding), treatment of pneumonia and diarrhoea, emergency assistance with complications arising during childbirth, and treatment of acute and chronic conditions for persons of all ages (including transport of those with medical emergencies to a referral hospital). Fixed clinics were established within a one-hour walk of most population, and services were provided at the time of routine home visit to all homes. There were no significant additional health or development activities carried out in the intervention areas. Efforts were made to improve the availability of clean water and sanitation in the intervention communities, but these reached fewer than 10% of the households. Further information about access to primary healthcare in the Carabuco area and about the implementation of programme services in Carabuco and Mallco Rancho has been reported elsewhere (22,23).

Primary healthcare was well-developed in the intervention communities by 1993. An assessment conducted then documented that 95% of children aged 12-23 months in the intervention areas were enrolled in the health programme. Review of their immunization cards showed that 78% of children were fully vaccinated, and 80% had been weighed and the result recorded on a growth chart during the previous 12 months. In addition, the coverage evaluation surveys demonstrated that 75% of mothers had heard of oral rehydration therapy, and 60% were able to correctly prepare oral rehydration solution. Similarly, 60% of mothers with a child showing danger signs of pneumonia during the past two weeks reported seeking medical treatment for their children (22). One notable exception in regard to high level of coverage of services in the intervention communities was the distribution of high-dose vitamin A capsules among children, which was sporadic between 1990 and 1993 due to repeated changes in MoH policies and sporadic unavailability of capsules.

Prior to April 1992, the populations in the comparison communities were served by minimally-staffed government clinics that lacked supplies. The staffing levels of primary healthcare providers in the comparison areas were much lower compared to the intervention areas (Table 2). The clinics in the comparison areas were frequently closed unexpectedly and, when they were open, the use was modest compared to the use at ARHC facilities.

In 1992, ARHC documented that only 2% and 12% of children, aged 12-23 months, in Ancoraimes and Sipe-Sipe respectively had received the complete series of vaccinations (22). Levels of immunization coverage, growth monitoring, the mother's ability to prepare oral

rehydration fluid, the mother's knowledge of warning signs for pneumonia, and treatment-seeking behaviour for children with respiratory symptoms in the comparison communities were substantially less favourable than that in the intervention areas but similar to comparable groups elsewhere in Bolivia (Table 3).

Collection of information on vital events

In both intervention and comparison communities, registers were maintained for all children aged less than five years. Deaths, births, and total populations were tabulated from programme registries for each calendar year for the intervention areas. In the comparison areas, the calculation of mortality rates was based on data obtained during household visits at least every four months during April 1992-March 1993, when ARHC first began working in these communities. Data obtained later from the comparison areas could no longer be considered baseline data since ARHC programme activities were fully implemented by that time.

The calculation of mortality rates in the intervention areas was limited to data for 1992 and 1993 to provide maximum comparability with the data from the comparison areas during a similar time period. The two full years of data collected in 1992-1993 from the intervention communities were used so that the mortality rates there would be more robust. Beyond the services in the intervention areas provided by AHRC, no other events, such as epidemics or vaccine campaigns that could account for mortality differences between the intervention

Table 3. Comparison of child-survival programme information for ARHC intervention and comparison areas (1993-1994) and for Bolivia nationally (1989-1994)

Child-survival programme information	Percentage of target group			
	Intervention area (Carabuco and Mallco Rancho)	Comparison area (Ancoraimes and Sipe-Sipe)	Bolivia (DHS survey, 1989)*	Bolivia (DHS survey, 1994)*
Evidence of participation in the health services system as evidenced by possession of a growth and vaccination card among all children surveyed	95	31	18	28
Completion of the entire series of vaccinations (BCG, 3 doses of polio and DPT, and measles vaccine) among children aged 12-23 months	78**	8**	8†	28†
Mothers who could correctly prepare oral rehydration fluid	60	36	NA	NA
Mothers who could name at least one of the warning signs for acute respiratory infection	57	18	NA	NA
Mothers who sought assistance from a trained healthcare provider when their child developed cough and difficult breathing	42	21	23	31
Receipt of 3 or more growth monitoring during the previous 12 months among children aged 12-23 months	80	8	NA	NA

* Calculated by averaging DHS data for rural respondents and for respondents who have no more than five years of education

** Based on card documentation only

† Based on card documentation and mother's history

DHS=Demographic and health survey

NA=Not available

Sources: 1993 survey of households with a child 0-23 month(s) of age in Carabuco (unpublished); 1993 survey of households with a child 0-23 month(s) of age in Mallco Rancho (unpublished); 1992 survey of households with a child 12-35 months of age in Ancoraimes (unpublished); 1992 survey of households with a child 12-35 months of age in Sipe Sipe (unpublished); 1989 DHS data, based on card plus history (24); and 1994 DHS data, based on card plus history (25)

and the comparison areas, occurred before or during this time period.

Collection of information on vital events

In both intervention and comparison communities, registers were maintained for all children aged less than five years. Deaths, births, and total populations were tabulated from programme registries for each calendar year for the intervention areas. In the comparison areas, the calculation of mortality rates was based on data obtained during household visits at least every four months during April 1992-March 1993, when ARHC first began working in these communities. Data obtained later from the comparison areas could no longer be considered baseline data since ARHC programme activities were fully implemented by that time.

The calculation of mortality rates in the intervention areas was limited to data for 1992 and 1993 to provide maximum comparability with the data from the comparison areas during a similar time period. The two full years of data collected in 1992-1993 from the intervention communities were used so that the mortality rates there would be more robust. Beyond the services in the intervention areas provided by AHRC, no other events, such as epidemics or vaccine campaigns that could account for mortality differences between the intervention and the comparison areas, occurred before or during this time period.

Epidemiological and financial analyses

For quantitative comparisons, weighted averages of the two years of data from the intervention areas were used for calculating annual mortality rates. Mortality of children, aged less than five years, was estimated as the infant mortality rate plus four times the 12-59-month mortality rate. Absolute differences between the intervention and the comparison areas and risk ratios (expressed as percent reduction in risk of death) were calculated. The statistical significance of the differences between the study and the comparison areas was tested by comparing incidence rates (26). Confidence intervals for the difference between rates were calculated as described by Fleiss (27). Data were analyzed using Epi Info 6.0 (CDC, Atlanta, GA, USA) and SAS 6.11 (Cary, NC, USA).

Costs per participant in the programme and costs per child-life saved were calculated based on local programme costs. Local programme expenses were determined by adding personnel costs (including training costs), administrative costs, transportation costs, supply costs (including the value of items donated by MoH, such as vaccines, drugs, and supplies), and infrastructure costs. Capital expenses were depreciated and were included in determinations of annual costs. The cost of personnel provided by MoH was also included. Costs relating to the operation of the national ARHC office in La Paz and costs relating to the operation of ARHC's international office in the United States were not included.

The cost per year of life saved was estimated by first estimating the number of deaths in each one-year age group saved in the intervention areas by the programme (based on the difference in mortality rates between the intervention and the comparison areas and on the population in each age group). The number of years of life saved by the programme was calculated by subtracting from 65 the age at death for mid-point of each age group. Thus, for deaths in the second year of life, the mid-point is 1.5 years. Thus, the number of years of life for children in that age group whose deaths were averted was 63.5 times the number of deaths averted in that age group. The cost per year of life saved was computed to be the total programme costs per year divided by the number of years of life saved per year.

RESULTS

During January 1992–December 1993, 76 children died in the intervention areas, whereas in the comparison areas, 25 children died during April 1992–March 1993. Calculated annual infant and child mortality rates for each of the intervention and comparison areas are presented in Table 4. The lower infant mortality rate in Mallco Rancho compared to Carabuco is likely due to the slightly better socioeconomic conditions in Mallco Rancho (Table 1) and the closer proximity of the communities in the Mallco Rancho intervention area to local and referral health services.

In Table 5, mortality data for the intervention areas have been combined for the January 1992–December 1993 period and were compared with the one-year data obtained from the comparison areas during April 1992–March 1993. The differences in mortality rates were statistically significant for two of three age groups tested. For the age group of 12-59 months, there was a difference in mortality rates of 16.5 per 1,000 livebirths–from 22.2 in the comparison areas to 5.7 per 1,000 livebirths ($p<0.01$) in the intervention areas. For the age group of 0-59 month(s), there was also a statistically significant

difference ($p<0.001$) in mortality rates of 107 per 1,000 livebirths—from a rate of 205.5 in the comparison areas to 98.5 in the intervention areas. Only among infants aged 0-11 month(s) was the difference in mortality rates not statistically significant ($p>0.05$), despite an apparent difference of 41 deaths per 1,000 livebirths, from 116.7 in the comparison areas to 75.7 in the intervention areas. Separate analyses carried out by the authors in which the data used for calculation of mortality rates in the intervention areas were limited to the same time period as that used for the calculation of mortality rates in the comparison areas provided essentially the same findings, but were not statistically significant.

Table 4. Mortality rates among children aged 0-59 month(s) in intervention and comparison areas of ARHC, Bolivia, 1992-1993

Mortality rate by age	Intervention area				Comparison area	
	Carabuco		Mallco Rancho		Ancoraimes	Sipe-Sipe
	1992	1993	1992	1993	April 1992–March 1993	April 1992–March 1993
0-11 month(s) of age						
Number of deaths	19	16	9	12	9	5
Number of births	215	171	194	160	73	47
Population [(0-11 month(s)]	210	197	150	151	60	51
Infant mortality rate	88.4	93.6	46.4	75.0	123.3	106.4
12-59 months of age						
Number of deaths	6	4	7	3	5	6
Population (12-59 months of age)	922	880	729	967	235	250
Mortality rate per 1,000 children (12-59 months of age)	6.5	4.5	9.6	3.1	21.3	24.0
0-59 month(s) of age						
Number of deaths	25	20	16	15	14	11
Population [(0-59 month(s)]	1,132	1,077	879	1,118	295	301
Mortality rate per 1,000 children [(0-59 month(s) of age)]	22.1	18.6	18.2	13.4	47.5	36.5
Annual mortality rate per 1,000 livebirths	116.3	117.0	82.5	93.8	191.8	234.0
Mortality of children (<5 years)*	114.4	111.6	84.8	87.4	208.5	202.4

* Estimated as infant mortality rate + (4 x [12-59-month mortality rate])

Table 5. Differences in mortality rates between intervention and comparison areas, 1992-1993

Age group	Mortality rate		Difference between rates (95% Cl)	p value
	Intervention area (1992-1993)*	Comparison area (4/1992-3/1993)		
0-11 month(s)	75.7	116.7	-41.0 (-106.4 to 24.3)	>0.05
12-59 months	5.7	22.2	-16.5 (-30.9 to 2.1)	<0.01
0-59 month(s)**	98.5	205.5	-107.0 (-141.3 to -72.7)	<0.001

* Average of two years of combined data from both the intervention areas (1992 and 1993)
**Rate of mortality of children (aged <5 years) estimated as infant mortality rate + (4 x [12-59-month mortality rate])
CI=Confidence interval

The mortality rates in the intervention areas were 35.1% and 74.3% less than those in the comparison areas for the age groups of 0-11 month(s) and 12-59 months respectively. Overall, the 0-59-month mortality rate was 52.1% less in the intervention areas compared to the control areas.

Table 6 presents information on causes of death. Cause-specific mortality rates were lower in the intervention

communities for all causes, except 'other.' The differences in mortality rates of acute respiratory infection and diarrhoeal disease are responsible for most of the difference in the overall rates of mortality of children, aged less than five years, between the intervention and the comparison areas. Although the percentage reduction in mortality rates for these specific diseases was substantial (the reductions in the cause-specific mortality rates among children, aged less than five years, for diarrhoea, acute respiratory infection, other infections, and malnutrition ranged from 57% to 85%), none of these individual differences was statistically significant because of the small number of deaths in each category. Table 7 shows that the mortality rates for causes of childhood deaths that were specifically emphasized by the programme (diarrhoea, acute respiratory infection, and malnutrition) were almost four times less in the intervention areas than in the comparison areas (5.7 vs 21.8). A difference in mortality rates for causes not emphasized by the programme was also present, but to a lesser extent (12.4 vs 18.5). The modest mortality impact from causes not targeted in the intervention programme may be attributed to the stronger broader primary healthcare and referral services provided in the intervention areas. The total annual cost of the entire community-based primary healthcare programme for the entire population was US$ 9.86 per capita. Assuming that the entire programme is required to achieve the mortality impact demonstrated here, the cost per year of life saved is US$ 55, and the cost per child-life saved is US$ 3,214. (Further details regarding the cost aspects of the programme can be obtained from the senior author.)

Table 6. Causes of death among children aged 0-59 month(s) in intervention and comparison areas (rates per 1,000 children), 1992-1993

Likely cause of death	Intervention area (n=4,206)			Comparison area (n=596)			Difference in mortality rate	
	No.	Rate	% of total	No.	Rate	% of total	Difference between rates	95% CI
Diarrhoea	15	3.6	19.7	5	8.4	20.0	-4.8	-13.3 to 3.7
Acute respiratory infection	7	1.7	9.2	6	10.1	24.0	-8.4	-17.5 to 0.1
Neonatal asphyxia	11	2.6	14.5	2	3.4	8.0	-0.8	-6.6 to 5.1
Other infectious diseases	2	0.5	2.6	2	3.4	8.0	-2.9	-8.6 to 2.8
Severe malnutrition	2	0.5	2.6	2	3.4	8.0	-2.9	-0.1 to 16.1
Injuries/accidents	6	1.4	7.9	3	5.0	12.0	-3.6	-10.3 to 3.1
Other causes	10	2.4	13.2	1	1.7	4.0	0.7	-3.9 to 5.3
Unknown	23	5.5	30.3	4	16.0	16.0	-1.2	-0.1 to 22.0
All causes	76	18.1	100.0	25	100.0	100.0	-23.8	-41.3 to -6.3

CI=Confidence interval
Some totals do not add up because of rounding

Table 7. Grouped causes of death (by those causes targeted and not targeted by programme interventions) among children aged 0-59 month(s) in intervention and comparison areas (rates per 1,000 children), 1992-1993

Likely cause of death	Intervention area (n=4,206)			Comparison area (n=596)			Difference in mortality rate	
	No.	Rate	% of total	No.	Rate	% of total	Difference between rates	95% CI
Causes targeted by the primary healthcare programme: diarrhoeal diseases, acute respiratory infection, and malnutrition	24	5.7	31.6	13	21.8	54.1	-16.1	-27.4 to -4.8
Causes not targeted by the primary healthcare programme: neonatal asphyxia, other infectious diseases, injuries/accidents, other causes, and unknown	52	12.4	68.4	11	18.5	45.8	-6.1	-14.2 to 2.0
All causes	76	18.1	100.0	24	40.2	100.0	-22.1	-35.3 to -8.7

CI=Confidence interval
Some totals do not add up because of rounding

DISCUSSION

In this analysis, the 0-59-month mortality rates in rural areas of Bolivia where child survival and other comprehensive primary healthcare services had been fully implemented by ARHC were less than half of the 0-59-month mortality rates observed in geographically-adjacent and socioeconomically-indistinguishable areas where these activities were only minimally implemented. The relatively-larger impact on deaths from diarrhoea, acute respiratory infection, and severe malnutrition is consistent with the types of child-survival activities promoted by ARHC. There is no reason to suspect that the primary healthcare programmes in the intervention areas were any different from those in the control areas prior to beginning the interventions.

The prospective nature of data collection, the accuracy of data that document programme activities, the registration of deaths by cause, and the use of comparison areas are key strengths of this study. A major weakness of our study, however, is the lack of baseline data in the intervention and comparison areas that were collected at the same point in time. Nonetheless, we believe that the findings provide strong evidence for a reduction in the risks of infant and child mortality in the two intervention areas of Carabuco and Mallco Rancho that can be attributed to interventions of the ARHC programme.

We speculate that the impact on infant and child mortality achieved by ARHC in Bolivia was even greater than that demonstrated by the data reported here. There are several reasons for this:

First, the registration of deaths was likely to have been less complete in the comparison areas than in the intervention areas, thereby leading to the calculation of lower mortality rates in the comparison areas than, in fact, existed. It has been ARHC's experience and the experience of other researchers in the Andean region (28) that the completeness of vital events registration, particularly the registration of deaths during early infancy, improves with time in a specific geographic area because parents gradually develop greater confidence in field staff, and they become more willing to notify them of deaths which have occurred. The national mortality rates for infants and children aged 0-59 month(s) whose mothers have less than six years of education, as reported in the 1994 Bolivian National Demographic and Health Survey (25), were virtually identical to those we observed in the comparison areas in 1992-1993 (where the educational level is essentially the same). Findings of the national demographic and health survey are also subject to an under-reporting bias, particularly in rural areas and for deaths during the first few months of life.

Second, the impact of ARHC's programmes might have been even greater than reported here because some limited healthcare activities in the comparison areas did occur during the initial year of vital events registration there (April 1992–March 1993), and these programme activities may have had a modest influence on reducing infant and child mortality in the comparison areas during that period.

Third, the communities comprising the comparison areas were more centrally located and easier to reach than the other communities of Ancoraimes and Sipe-Sipe. The communities comprising the intervention areas, on the other, were more geographically disperse. Since the persons living in the more centrally-located communities of Ancoraimes and Sipe-Sipe (comprising the control areas) had readier access to transportation and health services and since they were more likely to have had somewhat better socioeconomic characteristics than those living in the more isolated communities of Ancoraimes and Sipe-Sipe, it is quite possible that the mortality rates in the communities from which data for the control areas were derived were less than in other communities of the control areas which were not part of the initial vital events-registration activities. In other words, if we had been able to collect vital events information from the entire populations of Ancoraimes and Sipe-Sipe, the observed mortality rates might well have been even higher. The socioeconomic data for Ancoraimes and Sipe-Sipe are based on a survey of the entire population, whereas the mortality data are derived from a smaller group of communities in these same areas.

Chen (29) suggests that,

"… the ideal design for evaluating an intervention would include an estimate of the long-term trends occurring previously in the same population, a documentation of the changes in mortality during and immediately after the intervention over a period of say 5 years, a control group, and perhaps data on causes of death that were targeted by the intervention. All these conditions are rarely met, and conclusions are usually based on partial information …. Even this method is subject to a host of

limitations as control and intervention areas can never be fully matched for all confounders."

A number of the elements of an ideal design, as defined by Chen, are present in our study. A major drawback of our study, however, is that the vital events-registration systems were not fully operational in the intervention areas until after ARHC's primary healthcare programmes were well-underway there. Another major drawback is that the vital events-registration systems were not implemented in all the communities of the comparison areas until programme implementation had been underway in the intervention areas for at least 4-5 years.

Ideally, a vital events-registration system should have been in place in both intervention and comparison areas prior to beginning the implementation of any programme, and the changes in mortality in both intervention and comparison areas should have been monitored prospectively. However, for multiple reasons, an ideal study methodology could not be implemented: there were limitations of funding, and the funds that were available were for service-delivery, not for programme evaluation; the field methodology was not well-developed; and achieving the full collaboration of the community—a prerequisite for the methodology—was a slow process.

Although the findings of this study do not 'prove' beyond the shadow of a doubt that the programme interventions were responsible for the mortality reductions observed, they do provide strong evidence in support of such an assertion. Given the difficulty of demonstrating such effects in health programmes and the limited information in the scientific literature regarding the mortality impact of health programmes, we believe that these findings are noteworthy.

The 0-59-month mortality rate per 1,000 livebirths in Ancoraimes declined from 209 in 1992 to 105 five years later. The 0-59-month mortality rate in 1997 is based on vital events registration for the entire population of the 52 communities in the Ancoraimes area, not just for the eight communities included as the comparison area in 1992. Programme activities continued from 1992 until 1997 and beyond, and vital events were registered through routine systematic home visitation during this same period. Unfortunately, follow-up data from Sipe-Sipe are not available. ARHC's experience now with seven different project areas in Bolivia has demonstrated that most reductions in childhood mortality are achieved during the first six years of programme implementation. Most earlier reports on the effects of health programmes on infant and child mortality, as we noted initially, did not have control or comparison groups and lacked other supporting evidence, such as information about coverage of services (3-20). Recent reports on demonstrable impacts of health programmes on infant and child mortality are few. The Matlab field station of ICDDR,B: Centre for Health and Population Research reported a 9% reduction in child mortality between 1979 and 1981 (compared to a 2% decline in the control area) and a further 32% reduction between 1981 and 1987 as a result of maternal and child-health interventions (5,9,10). In the U.S. Agency for International Development-funded Combating Childhood Communicable Diseases Project, a multi-country project conducted in several African nations during the 1980s, the proportion of infants and young children dying before the age of five years declined by 17% in Zaire and by 32% in Liberia (12). However, these findings were obtained using retrospective household surveys for the identification of childhood deaths, a less-than-ideal methodology (29).

In the area of Maharashtra, India, served by the Jamkhed Comprehensive Rural Health Project using strategies similar to ARHC's, the infant mortality rate declined over a two-decade period from 165 to 20 per 1,000 livebirths (8,15). A recent prospective controlled trial of home-based neonatal care in another area of Maharashtra (Gadchiroli), India, demonstrated statistically significant declines of 62% and 71% in neonatal and perinatal mortality respectively (18). There, village health workers were trained to manage birth asphyxia, premature birth, low birth-weight, hypothermia, and breast-feeding problems. In addition, they were taught to diagnose and treat neonatal sepsis.

In the rural Artibonite Valley of Haiti, served since 1956 by Hospital Albert Schweitzer using strategies similar to ARHC's, the 0-59-month mortality rates have declined over a 30-year period from 266 to 69 per 1,000 livebirths, while for Haiti as a whole the rate has fallen from 230 to 122. In rural Haiti, the 0-59-month mortality rate is still 156, which is 2.3 times greater than that in the Hospital Albert Schweitzer service area. The infant mortality and 12-59-month mortality rates for rural Haiti are currently 1.8 and 3.8 times respectively, the rates for the Hospital Albert Schweitzer service area (30)

ARHC's annual per-capita total local programme cost of US$ 10 contrasts favourably with US$ 14 per capita spent in poorest countries on healthcare (31) and with

US$ 34 per capita spent from all sources in Bolivia in 1990, including government health expenditure of US$ 10 per capita (32). According to the WHO's Commission on Macroeconomics and Health, an expenditure of US$ 10 per capita is affordable for very poor countries, such as Bolivia, although scaling up of such a programme would require a strong commitment to the CBIO approach, which is lacking at present (33). Nevertheless, the findings of this study suggest that such a programme could be effective if it were applied at the same level of quality as in our study setting. However, 'going to scale' is a major complicated task fraught with great risk but potentially successful if carried out gradually with a strong monitoring and evaluation effort to identify problems and make adjustments (34,35).

Is US$ 55 a reasonable cost of saving one year of life in a poor country like Bolivia? Is US$ 3,214 a reasonable cost of averting a death? These questions do not have straightforward answers and depend on a careful examination of a series of issues, such as (i) compared to using a similar amount of money for what?, (ii) paid for by whom?, and (iii) is there a less expensive way to achieve the same result? In our view, such an investment in the saving of human life is fully justifiable compared to similar resources being expended in developing countries by individuals for less vital expenses (such as over-the-counter drugs for minor ailments, cigarettes, drinks, and so forth) and by governments for military expenses and for other less vital bureaucratic activities. Whether or not a similar effect could be achieved with a less-expensive approach would require further field trials, which we believe should be carried out. In the end, the issue is a social and political one: are governments and local leaders aware of the benefits of such programmes and the activities required of such programmes to obtain the potential mortality effect, and are they willing to forego other expenditures to ensure that the comprehensive primary healthcare programmes are available to the entire population?

The data provide strong support for the conclusion that it is possible to significantly reduce infant and child mortality within a six-year period after beginning child-survival programme operations, using a mix of strategies, including household visits, health education, nutrition promotion, readily-accessible clinic services, and transportation of emergencies to a referral hospital. The community-based comprehensive primary healthcare programme approach used here can achieve the goal of significantly reducing infant and child mortality at a reasonable cost.

Despite encouraging recent progress (35-41), stronger scientific, political and financial support is needed for community-based primary healthcare programmes in less-developed countries. A stronger commitment is needed among national governments and international donors to support large-scale community-based initiatives that encourage the use of existing financial and human resources in local communities, that foster local capacity, that are evaluated on an ongoing basis, and that are expanded to serve larger populations after implementing changes based on findings from these evaluations (35,37). The approach outlined here provides a promising set of principles and methods by which mortality of children, aged less than five years, can be reduced through health interventions.

We readily acknowledge the limitations of this study: the findings are based on data from small populations in both intervention and comparison areas, and baseline data from the comparison area at the time when the programmes began in the intervention areas are not available. Results of better-designed and larger field trials of community-based comprehensive primary healthcare programmes in multiple regions of the world can provide a stronger scientific basis for developing this approach further in developing countries.

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