

**The Impact of Maternal Literacy on Child Survival
During Nicaragua's Health Transition**

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Overview and Summary

This is a PhD submitted by published papers under Clause 2 of the Ordinance and Regulations of the University of Liverpool. A total of seven papers are presented plus two letters as annexes. Though a study of this size must inevitably be a collaborative effort, as principal investigator I personally was responsible for all aspects of the research including study design, instrument development, sampling, data processing, analysis, interpretation and writing up the final results. This is not to understate the tremendous amount of work put into the project by the field manager, Jeffrey Cassel, my co-authors and all of the field staff, to whom I am extremely grateful.

It begins with a paper reviewing historic trends in child survival in Nicaragua in the 1970s and 1980s during which, it was discovered, an extremely rapid decline in infant mortality took place. Though other 'breakthroughs' in infant mortality had been reported in the scientific literature elsewhere, this article presented the scientific community for the first time, firm evidence that a health transition had also taken place in Nicaragua, and offered some explanation for the underlying causes of this transition. The Sandinist government and supportive political groups had been alleging for some time that remarkable gains in child survival had taken place in Nicaragua since the 1979 revolution, but no one had conducted a careful and systematic evaluation of the available evidence for this. By putting together indirect (ie Brass type) mortality estimates from various surveys and censuses, it was possible to confirm that Nicaragua had indeed undergone, and perhaps was still enjoying, a period of rapidly declining child mortality. This work revealed however, that the onset of Nicaragua's breakthrough in child survival did not coincide with the overthrow of the Somoza dictatorship and the increased emphasis placed on health and education by the left-wing Sandinist government.

In fact, it had begun some five years prior to the revolution and unlike other countries where rapidly declining infant mortality had coincided with a period of strong economic growth, in Nicaragua it occurred as the economy entered a period of stagnation and

decline which was to continue almost unabated for some twenty years. Clearly, an understanding of what brought about such gains in health under conditions of recession could have tremendous policy implications and therefore an attempt was made to identify the causes. Among the possibilities examined were changes in breast-feeding practice, increased rates of immunization, improved nutrition, better access to water supplies and sanitation, higher levels of education and malaria control programmes. A wide variety of data sources were consulted to obtain trend information in each of these areas. Through a process of elimination it was concluded that access to health services, and in particular access to primary care, was what enabled mothers to ensure the survival of their infants. It was not possible to say, though, how this access to primary care actually led to improved child survival. Individual programmes such as immunization, growth monitoring and oral rehydration were either not yet functioning, or were functioning poorly.

Subsequent results from data gathered in this investigation support the importance attached in the paper to the establishment of a nationwide network of primary care facilities. It is unfortunate that there was not sufficient data available at the time to be able to identify which interventions were responsible for the observed health gains. One possibility which was not given serious consideration in the paper is that greater access to health services increased the consumption of antibiotics. This would not only have reduced case fatality rates from acute respiratory infection but would also have decreased transmission within families, particularly from older children acquiring infections outside the home to infants and young children. If bacterial respiratory infections are like measles, then case fatality rates may be much higher when the index case is within the family than when the infection is acquired outside the home.¹ Hence, a relatively small increase in use of antibiotics or in uptake of measles immunization or

¹/ Aaby, P. Social and behavioural factors affecting transmission and severity of measles infection. Chapter 51 in John Caldwell, Sally Findley, Pat Caldwell, Gigi Santow, Wendy Cosford, Jennifer Braid and Daphne Broers-Freeman (eds), *What we know about Health Transition: The cultural, social and behavioural determinants of health*. Health Transition Series No. 2 (Vol. II), Health Transition Centre, Australian National University, 1990.

even an improvement in the quality of the cold chain, could have a striking effect on infant mortality rates. The subsequent introduction of oral rehydration therapy may have also contributed to the effectiveness of health services in preventing the deaths of young children.

Since the publication of this article it has been noted that most other countries in Central America also experienced sharp declines in infant mortality at around the same time as Nicaragua. It does not seem to matter whether the government was left-wing or right-wing. Indeed, from the sources examined it became clear that health policy did not change as radically as the political rhetoric of governing parties, but instead appeared to be far more influenced by international agencies such as the Pan American Health Organisation and the United States Agency for International Development (USAID).

The finding that Nicaragua's infant mortality rate began to fall well before the 1979 revolution, and the assertion that post-revolutionary health policy was not as radically different from that which preceded it, did not please some of the left-wing activists who, in earnest support of the Sandinist government, had attempted to create the impression that it was this government, and only this government, that was responsible for any recent health benefits accruing to the population. Thus, a critique of the paper was published (without our prior knowledge), in *Links*, one of the development journals in the United States. Our reply to the critique is included as an annex to the PhD. It gives a reasonable idea of the arguments used in the original critique as well as our response to them.

Reductions in the rate of illiteracy could not explain the onset of the breakthrough in child survival but may have helped to sustain it. Indirect mortality data from censuses and survey demonstrated a strong and consistent association between a mother's level of education and the survival of her offspring. A review of the literature showed that this relationship had been documented for many years in studies from very diverse settings. However the usual interpretation, that education is linked with infant mortality because it is a good proxy for socio-economic status and that it is wealth, not education,

that determines a child's survival chances, had been challenged in an article published by John Caldwell in 1979. Caldwell argued that in fact education itself does lead to better child health and he put forward a number of mechanisms to explain how this might occur.

Nicaragua offered a unique opportunity to gain insight into these questions through what was almost a natural social experiment. Shortly after taking power in the 1979 revolution, the Sandinist-led government had embarked upon an ambitious programme of adult education with the aim of eradicating illiteracy in the country. The programme began with the National Literacy Crusade through which it was claimed that the rate of illiteracy in the adult population was reduced from 50% to 13% in barely six months. If this were true, then by the late 1980s there was a large cohort of women who had become literate, and unlike literate women virtually anywhere else in the developing world, were no more socially or economically privileged than the illiterate. This meant that, perhaps for the first time ever, there was the possibility of examining how maternal education affects child health and survival, free from the confounding effects of wealth.

To confirm the claims made about the success of Nicaragua's National Literacy Crusade, and assess the actual impact of adult education programmes in the country, a study was carried out of the historic trends in Nicaraguan literacy rates, focussing on female literacy. This is the main subject of the second paper in this thesis. It was found that the initial claims were probably exaggerated. Just as with the figures for infant mortality, the statistics quoted (and endlessly requoted by others) gave the impression that the situation inherited by the Sandinist government was worse than it really was. Nevertheless the adult education initiatives of the early 1980s did produce a large cohort of women who, had it not been for these efforts, would almost certainly have remained illiterate for the rest of their lives.

This paper also provides a summary of the original design and hypotheses in this investigation. A research proposal to identify a large group of women who were taught to read and write exclusively through adult education, and to compare the health of their

offspring with that of women who remained illiterate and others who had become literate as young girls attending school, was written and presented to the Overseas Development Administration's HP ACORD programme. It was initially funded for a period of two years from 1991. It will be noted that the pathways through which literacy was hypothesised to affect child health differ slightly from those tested in the final phase of the study. It was decided that a mother's knowledge of health matters was likely to be correlated with her woman's previous experience and interactions with health services and therefore this might be a consequence rather than a cause of child health outcomes, but also, this and the ability to follow decontextualised instructions together represent the effects of differences in cognitive ability which was measured instead. Similarly, the ability to operate in bureaucratic settings was considered to be related to both locus of control and modernism and therefore redundant as a factor in its own right. One factor not included in this initial theoretical framework but incorporated in the final battery of tests was social support.

In the first phase of the investigation, archives of the National Literacy Crusade were used to identify all women resident in Masaya province who had become literate exclusively through adult education. In addition, an approximately equal number of illiterate women and women who had become literate by attending school were matched to the adult education group by age and neighbourhood. A brief (two page) survey instrument was designed and applied to the women in each of the groups. The instrument incorporated a simple literacy test, gathered data on the survival of the woman's children, and recorded nutritional status in those under 10 years of age.

In conducting the first round of interviews height measurements were made, not only of children aged 2-9 years, but also of the women themselves since height is a known correlate of socio-economic status, and unlike most such indicators which relate to one's present economic standing, it gives some indication of the wealth of the family in which the woman was brought up. This is important because it has been suggested that it is the background from which a woman comes that determines both her literacy, and the psycho-social attributes that might affect her children's health. However, the traditional

technique used to measure height is problematic, partly because of the difficulty of finding level ground and perpendicular supports against which to measure, and partly because measuring rods are bulky and not easily carried by field workers travelling on foot. It was with this in mind that I invented an electronic stadiometer. A description of this apparatus and its reliability statistics makes up the third paper in the thesis.

The utility of this invention is evidenced in the subsequent papers by the importance of mothers' height as a risk factor for child mortality and malnutrition, and by the highly significant differences between height of women in the formal schooling group and the height of women in both the adult education and illiterate groups. Since height was associated with both exposure (education) and outcome (child survival) then it became a potential confounding variable which needed to be controlled for in the analysis. Accurate measurement of height made possible by the electronic stadiometer ensured that its impact on child survival was not incorrectly attributed to the acquisition of literacy.

The fourth paper presents the main results of the first survey, which it has to be confessed, gave unexpectedly strong support for Caldwell's theory. Mortality and malnutrition risks in the offspring of women who became educated exclusively through Nicaragua's adult education programme were significantly lower than those in the children of illiterate mothers. Moreover, the survival advantages of children in the adult education group appeared to begin after the National Literacy Crusade, whilst mortality rates beforehand were very similar in the two groups.

On the basis of these exciting findings from the first survey a further period of two years funding was granted in order to confirm the indirect mortality estimates with results derived from a full birth history, and to explore which if any of the various psycho-social mechanisms hypothesised to account for the association between literacy and child health, had the greatest explanatory power. This second phase of investigation drew upon qualitative results from in-depth semi-structured interviews conducted by the project's anthropologist to develop the new questionnaire.

In preparing and revising the paper which reported the results of the first round survey a reviewer made the comment that the better health and survival of the children of literate mothers was “almost certainly the result of differences in intelligence and motivation between the two groups of women”. It was partly as a result of this comment, that I decided to incorporate an intelligence test among the battery of psycho-social measurements being made. Motivation, expressed as commitment to child survival, was an area which had already been highlighted by the study anthropologist (Germana Sanchez) as a potentially important explanation for the observed differences in mortality rates and a scale had been developed to measure this. Intelligence though, was of particular interest because it was not a factor that had received much attention in the literature as a possible reason for the link between education and child survival. When it was discovered that there were major differences between the education groups in terms of their intelligence, and that intelligence itself was a strong predictor of child survival, it was decided to analyse this particular variable in greater depth. Coincidentally, there was considerable interest in role of intelligence in social stratification generally, owing to the recent publication of Murray and Herrnstein’s controversial best-seller *The Bell Curve*.²

The measurement of intelligence presented some problems given the fact that many of the existing tests require literacy or are available only in English. Advice was sought and gratefully received from Professor Kevin Connolly of Sheffield University who recommended using Raven’s Coloured Progressive Matrices on the grounds that the test was simple to apply, did not require literacy, and had been validated in culturally diverse populations.

Given the controversy surrounding intelligence, both as a construct and in terms of its value as a predictor of social outcomes, the results which are presented in the fifth paper, will probably please no one. Maternal intelligence was found to be significantly associated with child survival but not as strongly so as some of the other psycho-social

^{2/} Herrnstein RJ and Murray C. *The Bell Curve: Intelligence and Class Structure in American Life*. New York: Free Press, 1994.

factors examined in the seventh paper. Nor did it account for much of the relationship between education and child health. On the other hand, the finding that literacy was much more strongly related to improved survival among women of low intelligence could have important policy implications.

The sixth and final paper in the thesis goes back to addressing the main research question—whether and how the acquisition of literacy by women affects health and survival of their children. This time the results are based on analyses of the subset of 1294 women reinterviewed in the second survey. The full birth history which was recorded in this later questionnaire enabled mortality statistics to be disaggregated into neonatal, post-neonatal, infant, child and under-five rates, which of course greatly aids interpretation. The fact that the association between maternal education and child survival was seen with direct mortality data as well as with the indirect data gives support to the validity of the conclusions in the earlier paper. More importantly though, this paper presents evidence that certain psycho-social factors play a significant role as determinants of child survival in their own right and explain a substantial portion of the maternal education - child health relationship. The strong correlations between four of them—locus of control, modernism, commitment to child survival, and intelligence—suggest that they are probably not independent entities, but rather components of a more general cultural complex that is either acquired through education or that increases a woman's chances of becoming literate. Their precise point in the causal chain is impossible to determine without conducting some form of randomised intervention trial, and this must be acknowledged as the main methodological limitation of this study, but given the practical and ethical problems that would confront such a trial (not to mention its cost) there is little possibility that this issue can be adequately resolved in the near future.

So what then, has this research contributed? To begin with, it has provided evidence that primary health care, understood to mean greater population access to a handful of simple yet effective preventive and curative interventions, may be responsible for much of the rapid decline in infant and child mortality experienced by many developing countries (outside sub-Saharan Africa at least), in the 1970s and 1980s. It has

documented for the first time, a link between the acquisition of literacy by adult women and improved child survival, independently of any economic advantage. It has objectively assessed the role of intelligence, finding that it is a significant determinant of child survival, but only really in the women with no education. It has revealed that locus of control and commitment to child survival are both important determinants of child health in this setting, and that together they may take us quite a long way towards explaining why the children of educated mothers are healthier than those of mothers without education, whilst questioning whether education produces these attributes or is the outcome of them. Sidelines to the main investigation have led to the invention of a simple new apparatus for measuring height in field studies, and to the discovery that even in a so-called *machista* society, women may prefer daughters over sons. Finally, it has shown how important it is for scientists to resist being carried away by the rhetoric of even well-meaning politicians prepared to misquote and misuse data for their particular ends, and in doing so, can stand in the way of an accurate appreciation of social transitions and their causes.

PAPER I: Sandiford P, Morales P, Gorter A, Coyle E and Davey Smith G. Why do child mortality rates fall: An analysis of the Nicaraguan experience. *American Journal of Public Health*, **81**(1):30-36; 1991.

This paper was the subject of an editorial in the issue of the *American Journal of Public Health* in which it was published. It has been summarised and published as a digest in *International Family Planning Perspectives* under the title "Better Access to Health Services in Nicaragua Lowered Infant Mortality", 1991, **17**(2):77-78. An abstract of the paper entitled "Perché diminuiscono i tassi di mortalità infantile? Analisi dell'esperienza nicaraguense" has also been published in *Infant Nutrition Digest* (Italian) pp 33-34, no. 2, July 1992).

Why Do Child Mortality Rates Fall?

An Analysis of the Nicaraguan Experience

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ABSTRACT

A comprehensive review of available sources of mortality data was undertaken to document the changes that have occurred in infant mortality in Nicaragua over the last three decades. It was found that a rapid fall in infant mortality commenced in the early 1970s and has continued steadily since. Trends in several different factors which might have led to this breakthrough were examined including; income, nutrition, breast feeding practices, maternal education, immunizations, access to health services, provision of water supplies and sanitation and anti-malarial programs. Of these, improved access to health services appears to have been the most important factor. At a time when the number of hospital beds per capita population was dropping, increasing numbers of health care professionals, particularly nurses, were becoming available to staff primary health care facilities built in the 1960s. These were provided at least partly in response to the growing political turmoil enveloping the nation at that time. Certain Nicaraguan cultural attributes may have added to the impact of the reforms. Efforts in the field of public health made since the 1979 insurrection appear to have maintained the decline in child mortality.

INTRODUCTION

Poor child health in developing countries continues to be a source of concern¹. In recent years it has become apparent that while poverty is probably the major factor affecting survival in the early years of life, there are undoubtedly other influences playing an important role. Some countries, in spite of a low per capita gross national product, have succeeded in achieving mortality levels close or equal to those of the industrialised world. In contrast, there are others with poor levels of child health despite enjoying relatively high per capita incomes². Efforts have recently been made to identify the factors beside socio-economic status which are determinants of infant mortality. In 1985 the Rockefeller Foundation sponsored a conference which studied the striking mortality reductions in Kerala State (India), Sri Lanka, Costa Rica, and China³. In each case, mortality has fallen sharply over a relatively short period leading to high life expectancy relative to national income. Seven conditions were purported to be essential to the observed improvements. These were; female autonomy, education (especially female), the provision of accessible health services, a mechanism to guarantee the efficient operation of health services, an adequate minimal standard of nutrition, universal immunization, and a commitment to the establishment of effective antenatal and obstetric services².

Nicaragua is another country which has experienced a recent breakthrough in child mortality. This article describes that breakthrough and looks at its relationship with some of the factors alleged to be important determinants of child mortality. It is hoped this work serve as a model for the type of intersectoral data analysis advocated recently by de Kadt⁴.

METHODS

Seven different sources of data were identified which could provide time-located estimates of infant mortality in Nicaragua from 1960 to 1986⁵⁻¹¹. A brief description of each source of data is given in the Appendix. Except for data obtained from the Civil Register, the infant mortality estimates were derived using the Brass technique based on the ratio of surviving to ever born children of mothers classified by five-year age group. The rationale behind this method is that the proportions dead of ever born children for women of a certain age correspond to discreet child survival probabilities. These survival probabilities can be used to calculate infant mortality rates (IMRs) if one assumes a typical age pattern of mortality. In this case the Coale-Demeny 'West' model of mortality was used¹².

Variations of the Brass method have been developed which allow the estimation of trends in mortality change, recognising that the deaths in children born to women aged 15-19 have occurred more recently than the deaths in children of women aged 45-49. The Trussell method, which was employed in this analysis is one such variant¹³. It provides time locations for the infant mortality estimates obtained from each five-year age group of mothers.

Estimates of infant mortality from the death register were calculated by dividing the number of deaths registered in each year by the projected population under the age of one. Death registration is well known to be variable and incomplete so these figures were not used in further calculations. However, the relatively low rate of omission for birth registration allows a more accurate estimation of the IMR by asking about the survival of preceding births at the time of registration. The data for 1986 (SINEVI-86) was analyzed in this way by the *Centro Latinoamericano de Demografía* (CELADE)¹¹.

There are a number of factors which are believed to be important determinants of child mortality. They include income, nutrition, maternal education, breast feeding,

immunization coverage, the provision of health services, access to water supplies and sanitation, malaria control, as well as certain cultural attributes of the population. Trends in these factors were examined and related to the observed changes in infant mortality in Nicaragua from 1960 to 1989. Wherever possible, data were obtained from the original sources in Nicaragua by visiting libraries and documentation centres in government ministries and institutions.

Data on per capita Gross National Product (GNP) was obtained from an analysis performed by the National Autonomous University of Nicaragua¹⁴. It was not possible to accurately quantify changes in income distribution.

An assessment of trends in child nutritional status was based on 3 surveys carried out nationwide samples of children in 1966, 1977-8 and 1986^{15,16,17}. Height for age was used as the indicator of nutritional status as it was the only one measured in all three surveys. In two of the surveys^{15,16} the children measured were under the age of 5, in the third they were school children aged 6-9 years. Figures for food production and caloric intake were derived from World Bank¹⁸ and United Nations Food and Agricultural Organization¹⁹ statistics respectively. The frequency of breast feeding in 1977 and 1988 was estimated from two ad hoc surveys performed in Managua^{20,21}.

Levels of illiteracy in Nicaragua were obtained from the censuses of 1950²², 1963²³ and 1971⁵ and from the EDENIC-78¹¹ and ESDENIC-85 surveys. Rates were calculated for the total population aged 10 years and over, for the urban and rural populations, and for women aged 15-44 years.

An analysis of Ministry of Health cause of death statistics by CELADE documents changes in death rates in children due to immuno-preventable diseases¹¹. These were compared with an indicator of vaccination coverage, estimated by dividing the Ministry of Health figures for the annual number of inoculations by the population of children under the age of five for that year.

There have been several analyses of Nicaragua's health system, mostly comparing the situation before and after the 1979 insurrection²⁴⁻²⁷. These were reviewed and combined with statistics from the health sector^{10,28-30} (public and private) to obtain an overview of the trends in the provision of health services - both as infrastructure and as human resources - from 1960 to 1985.

National statistics were used to determine what changes had taken place in domestic water supply and sanitation facilities^{10,30}. Figures for latrine construction were taken from Ministry of Health records²⁸. An analysis by Garfield and Vermund³¹ and national records of laboratory tests for malaria were used to look at trends in the incidence of malaria.

RESULTS

Infant Mortality Estimates

Figure 1 shows the infant mortality estimates from each of the aforementioned sources plotted against time. Estimates from ESDENIC-85, SINEVI-86 and the 1971 Census, the three largest databases, give a consistent profile of the trend in mortality. Moreover, the IMRs from the sentinel sites study agree remarkably well with those of ESDENIC-85. There is some divergence in the mortality estimates from EDENIC-78, particularly for the early 1970s but these are based on data from a small number of women and hence this may be due to sampling error. The rates calculated from death registration are incompatible with the other estimates, a reflection of gross inadequacies in coverage of this system. They are not used in further analyses.

A weighted average of infant mortality estimates from the 1971 census, the EDENIC-78 and ESDENIC-85 surveys, the SINEVI-86 analysis of birth registration and the sentinel sites study was made for each two-year interval. Rates obtained from women aged 15-19 years were not included as these are well known to be unreliable¹³. The results are plotted in figure 2. Figure 3 presents the same data plotted on a logarithmic scale which more appropriately portrays the change in the rate of decline. Taken as a whole, the studies indicate that the rate of fall in infant mortality, which was slow in the 1960s, increased sharply in the early 1970s, and that this rapid decline was still continuing in 1986. The infant mortality rate drops on average by 4.7 deaths per thousand live births for each year from 1974 to 1986. Assuming a 'West' mortality schedule, this is equivalent to an annual increase in life expectancy of 0.75 years each year over this 12 year period.

Figure 4 presents urban and rural IMRs from the 1971 Census and ESDENIC-85. Changes in the definitions of 'urban' and 'rural' and internal migration make interpretation difficult but there is no clear evidence that in Nicaragua the breakthrough was more pronounced in rural areas than in urban areas.

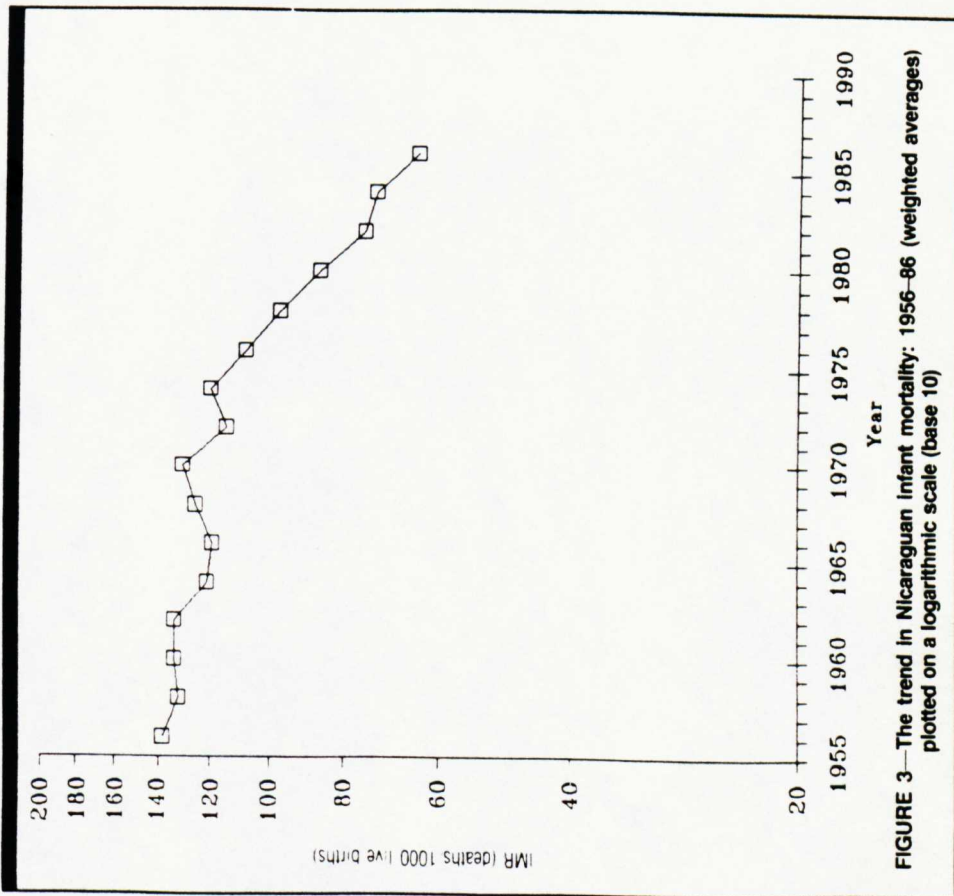


FIGURE 3—The trend in Nicaraguan infant mortality: 1956–86 (weighted averages) plotted on a logarithmic scale (base 10)

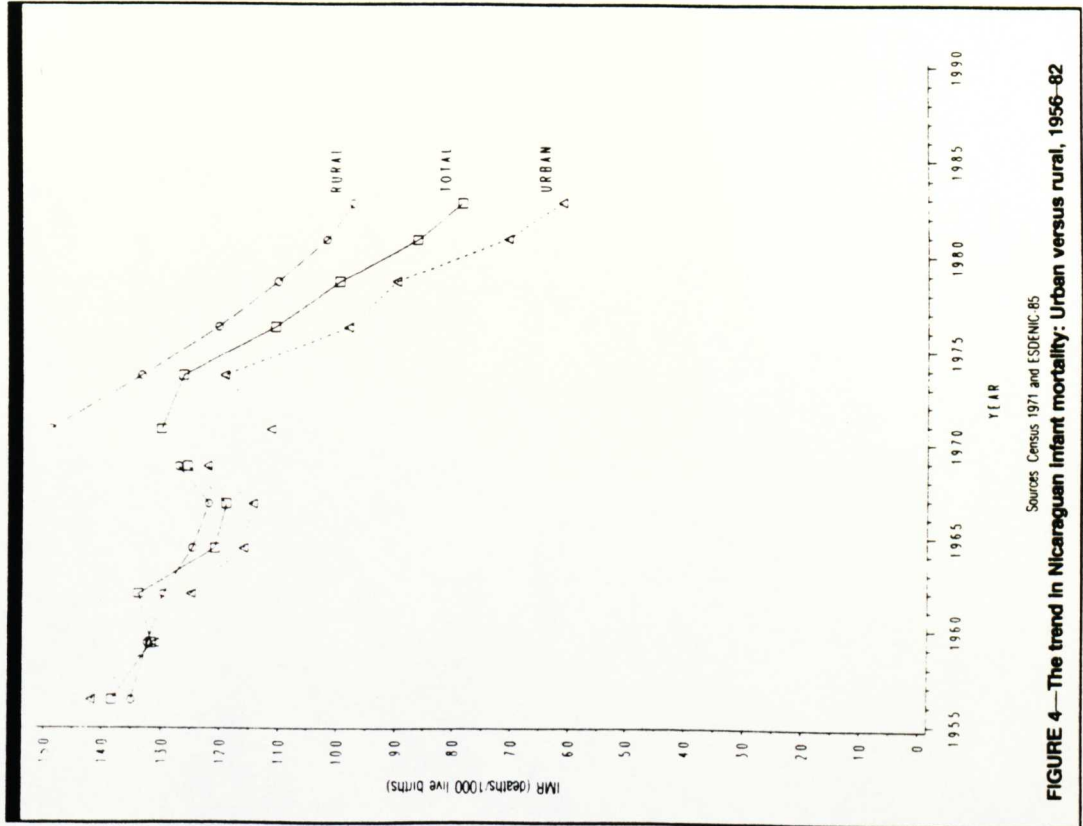


FIGURE 4—The trend in Nicaraguan infant mortality: Urban versus rural, 1956–82
Sources: Census 1971 and ESD/ENIC 85

Differential infant mortality rates according to levels of maternal education are provided by the CELADE analysis. In the three time periods examined—1966-7, 1973-4 and 1982-3—infant mortality rates for mothers with secondary or higher education were considerably lower than for mothers with primary or no formal education. The results suggested that this differential narrowed over the period in question.

Explanations for the Decline in Child Mortality

How can this sharp drop in child mortality be explained? In the first place, it should be recognised that more than one factor may be involved. The reason that mortality started to fall may be different from the reason that it continues to fall. Since this is not a controlled experiment, causes can easily be confused with effects and one is always left in doubt as to what would have happened in a different set of circumstances. Nevertheless, the Nicaraguan case has some very interesting features which make it worth examining in greater detail.

Income

The observed infant mortality breakthrough in Nicaragua does not correspond to a rise in general living standards. Per capita GNP rose rapidly in the early 1960s but flattened off in the 1970s before falling sharply in the 1980s. This fall may have been offset somewhat by a more equal distribution of wealth following the insurrection (as a result of the wages policy, food subsidies and rationing, price controls, and rent controls), but there is insufficient data to quantify changes in income distribution over this period.

Nutrition

In 1966, 36% of children under the age of 5 were found to be below 2 standard deviations in the reference range for height for age. In the survey performed from 1977 to 1978, 26% of children under the age of 5 were below 2 standard deviations for height for age and in 1986 the corresponding prevalence of stunting in first grade school

children (aged 6-9 years) was 22%. Though Nicaragua has high rates of primary school attendance, poor children tend to start later than the rest. This produced an age bias in the results of the 1986 survey such that in 6 year old first grade children the prevalence of low height for age was only 14.5% compared with 32.7% for 9 year old first grade pupils.

Despite the deficiencies in the available data, it would seem reasonable to conclude that nutritional status in Nicaraguan children improved steadily from 1966 to 1986, but the factors leading to this improvement are uncertain. Food production in 1986 was only 70% of what it was in 1967 having fallen sharply from its peak in 1978. The number of food calories per head of population dropped from 2410 in 1970 to 2344 in 1975 and then to 2258 in 1980, recovering slightly by 1983 to 2304.

On the other hand, a variety of programs and activities aimed at improving child nutrition already existed in 1970³². These were expanded in 1973 in response to the threat posed by the 1971 drought and the 1972 earthquake. A milk distribution program of the Ministry of Public Health was in operation since the 1960s but was gradually abandoned in the late seventies. It was recommenced for several years following the 1979 insurrection along with other policies aimed at establishing an adequate nutritional standard. These included food subsidies, rationing, and supplementary feeding programs for pregnant women and malnourished children.

Breast feeding

The limited data available suggests that there has been no increase, and perhaps a decrease in the average duration of breast feeding in Nicaragua over the period of rapidly declining child mortality. In 1977 58% of mothers in Managua were breast feeding their children for at least six months. In 1988 only 33% of children between three and five months of age were still receiving breast milk.

Maternal Education

The changes in the rate of illiteracy in Nicaragua are summarized in table 1. The tendency has been for illiteracy to decrease throughout the period from 1950 to 1985. The overall drop in illiteracy is greater than the individual falls in urban and rural areas because of migration to the town and cities. The slowest rate of change in the overall prevalence of illiteracy was observed between 1971 and 1978. Between 1978 and 1985 there was a marked drop in the prevalence of illiteracy, mainly as a consequence of the 1980 National Literacy Crusade and the extensive adult education program which followed.

Immunizations

Mortality due to diseases preventable by immunization in the ages 1-4 dropped from 21 per 10 000 in 1975 to 3 per 10 000 in 1986 (or from 17% to 4% as a proportion of total mortality in this age group). Unfortunately, the poor quality of the statistics did not permit a similar analysis for children under one year of age.

TABLE 1—Trends in Nicaraguan Illiteracy Rates, 1950-1985

Year	Total ^a	Urban ^a	Rural ^a	Women ^a
1950	62%	30%	80%	61%
1963	49%	21%	70%	50%
1971	42%	18%	66%	43%
1978	39%	17%	63%	38%
1985	25%	13%	40%	26%

^a/ Refers to the population aged 10 years and over

^b/ Refers to the population aged 15-44 years

Sources: 1950 Census³⁸, 1963 Census³⁹, 1971 Census⁶, EDENIC-78¹², ESDENIC-85 (unpublished data).

Table 2 shows the change in rates of immunization over the period from 1970 to 1985. Prior to 1979 rates of vaccination coverage varied widely as periodic campaigns were launched in response to cyclic epidemics of immuno-preventable disease. Since 1979 coverage has been higher and

TABLE 2—Average Number of Vaccines Administered per Child Under the Age of Five

Years	DPT	Polio	BCG
1970-75	0.59	1.02	0.21
1976-80	0.48	1.24	0.17
1981-85	0.99	2.66	0.33

shown less variation. The participation in massive nationwide vaccination campaigns of large numbers of voluntary health workers in the years immediately following the insurrection was probably the main factor in this improvement.

Health Services

In comparison with other developing countries, Nicaragua's health system suffered more from maldistribution of resources than from a lack of investment. Health service infrastructure and personnel were concentrated in the cities and particularly in the capital. In the 1960s and 1970s efforts were made to redress this imbalance and improve access to health care. A USAID loan of \$US 2.2 million was received in 1965 to set up 55 health centres and provide outreach programs in rural areas. By 1974 there were 33 hospitals, 93 health centres and 38 health posts spread throughout the country, and the Rural Mobile Health Program provided care to remote areas. More primary health care facilities were built in the first years following the insurrection.

Though considerable infrastructure was already installed by 1973, an evaluation of the 55 health centres built from USAID loan found low utilization rates owing to the lack of personnel, supplies and management support. Two further USAID grants were made in the mid-seventies to correct these deficiencies.

In contrast to the growth in primary health care facilities, there was a general deterioration in hospital care since the early 1970s. The number of hospital beds per capita peaked at 2.6 in 1971 and has gradually dropped since. The National Social Security Institute (INSS) grew slowly but steadily from 1960 to 1980. In 1963 only 4.1% of the population were insured. By 1971 coverage of the population had increased to 7.5% and by 1978 to 8.4%. In 1980 under the Government of National Reconstruction coverage reached 10.1% of the population.

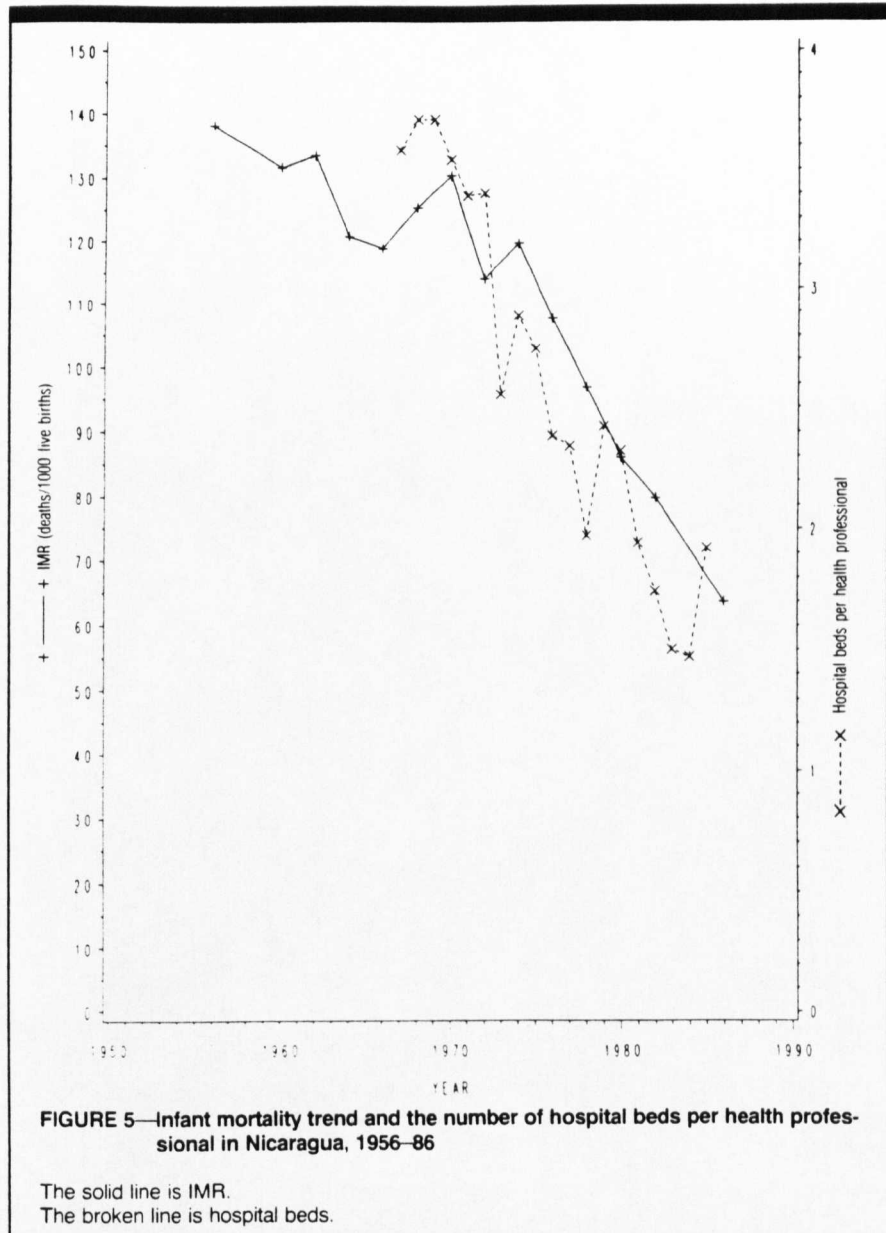
The number of doctors and especially nurses per head of population increased between 1974 and 1985. From 1970-1974 there were 5.4 doctors and 2.3 nurses per 10 000 inhabitants. For the period 1975-1979 there were 5.8 doctors and 2.6 nurses per 10 000 population and in the five years from 1980-1984 there was an average of 6.0 doctors and 3.3 nurses per 10 000 population. The impact of the increased availability of health care professionals (together with dropping numbers of hospital beds per head of population) was reflected in rising per capita rates of hospital discharge and rapidly increasing numbers of outpatient consultations (especially emergency consultations).

Other Public Health Measures

Nicaragua undoubtedly had low rates of access to plentiful clean water supplies and sanitation prior to 1974, but the situation has changed little since then. In 1981, the number of urban domiciliary connections was almost identical to that prior to the earthquake in 1972. Latrine construction by the Ministry of Health, which averaged 4590 per year from 1974-1978 was barely sufficient to keep up with the increase in the rural population.

The use of residual insecticides for the control of malaria decreased steadily in the late 1970s as the WHO campaign for the elimination of malaria lost its momentum. The number of notified cases varied widely from one year to the next but showed no secular downward trend from 1972-1982. The average annual reported number of laboratory confirmed cases was 15386 from 1972-1976 and 18738 from 1977-1981. A renewed

effort was made to control malaria in 1981 by the administration of mass chemoprophylaxis but the impact was transient.



DISCUSSION

From a variety of sources of infant mortality estimates, this paper has documented a rapid decline in infant mortality in Nicaragua which commenced in about 1974 and was still in progress in 1986. The rate of decline since 1974 is impressive, particularly considering that it occurred at a time when the mortality decline in most countries of Asia, Africa and Latin America was slowing down³³. The rate of improvement in life expectancy is similar to that experienced by either Costa Rica (at 0.70/year) and Kerala State (at 0.80/year) during their respective periods of rapid mortality decline, but is not as high as Sri Lanka's (at 1.7/year)²

Much work on the determinants of reductions in child mortality has focused upon economic factors. It has often been difficult to separate the role of health and other social interventions from general economic progress, since changes have occurred in parallel. In Nicaragua, this was not the case as the sharp drop in child mortality took place at a time when the general living standards of the population, measured in terms of per capita national income, actually decreased.

Though there was some improvement in the nutritional status of Nicaraguan children between 1966 and 1988, this was probably more due to a reduced burden of infectious illness than to increased food intake. The factors which led to a drop in the incidence, severity or duration of infection are possibly the same as those which brought about lower child mortality. It is difficult to follow breast feeding practice over the last 20 years but it does seem that exclusive breast feeding is still far from the norm for a variety of reasons³⁴. While health education materials were concerned with promoting breast feeding, the free milk provided by Ministry of Health programs before and after the insurrection may have actually encouraged mothers to abandon the practice.

The 1974 turning point in child mortality does not appear to have been brought about by a sudden increase in levels of female literacy, although this factor may have contributed to more recent falls in child mortality. Similarly, most of the reduction in

mortality due to diseases preventable by vaccination probably occurred some time in the early 1980s and does not coincide with the onset of the decline in child mortality.

It is worth commenting that the introduction of oral rehydration therapy for the management of diarrhoea did not occur until the middle of the period of rapidly declining mortality. The Ministry of Health's plan for 1976-1980³⁵ does not even mention ORT and indeed it was not until 1980 that oral rehydration units were established in health centres and health posts.

The results of this investigation suggest that the availability of water supply and sanitation did not improve significantly from 1974-1986. Any improvement in malaria control is unlikely to have been sufficiently great to account for the decline in infant mortality given that malaria is not a major cause of death in this age group in Nicaragua³⁶.

The most plausible explanation for the onset in 1974 of Nicaragua's rapid decline in infant mortality, can be found in the changes in health services which started to take place at that time. The combined impact of declining per capita numbers of hospital beds with increasing numbers of health care professionals, meant greater availability of personnel to work in the understaffed clinics which had been built in the 1960s. In other words, there was in effect a sharp shift in resources away from hospitals and towards primary and secondary health care. Figure 5 shows how the number of hospital beds per health professional dropped sharply in 1972 and showed a tendency to decrease until at least 1984.

The reason for this sudden shift in the nature of health care in Nicaragua is complex. The decreasing availability of hospital beds was due to a combination of the devastation resulting from the earthquake, the war, rapid population growth and economic constraints to public spending. Training of health care professionals, on the other hand surpassed the increase in population.

Political influences have no doubt also played a part in this situation. The decline and fall of Somoza has been dated from the 1972 earthquake^{24,37} and political turmoil has been the norm ever since. A mass popular movement grew up in the late seventies culminating in the 1979 insurrection. Perhaps sensing that the ground was slipping out from beneath him, Somoza with United States aid, began to make significant investment in social programs. In these programs the government tried to target areas with major guerilla activity²⁴.

In post-revolutionary Nicaragua, political factors have been equally important. The Sandinist National Liberation Front took power on a program in which health and education were key components³⁸. In the president's speech on the 10th anniversary of the Nicaraguan Revolution, reductions in rates of illiteracy and infant mortality were the first items held up as gains of the revolution³⁹.

Cultural factors may also have been important. Although tradition changes too slowly to explain a sudden reduction in mortality of the sort experienced by Nicaragua, certain cultural attributes facilitate rapid reductions in mortality. Primary health care programs can have little impact without appropriate patterns of health-seeking behaviour. In Nicaragua, there exists what has been described as a 'pill culture'⁴⁰. People regard orthodox medicine and its providers (i.e. doctors and nurses) with high esteem. Manufactured pharmaceuticals, particularly when given by injection, are generally preferred to traditional herbal remedies although often both will be employed. Nicaraguans readily change treatments when a rapid improvement is not seen and are highly sensitive to the progress of illness in their children. As a result, when health services became more generally available in the 1970s and 1980s, the population quickly made use of them.

It is interesting to compare Nicaragua's period of rapid mortality decline with that of neighbouring Costa Rica which also occurred during the early 1970s^{41,42}. Both countries had experienced a slow rate of improvement during the 1960s - a phenomenon common to many developing countries³³. In Costa Rica, the drop in infant mortality was greater

in rural areas than in urban areas, both in relative and absolute terms. An analysis of Costa Rica's recent decline in infant mortality also shows up the singular importance primary health care⁴².

Having reviewed the available data is possible to postulate the following scenario. In the late 1960s United States aid was used to pay for the construction of primary health care facilities throughout the country. In the 1970s, earthquake, war, rapid population growth and economic recession reduced the number of hospital beds per capita. At the same time there was an increase in the supply of nurses and doctors per head of population which made it possible to staff the recently built primary health care facilities. The net effect was an increase in the relative importance of primary and secondary health care vis a vis tertiary health care. The health care facilities provided gained rapid acceptance from the population which already had some cultural affinity for Western medicine.

The social reforms contributing to declining child mortality were made by an isolated and threatened dictatorship in response to the mobilization of impoverished sectors of society. They were continued and extended following the insurrection, as part of the political program of the Sandinist government which replaced the dictatorship. In early 1990, a new government was elected which is committed to contraction of public expenditure. Monitoring the effects of this change in policy on child health and survival, will provide an opportunity to explore the validity of the explanations advanced in this paper.

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TABLE A—Sources of infant mortality statistics in Nicaragua

Date	Data Source	Type of Data	No. Women Ages 15-34	Regional Coverage ^a %
1971	National	Population census	256,907	100
1978	EDENIC-78 ⁸	Sample survey	6,237	91
1985	ESDENIC-85 ⁹	Sample survey	22,000 ^b	100
1986-88	Sentinel Sites ¹⁰	Sentinel sites survey	9,615	54
1956-86	SINEVI ¹¹	Death registration	—	100
1986	SINEVI-86 ¹²	Birth registration	112,200 ^b	100

Source: References 6-12

^aThe proportion of the inhabitants of the country included in the reference population.

^bApproximate only.

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APPENDIX—Sources of Infant Mortality Statistics in Nicaragua

A review was performed to identify the various sources of data on national child mortality rates in Nicaragua from 1960 to 1989. These are shown in Table A. A note of explanation is necessary about each of the data bases.

The 1971 Census

The last national census of Nicaragua took place on April 20th, 1971. Since then, war and lack of funding have prevented the government from carrying out another population census. The 1971 census registered a total population of 1 878 000. The overall rate of omission is thought to be 6.3% but in 19 of the 126 municipalities there was an average omission rate of 32% and in a further 18 municipalities the rate was 22%⁵. An 'experimental census' was carried out in 1969 as a prelude to the 1971 census but its sample was small and unrepresentative of the entire population so the results are not presented here⁴³.

The National Demographic Survey of Nicaragua (EDENIC-78)

This was a survey carried out from 1977 to 1978 which included retrospective questions for indirect mortality estimation. It was a follow-up study in which it was intended to compare indirect estimations of mortality with prospective estimates derived from the household change technique. Unfortunately, during the 1979 insurrection all of the prospective data from this survey was lost, leaving only the retrospective questions for mortality estimation. Some of retrospective data was also lost. The Atlantic Coast Departments of Zelaya and Rio San Juan were excluded from the sampling frame. Although the infant mortality rate in this area is probably higher than in the rest of Nicaragua, it is inhabited by only 8.6% of the population.

The Socio-demographic Survey of Nicaragua (ESDENIC-85)

This large household survey took place in 1985, aiming to generate up-to-date demographic and socio-economic information for the whole country, given that the census planned for 1982 had been suspended. Technical assistance was provided by CELADE and the United Nations Department of Technical Cooperation for Development⁴⁴.

A pilot test in 535 homes was performed in September 1984 and definitive data collection commenced in July 1985. In contrast to EDENIC-78 which excluded the Atlantic Coast, the

APPENDIX (cont)—Sources of Infant Mortality Statistics in Nicaragua

reference population of ESDENIC-85 covered the entire country. A two-stage cluster sample of 18 000 homes was chosen.

The Sentinel Sites Study

In 1986 the Ministry of Health (MINSa) in collaboration with consultants from UNICEF, established a set of 34 sentinel sites in 3 regions of the country⁹. These were intended to provide accurate population-based data on morbidity, mortality and health service utilization for planners and administrators. The sentinel sites were selected by regional teams on the grounds that they be 'representative' of the health conditions of their region. Data was collected by household survey with indirect questions on child mortality.

The National System of Vital Statistics (SINEVI)

In the 1960s, the civil register was administered by the Directorate General of Statistics and Censuses which was part of the Ministry of Economy. In 1970 the DGEC merged with the Department of Economic Studies of the Central Bank to form the Executive Office of Surveys and Censuses (OEDEC). Vital events were registered in the Offices of the Civil Register in each municipality. The data was published annually in the Statistical Yearbook. Coverage was estimated at 70% for births and 30% for deaths. Only 48% of registered deaths were certified by a doctor. The Ministry of Health was responsible for processing cause-specific mortality rates which were not published in Nicaragua but were sent to the World Health Organization⁴⁵.

When the new government took power in 1979, several changes were introduced to improve the registration of vital statistics but despite these measures, serious deficiencies in death registration remain. In 1987 overall coverage was estimated at 47%³⁶, but only about 34% of infant deaths are reported¹¹. Birth registration is somewhat better - in 1983 coverage was calculated to be somewhere between 79.3 and 86.5%, varying from less than 60% in the rural population to about 95% in the urban population⁴⁶.

PAPER II: The Nicaraguan Literacy Crusade: How lasting were its benefits?
Development in Practice, 4(1):35-49, 1994.

A similar (though not identical) version of this paper entitled “Twelve Years On: Women's Literacy in a Nicaraguan Municipality.” was published in the *International Journal of Lifelong Education* [1995; 14(2):162-171] in order to reach the pedagogical specialist audience. It has not been included as part of this PhD.

The Nicaraguan Literacy Crusade: How lasting were its benefits?

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Abstract

In 1981 Nicaragua was awarded a UNESCO prize in recognition of the success of the 1980 National Literacy Crusade (CNA) through which, it was claimed, three quarters of the country's illiterate had been taught to read and write. This article reports the follow-up of several hundred of the female CNA graduates. It finds that, a decade later, a significant proportion of them are no longer able to read or write; and that of those who can, many had previously attended formal schooling as children for several years. An assessment of national census and survey figures suggests that probably about 9% of the population became literate solely as a consequence of Nicaragua's ambitious adult-education interventions in the 1980s. Other benefits, such as its impact on child health and survival, have yet to be quantified.

Background

Nicaragua has had a turbulent political history throughout the twentieth century. After being ruled by a dictatorship of the Somoza family for almost fifty years, the people finally overthrew the government in an insurrection led by the Sandinista National Liberation Front (FSLN) on July 19 1979. The FSLN-led Junta of National Reconstruction set about implementing a number of reforms aimed at tackling some of the country's serious problems in the fields of education, health and social welfare. On the economic front the government nationalised all banks and insurance companies and confiscated a large amount of property abandoned by the Somoza family and their closest allies. Under President Reagan, worried by the Marxist-Leninist rhetoric of the Sandinistas and afraid that incipient revolutionary movements elsewhere in Central America might repeat the Nicaraguan experience, the US government prohibited trade with Nicaragua and spent millions of dollars to establish equip and maintain a counter-revolutionary guerilla army, known as the 'contras'. The terrorist tactics used by the contras did little to gain them the support of the Nicaraguan population, but the resources that had to be spent on national defence meant that there was little left to continue the ambitious social programmes begun in the early 1980s. As the economy deteriorated — owing to the combined effects of the trade embargo, the war, the Latin American debt crisis, and the government monetary and fiscal policies, popular support for the FSLN began to diminish. In 1990, a centre-right coalition of 14 opposition parties took power in the first fully-contested free elections in the country for many decades.

Initially, however, the post-revolutionary government had enjoyed considerable support, both at home and abroad. With financial support from the international community, particularly the USA in the last months of the Carter Administration, it was able to implement policies which led to significant advances in health and education. Despite the economic crisis, Nicaragua continued to build a health system based upon the principles of primary health care and so succeeded in sustaining the decline in child mortality which began in the mid-1970s (Sandiford *et al* 1991). But probably the most

original and memorable of these advances in the social sector was the National Literacy Crusade (CNA) which took place in 1980.

The National Literacy Crusade

A literacy census conducted in 1980 indicated that slightly over half the population over ten years old were illiterate (MED/INEC 1980). This clearly presented a major obstacle to social, economic, and political development. Moreover, the FSLN manifesto had pledged that upon the defeat of Somoza there would be 'a massive campaign to immediately wipe out illiteracy' (Tirado 1985).

Within eight months of taking power, the government mobilised and trained 95,582 students, teachers, and others for a five-month intensive adult-literacy programme (Arrién and Matus Lazo 1989) — the *Cruzada Nacional de Alfabetización*. This drew on Paulo Freire's methodology, combining syllable families to make words, and linking these to the students' world through group discussion in each lesson. The content stressed development themes, and was steeped in the ideological perspective of the FSLN.

Figures released after the official evaluation of the Crusade claimed that as a result of this massive social intervention 406,056 men and women had become literate. This reduced the official illiteracy rate to approximately 13 per cent — well within the goal of 10-15% quoted by the CNA coordinator and Jesuit priest, Fernando Cardenal (Cardenal and Miller 1981). In 1981 Nicaragua was awarded UNESCO's Nadeshda Krupskaya prize in recognition of the success of the CNA.

The Programme of Basic Adult Education

However, the government's efforts to reduce illiteracy did not end with the CNA. In the years that followed, the country embarked upon an ambitious programme of basic adult education (PBEA) to consolidate the gains of the CNA and to offer a second chance at

literacy for those illiterate adults who had not participated in the original Crusade. The PBEA reached a peak attendance in 1983, with an official enrolment figure of almost 190,000 students (Torres 1983). PBEA was conceived as a 'special elementary school' for adults: the vanguard of the 'battle for the Fourth Grade'. Classes were run after the normal working day with a curriculum covering maths, language, natural science, history and geography — again with a heavy emphasis on examples from daily life.

Inevitably, not all students persisted with the classes. People's sustained participation in education was not helped by the economic sanctions imposed on Nicaragua by the USA — nor by the escalating war, which also undermined economic and social conditions, forced cutbacks in development programmes, and reduced confidence that education would actually enhance the material conditions of the poorer sectors. Even without such difficulties there would be some drop-outs in any adult-literacy programme, no matter how good it was. Nevertheless, by 1985 the official illiteracy rate of 25 per cent was still less than half the 1979 figure (INEC 1989).

It is now appropriate to assess the medium term achievements of literacy initiatives in Nicaragua during the revolutionary period of 1979-1990. Reporting results of the literacy component of a project addressing the relationship between maternal literacy and children's health, this article represents the beginnings of such an assessment. It presents an outline of the study, and an analysis of the medium-term impact on female literacy of Nicaragua's widely publicised national literacy crusade and subsequent adult education programme.

ADULT EDUCATION INTERVENTIONS AND THEIR IMPACT ON HEALTH

Literacy, and particularly female literacy, is believed to have many positive social and economic impacts which contribute to a society's development. One important potential benefit of female literacy which has received increasing attention in recent years is an improvement in child health and survival. It is well known that indices of health among children correlate closely with the educational standards of their mothers. In fact, 'the

association of literacy and health is found in such a variety of conditions ... that an understanding of the mechanisms of this effect should stand high on a scientific research or policy analysis agenda' (Grosse and Auffrey 1989).

What is not established, however, is the extent to which this correlation means that maternal education can serve as a proxy for social class, values, beliefs, and any other components of the education-health equation that place the children of women who have had even a very basic school education at a lower risk of death and disease than those of illiterate women. Does maternal literacy have an independent positive influence on children's health? Might literacy campaigns be an effective — and cost-effective — intervention for improving children's health? Already, it has been argued that if the link is indeed causal, then '...even the sum of "direct" mortality effects of doubling everyone's income, providing every household with a flush lavatory and piped water, and turning every agricultural labourer into a professional/white collar worker would be less than the "direct" effect of providing 10 years of schooling for each woman' (UN 1985b). But if maternal literacy does have an independent effect on children's health, what are the mechanisms which mediate it? Can a better understanding of the underlying processes assist policy-makers to bring about greater benefits from other health-related programmes?

One implication of the official literacy figures is that many of the Nicaraguan women who were illiterate in 1979 learned to read and write as a result of the CNA and PBEA. In general, such women are not from privileged backgrounds, and most had apparently received little or no formal schooling as children. Consequently, they present an excellent opportunity to investigate the impact of maternal literacy on child health, free from most of the confounding effects of wealth and privilege.

In an earlier study the Latin American Centre for Demography (CELADE) analysed the trend in Nicaraguan infant mortality by maternal education, separating the group with no formal schooling into those who are literate (presumably mainly through the CNA

and PBEA) and those who are illiterate (Behm and Primante, 1977). Three points stand out from the findings:

- Infant mortality has fallen rapidly in Nicaragua during the past two decades.
- The marked differences in infant mortality appear to correspond to different levels of maternal education.
- The infant mortality rates among children whose mothers became literate through adult education are virtually identical to those of the group whose mothers had had primary schooling.

Here, it is the third point that is most relevant, for it suggests that, assuming that the socio-economic status of the illiterate and adult-educated groups of mothers is similar, women's adult education can itself significantly improve child survival.

This interpretation does presuppose that prior to the CNA and PBEA, the infant mortality rate among children whose mothers became literate by adult education was the same as that within the group that remained illiterate — in other words, it assumes that the difference in infant mortality observed subsequently can be attributed to the women's having become literate. However, this is not necessarily so. It is equally plausible that the women who learned to read and write through adult education already possessed certain values, beliefs, skills or privileges not enjoyed by the group of illiterate mothers, which might have influenced the health and survival chances of their children, even without the CNA and PBEA.

THE MATERNAL LITERACY AND CHILD HEALTH STUDY: DESIGN AND SCOPE

Aim and phases of the study

The study was designed to examine the link between child health and maternal literacy by comparing the morbidity and mortality experience of children in three groups of women: illiterate mothers; mothers who became literate exclusively through formal schooling; and mothers who became literate as adults, exclusively through the CNA and PBEA.

There are three phases to the inquiry. The first attempted to quantify the hypothesised association between maternal literacy and children's health, using standard epidemiologic, demographic and anthropometric methods. It assumed that before the CNA, the illiterate and adult literate groups were similar in relevant respects, so that differences between them in rates of child morbidity and mortality would be mainly due to the impact of adult literacy interventions. In contrast, differences between the 'adult education' and 'formal schooling' groups (assumed to be of markedly different socio-economic status) would presumably reflect the importance to child health of social and economic factors.

The second phase was qualitative, employing ethnographic techniques on a sub-sample of informants to identify differences between the groups in psycho-social factors, use of health resources outside the home, and domestic child-care practice which might account for the quantitative associations with health and survival found in the first phase. These first two phases have now been completed.

A third phase is intended to address the psycho-social factors and behaviours which seem to be linked to both female education and child health. Incorporating these within a detailed, large sample survey will permit a comprehensive model of the links between female education and child health to be developed and tested.

The study site

The Department of Masaya, with an estimated 1985 population of 207,000, was chosen as the study site. The smallest Department in Nicaragua, it has the highest population density at 300 inhabitants per square kilometre. Some 47 per cent of people live in rural areas, reflecting the average for the country as a whole. Masaya was chosen for four reasons:

- Prior to the CNA, 48 per cent of women from that area were classified as illiterate, making it relatively simple to obtain both the schooled literate and illiterate cohorts of mothers (MED/INEC 1980).
- Masaya had one of the more active and successful adult education programmes during the 1980s. This made it easy to identify women who became literate through the CNA and PBEA.
- The population is relatively homogeneous in economical and cultural terms, which reduces potential confounding by these factors.
- Masaya has a relatively good road system, making most of the area under study accessible throughout the year.

Quantitative data collection: the sample

The sample was drawn from women aged 25-49 who had given birth to at least one live infant, and who gave verbal consent to participate in the study. The aim was to find at least 500 women who became literate as adults *exclusively* through the CNA and PBEA. Literacy was measured by a simple reading and writing test, which is the first item in the questionnaire described below.

Each of these women was matched by age (in five year intervals) to one or two illiterate mothers, and one or two school-literate mothers, all from the same neighbourhood. Matching by neighbourhood helped to remove some of the confounding effects of social and environmental factors such as rural, peri-urban or urban residence, access to health services and, to some extent, socioeconomic status. Thus each 'adult literate' woman defines a single matched set, containing either three or four subjects.

For each group of women, the social and economic characteristics measured showed that, compared with the illiterate mothers, women who became literate exclusively by formal schooling were younger, taller, from a wealthier household, and more likely to have a literate husband (or partner), mother or father. The women in the adult education group were also younger and taller, but only according to a few indicators were they wealthier than the illiterate group. Interestingly, the women who became literate exclusively by adult education were significantly more likely to have a literate mother — but not a literate husband/partner or father — than the women in the illiterate group.

Quantitative data collection: the instruments

Anthropometric indicators were used as proxies for the general health status of the children under five years old. Protein-energy malnutrition, besides being a major health problem in its own right, is closely related to other causes of child morbidity. Malnutrition is both a cause and a consequence of high rates of diarrhoeal disease (Sepulveda *et al*, 1988; Schorling *et al*, 1990). Thus it offers a useful indicator of general child morbidity in countries like Nicaragua where there is a high incidence and prevalence of infectious disease in children. Anthropometric indices are also good predictors of child mortality (Ebrahim, 1983).

Each child's age was recorded and measurements were made of mid-upper arm circumference, height and weight. A rather innovative method was used for determining height consisting of an ultrasonic measuring device of the sort used by real estate agents to a ruler and spirit level. The ruler is rested on the top of the subject's head and when

the spirit level indicates that it is perfectly horizontal, several readings are taken of the distance from the end of the ruler to the ground (ie the height). This system has proven to be relatively inexpensive (each measurer costs less than £25), fast, portable and above all, accurate with a coefficient of reliability of 0.88.

The field-workers were carefully trained in these measuring techniques and in administering the interview questionnaire which accommodates the reading and writing test (see appendix). For child mortality estimation the questionnaire records the surviving proportion of a woman's live-borne offspring, and the rates were calculated by (Brass type) indirect methods (United Nations, 1985a).

Confounding variables and potential effect modifiers were also recorded during the interview. These include such factors as the number of children in the household, the total number of persons living in the dwelling, the number of bedrooms in the home, physical access to health services, the main water supply, sanitation facilities, and household indicators of wealth (e.g. the type of floor in the house, ownership of a vehicle etc).

Qualitative data collection: the sample

Having established the existence and magnitude of the link between maternal literacy and child health, the underlying mechanisms and processes by which the CNA and PBEA affected child health and survival were then examined. Anthropological methods of data collection were used to reveal the potential psycho-social and behavioral processes underlying the relationship between education and child health.

Since ethnographic research is time-consuming, only relatively small numbers of subjects can be investigated. These had to be selected in a manner which ensured that the information collected from each contributed as much as possible to generating or testing hypotheses. The qualitative phase of the research looked at eight possible mechanisms through which female literacy might lead to improved child health. These were:

- **Desired family size:** This is often referred to as the ‘trade-off’ between quality and quantity in the goals of child-bearing. The idea is that literate women are more likely to adopt the pattern of a small nuclear family, in which children are viewed as objects of indulgence rather than as sources of income or as guarantors of their parents’ security in old age. Having fewer children ensures that a greater share of the family’s resources can be dedicated to each one, and the higher investment made in each child may result in a stronger commitment to their health and survival.
- **Greater orientation towards the future:** This refers to the willingness of individuals to invest in the present for a potential future benefit, or simply the propensity to defer gratification (Fuchs 1986). It has been suggested that these characteristics are associated with female education, either because women who are prepared to make commitments for the future benefits choose to invest their time and energy in gaining an education; or because schooling actually makes women more willing to invest at a lower rate of return. Such women may also be more likely to make personal sacrifices to guarantee the survival and health of their children.
- **Modernity:** Adherence to traditional beliefs is thought sometimes to lead to harmful nutritional practice (such as the abandonment of breast-feeding when a child becomes ill), or the failure to make use of modern health care services (such as measles immunization) which reduce child morbidity and/or mortality. To the extent that literacy may be linked to a person’s willingness to abandon traditional beliefs or customs, and thence to more effective health-seeking behaviour and child-care practice, adherence to such beliefs may help to explain how female literacy correlates with lower child mortality and reduced risk of malnutrition (Caldwell 1979).
- **Control vs fatalism:** Some researchers suggest that women who believe they have considerable control over the world around them will be more active in the

care of their children than those who hold a more fatalistic outlook. Such women are said to have a more internal 'locus of control' (Rotter 1966).

- **Knowledge of preventive and curative health measures:** A mother's knowledge of the causes, prevention, and cure of diseases, and of the nutritional requirements of infants and children, may influence her ability to prevent death and malnutrition in her children. It is plausible that being literate increases a woman's level of knowledge and/or ability to acquire it (Caldwell 1979).
- **Decision-making power:** Unless a woman has decision-making power within the household to enable her to take effective action for the health of her children, other psycho-social factors listed become irrelevant. Literacy may increase a woman's decision-making power by raising her status *vis à vis* others in the family such as her husband/partner, mother-in-law, or children (Caldwell 1979).
- **Capacity to function in bureaucratic settings.** The literate woman may also derive some power from the effect of education on the attitudes of those around her. In health bureaucracies, doctors, nurses and other health workers may allow an educated woman to press them into giving urgent help to her sick child, while they would not tolerate such behaviour from an uneducated person (Orubuloye and Caldwell 1975). LeVine *et al* (1990) have also noted the relevance of skills acquired through formal schooling to a woman's ability to function strategically in institutions that often ignore or neglect their clients.
- **Ability to remember and enact decontextualised instructions.** The ability to preserve children's health may rely partly on an ability to learn new procedures without having witnessed them before. Schooling may give women the skills they need to understand, remember and follow decontextualised instructions.

To establish the relative importance of these various hypotheses, it was necessary to examine both the relationship between the exposure (literacy) and the explanatory

mechanisms, as well as the relationship between the latter and the outcome — good or poor child health. Hence the anthropological data were collected from five sets of women: an illiterate group, an adult-literate group, a schooled literate group, a group whose children had experienced relatively good health, and a group whose children had experienced relatively poor health.

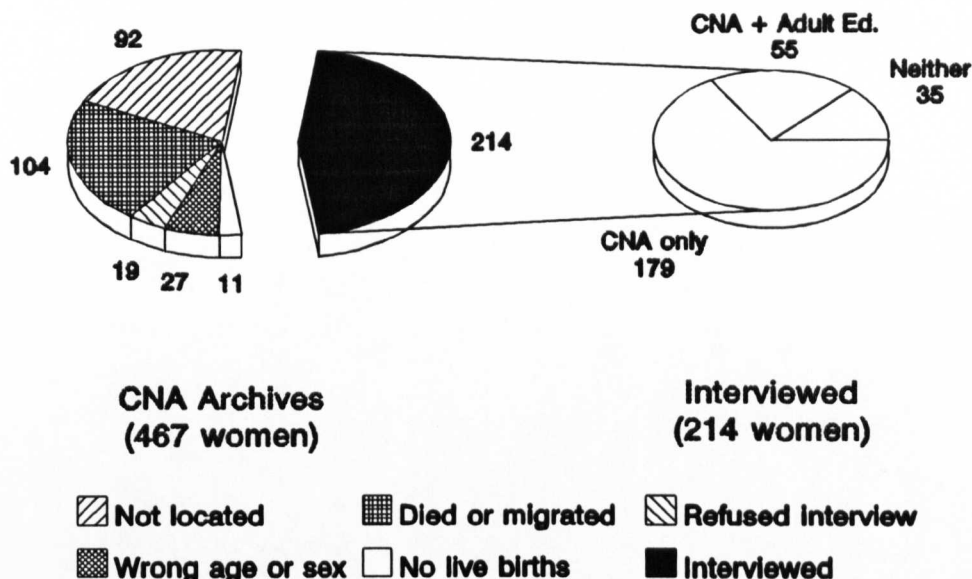
In the last case, women were selected whose last-born child died within the last ten years. The anthropologist asked the mother about the circumstances surrounding the child's death and her responses to them. Focusing on an actual event in a person's life obviously yields data of greater validity than information obtained by asking about a hypothetical situation. This sample offered two additional advantages. Firstly, it provided an opportunity to verify that the death actually did occur and had not been mistakenly recorded by the initial interviewer. Secondly, it enabled a 'verbal autopsy', using a standard set of questions (Smith and Morrow 1991) to indicate the child's probable cause of death — information which could later be used to look for differences in mortality from ostensibly preventable causes.

The anthropologist employed a variety of methods in the interview, including a vignette to elicit the woman's 'level of fatalism'. This was a story of the death of a child, in which alternative interpretations of responsibility for the death are possible. The woman was asked to state whether she feels the child's death was inevitable, perhaps an act of God, or whether it could have been prevented by some actions on the part of one of the characters in the story (the mother, the father, or the hospital doctor).

THE MEDIUM TERM IMPACT OF NICARAGUA'S ADULT-LITERACY INTERVENTIONS

Results from the quantitative phase provide some indication of how lasting the educational gains have been of the adult literacy work carried out between 1980 and 1992. The graduation register from the CNA, together with Ministry of Education census carried out in 1989 and 1990, and records kept by the adult education

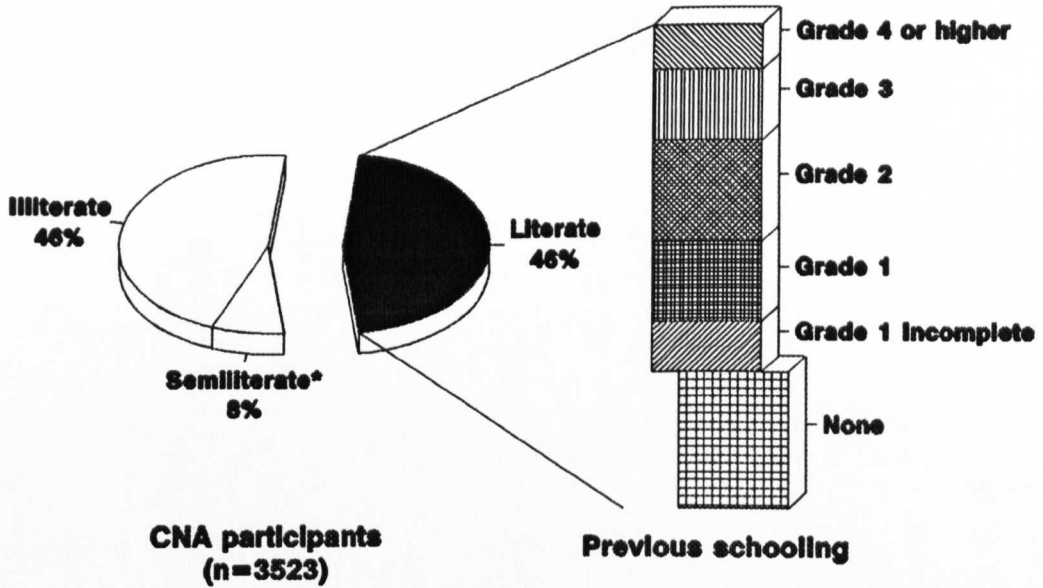
Figure 1. Identification of women from CNA archives



Based on results from the Nindirí municipality pilot study

promotores (promoters) and *coordinadores* (coordinators), were used to identify the women who were taught to read and write during the Crusade. As Figure 1 shows, many of these women proved to be difficult or impossible to locate. Moreover, a significant proportion of those located were not suitable for study purposes, for various reasons. However, even among those who were finally interviewed, some 16 per cent denied having ever participated in the CNA. In many cases this appears to be because their names were included as ‘graduates’, even if their only participation was to enrol. Not infrequently, literacy teachers — *brigadistas* — did not remain more than a few days in their assigned village, but nonetheless registered their pupils as having ‘defeated illiteracy’. In other cases — and it is impossible to discover what proportion — women seemed to want to hide the fact that they had been involved in one or more of the activities organised by the previous government. It is also true that many women were unable to participate, or dropped out of the adult education programme, because of pregnancy, commitments to child care, paid employment or (in the worst of cases) because their husbands/partners would not allow them to study.

Figure 2. Current literacy and previous schooling of CNA participants



*** Can read but not write**

Figure 2 shows the current literacy status of the women we interviewed who admitted to an involvement in the CNA. A significant proportion (46 per cent) of these are now illiterate, in the sense of having failed the simple test at the beginning of the questionnaire. Some of them may have learned to read and write to at least the level adopted in the CNA final examination as the baseline for being literate but, through subsequent lack of use, have now become functionally illiterate and so lost these (minimal) decoding and encoding skills. Others it seems, never learned to read and write, yet were recorded as literate for reasons which remain unclear.

This also shows that the majority of CNA 'literate' had actually attended primary school for at least some period, many having completed second grade or more. It seems that a large number of those who participated in the CNA did so in order to strengthen an existing ability (albeit tenuous and/or minimal) to read and write. This is, of course, a good thing. However, it does imply that the impact of the CNA on Nicaragua's illiteracy rate may not have been as dramatic as was originally estimated.

Even so, the success of the adult-education initiatives from 1979 to 1990 is significant. In the study area alone, we identified over 400 women who had never attended primary school and yet can now claim to have at least basic literacy skills. Others became literate despite having failed to do so during their brief encounter with school. Of the group who attended primary school but did not complete their first grade, we estimate that more than 80 per cent acquired literacy through the CNA or PBEA. Finally, although some women had learned to read and write at school, the PBEA gave them the chance to enhance or revive their reading and writing abilities.

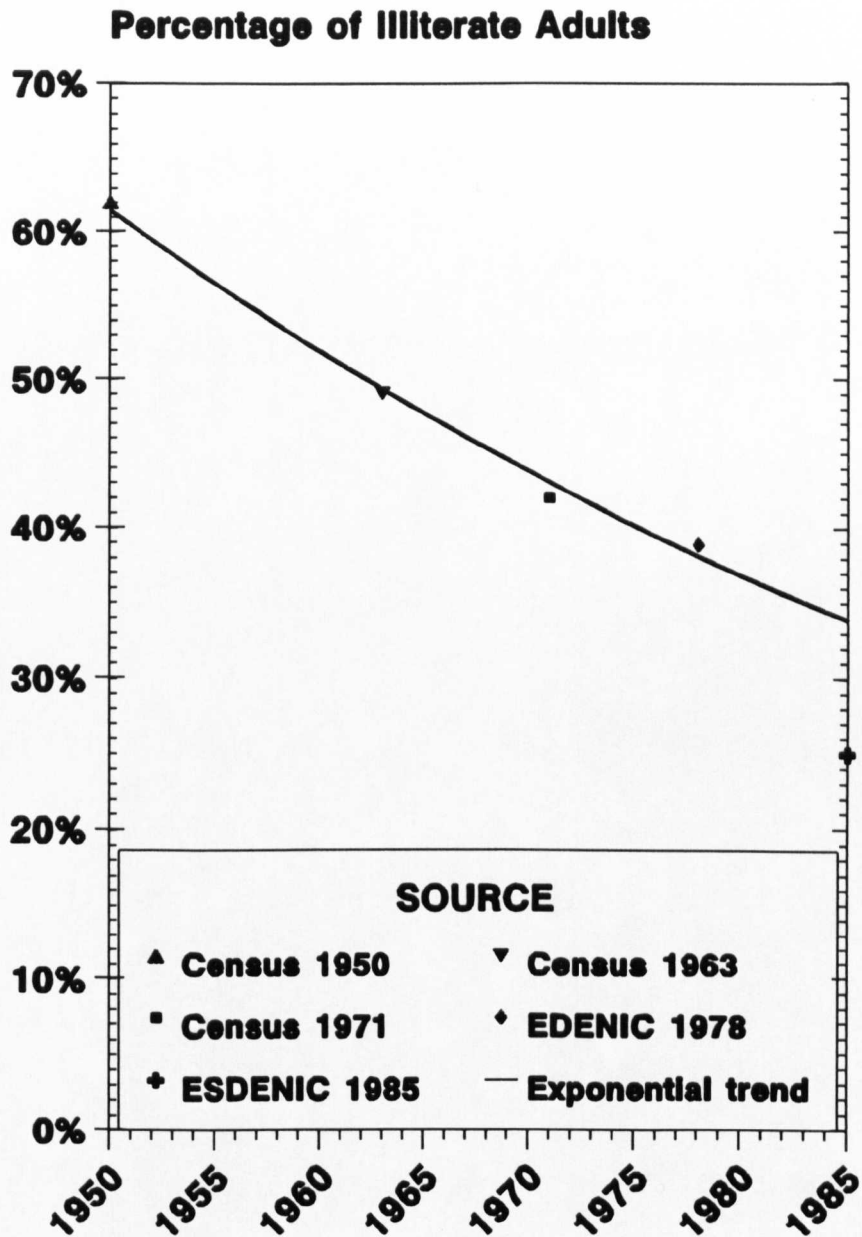
OTHER INDICATIONS OF THE IMPACT OF ADULT EDUCATION IN NICARAGUA

Assuming that the experiences recorded in Masaya are reasonably typical of Nicaragua's adult literacy programme as a whole, it would appear that its real medium-term impact may have been rather more modest than had been hoped. Closer inspection of the official statistics is, therefore, justified.

The official assessment of the impact of the CNA and the PBEA depended upon obtaining reliable estimates of the illiteracy rate before and after the programme. The ESDENIC survey of 1985 (INEC 1989) which was carried out with technical assistance from CELADE probably provides as accurate an estimate of the illiteracy rate for that year — 25% overall — as its sample size permits. Notwithstanding the consternation that the publication of the ESDENIC figures caused within the Ministry of Education at the time, it does seem reasonable to expect that drop-outs would have led to an increase in the rate of illiteracy from the declared post-CNA level of 12.9 per cent, so that the two estimates are not inconsistent.

In contrast, the estimate of 50% illiteracy which was derived from the 1980 literacy census carried out jointly by the Ministry of Education and the National Institute of Statistics and Censuses (MED/INEC 1980) is higher than that obtained in either the

Figure 3. The trend in Nicaraguan illiteracy: 1950-1985



1963 census, the 1971 census, or the 1978 EDENIC survey and is, therefore, of questionable validity (Figure 3). It was carried out in haste, at low cost, with scant training of the enumerators and in a political climate where unflattering reports of the

legacy of the Somoza regime were given considerable credence. Indeed, our Masaya study showed that the quality of data collected by the *brigadistas* was often poor, given the frequent errors made in recording names, ages, sex, and extent of participation in the CNA.

Even if the proportion of illiterate *had* dropped from one half to one quarter of the population between 1980 and 1985, this should not be attributed entirely to the CNA and PBEA. As Table 1 shows, the rate of illiteracy in Nicaragua, as in most Central American countries, had been falling slowly but steadily since at least the 1950s. It is legitimate to ask what reduction in illiteracy might have occurred in the absence of Nicaragua's 1980s adult-education interventions.

Table 1. Central American trends in illiteracy, 1970-1990

Country	Female illiteracy (%)		
	1970	1990	Reduction
Nicaragua	43	25*	42
Guatemala	63	53	16
Honduras	50	29	42
El Salvador	47	30	36
Costa Rica	13	7	46
Panama	19	12	37

(*Based on a 1985 survey (INEC 1989))

(Source: UNICEF (1992))

The trend in the illiteracy rate from 1950 to 1985 based on national censuses and surveys, demonstrates that, even with these lower estimates for the pre-CNA illiteracy rate, the 1985 level was still about 10% lower than might have been predicted on the basis of existing trends (see Figure 3). In numerical terms, this implies that over 300,000

more Nicaraguans became literate during the early 1980s than would otherwise have been expected.

Some of this reduction in illiteracy will almost certainly have been due to the enormously increased level of primary-school enrolment which occurred after the Revolution, as a consequence of Sandinista education policies. From 1978 to 1983, primary-school enrolment increased from 396,640 to 564,996 with the most rapid growth occurring in rural areas (Arrién and Matus Lazo 1989). However, it is still likely that a significant proportion of literacy improvement was an outcome of the CNA and PBEA. In addition to those who became literate, many more must have improved upon their existing ability to read and write. Although those who have retained their literacy skills probably benefited most from the adult education, even the women who failed to become illiterate, or who subsequently lost their literacy skills, may have experienced the changes in the values, beliefs, power or behaviour that literacy is believed to generate — and which may well explain its purported impact on child health (Sandiford 1992). Indeed, the encoding and decoding skills of literacy may be less relevant to the impact of adult education on individual and social development than other factors: for example, the exchange of ideas and values between the young instructors and the peasants is frequently quoted as one of the most valuable learning opportunities made possible by the CNA.

A not uncommon example of the sort of impact that adult education can have on women's lives in Nicaragua is illustrated by the case of one woman in our study. Through the CNA and PBEA she gained numeracy skills which encouraged her to learn sewing. She explained in the interview with the study anthropologist (GS) that addition and subtraction were necessary for the measurements she uses. Her husband purchased a sewing machine which enabled her to maintain the family income when he lost his job. Throughout her interview, she busily sewed school uniforms which she sells. Besides now being able to earn a living wage, she reported that her power to make important decisions within the household had increased substantially. Such are the 'knock-on'

effects of literacy, which are difficult to measure but so important in gaining a comprehensive understanding of the subject.

Another woman who participated in the PBEA told us of how she felt when learning to read and write:

My children would ask me if I would help with their homework, but I couldn't because I didn't understand the letters. It was hard for me not to be able to help them. But when the Crusade came I thought this was my opportunity. Before the CNA I couldn't write my name. I didn't even know what letter my name began with. I had to be led by the hand when I began - but the more I learned the more I could do on my own. When I finished the literacy primer I could read, and by the second level [of PBEA] all seemed easy to me ... Slowly I lost the fear. When I saw I could do it on my own I was thrilled. And in the end I learned."

Their desire to be more numerate seems to have been one of the main reasons why women participated in the CNA and PBEA, partly because these skills are valuable for jobs such as selling goods and sewing. Many women expressed the opinion that there should have been more maths and less politics in the content of the adult-education materials. On the other hand, most felt that the programme had been extremely valuable to them because, even if they were not able to read and write fluently, they could at least sign their names and understand written notices and communications. This, they felt, made them less susceptible to being 'taken in'. When our anthropologist (GS) visited people's homes and explained the aims of our research, many women were very interested because they believed it meant that a new literacy campaign was to be launched. Unfortunately, we had to disappoint them.

CONCLUSIONS

A thorough evaluation of the lasting effects of Nicaragua's massive efforts to reduce adult illiteracy has long been needed. This work represents just the beginning of such an assessment. Not surprisingly, it has demonstrated both the limitations of the adult-education programme and its achievements. Campaigns of this sort are often criticised for their short-term orientation, but of course the long-term solution to illiteracy is the universal education of children, which the 1979-1990 Nicaraguan government policy also aimed to achieve. The CNA was necessarily a stop-gap measure, yet one which for many in Nicaragua conferred important benefits and for which there is continuing appreciation.

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PAPER III: Sandiford P, Cassel J, Melendez D, Coldham C. The Electronic Stadiometer: An appropriate technology for height measurement in health surveys. *Tropical Doctor*, 24-25, January 1994.

The Electronic Stadiometer: An appropriate technology for height measurement in health surveys

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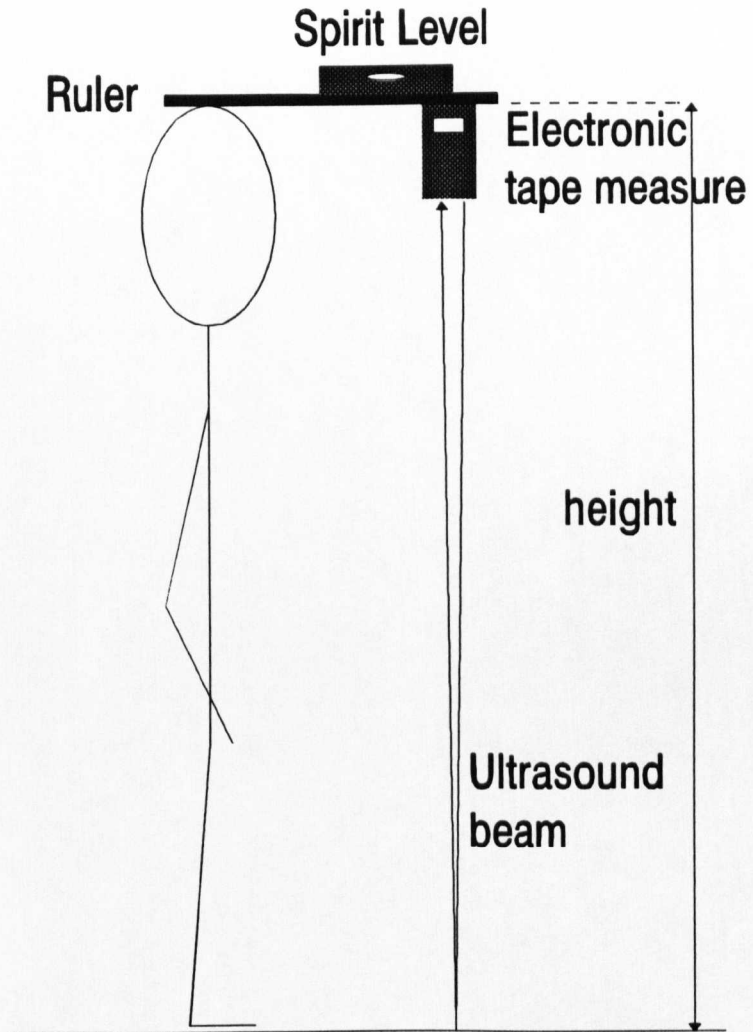
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Introduction

Height for age and weight for height are two of the fundamental indicators of protein-energy malnutrition and together they provide the information necessary to apply the Waterlow classification of children as normal, stunted, wasted or wasted and stunted,¹ each of which implies a quite different public health priority.² One of the recognised problems in using the Waterlow classification however, is the difficulty in accurately measuring height owing to the lack of low-cost light-weight height measuring equipment.² Not only are conventional stadiometers heavy, they are also often bulky and therefore very difficult to carry in field surveys. Furthermore, many types of stadiometer require solid perpendicular structures against which to measure.

Height is also a useful indicator in adults and has been used on a number of occasions as a proxy for socio-economic status.^{3,4} It is particularly valuable in places where income estimates are unreliable (as they tend to be in developing country settings with a significant proportion of subsistence farming and/or irregular informal work) or in situations of high social mobility where it is the person's childhood and adolescent socio-economic welfare which is of greatest interest to the investigator. This short report describes an apparatus which we designed to measure height in women and children in a large study of the impact of maternal literacy on child health in Nicaragua.

Figure 1. The Electronic Stadiometer.



The Apparatus

The apparatus is simply an electronic tape-measure of the sort used by real estate agents to measure house size, connected to a metal rule and spirit level (figure 1). There are various types of electronic tape-measure on the market. We chose to use the *Smarttape*, manufactured by TTI (2 Hollyhedge Rd, West Bromwich, West Midlands B71 3AA) and sold at a retail price of approximately £25. It is powered by a 9 volt alkaline battery

which it is claimed will give up to 100,000 readings. In practice we found that battery life was quite short, perhaps because field workers often forgot to turn the *Smarttape* off after each measurement. Two rubber bands were used to hold the *Smarttape* against the lower edge of a metal ruler. A spirit level with a magnetic strip on its base was placed on top of the ruler. Based on the principal of parallax, the *Smarttape* uses ultrasound to measure the distance from the ground to the base of the ruler — automatically adding in its own length. Adding in the price of the spirit level and metal rule gives a total unit cost for the electronic stadiometer of less than £30.

Accuracy

A reliability analysis was carried out by repeating the height measurements on 338 women on different days and in most cases, by different observers with different electronic stadiometers. The mean height of the women obtained in the first measurement was 150.98 cm compared with 150.38 cm for the second measurement. The intraclass correlation (reliability) coefficient was 0.88 which is good considering that this is based on actual field use and includes within-subject variation, inter-observer variation and variation between the 12 *Smarttape* units used. Within-subject variation alone is typically around 1 cm in adults over the course of the day with the highest height measurements obtained in the morning.² The standard error of measurement was found to be 2.2cm.

Durability

Virtually no problems were encountered with the spirit levels and rulers although it is important that the rule does not readily bend. The *Smarttapes* on the other hand, were a little more delicate. Of the 12 purchased, only seven were in full working order at the end of the study. Some were damaged when dropped, others were made inoperable by rain. Nevertheless, considering that 10,487 height measurements were recorded, a life span of approximately 2000 measurements per unit (ie a cost of about 1½ pence per

recorded measurement), does not seem exorbitant. A more solid construction is however, desirable for field work of this nature.

Acknowledgement

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An article about this paper entitled "Literate women make better mothers" was written by Helen Epstein for the *New Scientist*, 1995; **146**(1975):8. Another article entitled "L'alfabeto fa bene alle mamme" was written about it by Sarah Tobias for the Italian newspaper *Il Manifesto*, 12 May, 1995. It was also reported by the BBC on the *Via Libre* programme and on the *Ciencia al Día* programme of their Latin America service.

The Impact of Female Literacy on Child Health and its Interaction with Access to Health Services

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Abstract

Research has consistently demonstrated a strong correlation between female education and child health, but the absence of data from intervention studies has left open the possibility that it be due to the confounding effects of wealth or social privilege. Moreover, it is not known what mechanisms mediate the education-health link nor how it is affected by access to health services. In Nicaragua during the 1980s, thousands of adults became literate through a mass education campaign. This provided a rare opportunity to measure the impact of female literacy on child health for women who otherwise would have almost certainly remained illiterate for the rest of their lives, and to assess whether access to health services increases or decreases the advantage conferred by education. Results from this retrospective cohort study of 4434 women show that the children of women who became literate exclusively by adult education have a significantly lower mortality rate and risk of malnutrition than those of women who remained illiterate. Furthermore, when the infant mortality rates are given approximate time locations, one sees a sharp reduction following the adult education campaign for the adult education group but not for the illiterate or formal schooling groups. The survival advantage conferred by education was significantly greater in those with poor access to health services. The results also suggest that the effect of education in reducing the risk of malnutrition operates independently of its effect on mortality and that both are independent of wealth and the parents' decision to educate their daughter.

Introduction

Studies from many different developing countries have shown that maternal literacy and schooling are closely related to child health and survival. The strength of the observed association has led to the suggestion that "...even the sum of 'direct' mortality effects of doubling everyone's income, providing every household with a flush lavatory and piped water, and turning every agricultural labourer into a professional/white collar worker would be less than the 'direct' effect of providing 10 years of schooling for each woman."¹ It has also been argued that education has contributed more to mortality decline than the provision of health services.²

Bicego and Boerma³ have pointed to three important questions regarding this association. Firstly, 'to what extent is the observed relationship merely a function of education's link to economic status?' The bold assertions quoted in the first paragraph obviously assume a causal link, but the data upon which they are based is entirely from observational studies of women who acquired their education as children through formal schooling. It is well known however, that attendance at school, and consequently female literacy, is dependant upon a whole host of economic, social and even psychological factors which might independently account for the education - child health link.⁴ For example, the ability to send one's children to school, in most developing countries, depends upon the family having a certain level of income, and as a general rule, the wealthier the family the longer the children remain at school. But these higher levels of income and wealth also enable the children to have better nutrition and better access to health services.⁵

Another possible explanation is that women acquire certain values or beliefs from parents which are correlated with health and survival of their offspring, and that these same cultural attributes affect a parent's decision to educate their daughters.⁶ It seems plausible, for example, that families who invest in an education for their daughters might value the survival of their offspring more highly than families who do not send their daughters to school. If these values are passed from one generation to another, then the

female education / child health association may simply be a reflection of this transfer of 'cultural capital'.

Since 1979, analyses of data from the World Fertility Survey⁷⁻⁸, from the Demographic and Health Surveys³, and from national censuses and surveys from many different countries have shown that the education / child health association often persists after controlling for socio-economic status.⁹⁻¹² This has led many scientists and policy-makers to accept Caldwell's view,¹³ that education itself actually gives rise to changes in a woman's values, beliefs, power or knowledge, which in turn lead to lower child mortality either through better domestic child care, or more effective use of health services.

However, the absence to date of published intervention studies has meant that the direction of causality remains uncertain. Almost universally, wealth and social privilege are so inextricably linked to the acquisition of literacy and other educational attainments and so difficult to accurately measure in developing countries, that it is virtually impossible for statistical methods to completely control for their effects. In other words, if statistical control by imperfectly measured socio-economic status removes about half of the apparent advantage education advantage, how much would be left if it were perfectly measured? Cleland and van Ginneken⁵ recognise this caveat but dismiss it on the grounds that the bias would be cancelled out by other biases tending to underestimate the impact of education on child health.

Assuming that the association is indeed causal, the second question asked by Bicego and Boerma is 'what behaviours serve to mediate the education advantage in child health and survival?' In fact, even if the association is due to economic or other social factors, knowledge of the pathways through which they operate is still of considerable interest and potential importance for the design and implementation of health interventions. In particular, policy-makers need to know whether female education or its correlates operate through changes in domestic child care practice, through variation in the initiation, pace and size of child-bearing, or whether they improve child health by altering

use of extra-domiciliary health resources. If it is the latter, then it may be that illiteracy represents a major socio-cultural barrier to health service utilization and hence education initiatives will increase the effectiveness of health service interventions. If education facilitates home-based child care or alters family formation patterns then it may, to some extent, substitute for health services by obviating the need for professional care and therefore reducing the apparent effectiveness of health service provision in securing health gains.

The third question raised by Bicego and Boerma is closely related to the second. 'Does greater physical access to health services widen or narrow the differences between children of more educated and those of less educated mothers in the use of child-health related services and ultimately in the child survival chances?' The answer will depend partly on the relative importance of the different mechanisms outlined above. If education increases demand for health services, then as access improves from very low levels, it will be the educated who are the first to benefit and health outcome differentials will increase. However, as access improves further, demand by educated women may reach saturation point, enabling utilization by the uneducated to increase at relatively faster rate so that differentials drop.

In the case where education improves domestic child care, the advantages are likely to be eroded as physical access to health services increases because the home-based care can be more readily substituted for by professional care (assuming of course that the latter is more effective). There is also however, the possibility that domestic child care is only better among the educated because they are more receptive to the ideas and practices encouraged or facilitated by health workers. In other words, the prevalence of education-related domestic child care practices may itself be dependent upon physical access to health services. In short then, a knowledge of the interaction between education differentials in child health and physical access to health services does not on its own, allow the mechanism of action to be determined.

For the reasons outline above, research undertaken in the few settings where women who become literate are of similar socio-economic status to those who are illiterate can be particularly informative as they reduce the possibility of socio-economic confounding and facilitate identification of the mechanisms. One such setting is Nicaragua where in 1980, a major social intervention aimed at eliminating adult illiteracy was commenced. A mass campaign called the *Cruzada Nacional de Alfabetización* (CNA) or 'National Literacy Crusade' mobilised almost 100,000 students and teachers to all parts of the country and taught 406,056 illiterate adult men and women how to read and write.¹⁴ This was followed by an ongoing programme of night classes to consolidate the literacy gains. Between 1980 and 1985, it is estimated that 9% of Nicaraguans over the age of 10 years acquired literacy through adult education.¹⁵ Were it not for Nicaragua's adult education programme, this cohort of women would almost certainly have remained illiterate for the rest of their lives. It therefore offered a unique opportunity to examine the impact of female literacy by comparing child health in the offspring of the women made literate through the adult education intervention with that of children from women of very similar socio-economic status who remained illiterate. This paper reports results from a retrospective cohort study of the impact of Nicaragua's adult education programme on child health and survival.

Methods

The impact of female literacy by adult education was assessed by comparing child survival and nutritional status in the offspring of three groups of women, defined according to their literacy and the manner in which they became literate. One group is comprised of illiterate women, another of women who became literate attending primary school as children, and the third is made up of women who acquired literacy by adult education. Women who attended both primary school and adult literacy classes, and 'semiliterate' women who could read but not write were excluded from the analyses.

The study aimed to recruit any female resident of Masaya province aged 25-49 who became literate through adult education, provided that she had also given birth to at least one live infant. Women under this age were less than 15 years old during the CNA and were excluded because they might still have become literate as 'children' through formal schooling. From the archives of the CNA the names and addresses of women fulfilling these criteria were entered onto a computer database. Lists by community were generated and a field worker was sent to determine which women were still resident within the study zone, check their ages, ensure that she had delivered at least one live born baby, and then solicit her agreement to participate in the study. Women in the adult education group were also identified using local Ministry of Education censuses (available only in some of the municipalities), lists of ex-students supplied by the adult education tutors, and in localities with no other data sources, by carrying out a house to house census.

Each woman in the adult education group was matched by age and neighbourhood to at least one illiterate woman and one woman who became literate by attending primary school as a child (formal education). Matching was performed by visiting houses in a random direction from the house of the woman in the adult education group.

A structured questionnaire was administered to each study subject. Literacy was determined by a simple reading and writing test. Questions were included on the number

of children the woman had delivered alive, the number who are still alive, and the number who had died. These permitted time-located infant mortality rates to be estimated from the Coale and Demeny 'West' model life tables¹⁶ using the Trussell variant¹⁷ of the Brass method.¹⁸ The rationale behind the Brass method is that the proportion dead of ever born children for women at a given age corresponds to a discrete child survival probability. These survival probabilities can be used to calculate infant mortality rates if one assumes a standard age pattern of mortality. Since deaths in children born to say, women aged 25-29 have generally occurred more recently than those in children of women aged 45-49, the infant mortality rate estimated from each five-year age group of mothers can be approximately located in time.

Potential confounders and/or effect modifiers were recorded including the number of children in the household, socio-economic status, access to health services, the type of water supply and presence of sanitation facilities, the mother's marital status, employment outside the home, and child care arrangements. Because it is difficult to obtain reliable measurements of household income, housing characteristics and asset ownership were used as indicators of economic welfare as they have been in other Nicaraguan surveys.¹⁹

Anthropometric indicators were used as proxies for the general health status of the women's children under the age of 5 years. Protein-energy malnutrition, as well as being a major health problem in its own right, is closely related to other causes of illness such as diarrhoea.^{20,21} Anthropometry therefore offers simple indicator of general child morbidity in countries with high rates of infectious disease. In addition, anthropometric indices, particularly mid-upper arm circumference (MUAC), are good predictors of child mortality.^{22,23} All children present under the age of 10 had their MUAC recorded. In addition, the height of those over two years old and the weight of those under three years old was measured and recorded. MUAC was measured using paper insertion tape measures which give readings in two millimetre intervals. Weight was measured by suspending the child in a harness from a spring balance tied usually to a tree. To

measure height, a simple apparatus was invented consisting of a spirit level, and an ultrasonic tape measure.

Data was double-entered into the computer using a *dBase IV* programme with automatic range and consistency checks. Weight-for-age and height-for-age z-scores based on the NCHS standard²⁴ were calculated using the programme *Anthro*. A separate *dBase* programme converted the MUAC measurements into percentages of the reference level using the Burgess and Burgess standard²⁵ for children under 12 months of age and the US NHANES standard²⁶ for older children. Children two or more standard deviations below the reference median were defined as have low weight-for-age. Since there was a high prevalence of stunting low height-for-age was defined as three or more standard deviations below the reference median. For low MUAC-for-age, the cut-off point was at 90% of the reference median.

The significance of differences in socio-economic status was assessed using the Mantel-Haenszel test and the Mann-Whitney U test. The relative risks for child mortality and malnutrition associated with each category of literacy were estimated by logistic regression analysis before and after controlling for potential confounders.²⁷

For the purpose of testing whether mortality differences between the education groups could be explained by the higher prevalence of malnutrition among the illiterate, an aggregate index was generated for each family based on the recorded anthropometric measurements. A separate index was generated for weight-for-age, MUAC-for-age and height-for-age. Each index was calculated as follows:

$$I = \sum_{n=1}^N M_n (1 - p_n) / N$$

where: I = Family malnutrition index;
 N = Number of children measured;
 M_n = Nutritional status of child n ; 1 if malnourished, 0 if normal; and

p_n = Prevalence of malnutrition in child n 's age-sex stratum of the total study population

Results

Of the 4434 women interviewed, 422 were women who became literate purely through adult education, 1727 were illiterate, and 733 had become literate exclusively by formal schooling. The remainder were either semi-literate or of mixed education.

Differences in socio-economic status between the groups of women are shown in **Table 1**. As expected, the women who became literate through attendance at primary school are significantly better off than the illiterate. In contrast, the literate women in the adult education group differ significantly from the illiterate only in a few of the indicators, suggesting that although they may be from slightly wealthier families, the difference between them is not large.

Table 2 summarises the results from comparisons of the infant mortality rates in each group. The proportion of dead offspring for women in the adult education and formal schooling groups is consistently lower than in the illiterate group and overall, the proportion of children dead was 16% lower in the offspring of women in the adult education group than among those of illiterate women ($p < 0.01$). However, the difference between the two is much greater in the post-CNA period than in the pre-CNA period. The same general pattern is also seen with the infant mortality rates where the relative risk in the adult education group compared with the formal schooling group changed from 0.95 in the pre-CNA period to 0.79 in the post-CNA period.

Among the offspring of the formally schooled women the mean proportion dead was 32% lower than among those of illiterate women ($p < 0.001$) and 19% lower than among those in the adult education group ($p < 0.01$). In this case, the difference in infant mortality between the illiterate and formal schooling groups remained almost constant

from the pre-CNA to the post-CNA period. In contrast, the mortality differences between the formal schooling group and the adult education group were greatest in the pre-CNA period.

The trend in infant mortality from 1978 to 1987 is shown for each group in **Figure 1**. In the children of illiterate women infant mortality remained almost constant, varying within a range of less than 10 deaths per thousand live births. In the formal schooling group there was a sharp drop in the infant mortality rate between 1978 and 1981 (prior to the CNA), but since then it has remained fairly constant. The most interesting aspect of **Figure 1** however, is the change in infant mortality in the adult education group. This falls sharply from a level similar to that of the illiterate group prior to the CNA, to a rate after the CNA very close to that of the formal schooling group. This is consistent with the hypothesis that the acquisition of literacy skills leads directly to an increase in child survival.

Table 3 presents results from the analysis of the anthropometric data as age-specific prevalences of protein-energy malnutrition. The prevalence of low MUAC-for-age was 60% higher in children of the illiterate than in children of women in the adult education group ($p < 0.001$). Though the prevalence of low MUAC-for-age in the children of formally schooled women was 13% lower than in those of the adult education group the difference was not statistically significant. Children in the illiterate group were about three times as likely to be malnourished as those in the adult education group ($p = 0.01$) based on the prevalence of low weight-for-age. However, for this indicator children in the formal schooling group were no better off than those in the adult education group. The children in the adult education group also enjoy a 34% lower risk of severe stunting compared with those of the illiterate ($p < 0.05$), and the offspring of formally schooled women had only half the rate of the adult education group ($p < 0.01$).

Crude and adjusted odds ratios from the logistic regression analyses are shown in **Table 4**. Two models were tested. The first sought to examine whether the observed differences in mortality and risk of malnutrition persisted after controlling for the socio-

economic factors listed in **Table 1**. The results show that there was only a small attenuation of the mortality and nutritional advantages in the adult education group compared with the illiterate group. Only the odds ratio for low height-for-age became insignificant in the adjusted model. For the comparisons between the formal schooling and adult education groups, control for socio-economic status widened the mortality and low weight-for-age differences but rendered insignificant the difference in the risk of low height-for-age.

The second model in **Table 4** examines whether the differences in mortality might be explained by the apparent nutritional advantages associated with education. The results show that no matter which family malnutrition index is used, the mortality odds ratios for both the illiterate and the formal schooling groups compared with the adult education group remain virtually unchanged.

The logistic regression analysis also revealed that access to health services significantly modifies the effect of female education on child survival ($p < 0.01$). **Figure 2** shows that the odds ratio for child mortality in the illiterate group compared with the adult education group increases steadily with travelling time to the nearest health centre. A similar interaction between education and physical access to health services was also seen for the comparison between the illiterate and the formal schooling group ($p = 0.01$). For the various indicators of malnutrition however, the interaction between access to health services and education (illiterate versus adult education) was either insignificant (weight-for-age) or of just borderline significance (height-for-age and MUAC-for-age).

Discussion

Growth in our understanding of the relationship between female education and child health has been inhibited by having to study women who acquired their education through formal schooling. As has already been pointed out, this makes it difficult to distinguish between the effects of the education and those of the social and economic advantages associated with schooling in developing countries. The existence in Nicaragua of a large cohort of women who became literate exclusively by adult education provides an opportunity to circumvent some of these constraints to gain a greater knowledge of how important education is to child health and of the likely pathways by which it may have its effect. The newly literate women are similar in socio-economic profile to the ones who remained illiterate and significantly worse off than those who were educated by formal schooling. Were it not for the adult education programme these women would in all likelihood have remained illiterate for the rest of their lives. Moreover, by comparing the survival of children within this group who were born before the CNA with those born after it, it is possible to obtain another measure of the health impact of the programme.

Results from this investigation strongly support the contention that education plays a critical role in child health and survival, independently of other social and economic advantages. Not only was survival significantly higher in the offspring of women in the adult education group compared with those of illiterate women but also, within the adult education group, survival was better for the children of women who were likely to have given birth after the CNA rather than before. Controlling for household wealth, education of spouse and parents, parity, access to health services, water supply and sanitation by logistic regression did not greatly attenuate the differentials in mortality or prevalence of malnutrition between the two groups. The apparent mortality effect of adult education appears to be equivalent to about 2 years of formal schooling if one uses Cleland and van Ginneken's estimate of a 7-9% reduction in mortality for each year of maternal education.¹² However, if it were possible to exclude from the analysis those children in the adult education group who were born and raised through the period of

high mortality risk (up until say two years of age) before their mother became literate, then the observed effect of literacy on survival is likely to be even greater.

The results of the study enable us to discount some of the other hypotheses that have been put forward to explain the association between female education and child health. One of these is that the differences in health and survival result from the transmission to the mother of her parents' values and beliefs which influenced their decision to send her to school, and which are at the same time, values and beliefs of benefit to child health and survival.⁶ Since none of the women in the adult education group attended primary school but 42% of the illiterate group received at least some primary education, transmitted parental values cannot in this case explain the observed differences in mortality and prevalence of malnutrition.

Another theory that can be dismissed is that the female literacy / child health association is due to the classroom providing a model of intense adult-child interaction which implicitly conveys the notion that children are publicly valued citizens.²⁸ With adult education, the classroom interactions are of course adult-adult. The estimated timing of the reduction in child mortality associated with adult education makes it less likely that preexisting psycho-social attributes favouring child survival such as self-confidence, family decision-making power, aspirations to 'improve oneself', or simply intelligence are the cause of literacy by adult education and not the effect of it.

Some insight into the mechanisms by which education might affect child health is provided by these findings. To begin with, the fact that the association strengthened when birth order was included in the regression model suggests that at least this component of the pattern of family formation does not explain the differences in survival or nutritional status. There was a higher proportion of uniparous women in the adult education group than in the illiterate group and the mortality of first born children was significantly greater than that of subsequent births. Bicego and Boerma's analyses of the Demographic and Health Surveys also failed to explain mortality differences on the basis

of family formation factors³ but Hobcraft's suggestion that differences in the age at which childbearing commences might be important, could not be tested in this study.⁴

The question as to whether the lower child mortality in the adult education group compared with the illiterate group reflects differences in health service utilization or differences in domestic child care practice is difficult to answer. One interpretation is that better domestic child care reduces the risk of malnutrition and in doing so, lowers the risk of mortality (albeit to a lesser extent). However, since the mortality odds ratios were unaffected by controlling for the family malnutrition index it would seem that the nutritional and survival effects of education do not lie on the same causal pathway. It may be, for example, that literacy reduces a child's risk of mortality by altering patterns of health-seeking behaviour, but lowers its risk of malnutrition by improving feeding practices (despite the tendency for educated women to wean at an earlier age⁷).

It is highly unlikely that the CNA affected feeding practices by teaching women about the nutritional value of different foodstuffs or about measures to prevent diarrhoea and other diseases known to cause protein-energy malnutrition. The ministry of health did provide each tutor with a 'health booklet' to enable them to discuss concepts of hygiene and preventive health care in their free time,²⁹ but the health component of the formal CNA teaching materials was otherwise negligible, so if there are differences in knowledge they are probably be due to indirect effects of literacy on the women's ability to acquire health-relevant information. However, studies have generally found only a weak correlation between education and knowledge of nutrition, and it has been pointed out that 'facts' are not always incorporated into the belief systems that determine behaviour.³⁰

Interestingly, the difference between the children of illiterate mothers and those of women in the adult education group in mean weight- height- or MUAC-for-age was not statistically significant. The significant differences were in the proportion of children below the threshold for malnutrition. In other words, although literate women seemed to be able to prevent their children from becoming moderately or severely malnourished,

the growth of their 'normal' children was not greater than that of the non-malnourished children in the illiterate group. Perhaps this is because the literate woman values her children more than the illiterate woman and is therefore more likely to notice and intervene when one fails to thrive. Perhaps it is because she feels (and therefore is) more capable of influencing her child's health. Despite widespread scepticism of the potential of mass education campaigns to alter attitudes, the acquisition of literacy skills, especially in adulthood, must surely have a profound impact on a woman's assessment of her own ability.³¹ Or perhaps becoming literate gives her the power within the home to take or influence decisions affecting her children's health and nutrition (such as the protein-energy composition of their diet).¹³

Physical access to health services *per se* was not significantly associated with any reduction in child mortality. Indeed, the interaction with access to health services was not due to the children of illiterate women suffering a relatively greater increase in mortality as access decreased, compared with those in the adult education and formal schooling groups. Rather, it was because the mortality rates in the latter *dropped* as access to health services worsened, whilst in the illiterate group they remained virtually constant.

This seemingly counter-intuitive result can be explained in two reasonably plausible ways. One possibility is that the women in the adult education group living further from health units learn and apply child care practices which substitute for those performed by the health services, and do so more effectively (eg home-based oral rehydration therapy versus institutional rehydration). This would fit with Cleland and van Ginneken's belief 'that domestic behaviour is the key to the enhanced survivorship of children born to educated mothers.'⁵ The second possibility is that the women in the adult education group who reported longer travelling times to their nearest health unit, were actually selecting more elaborate facilities with a presumably better quality of care. For example, they may prefer to use the town health centre staffed by a doctor rather than the village health post staffed by an auxiliary nurse with very limited training. It was not possible

from the data collected in this study to determine the relative importance of each possibility.

The finding that adult education, and not just primary schooling, is associated with significant child health benefits has important policy implications. A better understanding of the psychological and social effects of female literacy that bring about child health improvements may have radical implications for the design of health interventions. Could general female adult education be more cost-effective than specific health education? Could it be that education is a more cost effective health intervention than increasing access to health services? This study has provided important insight into these questions but remains a long way from producing definitive answers.

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Table 1. Socio-economic differences by type of education^a

	Illiterate	Adult Education	Formal Schooling
Mean age (years)	37.2	35.1****	34.9****
Mean no. of live children	5.4	4.9***	4.2****
Height (cm)	150.5	151.4**	152.4****
Literate husband	69%	71.0%	84.0****
Literate mother	19%	27.0%**	47.0****
Literate father	43%	46.0%	68.0****
Employment outside the home	34%	29.0%	25.0***
Informal house construction	21%	16.0%*	10.0****
Well or piped water source	62%	62.0%	73.0***
Latrine	92%	92.0%	95.0**
Concrete or tiled floor	24%	33.0****	49.0****
Iron bars on windows	5%	8.0**	15.0****
Refrigerator ownership	3%	4.0%	12.0****
Motor Vehicle ownership	1%	2.0%	5.0****
Mean number of bedrooms	1.73	1.8	1.9***
Mean number of occupants	7.28	7.2	6.6****
Occupants per bedroom	4.83	4.6*	4.0****

^a Significance tests compare the adult education and formal schooling groups with the illiterate group.

* p<0.05 ** p<0.01 *** p<0.001 **** p<0.0001

Table 2. Child mortality and female literacy

Age of mother	Time location	Illiterate			Adult Education			Formal Schooling					
		Dead	Alive	Proportion	Dead	Alive	Proportion	Dead	Alive	Proportion	IMR	RR	
45-49	1978	483	1733	0.218	69	300	0.187	105	87	451	0.162	92	0.81
40-44	1981	338	1617	0.173	51	246	0.172	105	50	425	0.105	68	0.64
35-39	1983	432	2112	0.170	74	438	0.145	96	69	553	0.111	76	0.68
30-34	1985	212	1299	0.140	37	323	0.103	75	39	353	0.099	73	0.70
25-29	1987	154	922	0.143	41	346	0.106	81	53	487	0.098	76	0.71
Pre-CNA	1978-1981	821	3350	0.196	120	546	0.180	105	137	876	0.134	80	0.73
Post-CNA*	1983-1987	798	4333	0.151	152	1107	0.118	84	161	1393	0.070	75	0.70
Total*	1,984	1619	7683	0.169	272	1653	0.143	92	298	2269	0.101	77	

*/ Values for pre-CNA, post-CNA and total proportions of infants dead and infant mortality rates are unweighted means of the relevant strata.

Table 3. Protein-energy malnutrition and female literacy

Anthropometric indicator	Adult Education			Illiterate			Formal Schooling		
	Low*	Normal	Proportion	Low*	Normal	Proportion	Low*	Normal	Proportion
MUAC-for-age									
< 1 year	3	51	0.056	20	137	0.127	6	43	0.122
1 year	9	32	0.220	57	117	0.328	5	52	0.088
2 years	6	47	0.113	38	155	0.197	6	65	0.085
3-5 years	16	167	0.087	99	595	0.143	17	239	0.066
6-9 years	42	203	0.171	268	734	0.267	51	252	0.168
<i>Standardised proportion</i>			0.134			0.215			0.117
Weight-for-age									
< 1 year	2	50	0.038	10	140	0.067	2	44	0.043
1 year	6	33	0.154	41	120	0.255	7	45	0.135
2 years	0	16	0.000	24	54	0.308	4	27	0.129
<i>Standardised proportion</i>			0.064			0.191			0.102
Height-for-age									
2 years	2	36	0.053	13	109	0.107	1	41	0.024
3-5 years	18	159	0.102	103	574	0.152	9	243	0.036
6-9 years	13	232	0.053	76	916	0.077	12	291	0.040
<i>Standardised proportion</i>			0.072			0.109			0.036

* Low means more than two standard deviations below the reference median for weight-for-age and height-for-age, and less than 85% of the reference median for MUAC.

Table 4. Logistic regression analyses

	Illiterate versus Adult Education		Formal Schooling versus Adult Education	
	Crude Odds Ratio ^a (95% C.I.)	Adjusted Odds Ratio ^b (95% C.I.)	Crude Odds Ratio ^a (95% C.I.)	Adjusted Odds Ratio ^b (95% C.I.)
MODEL 1: MORTALITY AND MALNUTRITION CONTROLLING FOR SOCIOECONOMIC VARIABLES				
Mortality	1.23 (1.07 - 1.42)	1.19 (1.03 - 1.37)	0.79 (0.65 - 0.94)	0.75 (0.63 - 0.90)
Low MUAC-for-age (<90% of median)	1.84 (1.41 - 2.40)	1.76 (1.34 - 2.32)	0.86 (0.61 - 1.20)	0.98 (0.69 - 1.39)
Low weight-for-age (Z score < -2)	2.75 (1.27 - 5.95)	2.81 (1.26 - 6.27)	1.23 (0.48 - 3.12)	1.54 (0.58 - 4.09)
Low height-for-age (Z score < -3)	1.57 (1.06 - 2.30)	1.42 (0.95 - 2.12)	0.49 (0.28 - 0.85)	0.62 (0.35 - 1.09)
MODEL 2: MORTALITY CONTROLLING FOR FAMILY MALNUTRITION INDEX				
Mortality adjusting for MUAC-for-age index	1.25 (1.07 - 1.46)	1.25 (1.07 - 1.45)	0.84 (0.69 - 1.01)	0.84 (0.69 - 1.02)
Mortality adjusting for weight-for-age index	1.29 (0.99 - 1.67)	1.25 (0.96 - 1.63)	0.81 (0.58 - 1.14)	0.81 (0.58 - 1.14)
Mortality adjusting for height-for-age index	1.25 (1.07 - 1.47)	1.24 (1.06 - 1.46)	0.82 (0.68 - 1.00)	0.83 (0.68 - 1.00)

^a Adjusting only-for-age of mother (for mortality) or age of child (for nutritional status).

^b Model 1 controls for all variables in table 1 (plus the mother's calf circumference for anthropometric indicators). Model 2 only adjusts for the specified family malnutrition index.

Figure 1. Time located infant mortality rates by education.

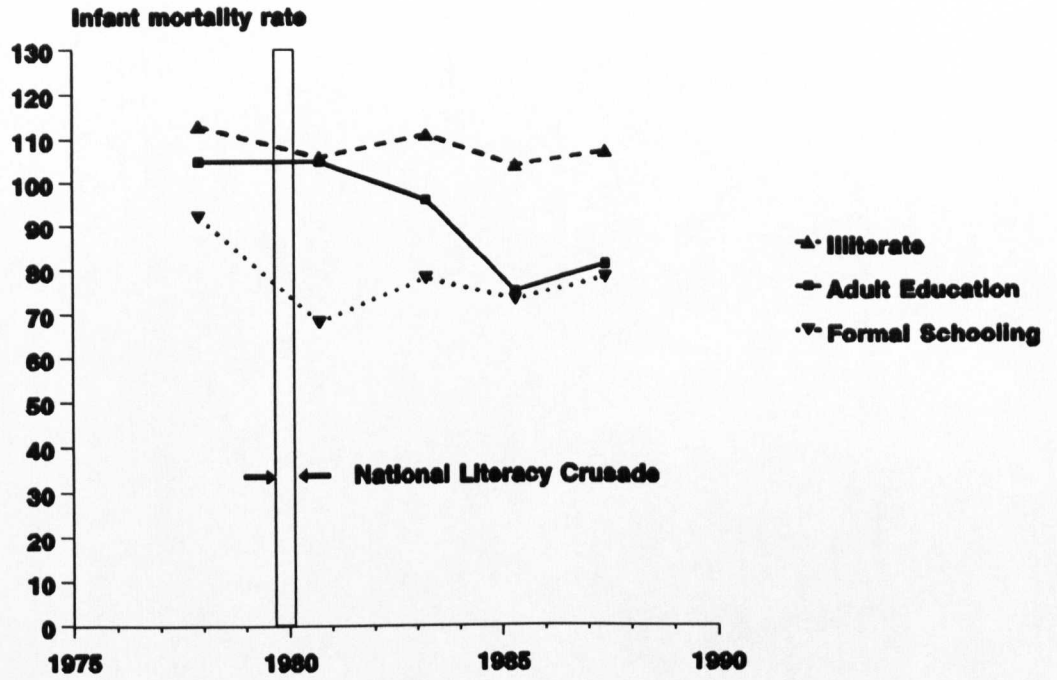
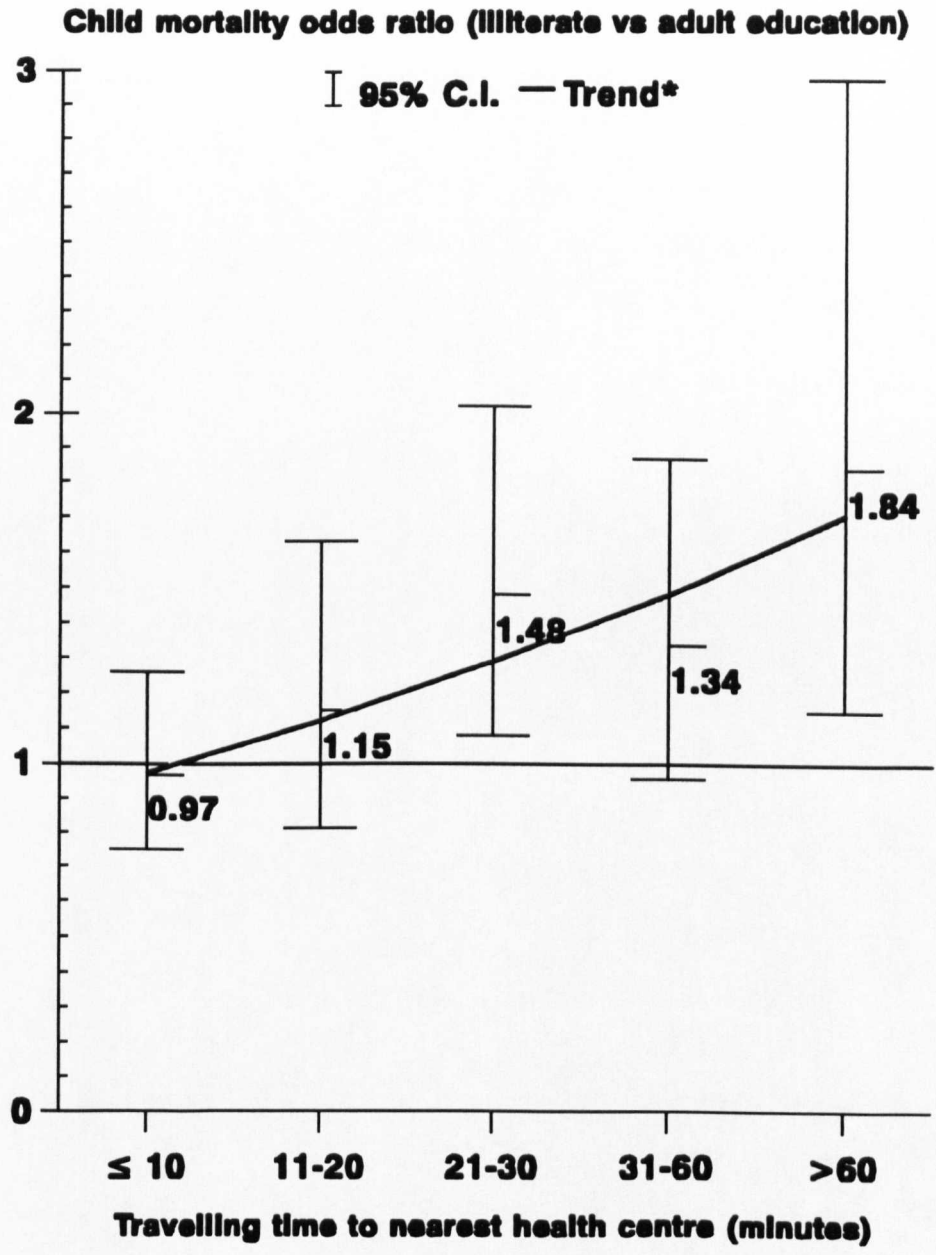


Figure 2. Modification of the effect of literacy on child mortality by access to health services



* p<0.01

Summary

Studies from many countries have consistently demonstrated a strong correlation between female education and child health, but the absence of data from intervention studies has left open the possibility that this association is due to the confounding effects of wealth or social privilege. In Nicaragua during the 1980s, thousands of men and women became literate through a mass adult education campaign. This provided a rare opportunity to measure the impact of female literacy on child health and survival for women who would otherwise have almost certainly remained illiterate for the rest of their lives.

A retrospective cohort of women who became literate exclusively by adult education was identified and matched on age and neighbourhood to a group of illiterate women, and a group of women who became literate by attending primary school as children. The survival of their offspring was recorded and anthropometric indicators of nutritional status were calculated in the children under 10 years old.

Of the 4434 women interviewed, 422 were women who became literate purely through adult education, 1727 were illiterate, and 733 had become literate exclusively by formal schooling. Indicators of socio-economic status for the adult education group differed only slightly from those for the illiterate group.

The proportion of dead offspring was 16% lower in the adult education group than in the illiterate group. However, with time-located estimates, the child mortality difference between illiterate and adult education groups was much greater after the literacy campaign than before it. Children in the adult education group had a significantly lower risk of malnutrition than those in the illiterate group whether measured by low arm circumference-for-age, low weight-for-age or low height-for-age. All of these differences remained significant after controlling for socio-economic factors except that in height-for-age which seemed more sensitive to wealth than the other indicators of protein-energy malnutrition. Analysis of the malnutrition indices showed that the

families of women with high rates of malnutrition were not necessarily the ones with high rates of mortality. A statistically significant interaction between education and physical access to health services was detected for mortality such that the children of educated women who travelled furthest to health services had particularly good rates of survival compared with those of other women.

Results from this investigation strongly support the contention that education's link with child health and survival is causal and independent of other social and economic advantages and not due to a selection bias. The mechanisms by which literacy affects health remain unclear, but may be various and different for mortality than for malnutrition.

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Does intelligence account for the link between maternal literacy and child survival?

SHORT TITLE: MATERNAL INTELLIGENCE AND CHILD SURVIVAL

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ABSTRACT

The strong and consistent correlation between maternal education and child health is now well known, and numerous studies have shown that wealth and income cannot explain the link. Policy-makers have therefore assumed that the relationship is causal and explicitly advocate schooling as a child health intervention. However, there are other factors which could account for the apparent effect of maternal education on child morbidity and mortality, one of which is intelligence. This paper examines the effect of maternal intelligence on child health and looks at the degree to which it can explain the literacy associations with child survival and risk of malnutrition. The data are from a retrospective cohort study of 1294 mothers and their 7475 offspring, of whom 454 were women who had learnt to read and write as adults in Nicaragua's literacy programme, 457 were illiterate, and 383 had become literate as young girls attending school. The women's intelligence was tested using Raven's Coloured Progressive Matrices.

Acquisition of literacy was strongly related to intelligence. Statistically significant associations with maternal literacy were found for under five mortality, infant mortality, and the risk of low mid-upper-arm circumference (MUAC) for age, before and after controlling for a wide range of socio-economic factors. Under five, child (1-4 years), infant and post-neonatal mortality plus the risk of low height for age were significantly correlated with intelligence, but only with infant and under mortality rates did the association remain significant after controlling for socio-economic factors. A significant interaction between intelligence and literacy for under five mortality was due to literacy having a strong effect in the women of low intelligence, and negligible for those of high intelligence. This study provides evidence that intelligence is an important determinant of child health among the illiterate, and that education may have the greatest impact on child health for mothers of relatively low intelligence.

KEY WORDS

intelligence, child health, maternal education, maternal literacy

INTRODUCTION

A strong association has consistently been found between maternal education and child survival. Until Caldwell's seminal paper (Caldwell 1979) it was generally assumed that this association was a reflection of differences in wealth and that it was wealth, not education, that helped ensure high rates of child survival. However, statistical analyses controlling for wealth have often demonstrated that wealth explains only a small part of the reduced mortality risk experienced by the offspring of educated mothers (Grosse and Auffrey 1989; Cochrane 1979; Grossman 1982; Cleland and van Ginneken 1989). Caldwell (1994) and others therefore began to believe that education in itself could lead to improvements in child survival. This view was strengthened by a recent study showing that even the children of women who learnt to read and write as adults enjoyed lower rates of childhood mortality than those of illiterate mothers (Sandiford *et al.* 1995). Already many international donor and lending agencies, including the influential World Bank (1993), operate on the premise that maternal education yields benefits in terms of child health and survival.

It is perhaps rather surprising then, that alternative explanations for the link between maternal education and child health have not been fully explored. One of these is that education and child health are both associated with the mother's intelligence and it is this, not her education *per se*, that explains the observed differences in mortality rates. Indeed, this possibility has been recently advanced by the controversial commentators on contemporary American society, Charles Murray and Richard Herrnstein (1994) in their best-selling book *The Bell Curve*, though they were unable to identify any studies which had tested the hypothesis.

In exploring a possible link between intelligence and child health it is important to recognise that this is a highly controversial topic and one in which there is no consensus on the underlying theory. Many years ago, Spearman (1972) posited that there exists a general factor *g* in mental ability, and an extensive review of the empirical evidence by Perkins and Saloman supports this view (1989). Evidence that *g* is, in turn, composed

of other factors is much weaker although a division between verbal and spatial abilities detected in psychometric studies seems to be supported by recent neuropsychological studies (Anderson 1992). Most modern theories of intelligence fall into what has been called the information processing class which are based on an understanding of the different steps and pathways in knowledge acquisition, in contrast to the focus on the different components of intelligence in psychometric theories (Connolly and Kvalsvig 1993). Anderson (1992) presents one such model which explains most of the empirical consistencies and inconsistencies. According to his model, intelligence tests actually reflect individual differences in knowledge, but intelligence (or *g*) as a property of thinking, refers first and foremost to variation in the speed of basic cognitive processing, and secondly, to variation in the power of the two specific processors (verbal/propositional and visuo-spatial corresponding to the aforementioned cognitive abilities). It is thought that the type of processing may be different between these two with simultaneous processing linked to spatial ability while successive processing is linked to verbal skills.

Conceivably, the acquisition of literacy is affected by or correlated with either or both of these abilities, which in turn could influence child health and survival. For the purposes of this study, a test of simultaneous processing (the visuo-spatial processor) was chosen for two reasons. Firstly, because it was felt that this would be the facet of intelligence most likely to explain the association between female education and child health, as it is thought that this ability makes it easier to think about complex situations. Secondly, because the tools available for measuring successive processing (the verbal/propositional processor) often require literacy or English language. In any case, there is a close correlation between the test scores of the two (largely because they are both highly dependant on the basic processing speed) and thus a measure of one is to some extent at least, also a measure of the other.

This paper tests the hypothesis that the better health and survival of educated mothers is due, not to her schooling, but to her intelligence, which if true, would cast doubt upon the assumed effectiveness of schooling as a health intervention. The data are from a

retrospective cohort study of maternal intelligence and child survival in the offspring of women who became literate as adults during Nicaragua's widely acclaimed National Literacy Crusade (NLC) of 1980 and its follow-up, the People's Basic Adult Education Programme, through which the government attempted to eradicate illiteracy. This cohort is compared with a matched sample of women who remained illiterate, and another, of women who became literate as girls through the traditional means of formal schooling. To the authors' knowledge, it is the first such investigation of a link between maternal intelligence and child health.

The NLC mobilised almost 100,000 students and teachers to all parts of the country and it is credited with having taught 406,056 illiterate adult men and women how to read and write (Arrien and Matus Lazo 1989). Despite high levels of recidivation, it is estimated that between 1980 and 1985 9% of Nicaraguans over the age of 10 years acquired literacy through adult education (Sandiford *et al.* 1994). Were it not for Nicaragua's adult education programme, this cohort of women would almost certainly have remained illiterate for the rest of their lives.

METHODS

The study aimed to recruit all female residents of Masaya province aged 25-49 who had become literate through adult education, provided that she had also given birth to at least one live infant. Women under this age were less than 15 years old during the NLC and were excluded because they might still have become literate as 'children' through formal schooling. Women who attended both primary school and adult literacy classes, and 'semiliterate' women who could read but not write were also excluded from the analyses. From the archives of the NLC the names and addresses of women fulfilling these criteria were entered onto a computer database. Lists by community were generated and a field worker was sent to determine which women were still resident within the study zone, check their ages, ensure that each had delivered at least one live born baby, and solicit their agreement to participate. Women in the adult education group were also identified using local Ministry of Education censuses (available only in some of the municipalities),

lists of ex-students supplied by the adult education tutors, and in localities with no other data sources, by carrying out a house to house census.

Each woman in the adult education group was matched by age and neighbourhood to at least one illiterate woman and one woman who became literate by attending primary school as a child (formal education). Matching was performed by visiting houses in a random direction from the house of the woman in the adult education group.

Data was gathered in two separate structured questionnaires, carried out approximately one year apart. In the first, which was administered to all of the women, literacy was determined by a simple reading and writing test. Women were handed one of three short sentences (eg *los peces viven en el agua* - fish live in water) printed in large letters on a card and asked to read it. If they could read every word in the sentence then they were marked as able to read. They were then asked to write one of the other three sentences and if they could do this as well as reading the sentence then they were classed as literate for the purposes of this study.

Potential confounders and/or effect modifiers were recorded including the number of children in the household, socio-economic status, access to health services, the type of water supply (piped, private well or other) and presence of sanitation facilities, the mother's marital status, employment outside the home, and child care arrangements. Because it is difficult to obtain reliable measurements of household income, housing characteristics and asset ownership were used as indicators of economic welfare as they have been in other Nicaraguan surveys (Gorter *et al.* 1991).

In the first round questionnaire, anthropometric indicators were used as proxies for the general health status of the women's children under the age of 5 years. Protein-energy malnutrition, as well as being a major health problem in its own right, is closely related to other causes of illness such as diarrhoea (Sepulveda *et al.* 1988; Schorling *et al.* 1990). Anthropometry therefore offers a simple indicator of general child morbidity in countries with high rates of infectious disease. In addition, anthropometric indices,

particularly mid-upper arm circumference (MUAC), are good predictors of childhood mortality (Briend *et al.* 1987; Chen *et al.* 1980). All children present under the age of 10 had their MUAC recorded. In addition, the height of those over two years old and the weight of those under three years old was measured and recorded. MUAC was measured using paper insertion tape measures which give readings in two millimetre intervals. Weight was measured by suspending the child in a harness from a spring balance tied usually to a tree. To measure height, a simple apparatus was invented consisting of a ruler, a spirit level, and an ultrasonic tape measure. This invention and a study demonstrating its reliability are described elsewhere (Sandiford *et al.* 1994).

The second structured questionnaire was administered to a subset of the 4400 women initially interviewed. It attempted to gather much more detailed information than the first, including a full birth history to allow age and sex-specific mortality rates to be calculated, and a battery of psycho-social tests of which intelligence was one. This subsample included all of the 489 women identified from the first interview who had learnt to read and write exclusively as adults. An illiterate mother plus a mother who became literate at school were selected from the same age-community strata as each of the literate mothers who received adult education. Only 5% of the mothers were lost to follow-up.

Although measurement of 'intelligence' remains rather controversial, it is nevertheless an area in which much research has been conducted and where standardised tests have been developed and validated. A number of tests were considered but in the end it was decided to use set A_B of Raven's Coloured Progressive Matrices (CPM) (Raven 1976). This is a non-verbal test that is especially good at measuring factor *g* and in particular, simultaneous processing ability (Anderson 1992). The Matrices have been very thoroughly validated and scores are highly stable in a wide variety of cultures. The coloured backgrounds on which the problems are printed attract attention, make the test spontaneously interesting, and obviate the need for too much verbal instruction (Raven *et al.* 1993). The test consists of 12 problems each of which requires the testee to select one of six alternative solutions. The test was applied without any time limit but was

normally completed by the woman in less than 10 minutes. The interviewer administered the test in the book form according to the guidelines provided by Raven *et al.* (1993), beginning with simple examples from the A scale to demonstrate the basic principles of solving the problems, before proceeding to the A_B scale where responses were recorded.

All data was double-entered into a computer using a *dBase IV* programme with automatic range and consistency checks. Weight for age and height for age z-scores based on the NCHS standard (NCHS 1977) were calculated using the programme *Anthro*. A separate *dBase* programme converted the MUAC measurements into percentages of the reference level using the Burgess and Burgess standard (1969) for children under 12 months of age and the US NHANES standard (Frisancho 1981) for older children. Children two or more standard deviations below the reference median were defined as having low weight for age. Since there was a high prevalence of stunting, low height for age was defined as three or more standard deviations below the reference median. For low MUAC for age, the cut-off point was at 90% of the reference median.

The associations of maternal literacy and intelligence with child health were demonstrated by logistic regression (Kleinbaum *et al.* 1988), calculating crude odds ratios (controlling only for family formation variables such as age and birth order) and comparing these with the odds ratio estimates after controlling for a wide range of socio-economic factors including:

- water supply (piped, well or water-hole)
- ownership of a latrine
- ownership of a refrigerator or car
- aspects of the house construction (number of bedrooms, dirt versus tile or concrete floor; and whether there were iron bars on the windows and doors)
- literacy of the woman's mother, father and spouse
- household structure (whether cohabiting with partner; number of house occupants per bedroom)
- the woman's height and calf circumference

- urban / rural residence and travelling time to nearest health facility
- whether the woman was in paid employment.

RESULTS

The basic quantitative data from the study shown in **Table 1** demonstrates that the socio-economic profile of women in the adult education group resembles that of the illiterate group far more than formal schooling group does.

Maternal literacy and child survival

The associations between maternal literacy and health outcomes are shown in **Table 2**. Crude and adjusted odds ratios are given for the risks of death and malnutrition in the offspring of women in the adult education group compared, on the one hand with those of illiterate women, and on the other, with those of mothers who became literate through formal schooling. Mortality odds ratios are presented for the second round interviews in which intelligence test data and full birth histories were collected. In addition, the mortality rates just for births from 1975 on are presented because of a statistically significant tendency for these to be higher than earlier births ($p < 0.05$ with infant mortality, $p < 0.10$ with under five and neonatal mortality rates).

The obvious explanation for this effect modification — that the offspring of women in the adult education group only gained a survival advantage over the children of illiterate mother after the former had become literate — does not seem to be correct. If that were the reason one would have expected the effect of literacy on infant, neonatal and post-neonatal mortality rates to date from 1980 and not 1975. Rather, it seems that it was only following the mid-1970s that a basic infrastructure of primary care services was established making the services and technologies available to the general population which would give them a degree of control over the survival of their children (Sandiford *et al.* 1991).

There are three important points to note from this table with regard to mortality. Firstly, there is a statistically significant overall association between maternal education and child survival in the first five years of life which remains virtually unchanged after controlling for a wide range of socioeconomic variables. Secondly, the mortality odds ratios are, as already stated, much higher for children born from 1975 on than for the whole sample and among this subgroup, there are statistically significant differences between the illiterate and adult education groups for under five, infant and neonatal mortality rates (although the latter loses significance after controlling for socioeconomic variables). Even the odds ratios for child mortality are large, if not statistically significant. Thirdly, child survival in the formal schooling group is not significantly better than in the adult education group.

Maternal literacy and malnutrition

Table 2 also shows how maternal literacy is related to the risk of malnutrition in the children of these women. Figures are given for malnutrition defined by low mid-upper-arm circumference for age, low weight for age, and low height for age. The results show that children of illiterate mothers are at about twice the risk of having an arm circumference below 90% of the reference median than those of women who became literate by adult education. There was not however, a significant difference in risk between children of the adult education group and those of the formally educated mothers. In contrast the crude risk of stunting was significantly lower for the children in the formal education group than for those of the adult education group, while there was no significant difference between the adult education and illiterate groups. Results for weight for age did not show any significant advantage for children of the adult education group compared with those of illiterate mothers.

Maternal literacy and intelligence

From **Table 3** it is clear that there is a strong and significant difference between the intelligence scores of women who became literate by adult education and those who

remained illiterate. In contrast, the difference between the intelligence scores of women who became literate by adult education and those who learnt to read at school is relatively small, and becomes insignificant after adjusting for socioeconomic factors. If the formal schooling group is divided into those who completed primary school (mean CPM score = 8.24) and those who did not (mean CPM score = 7.12), the gradient in scores by level of education becomes even more striking.

Maternal intelligence and child health outcomes

There were no significant associations between intelligence and mortality in the overall sample but, as with literacy, the relationship was much stronger for births from 1975 on (**Table 4**). Statistically significant crude associations between intelligence and health outcomes (post-neonatal, infant, child and under five mortality as well as risk of low height for age) were all confounded by socioeconomic factors to some extent, and of the two which remained significant after controlling for these factors (under five and infant mortality), only the former remained significant after adjusting for education.

Attenuation of the strength of association between maternal literacy through adult education and child health by controlling for intelligence.

The extent to which the association between maternal literacy and child health is explained by the intelligence of the mother is best examined by dividing the education groups into low, medium and high intelligence strata and assessing to what extent the relationships are changed. It transpires in fact, that there is a significant interaction between intelligence and education in their association with under five mortality ($p < 0.05$), and although not statistically significant, a similar trend is seen with infant mortality and low MUAC for age. The nature of this interaction is revealed in figures I and II. **Figure I** shows that while stratifying by intelligence does not greatly affect the risk associated with being born to an illiterate mother, maternal illiteracy is not a risk factor for children whose mothers are of relatively high intelligence. This is true, not only for under five mortality, but also for each of its component mortality rates, as well

as for the risk of low MUAC for age. Conversely, as **Figure II** illustrates, intelligence is only strongly linked to survival for the children of illiterate mothers. The same is true, but to a lesser extent, for the risk of low MUAC for age, low height for age, and low weight for age.

DISCUSSION

Clearly a randomised controlled trial would be the best way to assess whether education affects child health and survival independently of intelligence, but such research would not be either economically feasible as a way to measure mortality differences, nor ethical, given the substantial non-health benefits of education. This retrospective cohort study offers perhaps the best alternative means to determine the most plausible links between maternal literacy and child health. Indeed, in comparison with virtually all other investigations in this area which have relied upon women who became literate through formal schooling, it represents an important advance. The girls who attend school and become literate as children are from such a completely different social and economic background to their unschooled and illiterate counterparts that even with the most sophisticated statistical analyses, it is impossible to be confident that the results are not distorted by selection bias and confounding. By focussing on women who, had it not been for the literacy crusade would in all likelihood have remained illiterate for the rest of their lives, it has been possible to avoid some of these difficulties. Nevertheless, before one can be convinced that the observed links between a child's health and the education of its mother are causal, it is necessary to demonstrate that pre-existing attributes such as intelligence or motivation do not account for the differences. The results from this analysis take us one step further in that direction.

As with any study, the interpretation of the results must take into account potential sources of bias or inaccuracy. In this case, the validity and precision of Raven's Coloured Progressive Matrices as a measure of intelligence is crucial. In particular, it is conceivable that illiterate women might have performed relatively poorly in this test simply because they are less accustomed to studying the two dimensional images of dots,

lines, triangles and other figures from which the tests are composed. However, it would be reasonable to expect even illiterate women to be well acquainted with graphic images in a country with a reasonably strong literate tradition like Nicaragua, where one constantly encounters signs and advertisements, and where most families have access to television. Even if there were such differences it would mean observing more attenuation of the literacy - child health associations than can fairly be attributed to intelligence, since the intelligence of the illiterate would have been underestimated. Since little attenuation was seen anyway, it is unlikely that in practice this was a serious problem.

Of equal concern is whether Raven's Coloured Progressive Matrices are actually a good measure of intelligence. If they failed to capture variation in educative ability then the conclusion that intelligence does not explain the association between literacy and child health could be mistaken. Here it is comforting to know that the test has been validated on many occasions in diverse social and cultural settings, including with Spanish-speaking populations. In addition, high consistency ratings for this test were obtained in this population, with a mean Cronbach alpha of 0.64 for the 3 pilot tests and of 0.69 for the study as a whole. Moreover, consistency was almost identical for each of the education groups, despite there being sizable differences in their mean scores.

Notwithstanding the high reliability of the CPM scores, there are certain limitations to their validity as measures of educative ability. One of these is that the score obtained depends to some extent upon the mental energy devoted to solving the problems (Maistriaux 1959), which in turn, depends upon the value an individual places on dealing with abstractions. Differences in CPM scores by education could therefore be more of a reflection of differences in effort and the value attributed to solving the problems, than actual educative ability. This is important because effort itself, could be a valid explanation for associations with child health and survival.

Could the significant association between under five mortality and intelligence be due to differences in the effort made to solve the problems? If one considers that the

acquisition of literacy itself, particularly for the adult education group, required considerably greater effort than solving the problems, then any association between CPM scores and health that were due to motivational factors would be reduced after controlling for education. The results presented in **Table 4** showed that the link between infant mortality and CPM scores lost significance after controlling for literacy of the mother and even the non-significant odds ratios shifted towards one. Further evidence for the possible importance of a mother's willingness to dedicate some mental effort to solving problems is provided by the results (not presented) from Coombs' tests of family size and sex preference. Children of those women whose responses were 'not single-peaked', in other words, not logically consistent, had higher under-five mortality rates than those whose responses were single-peaked, although the differences were not statistically significant. Even here though, it is not possible to state whether the lack of logical consistency in their responses was a consequence of lower motivation or to having less cognitive ability. The error introduced by an unwillingness to devote mental energy to solving abstract problems is recognised by Raven *et al.* (1993) and represents a major limitation to the interpretation of the findings in this study.

The large differences in intelligence scores between women in the illiterate group and those who became literate by attending school, and between women literate women who completed primary school and those who did not, are hardly surprising. They are consistent with studies from the United States showing that duration of schooling correlates more closely with intelligence than with socioeconomic status (Hernstein and Murray 1994). Indeed, one might expect stronger correlations in this setting, given the weak enforcement of compulsory schooling laws and the widespread view that if a child is not 'doing well' in school, then it is acceptable to have him/her taken out. What is perhaps more interesting, is the finding that the intelligence scores of women in the adult education group are significantly higher than those of illiterate women and not significantly different from those of the women who became literate as children. If one assumes that the acquisition of literacy did not affect performance in the CPM test, then it is reasonable to conclude that cognitive ability (or motivation) is an important

determinant of how successfully women exploited the rather limited opportunities that they have had to learn to read and write.

Apart from the link with under five mortality, the crude correlations between intelligence and child health are all explained by socioeconomic factors and education. Similarly, the relative risks for the illiterate compared with the adult education group of under five mortality and low height for age (but not low MUAC for age) lose statistical significance after controlling for differences in intelligence. However, it is not particularly useful to think in terms of whether intelligence explains the effect of literacy or vice versa, given the existence of a significant interaction between these two variables (at least for under five mortality). The results from this study suggest that intelligence is an unimportant predictor of child survival if the mother is literate but a crucial one if the mother is not. Conversely, the acquisition of literacy appears to have a positive effect on child survival for most women except for those of relatively high intelligence. In other words, the acquisition of literacy effectively substitutes for the benefits of intelligence and vice-versa.

Why? One explanation is that there are certain skills, values, knowledge and/or attitudes that are needed to ensure child survival, which can be acquired either through literacy or through intelligence. These in turn predispose the mother to engage in health-seeking behaviours and domestic child care practices (including feeding) which contribute positively to the health of her offspring. Illiterate mothers of low intelligence who do not possess these attributes are effectively marginalised from modern society and their children's health suffers as a result. The fact that neither intelligence nor literacy were significantly associated with child survival until after 1975 adds weight to this theory because it was only from about then in Nicaragua, that the basic health service infrastructure and primary health care strategy was put in place, marking the onset of fall in infant mortality rates that was to continue for at least a decade (Sandiford *et al.* 1991).

An alternative explanation is that both CPM scores and the acquisition of literacy reflect a willingness to devote mental energy to solving problems. There is no doubt that an

adult woman had to make a significant effort to become literate notwithstanding the NCL. It is also clear that keeping a child alive and healthy requires both will and effort. In other words, if the acquisition of literacy and results from the intelligence test are both the outcomes of 'motivational dispositions', then the high mortality among the offspring of illiterate women with low intelligence may be due to these very same dispositions.

The policy ramifications of these two interpretations of the findings are quite different. The first explanation implies that literacy training will have a positive impact on child survival mainly for women of relatively low intelligence (with the proviso that there is a functioning primary health care system), and that education interventions should prioritise such women if this impact is to be maximised. The second explanation implies that unless women are highly motivated, their children will suffer excessive rates of mortality and malnutrition and education interventions will do nothing to change this. Until there is a more clear understanding of where literacy lies in the causal chain, the education of women, though in itself a worthy enough goal, cannot unequivocally be advocated as a policy to reduce infant morbidity and mortality, especially if this means diverting resources away from other interventions which are known to have a positive and direct effect on child health.

From this study it is impossible to be sure which of the two explanations is more likely to be correct. To do so requires a better understanding of how literate women of relatively low intelligence differ from illiterate women of similar cognitive ability and, among the illiterate women, how those of medium and high intelligence differ from those of low intelligence. Other psycho-social factors such as modernism, locus of control, power within the home, social support, and future orientation may provide the answer. Conceivably, both literacy and high intelligence could give rise to changes in one of these psycho-social factors such as locus of control, which in turn leads to better domestic child care and/or more effective health-seeking behaviour.

So Caldwell and his followers could still be correct to attribute a causal role for education in child health and survival. However, the results presented here suggest that

certain qualifications are necessary. Intelligence does explain some of the correlation and in particular, no differences in child survival were found between the illiterate and adult education groups for mothers of high intelligence. Hence, even if one does assume that education produces better child health, the benefits would not be spread uniformly. But the fact that education appears to offer the greatest benefit to women with the lowest intelligence and highest rates of child loss does make it a potentially important intervention for the pursuit of greater equity in child health outcomes.

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Table 1. Crude values for the study variables by type of education^a

	Illiterate	Adult Education	Formal Schooling
Mean age (years)	37.2	35.1****	34.9****
Mean no. of live children	5.4	4.9***	4.2****
Height (cm)	150.5	151.4**	152.4****
Literate husband	69%	71.%	84%****
Literate mother	19%	27.%**	47%****
Literate father	43%	46.%	68%****
Employment outside the home	34%	29.%	25%***
Well or piped water source	62%	62.%	73%***
Latrine	92%	92.%	95%**
Concrete or tiled floor	24%	33.%***	49%****
Iron bars on windows	5%	8.%**	15%****
Refrigerator ownership	3%	4.%	12%****
Motor Vehicle ownership	1%	2.%	5%****
Mean number of bedrooms	1.7	1.8	1.9***
Mean number of occupants	7.3	7.2	6.6****
Occupants per bedroom	4.8	4.6*	4.0****
Under five mortality rate ^b	128	95.**	90**
Child mortality rate ^b	36	25	17**
Infant mortality rate ^b	93	67.**	72*
Post-neonatal mortality rate ^b	66	50.*	57
Neonatal mortality rate ^b	29	18.*	17*
Prevalence of low weight for age	15%	11.%	14%
Prevalence of low MUAC for age	23%	14.%****	12%****
Prevalence of low height for age	11%	7.%*	4%***

^{a/} Significance tests compare the adult education and formal schooling groups with the illiterate group.

^{b/} Deaths per 1000 live births from 1975 on.

* p<0.05 ** p<0.01 *** p<0.001 **** p<0.00001

Table 2. Odds ratios and 95% confidence intervals for the associations between maternal literacy and health outcomes.

	Illiterate vs Adult Education group		Formal Schooling vs Adult Education group	
	Crude ^a	Adjusted ^b	Crude	Adjusted
<i>Mortality (all births)</i>				
Neonatal mortality	1.33 (0.95-1.86)	1.27 (0.89-1.94)	0.92 (0.74-1.40)	0.95 (0.60-1.50)
Post-neonatal mortality	1.14 (0.90-1.46)	1.11 (0.87-1.42)	1.08 (0.82-1.42)	1.07 (0.80-1.43)
Infant mortality	1.19 (0.98-1.46)	1.16 (0.94-1.42)	1.03 (0.81-1.30)	1.03 (0.80-1.32)
Child mortality (1-4 years)	1.33 (0.95-1.84)	1.36 (0.96-1.91)	0.68 (0.44-1.06)	0.68 (0.42-1.08)
Under five mortality (0-4 years)	1.22 (1.02-1.46)	1.21 (1.00-1.46)	0.90 (0.73-1.13)	0.91 (0.72-1.15)
<i>Mortality from 1975</i>				
Neonatal mortality	1.65 (1.04-2.61)	1.57 (0.96-2.57)	1.09 (0.62-1.92)	1.04 (0.56-1.96)
Post-neonatal mortality	1.32 (0.99-1.77)	1.29 (0.95-1.76)	1.15 (0.82-1.59)	1.11 (0.77-1.54)
Infant mortality	1.40 (1.09-1.80)	1.35 (1.03-1.76)	1.13 (0.84-1.51)	1.09 (0.92-1.51)
Child mortality (1-4 years)	1.48 (0.92-1.93)	1.53 (0.92-2.53)	0.74 (0.39-1.38)	0.75 (0.37-1.96)
Under five mortality (0-4 years)	1.41 (1.11-1.79)	1.37 (1.07-1.77)	0.99 (0.74-1.56)	0.97 (0.71-1.33)
<i>Malnutrition</i>				
Low MUAC for age ($<90\%$ of mean)	2.03 (1.52-2.72)	1.85 (1.36-2.52)	0.83 (0.57-1.25)	0.93 (0.62-1.39)
Low weight for age (z score ≤ -2)	1.26 (0.60-2.66)	1.62 (0.62-4.25)	1.28 (0.55-2.96)	2.23 (0.71-6.98)
Low height for age (z score ≤ -3)	1.73 (1.14-2.64)	1.39 (0.88-2.20)	0.47 (0.25-0.90)	0.59 (0.29-1.20)

^a/ Adjusted only for age of mother and year of birth (plus sex of child, and order of birth for mortality rates).

^b/ Adjusted also for all socio-economic variables.

Table 3. Intelligence scores of women in the different education groups.

	Crude	Adjusted
<i>Mean intelligence scores (unweighted)</i>		
Illiterate	5.11	5.32
Adult education	6.97	6.99
Formal schooling	7.45	7.22
<i>Difference between intelligence scores (weighted)</i>		
Adult education - illiterate	1.78 (1.45-2.12)	1.68 (1.34-2.02)
Adult education - formal schooling	-0.45 (-0.81- -0.09)	-0.17 (-0.54-0.20)

N=976 cases

Table 4. Odds ratios and confidence intervals for the association between maternal intelligence and child health outcomes.

OUTCOME INDICATOR	Adjusted for family formation factors only			Adjusted for demographic and socio-economic factors			Adjusted also for literacy of mother		
	Medium vs low	High vs low	Trend (p value)	Medium vs low	High vs low	Trend (p value)	Medium vs low	High vs low	Trend (p value)
<i>Mortality rate^a</i>									
Neonatal	0.98	0.66	N.S.	1.10	0.74	N.S.	1.21	0.90	N.S.
Post-neonatal	0.80	0.67	p<0.05	0.84	0.68	N.S.	0.87	0.74	N.S.
Infant	0.84	0.65	p<0.01	0.89	0.67	p<0.05	0.94	0.74	N.S.
Child (1-4 years)	0.81	0.54	p<0.05	0.81	0.59	N.S.	0.91	0.70	N.S.
Under five	0.82	0.60	p<0.001	0.85	0.63	p<0.01	0.91	0.71	p<0.05
<i>Risk of malnutrition</i>									
Low MUAC for age	0.72	0.54	N.S.	0.73	0.66	N.S.	0.80	0.78	N.S.
Low weight for age	0.81	0.96	N.S.	0.67	0.94	N.S.	0.65	0.83	N.S.
Low height for age	1.02	0.35	p<0.05	1.01	0.44	N.S.	1.12	0.55	N.S.

^{a/} Among children born from 1975 onwards.

Figure I. Relative risks of under five mortality and low MUAC for age for the illiterate compared with the adult education group, before and after stratifying by intelligence.

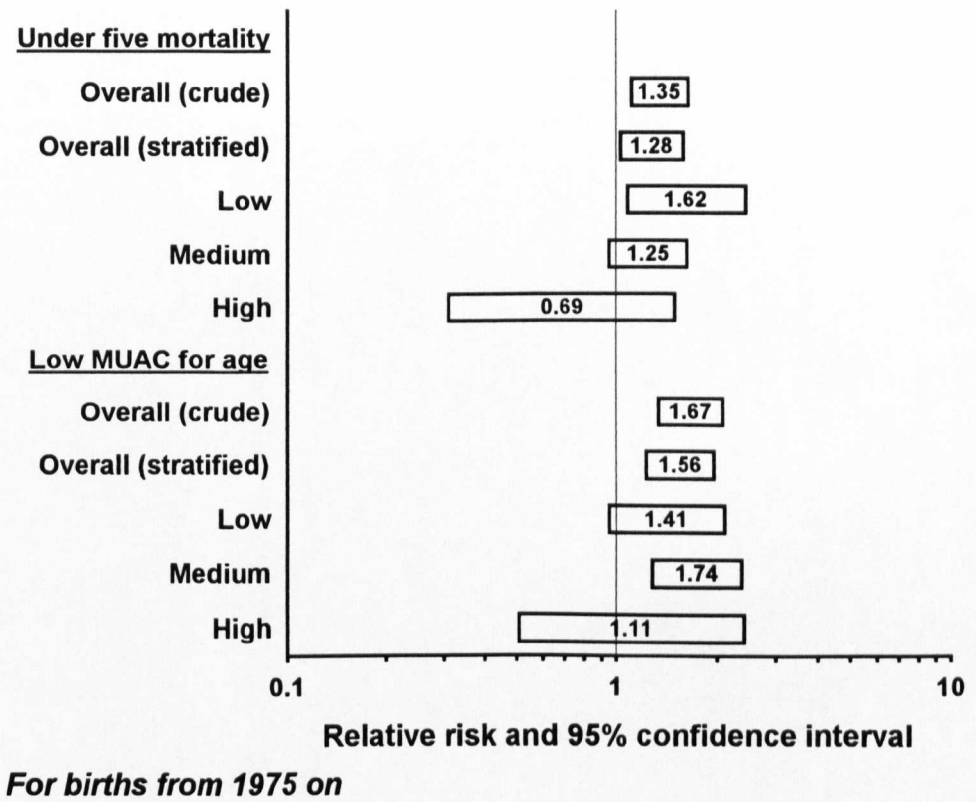
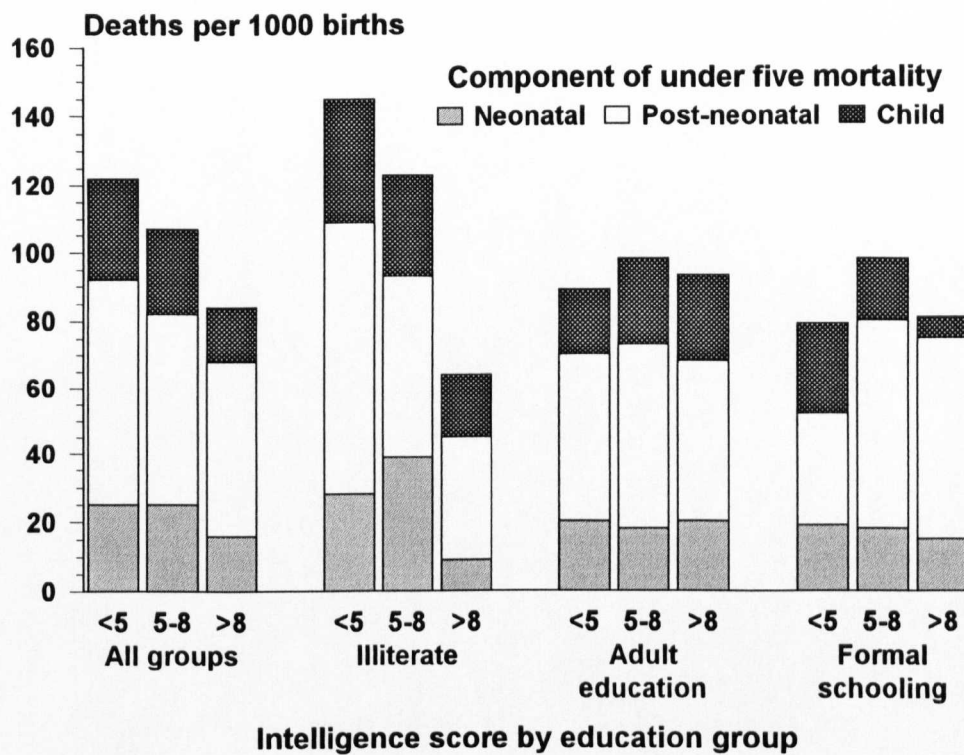


Figure II. Under five mortality rates by education and intelligence.



PAPER VI: Sandiford P, Cassel J and Sanchez G. Psycho-social factors as explanations for the link between maternal literacy and child survival. In press, *Health Transition Review*.

Psycho-social factors as explanations for the link between maternal literacy and child survival

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Summary

The strong association between maternal education and child survival is now well established but our understanding of how education might produce improvements in child health remains rudimentary. This paper examines seven psycho-social factors as potential explanations for the maternal education - child health link. These were modernism, social support, future orientation, locus of control, intelligence, power within the home and commitment to child survival. The study was designed to test the importance of each of these as risk factors for childhood death and malnutrition in their own right, and as explanations for the relationship of maternal literacy with these health outcomes.

Using a retrospective cohort design, it compared a group of mothers who had become literate in Nicaragua's National Literacy Crusade (NLC) and its subsequent adult education programmes, with mothers who remained illiterate and mothers who had become literate by attending school as young girls. Scales to measure each of these psycho-social factors were developed and tested before being applied in the survey of 1294 mothers, 494 of whom had become literate exclusively through adult education, the remainder belonging to the illiterate and formal schooling groups in roughly equal proportions. In addition to measuring each of these psycho-social dimensions, the survey instrument gathered a full birth history and measured nutritional status (height, weight and mid-upper arm circumference) in the children under 10 years of age.

Four of the seven factors were closely correlated with one another. These were modernism, locus of control, intelligence and commitment to child survival. It was also these four factors which were most strongly associated with maternal literacy. Two of them, locus of control and commitment to child survival were significantly related to post-neonatal, infant, child (1-4 years) and under five mortality risks among these women. These same two factors explained about a third of the apparent effect of literacy on these mortality rates, but for the much stronger relationship in births from 1975 on, they explained an even higher proportion of the under five and child mortality

rates and more still when intelligence was added into the model. The timing of the mortality decline in the offspring of women in the adult education group suggests that literacy is more likely to be the effect than the cause of differences in psycho-social attributes. It was concluded that mothers who place a high value on the survival of their children, and that believe they have the power to ensure their survival, generally experience lower mortality in their offspring. In addition, these mothers tend to be literate and/or intelligent.

Key words:

Maternal literacy, maternal education, child health, child survival, psycho-social factors, modernism, social support, time preference, future orientation, locus of control, intelligence, power.

Introduction

The publication in 1979 of Caldwell's seminal paper (Caldwell, 1979) proposing that education, rather than acting as a proxy for wealth and income, might actually have a direct positive impact on child survival has now gained wide acceptance, even amongst such influential agencies as the World Bank (World Bank, 1993). It was perhaps then an indication of the extreme complexity of the association between maternal education and child health when 15 years later Caldwell wrote: '...it is still hard to avoid the conclusion that the full exploration of the mechanisms [whereby maternal education is converted to low child mortality] with the obtaining of clinching proof has hardly begun' (Caldwell, 1994).

This study examines some of the possible reasons for the link between maternal education and child health in a cohort of mothers who become literate in Nicaragua exclusively through adult education, and in whose children a significant improvement in survival has already been documented (Sandiford *et al*, 1995). One of the priorities of the Sandinista-led government which replaced the Somoza dictatorship after a bloody revolution in 1979, was to reduce the rate of illiteracy which a special census in 1980 indicated to be 50% of the adult population (MED/INEC, 1980). A National Literacy Crusade was organised which took place between March and August 1980. Together with the subsequent Basic Adult Education Programme, this produced a sustained reduction in illiteracy in the country of about 10% according to our estimates (Sandiford *et al*, 1994). The women in this group became the focus of this study.

In the first phase of the investigation a cohort of women who had become literate exclusively by adult education was identified and quantitative relationships between her literate status and child mortality were established by comparisons with two control groups. A total of 4434 women were interviewed, 1727 of whom were illiterate, 733 who learnt to read and write exclusively by formal schooling, and 422 who had become literate exclusively by adult education. An additional 67 were included in the adult education group after a subsequent interview revealed that their exposure to formal

schooling had been minimal. The remainder were women who had become literate through a mixture of formal schooling and adult education, or who were semi-literate (could read but not write). Virtually no-one refused to participate in the study. A total of 7065 children were measured, 7046 for arm circumference, 5678 for height, and 1315 for weight.

Using Brass-type indirect methods for mortality estimation it was found that the children of women who became literate exclusively by adult education have a significantly lower mortality rate and risk of malnutrition than those of the mothers who remained illiterate (Sandiford *et al*, 1995). The survival advantage conferred by education was significantly greater in those with poor access to health services which fits with the results of Bicego and Boerma (1993) who noted a stronger education gradient in rural areas than urban areas in almost half of the 17 countries for which they examined data. Furthermore, when the infant mortality rates are given approximate time locations these were consistent with the effect on child mortality in the adult education group commencing about the time of the NLC.

In this article we present results from the second phase of the research in which we attempted to identify the mechanisms which might explain this significant association of child survival with literacy acquired exclusively through adult education. Although a child's health and survival is a function of various 'proximate' determinants such as domestic hygiene, nutrition, fertility control and use of health services (Cebu Study Team, 1991), the mechanisms by which literacy and education affect child health must operate at a still more basic level. Education-related differences in these health-related behaviours forming the main proximate determinants probably reflect more fundamental differences in psycho-social and cognitive factors. A number of such factors have been put forward as possible explanations for the apparent impact of maternal education on child survival. Among the most plausible are: locus of control, time preference (or orientation towards the future), social support, power within the home, modernism, intelligence and commitment to child survival. Before describing how each of these was

tested for their ability to account for the link between child health and maternal literacy, it is worth summarising the various theories as they have been put forward.

Commitment to Child Survival

One of the most fascinating and controversial hypotheses to have emerged from the debate on the role of maternal education in child health is the idea that literacy might increase the value that a woman places on children (Caldwell, 1979). There are two ways that education is thought to change the value assigned to children. The first stems from Caldwell's Wealth Flows Theory of Fertility Decline (Caldwell 1982: 347) in which it is posited that mass education increases the costs of child-bearing and makes high fertility economically disadvantageous. This sharply causes a shift from quantity to quality in the goals of child-bearing and child care (Martina, 1996), and a reversal of the traditional inter-generational flow of wealth from the young to the old. It encourages greater 'investment' in fewer children and, having decided to bear fewer children, greater importance is given to the survival of each. Scheper-Hughes (1992:401-2) even suggests that 'mother love' as currently understood, only came about with the rise in developed countries of this 'new' reproductive strategy of giving birth to relatively few infants and investing heavily in each. The 'old' strategy, still present in pre-transitional countries, was to give birth to many children and, on the expectation that only a few will survive infancy, and to invest selectively in those considered the 'best bets' for survival in terms of preferred sex, birth order, appearance, health, or perceived viability.

The second theory is that the teachers, fellow students and friends with whom girls and women interact with during and after attending school access instil in the latter a completely different set of social norms from those of traditional society - such as a desire for large families in which children are a source of cheap labour (inside and outside the home) and a form of insurance for their old age, where elders command total respect and have considerable decision-making power, and where women have relatively little power *vis a vis* their spouses and in-laws (LeVine *et al*, 1994a). The educated woman assumes the modern bourgeois view of the family that children are an indulgence

and having them is regarded as a pleasure in its own right. She expects a more egalitarian and cooperative relationship with her consort aimed at achieving residential independence from the parental generation. Children are awarded higher priorities in terms of care and consumption than in the traditional system (Caldwell and McDonald, 1981). Some evidence for such a shift in values was provided by a study from Mexico where LeVine *et al* (1991) found that schooling was inversely associated with the expectation of living with a son or a daughter in old age.

Differences in the ratio of female to male mortality found in various parts of the world (Hill and Upchurch, 1995) have been cited as evidence that the value assigned to a child is not absolute or constant. Bledsoe (1990) has highlighted how children of former unions (orphans, children of divorces, and illegitimate offspring) in Sierra Leone often experience neglect by step-parents. Also, Scheper Hughes' (1992) in-depth ethnographic studies of the behaviour of mothers towards their children in the Northeast of Brazil have demonstrated that in some cases at least, there is a process of selective neglect by which children are 'allowed' to die. Simons (1989) argues that maximum commitment to child survival is indicated by a preference for moderate family size and an equal preference for sons and daughters. In fact, an association was found in this study between the strength of a mother's gender preference (for sons or daughters) and higher child mortality (results not presented).

On the other hand, there is scant evidence that education does erode sex preferences or reduce excess female childhood mortality (Cleland and van Ginneken, 1988). Though the results are not presented in this paper, gender preference — as measured by the abbreviated Coombs sex preference scale (Coombs *et al*, 1975) — was not significantly associated with literacy. Indeed, it has even been suggested that educated mothers deploy their skills selectively in favour of children of the desired sex (Das Gupta, 1987). Cleland (1990) uses this finding and the weak association between survival and birth order as evidence against the importance of differential valuation of children due to birth order, timing or sex, as explanations for the link between schooling and mortality. Also, the virtual absence of any evidence that increased rates of female employment has led

to changes in reproductive behaviour (Cleland, 1996) calls into question an 'opportunity cost' exposition of the quantity/quality theory. Others have criticized this notion of commitment to child survival or 'neglect' as victim-blaming (Finerman, 1995; Donahue and McGuire, 1995), stating that neglect is rare, aberrant behaviour, and that what may appear to be instances of it are usually rational medical choices made under constraints on resources and therapeutic options.

If however, education does increase devotion to children, then one would expect that educated mothers might make a greater effort to ensure the health and survival of their offspring. Health-seeking behaviour, domestic and personal hygiene, nutrition and weaning practices might all be improved. But also they will marry later, reproduce at low risk ages and space births more widely (Cleland and van Ginneken, 1988). By having smaller families, overcrowding in the household is reduced, there is less sibling competition (for food etc) and cross-infection becomes less likely. The mother has more time to dedicate to the care of each child. Caldwell *et al* (1989) have noted that education is associated with a greater 'sensitization to illness and the risk of death' and propose the latter as the main reason for Sri Lanka's low rates of child mortality for its level of income. This association could be due to educated women possessing better knowledge of the signs and symptoms of illness but it is equally plausible that the greater sensitivity is due to educated mothers placing higher value on the survival of their children. Similarly, Guldan *et al* (1993) found that educated mothers exhibit greater 'seriousness', 'discipline' and 'attention' in feeding their children. The authors were careful to avoid making any judgment about 'the degree of their care or regard for their children' but their findings are definitely consistent with this possibility. Certainly the finding by Joshi (1994) that educated mothers allocate significantly more time to child care is evidence of greater commitment to her progeny's health and development.

Locus of Control

Another hypothesis is that when a woman becomes literate her outlook changes from a fatalistic one, where she perceives herself as the mere object of external forces over

which she has little influence, to a belief that her life chances (and those of her children) are very much under her own control (Caldwell, 1979). The concept of locus of control was originally introduced by Rotter (1966) who pointed out that individuals vary in the extent to which they believe that reinforcement is attributable to their own actions. Those whose locus of control is *internal* believe that their behaviour is responsible for the attainment of desirable (or undesirable) states of affairs. A person who is inclined to view a state of affairs as the outcome of factors beyond his/her control is said to have an *external* locus of control. A woman who is relatively fatalistic therefore has an external locus of control.

There is a substantial body of sociological literature on the notion of locus of control, and there have been many applications of this construct to health in developed countries at least (Wallston and Wallston, 1978). A number of modifications have been made to the original I-E scale developed by Rotter including the development of scales specific for attitudes to health (Wallston *et al*, 1976), and attempts to divide external loci of control into those where one feels controlled by 'powerful others' and those where 'chance' is what matters as in Levenson's multi-dimensional I, P and C scale (Levenson, 1978). Whether these newer scales have any significant advantages over the original scale is questionable (Cooper and Fraboni, 1990).

How does education reduce fatalism? According to Caldwell (1979) it does so by taking away traditional belief systems — central to many of which is a certain fatalism with regard to death and disease — and replacing them with Western ones. To the extent that Western belief systems challenge this and place greater responsibility on the individual, a woman's locus of control may become more internal. It would seem equally plausible, however, that the process of acquiring literacy must instil in a woman considerable confidence and a belief in her own power to achieve things. Cleland (1990) distinguishes between education's effect on a mother's sense of control over (and ability to manipulate) the outside world which he calls *instrumentality*, and its effect on her self-esteem for which he uses the term *confidence*. It would seem that both might give rise to a more internal locus of control.

A mother with an internal locus of control will have conviction in the value of her providing preventive and curative health care. She will therefore be more likely to initiate home remedies in the event of a child illness, and more likely to modify them in the event that the child does not respond to the treatment. She may however, be less inclined to seek 'expert opinion' if she feels that her child's recovery is totally within her control.^a Mothers who are less fatalistic will be more inclined to break with tradition and adopt the alternatives in child care and therapeutics that have become available in developing countries (Caldwell, 1979). It makes her more active in the care of her children and more sensitive to the course of their illnesses because she holds the belief that unfavourable outcomes are not inevitable. This effect on 'sensitization to illness' could, like commitment to child survival, be part of the explanation for Sri Lanka's unexpectedly low child mortality rate noted by Caldwell and others (1989). The self-confidence associated with an internal locus of control may also make the educated mother more prepared to badger doctors, nurses and dispensers into giving help to her sick children (Orubuloye and Caldwell, 1979).

As evidence that education internalises locus of control Shirley Lindenbaum (1990) has noted that men in Bangladesh recognise the greater self-sufficiency of educated women and the women themselves speak of becoming 'self-propelled'. Simons (1989) put forward the idea that the higher child mortality in Muslim countries reported by Caldwell (1986) may be due to the strong emphasis in Islamic doctrine on submission to the will of God, creating a tendency towards more external loci of control.

Though there has been a number of studies purporting to demonstrate the value of the locus of control construct in explaining health behaviours, overall the findings have been

^{a/} It is debatable whether resorting to extra-domiciliary health services is more likely in women with an internal locus of control or with an external locus of control. For the woman with an internal locus of control referral may be regarded as one of the actions that she can take to preserve the health of her child. On the other hand, the mother who believes her child's survival chances depend upon 'powerful others' may readily take the child to an outside healer. The same uncertainty exists regarding persistence with treatment.

inconsistent. This may have been due to measurement difficulties or the fact that it is just one of several factors determining health-related behaviour (Simons, 1990).

One of the strongest arguments against the locus of control construct as an explanation for the impact of maternal literacy on child survival is that mothers' perceptions of the control they have over their children's health may be based on their actual power to control events. In other words, a woman with an external locus of control may have because she really does not have the power to preserve her children's health. In this case then it would be the mother's power and autonomy which matters, and not her perception of it. Another problem with the locus of control hypothesis is that a woman with an external locus of control may cede decision-making responsibility to other carers who are more effective in preserving her children's health than she would have been (Simons, 1989). Finally, Ware (1984) makes the point that women who believe certain children are destined to die young and that certain diseases result from divine retribution, will often conduct an aggressive search for remedies since such judgements are confirmed only after the event.

Time Preference

Time preference refers to the willingness of individuals to invest in the present for a potential future benefit, or put more simply, the propensity to defer gratification (Fuchs, 1982). It has been suggested that time preferences are associated with female education, either because individuals who are prepared to trade off current costs for future benefits choose to invest their time and energy in gaining an education or because schooling actually makes women willing to invest at a lower rate of return.

Thus, educated women may become more willing to make sacrifices today for an anticipated future benefit. Investment by a mother in the health and survival of her children can be seen as an investment not just in their future, but also in her own, to the extent that those children will often be the source of her own economic and social well-being as she gets older.

Some evidence for this is provided by two studies which have found correlations between interest rate and years of schooling, one conducted in Israel (Maital and Maital, 1978) and one in Long Island (Fuchs, 1982). It is also hypothesised that these differences in time preference will express themselves in the mother's willingness to invest in health-enhancing measures for her children although the Long Island study found that the associations between time preference and health-related behaviours were small and not always statistically significant.

Social Support

Education seems to provide women with a broader social network (Cleland and van Ginneken, 1988). This could be at least partly because educated women are less constrained by cultural mores confining them to the home courtyard (Guldan *et al*, 1993). Studies in developed countries have shown that the number and quality of social supports available to individuals is a determinant of health and an essential component of the health care system (Wilkin *et al*, 1992). Hence the effect of education on child survival could be mediated through social support. For instance, the better social support enjoyed by educated women has been propounded to account for the fact that the education advantage in child survival is more pronounced in urban areas. Urban living may impose unique and difficult challenges on mothers where traditional familial mechanisms of support are weaker or unavailable (Bicego and Boerma, 1993).

Several cohort studies have shown a significant association between adult mortality (in both sexes) and social support even after controlling for pre-existing health status, health related practices and habits, social class, and age (Kunitz, 1990). None of the cohort studies explored whether social support might have an effect on child survival and certainly it is less likely to be important for infectious diseases of high virulence, but most childhood deaths in the developing world are caused by illnesses for which strong social networks could be of considerable benefit. For example, a mother with a sick child may be constrained from taking it to the doctor because there is nobody to look after her other children or the house while she is away. Friends and relatives can also

provide a mother with valuable 'tips' on how to prevent and manage illness in her children.

However, the studies have not all found social support to be important. Two studies of specific ethnic groups living in the United States (Japanese Hawaiians and Navajo Indians) failed to detect a relationship between social support and mortality (Kunitz, 1990; Reed *et al*, 1984). It was suggested that in these societies, social isolation is too rare to be a significant predictor of mortality. This may also be the case in Nicaragua. Furthermore, as Cleland (1990: 402) states, explanations that 'assume uneducated women to be largely secluded within their own immediate neighbourhood... may be convincing for North India or Bangladesh but are much less so for Brazil.'

Modernism

Caldwell's early discussion of the pathway from education to improved child survival awarded modernism a central role. Education, he said, 'provides a vehicle for the import of a different culture' and causes mothers to 'break with tradition' (Caldwell, 1979: 409). Schooling involves acquiring an understanding and commitment to modern science but it also means entering a part of the modern world. Western medicine is another part of the modern world which a mother enters more readily once a mother is *au fait* with the first part.

Literacy may bring about the adoption of Western models of child care and therapeutics, in addition to or instead of traditional beliefs and practices. Though perhaps not all Western therapies are effective and while some traditional treatments for illness definitely are, there are also many traditional rites which are either directly damaging or indirectly harmful by preventing or delaying other action (Caldwell, 1979). In particular, traditional patterns of nutrition rarely maximise the advantage to be gained from existing foodstuffs, and child care is often far from optimal.

Improved hygiene might also result from education by imparting a belief in microbial origin of infectious disease. In fact, this does not appear to be the case. Lindenbaum (1990) found in Bangladesh an almost universal belief that infant disorders are caused by spirit attack associated with bad winds. On the other hand, education does seem to be associated with better hygiene. Lindenbaum (1990) noted that children who attend school were cleaner than non-attenders and that men preferred educated women partly because they are said to keep the house cleaner. Joshi (1994) too, noted that women with schooling were neater and cleaner. Rather than changing because of new knowledge or skills, Lindenbaum argues that educated women are cleaner because they identify with a cluster of prestigious behaviours and attitudes.

Clearly the simultaneous belief in and practice of entirely different systems of disease classification and therapy is common (Cleland and van Ginneken, 1988). In Cariole, Ayurvedic medicine coexists with Western medicine. Mortality is kept low, according to Sushama (1990) because the latter is used for life-threatening conditions with traditional remedies reserved for self-limiting complaints. The failure of Ayurvedic medicine in itself to contain mortality is evident from Sri Lanka's life expectancy of little over 30 years during the 1920s (Caldwell *et al* 1989). In the case of sub-Saharan Africa, the inaccessibility of modern medical services may be preventing a more rapid mortality decline (Gaisie, 1990).

There is strong evidence from several developing countries for an association between education and the use of Western health services and particularly for preventive care (Becker *et al*, 1993; Cleland and van Ginneken, 1988; Bicego and Boerma, 1993; Joshi, 1994; Elo, 1992). On the other hand, a study in Indonesia found no clear linear relationship between a mother's education and the probability of child being fully immunized (Streatfield *et al*, 1990). The surprising finding by Preston and Haines (1991) that child mortality was not associated with maternal literacy in late nineteenth century United States may have been either because existing Western medical services were relatively ineffective, or because there was no competing paradigm to the Western model so even the illiterate made use of 'modern' health services (Caldwell, 1991). But

even in the contemporary studies, differential non-use of ante-natal care did not explain a significant proportion of the child mortality gradient by level of education (Bicego and Boerma, 1993), and the purported better hygiene of educated women according to Cleland (1990) does not seem to translate in lower rates of diarrhoeal morbidity although Hobcraft (1993) disputes this.

It is important to draw a distinction between the acquisition of a modernist belief system with its effect on use of Western health services, hygiene and child care practices, and other possible effects of modernisation such as greater devotion to children, less fatalism and a higher degree of female autonomy. The latter are examined explicitly as separate psycho-social factors in this study.

Knowledge, Ability and Intelligence

Though Caldwell has given it short shrift, the most widely held theory is probably that female literacy improves child survival through the knowledge that a mother gained in the process of learning to read and write, or through the access that those skills gave her to other sources of information. It has long been assumed by health educators and others, that knowledge by itself can lead to behavioural change and Preston and Haines (1991) argue convincingly that knowledge, or rather lack of it, was the fundamental reason why there was not a significant education gradient in child mortality in the US at the turn of the century. Mothers with greater understanding of disease causation, prevention and cure, and of the nutritional requirements of children, might employ better hygiene practice, recognise illness more readily, know the best treatment for a given illness, and make more appropriate use of health services (Hobcraft *et al*, 1984). They may also be more aware of their own health, avoiding harmful food taboos and strenuous work during pregnancy, and ensuring that they receive adequate antenatal care (Ware, 1984).

Large education differentials in knowledge concerning oral rehydration salts have been found in a number of the DHS surveys (Hobcraft, 1993), in knowledge about child

immunization in Indonesia (Streatfield *et al*, 1990), in nutrition knowledge in India (Christian *et al*, 1988), and in attributing illness to supernatural causes in Ghana (Fosu, 1981). Cleland and van Ginneken's (1989: 26) conclusion that 'it seems unlikely that schooling below the secondary level imparts sufficient understanding of health matters to guide maternal behaviour in later life,' does not imply that knowledge cannot explain the apparent effect of education. While schooling may not itself provide sufficient knowledge of medical matters to make a difference, it could provide women with the skills and ability needed to acquire that knowledge.

However, there are also a number of studies showing no important effect of schooling on health knowledge. One study found that final-year teacher-trainees knew no more about nutrition than primary school leavers, and that both groups know little more than the illiterate mothers of malnourished children seen at health clinics (Hoorweg and McDowell, 1979: 91). Another detected no differences between educated and uneducated women on a wide range of attitudes to aspects of child care (Kutty, 1989). As was pointed out in the previous section, education does not seem to change beliefs regarding the causation of illness. And the fact that even a very brief attendance in school and that even poor quality schooling is associated with better child survival casts doubt upon the notion that its effect is mediated through greater knowledge.

It seems far more likely that education, through something like what Joshi (1994) refers to as 'context familiarity', produces skills that enable mothers to make more effective use of health services, or makes them more competent in domestic child care. Among these skills, is the ability to use decontextualised language (LeVine *et al*, 1991) which might help her understand and follow instructions, learn novel procedures, get the attention of medical personnel, ask appropriate questions and generally be 'able to function strategically in an institution that often ignores or neglects its clients' (LeVine *et al*, 1994a). Joshi (1994) found that educated Nepali women did indeed demonstrate a greater capacity to use decontextualised language, as did LeVine *et al* (1991). Other aspects of context familiarity tested by Joshi were fluency or efficiency (in providing a clinical history) and confidence in speech. Both measures were correlated with the

woman's level of education. Further support for the importance of context familiarity was provided by the finding reported in LeVine *et al* (1994b) that the comprehension of health messages broadcast on the radio was correlated with maternal schooling.

These skills in the use of language possibly represent just a small portion of the differences in ability between educated and uneducated mothers. It is perfectly plausible that education confers (or at least correlates with) more basic measures of cognitive ability such as intelligence. Many years ago, Spearman (1927) posited that there exists a general factor in mental ability commonly referred to now as intelligence. An extensive review of the empirical evidence by Perkins and Saloman (1989) gives support for the existence of such a factor. There may even be different components to intelligence and in fact, though the evidence for this is much weaker, there does seem to be a real difference between the ability to understand complex concepts, and the ability to verbalise that understanding. Nevertheless, abilities of all kinds tend to be highly correlated and general measures of intelligence are good predictors of performance in all manner of tasks (Murray and Herrnstein, 1994).

The arguments in favour of a key role for intelligence in the link between maternal education and child health are strengthened by findings such as those of Das Gupta (1990) who points to the importance of a mother's 'basic abilities' as a possible reason for the tendency for the majority of child deaths to be clustered in a relatively small number of households. Of course these basic abilities like intelligence, may be innate, as Das Gupta implies. Intelligence could well be the cause of both success in schooling and success in ensuring the survival of children. There has been virtually no research into whether the strong association between education and child survival can be explained by a 'selection factor' as LeVine *et al* (1994a) put it, whereby parents choose to send only the more intelligent children to school (or as seems to be the case in Nicaragua, remove children who are not performing well). One exception is Wolf and Behrman's (1987) analysis of a sample of adult sisters which found that none of the child health outcomes examined (mortality and nutritional status) were significant once interfamilial differences in childhood related backgrounds were controlled for.

Indeed, it should be noted that virtually all of the other psycho-social factors considered in this paper as candidate pathways between maternal education and child survival could also be the consequence of family background or innate characteristics which contribute to, or are correlated with the woman's education but do not stem from it.

Autonomy and Power

Of all the possible psycho-social links between maternal education and child health it is perhaps female autonomy and empowerment, that education is said to produce, which has arisen the most interest. The same ideological shift to 'Western individualism' and bourgeois family values that has been suggested might increase mothers' commitment to child survival could also increase their power within the home to ensure the health and survival of their offspring and undermine the power of elders who do not share the same values (LeVine *et al*, 1991).

Part of the empowering action of education is its effect on the woman's locus of control, as has already been mentioned. But the literate woman may also gain power simply by the effect of her education on the attitudes of those around her. When operating in health bureaucracies, the doctors, nurses and dispensers may allow an educated woman to insist they give urgent help to her sick child, while they would not respond to such behaviour from an uneducated person (Orubuloye and Caldwell, 1979). Within the family, the educated woman commands greater respect from her husband, mother and mother-in-law, which greatly changes the traditional balance of family relationships (Caldwell, 1979). The educated woman is allowed to take more decisions alone, is consulted more frequently by her husband on important matters, and is given a greater freedom to innovate in the care of her children. The increased power of a woman within the family allows her to allocate her children a greater share and better quality of food (Caldwell and McDonald, 1981).

However, the decision-making power of uneducated women in traditional societies should not be underestimated and education by itself may not be enough to liberate

women. In fact educated women who marry men whose status and income are significantly superior to their own may actually lose relative power (Ware, 1984). Kaufmann and Cleland (1994) go so far as to state that educated women are if anything less autonomous than their uneducated counterparts in South Asia because they are more likely to marry men who will confine them to strict purdah. Also, in many parts of the developing world, low autonomy is related not just to gender, but also to age (Das Gupta, 1996). Caldwell makes the important point that even in traditional society women, and especially older women, can have considerable influence in family affairs through the advice they give men, provided that males are seen to be the ones actually making the decision (Caldwell, 1979). Those with the least power in much of Asia are young married women.

Whatever the effect of education on female empowerment, Das Gupta (1996) has provided good evidence that low maternal autonomy is bad for child survival in India. Using the place of delivery as an objective measure of the mother's autonomy, she presents data showing that when a child is born in the husband's home, neonatal, post-neonatal and infant mortality rates are all at least double what they are when the child is born in her mother's home.

Castle's (1993) study of intra-household differentials in women's status in Mali also purports to show the significance of maternal decision-making power for child health. By classifying women in terms of their intra-household status and family type, she finds quite striking differences in the proportion of children's recent illnesses that were treated and in malnutrition rates. However, the results are not unequivocal. The lowest probability that a child's illness would be treated was found where the mother was head of the household - with or without daughters-in-law. And two thirds of the children of female heads of household or head females with daughters-in-law were malnourished (although the lowest rates were found among children of women not living with a mother-in-law).

Methods

The field-work was carried out in Masaya province which had an estimated population in 1985 of 207,000. It is the physically the smallest province in Nicaragua but has the highest population density (300 inhabitants per square kilometre). Approximately 47% of the population live in rural areas which is similar to the country as a whole.

From the 4,434 women originally interviewed, a subsample was selected for the reinterview in the second phase. It included all of the 489 women identified from the first interview who had learnt to read and write exclusively as adults. These were age- and community-matched to approximately equal numbers of mothers from the illiterate and formal schooling groups. Only 5% of these mothers were lost to follow-up. Women who attended both primary school and adult literacy classes, and 'semiliterate' women who could read but not write were excluded. In the end a total of 1294 mothers were reinterviewed providing birth histories for 7475 children.

For the second phase of the research an instrument was developed to collect detailed data in six broad areas:

- (1) the psycho-social factors believed to link literacy with child health,
- (2) domestic child care practice,
- (3) use of extra-domiciliary health resources,
- (4) patterns of family formation,
- (5) morbidity due to common childhood illnesses,
- (6) levels and causes of mortality.

In developing the new instrument, nine pilot tests were conducted on a total of 640 women before a final version was settled upon.

Measurement of the psycho-social factors

A scale was developed to quantitatively measure each of the seven factors discussed in the introduction. This involved firstly gaining a clear understanding of the construct through a review of the literature in each area. Where possible, existing scales of proven validity and reliability were modified for use within the Nicaraguan context. In several cases however, it was necessary to develop the scales from scratch based on in-depth qualitative work carried out by the study anthropologist (GS). A great deal of time and effort was dedicated to ensuring that the items in these scales individually and collectively were relevant and understood within the Nicaraguan cultural and social environment by combining inputs from anthropologic, sociologic and epidemiologic perspectives.

The scales were tested in seven of the nine pilots. Internal consistency was monitored using the Cronbach Alpha statistic. An analysis was performed after each pilot test to aid decisions on the inclusion, modification and removal of individual items within the scales according to their discriminatory capacity and impact on overall consistency. This sometimes involved choosing expressions that are peculiar to the Nicaraguan context, but more often meant making quite minor changes in wording to ensure that each item was at once unambiguous yet able to discriminate between attitudes which from an outsiders perspective appear remarkably homogeneous. It is important to note that in constructing a scale there is a trade-off in making it sufficiently focussed to produce good internal consistency statistics without making it so narrow that the individual items become mere tautologies. Also, care was taken with the wording so that there was no obvious 'right' answer that the respondent would have expected the interviewer wanted to hear. Nevertheless, since attributes such as modernism and commitment to child survival are to a large extent normative, it is actually desirable that the respondents choose what would be considered the 'right answer' by their family and peers.

An English translation of the items in each scale is included as Appendix I. Appendix II contains reliability statistics for each of the scales and Appendix III describes the techniques used for data analysis.

Scale I: Commitment to Child Survival

The Commitment to Child Survival scale was the most difficult to develop because it was not possible to identify indicators used previously by other researchers. Most of the items were designed to separate women for whom children are an indulgence from those for whom they represent an economic asset, either because they provided labour (in the home, on the farm or working in the streets) or because they offered future security for the woman. Other items attempted to determine how much effort and investment a woman was prepared to make in order to ensure the survival of her child.

Scale II: Locus of Control

In this case there were a number of sources which could be drawn upon for identification of potentially useful items. These included Rotter's (1966) original I-E scale, the Wallston *et al* (1976) Health Locus of Control Scale, Levenson's (1978) I, P and C Scale, and the Wallston, Wallston and DeVellis (1978) Multidimensional Health Locus of Control Scale.

In the event it was decided not to make the scale multidimensional, although some of the responses reflect the division between internal, powerful others and chance loci of control. Similarly, some of the questions were drawn from health locus of control scales while others were based upon the general locus of control construct. It proved to be very difficult to obtain high levels of internal consistency with this scale, partly because the women being interviewed had some difficulty in dealing with abstract concepts.

Scale III: Time Preference / Future Orientation

Several attempts have been made to measure time preference through household surveys (Fuchs, 1982). They all essentially aim to determine a rate of time discount which individuals actually use in decision-making. The surveys have attempted to measure time preference either explicitly, by asking the respondent to state an interest rate at which s/he is indifferent to saving or spending, implicitly by asking him/her to choose between different sums of money offered at different points in time, or in qualitative terms by asking questions designed to elicit general attitudes to saving and investing.

Most of the experiences have not been very encouraging. Parameter estimates for individuals tend to be unstable and often inconsistent, with low correlations between different measures (Fuchs, 1982). There appear to be a number of problems. On the one hand, it must be recognised that differences across individuals in marginal rates of interest can be the result of difference in underlying preference functions (indifference curves) or differences in opportunities to borrow and lend. Also, an individual's implicit discount rate appears to vary with income and the sum involved. Investment decisions are of course highly sensitive to perceptions of risk, but also, for many people risk aversion seems to increase with the quantity of money involved. In health matters the risk is high because there is typically a great deal of uncertainty about the potential benefits. Measurement of time preference can also be complicated by expectations of inflation which will raise nominal discount rates but not necessarily real ones. To summarise, the estimation of time preference is subject to a number of contextual factors which affect reliability and make the validity of comparisons between individuals open to question.

Two time preference questionnaires were used to develop the scale (de Vaus, 1991; Fuchs, 1982). Within the Nicaraguan context it was found that explicit, and to a considerable extent, implicit questions were of little value, perhaps because the respondents had difficulty in understanding the concepts of interest rates and time/money trade-offs. As with the locus of control scale, it was important to avoid making the

questions too abstract, but also small changes in wording often had quite a marked effect upon consistency. Nevertheless, it was impossible to get the Cronbach α above 0.6 for this scale.

Scale IV: Social Support

In comparison with some of the scales this one was relatively simple to design as a number of models from developed countries were available which could be readily adapted to the Nicaraguan setting. These included the Rand Social Activities Questionnaire, the Social Relationship Scale, the Duke-UNC Functional Social Support Questionnaire, and the Norbeck Social Support Questionnaire (Wilkin *et al*, 1992). The scales incorporated items such as the frequency of contact with friends outside the home, attendance at church and other community groups, the support provided by individuals in case of problems with money, work or home life, and the amount of affection, affirmation and aid (symbolic or material) contributed by network members.

It was decided to use a modified version of the Duke-UNC Functional Social Support Questionnaire (despite concerns that it does not cover important dimensions of confidant and affective support) because of its brevity, the fact that it considers the quality of support and not just the amount, and the ease with which it could be used in the Nicaraguan context. Reliability was high from the outset and little piloting was necessary though the original version was altered somewhat. Three items were dropped, and one was changed slightly. The most significant modification however was to offer a choice of two possible responses to each item (many / few) rather than a five point Likert system.

Scale V: Modernism

As adherence to Western orthodoxy regarding the origins and management of illness is taken for granted in most developed country studies of the influence of psycho-social factors on health, it was only possible to find one published scale of traditionalism (de

Vaus, 1991). However, the semi-structured interviews yielded many questions which could readily indicate whether a woman was more or less traditional in her beliefs. They include what the woman felt to be appropriate sex roles, attitudes to pre-marital sexual relations, the degree of respect for elders, and the use of traditional healers. Though to the outsider these may appear to be quite a 'mixed bag', they jointly reflect different aspects of what is often called '*machismo*' and this is substantiated by the good internal consistency that the final version of this scale produced in the study proper (see **Table A** in Appendix II).

Although the reliability of the full scale varied considerably from one pilot test to the next, it was almost always possible to extract a subset of questions with good internal consistency. As the piloting proceeded, most of the original questions were retained, the modifications usually consisting of wording simplifications.

Scale VI: Intelligence

Although measurement of 'intelligence' remains rather controversial, it is nevertheless an area in which much research has been conducted and where standardised tests have been developed and validated. A number of tests were considered but in the end it was decided to use set A_B of Raven's Coloured Progressive Matrices (Raven, 1976). This is a non-verbal test which measures a person's ability to see discrete figures as spatially related wholes. It is especially good at measuring factor *g* and in particular, simultaneous processing ability (Anderson, 1992). The Matrices have been very thoroughly validated and scores are highly stable in many different cultures (Raven *et al*, 1993). The coloured backgrounds on which the problems are printed attract attention, make the test spontaneously interesting, and obviate any need for extensive verbal instruction. The test consists of 12 problems each of which requires the testee to select one of six alternative solutions. The test was applied without any time limit but was normally completed by the woman in less than 10 minutes. The interviewer administered the test in the book form according to the guidelines provided by Raven *et al* (1993), beginning with simple examples from the A scale to demonstrate the basic principles of

solving the problems, before proceeding to the A_B scale where responses were recorded. Pilot testing revealed high indices of internal consistency from the outset, as might have been expected given the extensive efforts that have been put into developing the test. Scores were calculated as the simple arithmetic sum of correct responses.

Scale VII: Decision-making Power in the Home

A number of attempts to measure a woman's decision-making power within the home have been reported in the literature (Ware, 1984; Castle, 1993) but there have been few actual scales developed. In any case, indicators of decision-making power are so culture-specific that it was not really possible to make much use of the other sources in developing this scale. For example, in rural Punjab, autonomy is reflected by who decides what should be cooked, and in where the woman gives birth (Das Gupta, 1987). Neither of these indicators would have been useful in Nicaragua. Hence the anthropological work was relied upon heavily in developing this scale which was mainly based on what the mother was able to do without asking the permission of another household member. This proved to be perfectly adequate and a simple 11 item scale with good Cronbach α coefficients was quickly settled upon.

Results

Basic results

Table 1 presents means and proportions for the various socio-economic factors measured in the study, along with rates of mortality and malnutrition among the children

Table 1. Crude values for the study variables by type of education^a

	Illiterate (N=419)	Adult Education (N=414)	Formal Schooling (N=342)
Mean age (years)	35.2	35.1	35.0
Mean no. of live children	6.5	6.0**	5.0****
Height (cm)	150.7	151.1	152.4***
Literate husband	72.%	74.%	87.%****
Literate mother ^b	18.%	31.%****	53.%****
Literate father ^b	47.%	46.%	69.%****
Urban residence	54.%	51.%	53.%
Employment outside the home	27.%	30.%	26.%
Well or piped water source	64.%	66.%	73.%*
Latrine	92.%	93.%	95.%
Concrete or tiled floor	30.%	35.%	50.%****
Iron bars on windows	6.%	8.%	15.%***
Refrigerator ownership	3.%	4.%	13.%****
Motor Vehicle ownership	1.%	2.%	4.%
Mean number of bedrooms	1.7	1.8*	2.0***
Mean number of occupants	7.4	7.2	6.9*
Occupants per bedroom	4.9	4.5**	4.0****

*p<0.05 ** p<0.01 *** p<0.001 **** p<0.00001

^a/ Significance tests compare the adult education and formal schooling groups with the illiterate group.

^b/ Excluding 'don't knows'

in each maternal education group. There is clearly a marked difference in socio-economic status between the formal schooling group of mothers and the illiterate, but between the adult education group and the illiterate there are no significant differences except in their parity and in the proportion of the women's mothers who were literate. Indeed, though the results are not shown in the table, there were more significant differences between the formal schooling group and the adult education group in socio-economic status. The variables for which there were significant differences between adult education and formal schooling groups were number of children ($p < 0.000001$), literacy of the husband ($p < 0.0001$), father ($p < 0.0000001$) and mother ($p < 0.0000001$), height ($p < 0.001$), water supply ($p < 0.05$), flooring ($p < 0.0001$), window bars ($p < 0.01$), ownership of a refrigerator ($p < 0.0001$) and the number of bedrooms in the house ($p < 0.05$).

The association between female literacy and child health

The crude rates of mortality and malnutrition for each education cohort are shown in **Table 2**. All risks for children in the adult education group are lower than for those in the illiterate group. These differences are statistically significant for infant mortality (relative risk = 1.22; $p < 0.05$), child mortality (RR=1.35; $p < 0.05$), under five mortality (RR = 1.21; $p < 0.01$), low MUAC for age (RR = 1.78; $p < 0.000001$), and severe stunting (RR = 1.63; $p < 0.05$). Risks were generally lower in the offspring of formally schooled mothers compared with the adult education group but the difference was statistically significant only for child mortality (RR = 0.65; $p < 0.05$) and severe stunting (RR = 0.55; $p < 0.05$). However, the analysis of the impact of literacy training is complicated by the fact that mortality rates in each education group have fallen sharply with successive birth cohorts (highly significant Chi Square test for trend in all mortality rates), as **Figure 1** illustrates, although the small numbers in each cohort make it unwise to read too much into the component mortality risks or shape of the trend.

It was expected that the mortality advantages of the adult education group would only accrue to those children born after the National Literacy Crusade and that the differences

Table 2. Risk of death and malnutrition by type of education.

INDICATOR	Adult Education			Illiterate			Formal Schooling		
	Cases	Healthy	Rate *	Cases	Healthy	Rate *	Cases	Healthy	Rate *
Neonatal mortality	67	2398	27	96	2586	36	38	1668	38
Post-neonatal mortality	147	2202	63	189	2351	74	107	1535	65
Infant mortality	214	2202	89	284	2351	108	144	1535	86
Child mortality	73	1860	38	107	1989	51	34	1341	25
Under five mortality	275	1860	129	369	1989	156	167	1341	111
Low MUAC for age	94	621	132	173	566	234	53	405	116
Severely stunted	39	530	69	67	533	112	14	357	38
Under-weight	15	120	111	20	111	153	12	70	146

* Per thousand at risk.

with the formal schooling group would be greatest in the period prior to the NLC. On initial inspection of the data (**Table 3**) this does seem to be the case since the apparent protective effect of literacy on child survival is significantly stronger for children born in later years. However, the turning point seems to be some time in the 1970s and not in 1980 as one would expect if the NLC were responsible. From **Table 3** it can be seen that the relative mortality advantage for children of mothers in the adult education group is greater for those born from 1975 on than for those born before 1975.

Indeed, this interaction effect is statistically significant for infant mortality rates ($p < 0.05$) and of borderline significance for neonatal ($p = 0.05$) and post-neonatal mortality ($p < 0.10$). Only the child mortality relative risk does not show this same change in magnitude from 1975 as **Figure 2** illustrates.

Figure 1. Trend in mortality rates by education status.

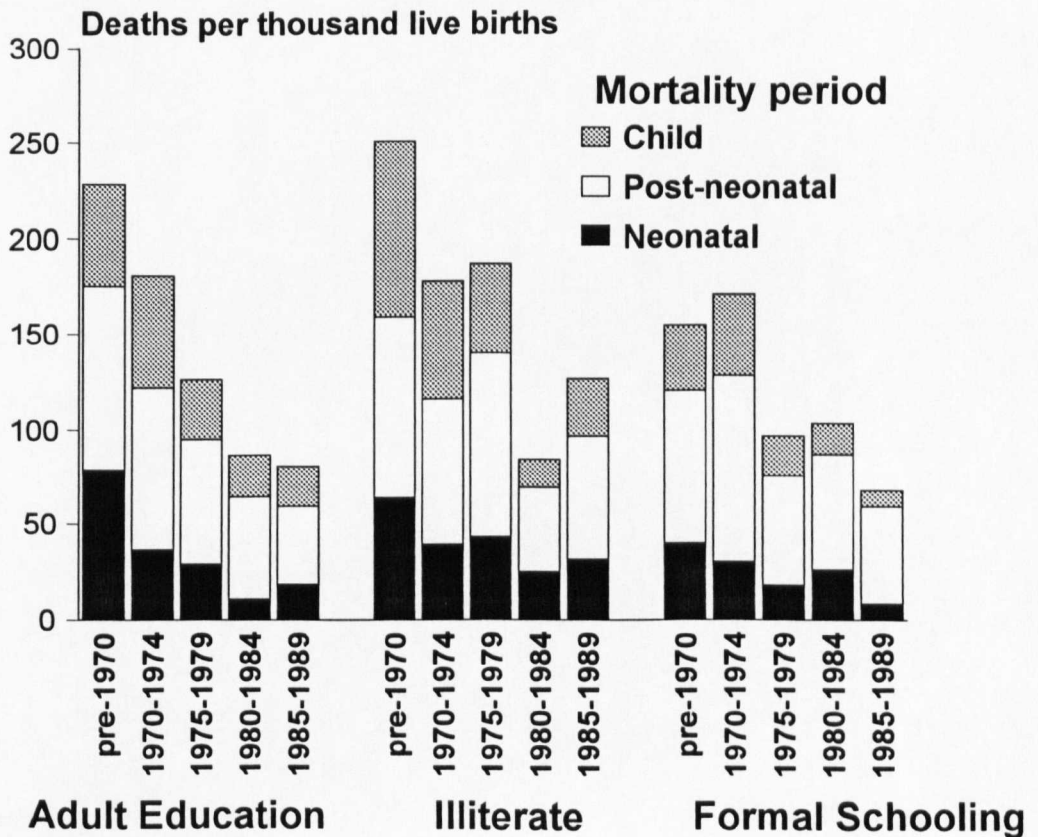


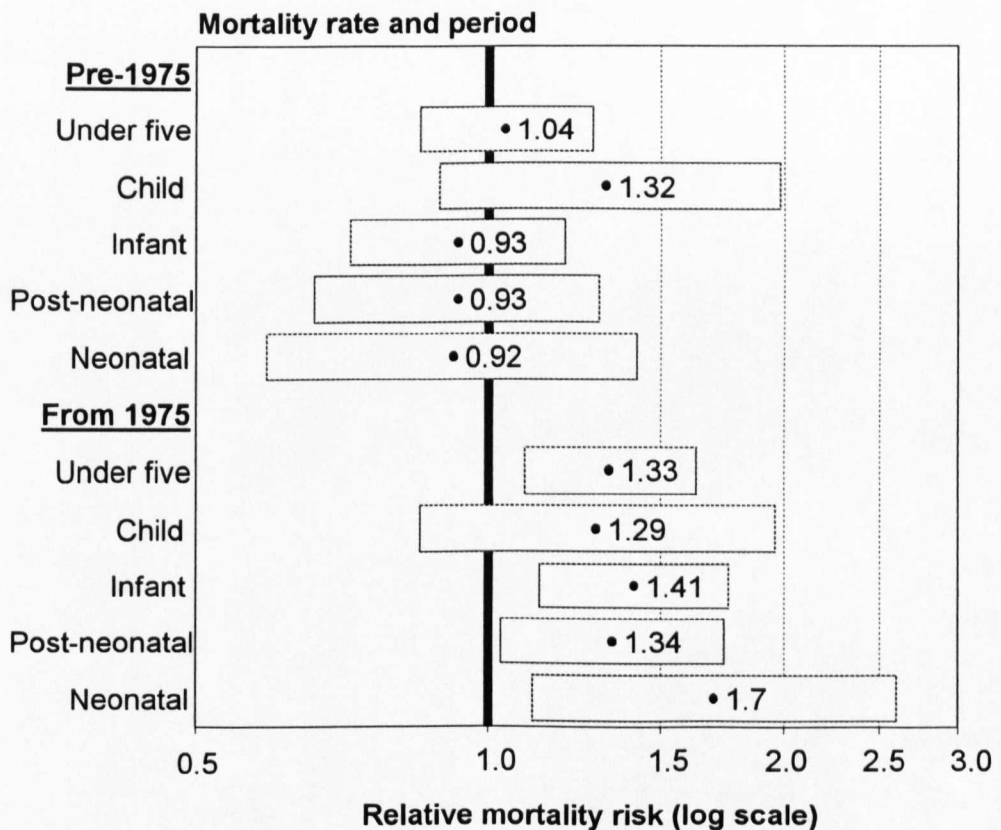
Table 3. Relative mortality risks by year of birth.

Mortality Measure	Year of birth							
	Pre-1970	1970-1974	1975-1979	1980-1984	1985-1989	1990-1994		
Neonatal	0.82 (0.47-1.44)	1.09 (0.53-2.24)	1.50 (0.78-2.90)	2.30 (0.90-5.88)	1.71 (0.76-3.84)	1.32 (0.30-5.87)		
Post-neonatal	0.97 (0.60-1.56)	0.89 (0.55-1.44)	1.48 (0.97-2.27)	0.84 (0.50-1.39)	1.61 (0.94-2.76)	2.13 (0.89-5.14)		
Infant	0.91 (0.64-1.29)	0.95 (0.65-1.40)	1.47* (1.04-2.09)	1.07 (0.69-1.64)	1.63* (1.05-2.53)	1.79 (0.84-3.81)		
Child	1.68 (0.94-3.02)	1.05 (0.60-1.84)	1.67 (0.89-3.12)	0.69 (0.29-1.62)	1.48 (0.67-3.26)			
Under-five	1.10 (0.83-1.45)	0.98 (0.73-1.33)	1.48** (1.10-2.00)	0.97 (0.67-1.42)	1.57* (1.06-2.31)			

* p<0.05 ** p<0.01

There are no significant mortality differences between the formal schooling and adult education groups although the lower child mortality rate in the formal schooling group was of borderline significance ($p=0.05$). It would appear then, that the offspring of women in the adult education group experienced reduced mortality relative to the illiterate group from about the mid-1970s. Possible explanations are offered in the

Figure 2. Relative mortality risks for children born to illiterate mothers compared with those of the adult education group, before 1975 and from 1975.



discussion section below but in view of this effect, subsequent analyses present results for both the full set of cases, and for the subgroup born from the year 1975 on.

The other factor which appears to influence the strength of the relationship between maternal literacy and child health is intelligence. In a previous paper we reported a significant interaction between the effect of maternal literacy on child survival and the mother's intelligence (Sandiford *et al*, 1997). It seems that the effect of education gets less the higher the intelligence of the mother (for under five mortality and low weight for

age $p < 0.05$). For this reason we present a separate set of results for the association between maternal literacy and child survival excluding women with above median intelligence.

The robustness of the mortality and nutritional status differences between the illiterate and adult education groups is explored in **Table 4** which gives odds ratios and 95% confidence intervals derived from logistic regression models. The first thing to note from this table is that there is very little sign of confounding by the many socio-economic factors introduced into the model. Adjusted odds ratios are almost all of similar magnitude and occasionally are actually larger than the crude odds ratios. The second point is that the odds ratios calculated from the children born after 1975 are generally larger and more statistically significant than those calculated on the full study population. This is particularly evident in the neonatal and infant mortality odds ratios where insignificant adjusted effects in the full sample conceal larger and statistically significant effects in the post-1975 group.

The analysis excluding the women of above median intelligence also reveals much stronger associations between literacy and child survival for all mortality rates except neonatal, and for low weight for age. In contrast to the post-1975 births analysis where the largest difference in odds ratio compared with the full sample was for neonatal mortality, among the women of low to average intelligence it was in child mortality where the greatest increase in odds ratio was observed.

Associations between literacy and the psycho-social factors

Before examining the associations between literacy and psycho-social factors it is important to note that virtually all of the latter are highly correlated with one another, as **Table 5** illustrates. Modernism, intelligence, locus of control and commitment to child survival are particularly strongly linked. Interestingly, it is in the scores for these four factors that the formal schooling and adult education groups differed most strikingly with those of the illiterate mothers (**Table 6**). The only factor for which there was a

Table 4. Crude and adjusted odds ratios (and confidence intervals) for mortality and malnutrition comparing the adult education group with the illiterate.

	All births		Excluding births before 1975		Excluding higher intelligence mothers ^a	
	Crude ^b	Adjusted ^c	Crude ^b	Adjusted ^c	Crude ^b	Adjusted ^c
<i>Mortality</i>						
Under five	1.23 (1.03-1.45)	1.23 (1.03-1.46)	1.38 (1.10-1.73)	1.39 (1.10-1.76)	1.38 (1.09-1.74)	1.38 (1.07-1.77)
Child (1-4 years)	1.33 (0.98-1.81)	1.36 (0.99-1.88)	1.30 (0.83-2.03)	1.43 (0.90-2.29)	1.70 (1.09-2.66)	1.82 (1.12-2.97)
Infant	1.20 (1.00-1.45)	1.20 (0.98-1.45)	1.43 (1.12-1.82)	1.39 (1.09-1.79)	1.31 (1.01-1.69)	1.31 (0.99-1.72)
Post-neonatal	1.16 (0.93-1.46)	1.17 (0.93-1.48)	1.33 (1.00-1.76)	1.30 (0.97-1.74)	1.27 (0.94-1.73)	1.33 (0.96-1.85)
Neonatal	1.29 (0.94-1.77)	1.27 (0.91-1.77)	1.72 (1.11-2.67)	1.72 (1.09-2.72)	1.34 (0.86-2.08)	1.29 (0.80-2.08)
<i>Malnutrition</i>						
Stunted	1.81 (1.19-2.75)	1.56 (1.00-2.46)			1.32 (0.77-2.28)	1.05 (0.56-1.98)
Under-weight	1.43 (0.68-3.02)	1.41 (0.54-3.63)			4.21 (1.10-16.08)	66.84 (1.33-3358.53)
Low MUAC for age	2.04 (1.54-2.71)	1.96 (1.45-2.64)			2.19 (1.47-3.27)	2.20 (1.39-3.48)

^a/ Excludes mothers above the median intelligence score of 6

^b/ Controlling only for age of mother, sex of child, year of birth (age of child for malnutrition), and birth order (mortality only).

^c/ Controlling in addition for water supply, sanitation, house construction, ownership of a refrigerator or car, employment, urban/rural residence, number and density of household residents, whether living with husband, travelling time to health facility, height and calf circumference of mother, and literacy of spouse and parents.

significant difference between the illiterate and formal schooling groups when there was not between the illiterate and the adult education group was social support. Future orientation did not appear to be related to education status at all.

Associations between the psycho-social factors and child health

Several of the psycho-social factors are strongly associated with mortality. In the full sample, locus of control and commitment to child survival are significantly associated with all mortality rates except neonatal for crude and adjusted models and even when the mother's literate status was included. This was also true for the post-1975 sample except that here, commitment to child survival was only significantly related to child and under five mortality. In fact it was child mortality with which both factors were most strongly associated. Modernism was consistently associated with under-five and post-neonatal mortality in the full sample. On the other hand, power within the home was not significantly associated with any mortality rate in either of the samples and future orientation was only significantly related to child mortality in the post-1975 sample, and then only for the adjusted model without the mothers' literate status.

The relationship with mortality, like that of literacy, was not entirely straight-forward. Again, the link between these factors and the risk of death tended to be much higher for the period from 1975 onwards than before 1975. The association between locus of control and the risk of dying was significantly stronger from 1975 on for under five and child mortality ($p < 0.05$), and almost so for infant mortality ($p = 0.05$). A stronger association with child mortality from 1975 was also observed for future orientation and power within the home ($p < 0.05$ in each case). From 1975 on, the association between social support and neonatal mortality was significantly stronger than before 1975 ($p < 0.01$), but paradoxically, the association with post-neonatal mortality was weaker from 1975 on ($p < 0.01$).

The only malnutrition odds ratios significant in the adjusted models (with and without controlling for maternal literate status) were for the association between social support

Table 5. Bivariate correlation coefficients for the psycho-social factors studied.

	Social Support	Power within the home	Modernism	Locus of control	Intelligence	Future orientation
Commitment to child survival	0.04	0.18***	0.43***	0.28***	0.24***	0.19***
Future orientation	0.03	0.03	0.19***	0.28***	0.12***	
Intelligence	0.13***	0.13***	0.34***	0.23***		
Locus of control	0.08**	0.11***	0.26***			
Modernism	0.10**	0.13***				
Power within the home	0.07*					

* p<0.05 ** p<0.01 ***p<0.001 p<0.0001

Table 6. Associations between psychosocial factors and maternal literacy.

Factor	Mean Psycho-social Scale Scores			Difference in mean score with adult education group	
	Adult education	Illiterate	Formal schooling	Illiterate	Formal schooling
Commitment to child survival	3.1	2.5	3.3	0.63****	-0.22
Future orientation	6.7	6.6	6.7	0.09	-0.02
Intelligence	7.0	5.1	7.5	1.86****	-0.54**
Locus of control	7.5	7.1	7.7	0.48****	-0.15
Modernism	3.1	2.6	3.6	0.51***	-0.48**
Power within the home	4.7	4.4	5.2	0.36*	-0.47**
Social Support	1.5	1.4	1.9	0.09	-0.40****

* p<0.05 ** p<0.01 *** p<0.001 **** p<0.00001

and the risk of stunting ($p < 0.05$ in both cases). Significant crude relationships of intelligence with stunting and low MUAC for age, and of modernism with stunting and low weight for age, lost significance after controlling in the adjusted models.

Attenuation of the education - child survival associations by adjusting for psycho-social factors.

The degree to which the associations between maternal literacy and child survival can be explained by the different psycho-social factors is shown in **Table 7**. If this association were fully explained by any variable then one would expect the relative risk for mortality comparing the adult education group with the illiterate to drop to one after including that factor in a logistic regression model. If it explains none of the association then the odds ratio should remain the same. The degree of attenuation (of log odds ratios) is expressed as a percentage beside the odds ratio obtained after including the factor(s) in the model. The table presents results for the full sample, and for the sub-sample of children born from 1975 on. Four of the seven factors, locus of control, intelligence, modernism and commitment to child survival, on their own explained 20% or more of the effect of literacy on one mortality measure or another, in at least one of the two analyses. For the full sample, commitment to child survival had the greatest explanatory power. For the sample excluding births before 1975, locus of control was the most important. Intelligence had little explanatory power for the full sample while modernism did not account for much of the effect of literacy on mortality of children born from 1975 on. None of the factors could explain any significant proportion of the effect of literacy on neonatal mortality.

There was some independence in the explanatory power of the different psychosocial factors. When all seven factors were included in the models, over a third of under-five mortality in the full sample, and over two fifths in the post-1975 sample was explained. In the full sample, the psycho-social factors were able to account for over half of the effect of literacy on post-neonatal mortality whilst for the post-1975 sample, almost three quarters of the effect was attributable to the psycho-social factors. Interestingly,

Table 7. Attenuation of the (log) odds ratio for the illiterate versus adult education groups by the inclusion of psycho-social factors in the logistic regression model.

Psycho-social factor(s) included in model	Under five mortality	Child mortality	Infant mortality	Post-neonatal mortality	Neonatal mortality
ALL BIRTHS					
None	1.23	1.36	1.20	1.17	1.27
Commitment	1.17 (25%)	1.26 (25%)	1.15 (23%)	1.11 (35%)	1.27 (2%)
Future orientation	1.23 (0%)	1.36 (0%)	1.20 (0%)	1.17 (0%)	1.28 (-1%)
Intelligence	1.19 (14%)	1.34 (5%)	1.17 (11%)	1.14 (17%)	1.28 (-1%)
Locus of control	1.18 (17%)	1.27 (23%)	1.16 (16%)	1.12 (28%)	1.29 (-5%)
Modernism	1.19 (16%)	1.31 (12%)	1.17 (14%)	1.13 (25%)	1.28 (-2%)
Power within the home	1.22 (4%)	1.36 (1%)	1.19 (3%)	1.17 (4%)	1.27 (1%)
Social support	1.23 (1%)	1.37 (-1%)	1.19 (1%)	1.17 (0%)	1.27 (1%)
All factors	1.13 (38%)	1.24 (32%)	1.12 (34%)	1.08 (54%)	1.29 (-5%)
Locus of control & commitment	1.14 (34%)	1.22 (37%)	1.13 (32%)	1.08 (50%)	1.28 (-2%)
BIRTHS FROM 1975 ON					
None	1.39	1.43	1.39	1.30	1.72
Commitment	1.31(17%)	1.26 (36%)	1.35 (10%)	1.27 (9%)	1.66 (6%)
Future orientation	1.39 (0%)	1.41 (4%)	1.39 (0%)	1.30 (0%)	1.74 (-1%)
Intelligence	1.29 (22%)	1.31 (26%)	1.34 (13%)	1.25 (14%)	1.69 (4%)
Locus of control	1.30 (21%)	1.22 (44%)	1.33 (15%)	1.23 (20%)	1.68 (4%)
Modernism	1.36 (7%)	1.36 (14%)	1.38 (4%)	1.27 (9%)	1.75 (-3%)
Power within the home	1.38 (3%)	1.33 (8%)	1.39 (1%)	1.30 (0%)	1.72 (0%)
Social support	1.38 (1%)	1.42 (4%)	1.39 (0%)	1.30 (0%)	1.72 (1%)
All factors	1.21 (42%)	1.10 (73%)	1.27 (28%)	1.19 (33%)	1.62 (11%)
Locus of control & commitment	1.26 (30%)	1.14 (63%)	1.30 (20%)	1.22 (23%)	1.64 (9%)
Intelligence, locus of control & commitment	1.21 (42%)	1.11 (71%)	1.28 (26%)	1.20 (31%)	1.65 (8%)
EXCLUDING WOMEN OF HIGHER INTELLIGENCE					
None	1.38	1.82	1.31	1.33	1.29
Commitment	1.36 (4%)	1.72 (10%)	1.32 (-2%)	1.30 (8%)	1.38 (-25%)
Future orientation	1.38 (-1%)	1.80 (2%)	1.33 (-5%)	1.34 (-3%)	1.32 (-9%)
Locus of control	1.34 (8%)	1.69 (13%)	1.29 (5%)	1.32 (3%)	1.27 (8%)
Modernism	1.35 (5%)	1.71 (10%)	1.31 (-1%)	1.30 (8%)	1.34 (-15%)
Power within the home	1.37 (1%)	1.82 (0%)	1.31 (1%)	1.33 (0%)	1.28 (3%)
Support	1.37 (2%)	1.79 (3%)	1.30 (2%)	1.32 (3%)	1.29 (-1%)
All factors	1.31 (15%)	1.65 (17%)	1.27 (13%)	1.23 (27%)	1.33 (-12%)

just two variables, locus of control and commitment to child survival, explained as much of the effect of literacy as all seven factors together for the full sample. For the survival of children born on or after 1975, three factors, locus of control, commitment to child survival and intelligence, accounted for as much of the association with maternal literacy as all seven factors combined.

An additional analysis of the attenuation of the maternal literacy - child survival association was made on the subsample of women of median or below median intelligence. In this analysis none of the factors could account for more than 15% of the maternal literacy association and only for post-neonatal mortality were all the psychosocial factors together able to explain more than 20% of it (results not shown). Similarly, analyses of the attenuation of the effect of maternal literacy on the risk of malnutrition were unable to detect significant explanatory power for any of the psychosocial factors (results not shown).

Discussion

By taking advantage of what was almost a natural experiment, this study has identified a cohort of women who became literate exclusively through adult education. They are in almost every respect socially and economically similar to illiterate women from the same communities, and quite different in these respects from the women who became literate in the 'normal' manner by attending school as young girls. The one major difference between them was in the proportion of their mothers who were literate. Whether these women's mothers directly helped some of the women to learn to read and write, or whether it merely encouraged them to make more effort is difficult to know but parental literacy did not itself greatly affect the other findings from the study.

In measuring mortality risks in the offspring of this cohort, and in matched illiterate and school-attending control groups, the importance of matching on age was highlighted by the marked increase in children's survival chances that has occurred in Nicaragua over

the last twenty years. That this fall has been registered in each of the education groups suggests that literacy itself does not entirely explain the reduction in mortality rates from the mid-1970s reported by Sandiford *et al* (1991). Interestingly, this mortality transition appears to have occurred in all three of the education groups, but most strikingly in the adult education group.

The differences in mortality rates between the adult education group and the illiterate increase greatly from 1975 on. This pre-dates the acquisition of literacy in the women of the former group and therefore cannot be attributed to it. If it were the acquisition of literacy that improves children's survival then one would have expected no association with literacy before 1980 and, possibly, a weakening association thereafter. Thus Das Gupta (1990) may be right that education is an endogenous correlate of variation in innate maternal abilities. The fact that education could not explain Nicaragua's breakthrough in child survival, despite being strongly associated with mortality also makes one query the direction of causality in this association. In other countries too, it has been difficult to attribute mortality decline to education (Hobcraft, 1993). In the case of Malaysia, DaVanzo and Habicht (1986) found a substantial positive effect of maternal education on survival was largely offset by the negative effect of decreases in breastfeeding, leaving most of the mortality decline from 1946 to 1975 unexplained. An alternative explanation, that some of the deaths of children born before 1975 were omitted, and that the chance of being omitted was greater for illiterate mothers than others, does not seem likely given the relatively high infant to under five mortality rate ratios compared with the Coale and Demeny West model of mortality.

The third explanation is based on previous analyses of the trend in infant and child mortality rates in Nicaragua which demonstrated that the period of rapid decline which began in the mid-seventies was mainly attributable to an increase in access to primary health care facilities (Sandiford *et al* 1991). It is plausible that the effects of education, or its psycho-social correlates, are mediated through the use of health services and therefore increases in access to such services widen the differences between education groups, especially for neonatal mortality where access to health services is of such

critical importance. This would also explain Preston and Haines' (1991) failure to detect an association between maternal education and child survival in American society at the turn of the century, where access to health care was either limited to the wealthier sections of society or where the services that did exist were simply not very effective at improving children's survival chances.

Given the difficulties faced in measuring psycho-social factors, it is perhaps surprising how strongly many of them were associated with education, mortality or both, and even more astounding that they were able to explain some of the education - mortality link. This is particularly true for commitment to child survival and locus of control where the reliability of the scales was not very high.

There is a legitimate concern that the high correlations between the scales might suggest that they are all actually measuring the same thing in different ways and that this is what affects mortality. However, the marked difference in the explanatory power of the different scales, and the fact that some were associated with education but not mortality and vice versa, can be cited as support for the view that they are actually measuring distinct psycho-social characteristics.

The significant differences in scores for modernism, commitment to child survival, intelligence and locus of control between the cohorts could (as suggested in the introduction) either be because education strengthens these attributes or because they form part of the psychological make-up of women who succeed in becoming literate. With intelligence for example, it is obvious that the ability to learn how to read and write in settings where opportunities to acquire these skills are limited, will inevitably be dependant upon cognitive endowments. On the other hand, the absence of differences between the illiterate and adult education groups for social support and future orientation were unexpected. Since there were large differences in the social support scores between the formal schooling and illiterate groups it would seem that this factor depends more on economic factors than education. In the case of future orientation it appears that it is the construct itself which is flawed. Probably, decisions relating to

future versus present consumption are highly context-specific or depend too greatly upon the family's current economic position.

Among the psycho-social correlates with mortality, locus of control stands out as the one factor which is significant in the crude and adjusted models both for all births and for the sub-sample born from 1975 on. Modernism and commitment to child survival were also important but to a lesser extent in the sample which excluded births before 1975. The relationship between intelligence and mortality was surprisingly weak given its close correlation with modernism, commitment to child survival and locus of control. The only statistically significant adjusted odds ratio was for the association between intelligence and under five mortality in the sub-sample of post-1975 births, and even this lost significance after controlling for the mother's education group. Since intelligence was measured with a higher degree of reliability than modernism, locus of control and commitment to child survival, it seems unlikely that the latter are serving in any way as a proxy for the mother's cognitive ability.

Power within the home and future orientation were found to be poor predictors of mortality, just as they were not strongly associated with the mother's education. In the case of power within the home, culture-specific factors may play a major role. Women in Nicaraguan society generally have greater autonomy than their Asian counterparts and this is reflected in the relatively strong preference of mothers for daughters detected in this study (results not shown). Indeed, it can even be argued that Nicaragua exhibits certain matrilineal characteristics. Female heads of household are common and women often earn a significant proportion of the family income. The absence of any link between decision-making power in the home and mortality is particularly interesting given the strong association between locus of control and mortality. Perhaps in Nicaragua, if not elsewhere, the power required in order to prevent childhood death is held by most women but not always recognised, so that it is the mother's perception of her power and not necessarily her actual power that determines her children's survival chances. Of course where a mother has little real power she is less likely to have an internal locus of control as the significant positive correlation between these two factors

implies, but it is worth noting that power within the home is also correlated with the other three factors that appear to have some bearing on mortality, viz. intelligence, commitment to child survival and modernism.

The risk of malnutrition does not seem to be as strongly predicted by psycho-social factors as the risk of mortality. Previous analyses from this study have suggested that though education is significantly linked with both mortality and malnutrition, the actual pathways may be quite distinct (Sandiford *et al*, 1995). These latest results support this contention. Although the adult education group have a significantly lower risk of stunting and low MUAC for age (and even of being under-weight for age in women of average to low intelligence), psycho-social factors were unable to explain these relationships or even to predict malnutrition in their own right (with the dubious exception of social support). A plausible interpretation of this finding is that while the literacy-survival link may be dependant upon differences in efficacy and frequency of utilization of health services, the link between education and nutritional status is the result of domestic child care practices such as breastfeeding and weaning.

However, the psycho-social factors did not offer any convincing explanation of the literacy effect on neonatal mortality either, despite the highly significant effect for the children born from 1975 on. If the literacy-survival association is explained psycho-social influences mediated through the use of health services, then one would have expected the higher neonatal mortality among illiterate mothers to have also been explained in this way, given the importance of health services in deliveries and perinatal care. But neonatal mortality was unrelated to whether the child was born in a hospital or at home (results not shown). Given the importance of low birth weight in neonatal mortality, the effect of literacy on neonatal survival may follow the same pathway as that of the other nutritional outcomes which were not closely related to psycho-social factors either, and which seems to be distinct from the pathway for survival at later ages where health services play a greater role.

The potential importance of commitment to child survival as an explanation for the association of literacy with child survival has been queried because presumed differences in child valuation based on birth order, spacing and gender have not tended to be correlated with mortality rates (Cleland, 1990). Yet in this study commitment to child survival was significantly associated with both schooling and child health outcomes, and it was one of the three factors which most attenuated the literacy - survival association. Its direct relationship with child survival and its ability to account for the some of the latter's association with literacy, therefore gives support to Scheper-Hughes' (1992) contention that the value a mother places on the health and welfare of her children is not constant and her commitment to their survival not absolute.

Probably the most notable finding from this investigation was that two or three psychosocial factors were able to account for a significant proportion of the apparent effect of literacy on child survival. Had it been possible to measure these variables more accurately (and this remains a challenge for future research), then an even greater proportion of the effect might have been accounted for. In order of importance, these factors were locus of control, commitment to child survival and intelligence. One might interpret the results to mean simply that mothers who place a high value on the survival of their children, and that believe they have the power to ensure their survival, will generally experience lower mortality in their offspring. In addition, these mothers will tend to be literate and/or intelligent.

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APPENDIX I: Items in the Psycho-social Scales

Note that the Intelligence Scale, set A_B of Raven's Coloured Progressive Matrices is not included here.

Commitment to Child Survival Scale

1. Do you think that it is good to have several children just in case one dies?
2. You should have children to enjoy or so that they look after you in old age?
3. When you know that a child is going to die, it is better to dedicate your efforts to the ones who remain?
4. You need to have children to enjoy yourself or so that they work and help the family?
5. If a mother puts all her efforts into caring for a sick child, she can risk the health of her remaining children?
6. The illnesses of ones children come from the surroundings or from negligence?
7. Is it true that sometimes God takes away a child in order to help very poor families?
8. What is more important, to have obedient children or educated children?

Locus of Control Scale

1. Are the majority of the problems that one faces are due to the will of God, to one's own mistakes, or to the mistakes of others?
2. If someone has no friends is it because s/he doesn't make an effort or because s/he has a bad character?
3. To get money, does one need luck or just to work hard?
4. In the development of your community can you take part or is it just the leaders who can take part?
5. When a person is run over by a vehicle, is it due to carelessness on their part, bad driving, or the will of God?

6. Do you feel that what happens in life is under your own control or under the control of others?
7. Can you cure some of your children's illnesses or do you always have to take them to someone who knows?
8. If you were to go to the health centre and they tell you that you cannot be seen until tomorrow, would you look for care elsewhere or would you go back the following day?
9. Having good health depends mostly on luck or does it depend on how well you look after yourself?
10. When things go badly is it always because of the mistakes one makes?

Orientation Towards the Future / Time Preference Scale

1. What is better, to prepare oneself now for old age or to enjoy the present?
2. If a child is doing badly at school, is it better to take him out so that he can help out in the house?
3. Is it better to solve problems only once they occur?
4. What would you prefer to have, a tray of eggs or two live chickens?
5. Is it better to make sacrifices thinking of the future or to enjoy life while you are young?
6. If you won the lottery, would you prefer to get all of the money at once or a greater quantity paid over a period of five years?
7. Suppose that you son or daughter was offered two jobs: one in which he would earn 1500 *cordobas* a month for at least two years and another where he would earn only 400 *cordobas* a month in a permanent job. What job would you recommend that he take?
8. Suppose that you got some extra money for Christmas. Would you invest it in buying food for the coming year or in a good Christmas dinner?

Social Support Scale

Do you have (many or few)...

1. ...opportunities to go out with other people?
2. ...people for whom it matter what happens to you?
3. ...opportunities to speak with some about family problems?
4. ...people who could give you support in case of need?
5. ...people who give you love and affection?

Modernism Scale

1. If one tries to make changes do things generally turn out worse?
2. Is it better to try new things or to always use old things?
3. Are older people always right or are young people sometimes right?
4. Is it the woman's job to clean the house or is it also the man's duty?
5. Do you have to be older to know a lot?
6. Is it better to marry than to live together with one's partner?
7. Do you believe that it is acceptable that a woman has sexual relations before marriage?
8. Is it always the woman's duty to cook and wash clothes for her husband?
9. If the husband has work is it the woman's duty to stay at home?
10. Are there certain diseases that doctors cannot cure but which *sobadoras* can?
11. Do you believe that there are people who can do evil with witchcraft?

Decision-making power within the Home

Do you have to ask permission from someone in order to...

1. ...take your child to a health centre?
2. ...take your child to a private doctor?
3. ...buy medicines?

4. ...visit a (female) friend living outside your community?
5. ...spend a night in the house of a (female) friend?
6. Who do your children have to ask permission from in order to go out with their friends?
7. Who brings the money into the household?
8. Who's name is the house in?
9. Who decides to send or remove your children from school?
10. Who give orders in your household?

APPENDIX II: Reliability of the Psycho-social Scales

Table A presents the Cronbach alpha statistics for each of the scales as measured in the final pilot and in the study proper. It also shows the maximum reliability that could be achieved by deleting items with a low correlation to the overall scale. Only the Commitment to Child Survival scale and to a lesser extent the Locus of Control Scale could be significantly improved by dropping some of the original items. Since these differences were for the most part small and of uncertain significance, it was decided to use the original rather than the abbreviated scales in the subsequent analyses.

Table A. Reliability statistics (Cronbach alpha) for the psycho-social scales in the final pilot and the study proper.

	Final Pilot				Study Proper			
	All items		Maximum reliability		All items		Maximum reliability	
	Items	α	Items	α	Items	α	Items	α
Locus of control	10	0.46	6	0.59	10	0.40	7	0.48
Commitment to child survival	8	0.27	3	0.58	8	0.41	6	0.53
Time preference	8	0.43	3	0.68	8	0.42	8	0.42
Social support	5	0.56	4	0.74	5	0.74	4	0.75
Raven's CPM	12	0.66	3	0.80	12	0.68	10	0.69
Power	10	0.51	2	0.95	10	0.82	10	0.82
Modernism	11	0.30	2	0.76	11	0.56	9	0.59

APPENDIX III: Data Processing and Analysis

Analyses were restricted to records with a full set of data on all potential confounding variables and effect modifiers except for: travelling time to the nearest health facility where for 29 cases the time was imputed from the median for other families in the same community or suburb; and the literacy of husband, mother and father where “don’t knows” were treated as a separate category in order to retain as many cases for the analysis as possible. A full set of psycho-social scores and data on potential confounders was available for 1175 of the 1294 women interviewed (6958 of the 7475 children in birth histories and 1929 of the 2078 children measured).

Differences in means between the education groups were compared using the Student’s t test while differences in proportions were assessed for statistical significance using the Yates-corrected chi square test. Mortality rates were calculated as survival probabilities with the denominator of the under five mortality rates including the number of living children aged five or more, plus all infant and child deaths in children who, had they survived, would have been aged five or more at the time of the survey. Those who were, or would have been less than five years old at the time of the interview were censored from under five mortality rates. Similarly the denominator for the neonatal and post-neonatal mortality rates includes all children who were (or would have been) aged one year or more at the time of the survey plus those who died within the period in question. *Epi Info 6* was used to determine crude and Mantel-Haenszel weighted relative risks (with stratified samples) for mortality comparing the illiterate and formal schooling education cohorts with the adult education group. These were tested for significance using the Mantel-Haenszel Chi-squared statistic and Greenland Robins confidence limits calculated. Differences in mean psycho-social scale scores between the literacy groups were computed and the t test for independent samples was used to assess whether these were statistically significant.

A danger in this type of study is posed by the possibility that bias in the relative risk estimates might have been introduced by mothers omitting the deaths of some children

in their birth histories. If omission of deaths did occur, it is probable that these were concentrated in children born many years ago, and they tended to be neonatal or infant deaths that were omitted rather than deaths after the first year of life. If, in addition, there were a greater tendency for illiterate mothers to omit deaths (as would seem plausible) then any relative survival advantage in the offspring of literate mothers would be underestimated in those earlier years, and particularly for neonatal and infant mortality rates. This possibility was explored by comparing the ratio of infant mortality to under five mortality for each education group with the ratio predicted from the Coale and Demeny (West) model mortality tables (Coale and Demeny, 1966). The observed ratios were all generally higher than those based on the model mortality tables except for the pre-1975 period in the adult education group where they were similar. Since one would expect the ratio to be lower than those of the model mortality tables if there were omission of deaths at young ages, it would appear that any recall bias in the study is relatively small, and if anything, would tend to underestimate mortality in the adult education group prior to 1975.

ANNEX I: Sandiford P, Coyle E and Davey Smith G. Why Nicaraguan Children Survive: Moving Beyond Scenario Thinking. *Links: Health and Development Review*, pp 11-12, Fall 1991.

This was a response to the critique of Paper I by Tony Dajer published in the Spring 1991 issue of *Links*. Two further critiques of this response, by Tony Dajer and Richard Garfield, were published in the same issue. Although this is not presented as one of the papers forming the main body of the submitted PhD, it is included as an annex since it provides the reader with a flavour for the political controversy which was generated by the original article.

Why Nicaraguan Children Survive: Moving Beyond Scenario Thinking

Peter Sandiford, Edward Coyle and George Davey Smith

We are grateful to Tony Dajer for assessing the wider implications of our study of the trend in Nicaraguan infant mortality and its possible explanations (*Links*, Spring 1991, “Why Nicaraguan Children Survive”). His article raises two points to which we wish to respond. First, he questions the factors we cite to explain the fall in infant mortality and second, he considers the wider implications of our conclusions.

Determining the factors which contributed to the infant mortality fall is necessarily *post hoc* speculation. The attribution of efficacy to specific factors depends on using available data to test plausible explanations. As Dajer recognizes, this is a complex task.

Once one accepts that child mortality began to fall sharply in the mid-70s, as Dajer now does, the intriguing question for health researchers is why this should have occurred at a time of economic slump, low intensity civil disturbance and under a government which gave a low priority to the social sector.

We did not claim, as Dajer suggests, “that Managua’s earthquake did what the US government tried unsuccessfully to do for twenty years: get doctors into the countryside.” Rather, our belief is that a combination of events led to a sudden shift in the allocation of health resources from hospital-based care in the capital city toward ambulatory care throughout the country, and that this process was continued and extended under the Sandinista government. This interpretation was arrived at by systematically eliminating other likely explanations - not a desire to glorify the achievements of biomedicine.

Dajer rejects our formulation but provides no coherent alternative explanation for the decline in infant mortality. Let us briefly address the “large holes” that he alleges destroy our argument.

His assertion that “AID funded clinics ... are notoriously ineffective” is simplistic. We accept that AID in the US and the Overseas Development Administration in the UK establish bilateral development projects within overtly political guidelines. The implementation of these projects however, is often well-advised by epidemiologists, population scientists and public health specialists. There is a danger of dismissing effective public health interventions because of disagreement or distrust of the general political aims of the funding agency. The WHO (despite rhetorical nods in the opposite direction) generally acts as an arm of international capital, yet its small-pox eradication campaign was successful. The AID evaluation team did find serious limitations within the health services in 1973, but we wonder what they would have concluded had they repeated their exercise in 1983.

Surprisingly, Dajer assumes that our reference to health professionals refers only to doctors. In fact the number of nurses in Nicaragua grew far more rapidly than the number of doctors and many of them probably staffed non-hospital health facilities (in urban as well as rural areas). While he rightly questions the value of traditionally-trained doctors, we are glad he reports “having lances many a gluteal abscess” himself.

The average number of recorded medical consultations in the years 1975-1978 was 45% higher than in 1970-1973. This fits well with our hypothesis, although one must remain skeptical of the data quality. That Nicaraguans are quick to avail themselves of orthodox health services when these are provided free at the point of delivery has been adequately demonstrated by several authors including Garfield and Williams (*Health and Revolution*, Oxfam UK, 1989). It also explains Nicaraguans’ tremendously detailed knowledge of pharmaceuticals that our studies of Nicaraguan health belief systems have revealed.

The second question Dajer raises is more challenging. Why was the announcement of a 33% decrease in the infant mortality rate so important to the “health Left”? Neither the Nicaraguan revolution, nor any other, was fought to reduce infant mortality. Revolutions and elections are fought and won primarily on programs for political and economic reform. These programs rarely provide detailed policy in specific areas such as health.

In Nicaragua, the policy priorities of the Government of National Reconstruction were stated explicitly as defense, production, education and health - in that order (Donahue J.M. *The Nicaraguan Revolution in Health*, Massachusetts: Bergin & Garvey, pp. 24-25, 1986). To hold any political process to an indicator of health outcome, no matter how sought after, is technically incompetent and politically naïve. In fact, the importance of the infant mortality rate within Nicaragua never gained the same prominence as it did within the international solidarity movement.

Why, then, did solidarity movements focus on this statistic rather than one in, say, the economic field? First, there was little good news to report from the economy. Second, health is not controversial, being seen as a good thing although not understood in its details by members of international solidarity movements. As such, it is a unifying and immediate issue for solidarity movements which avoids provoking factional dissent from within. It is, of course, also an easier issue to promote and obtain funds for than more nakedly political issues.

The marketing of the health issue in different solidarity campaigns also seems dependent less of the Nicaraguan reality than on the specific agendas of activists. In the UK, where a medically dominated National Health Service has been in existence since 1948, activists promote a non-professional, demedicalised public health. The UK solidarity movement emphasized community health workers and non-medical interventions, the success of which may have been greater at the rhetorical than the implementational level. From our limited reading of US solidarity publications, on the other hand, the emphasis seems to be upon the provision of professional health services. The contrast between such

provision by a poor and underdeveloped country with the lack of a national health service in the richest country in the world is indeed too attractive a paradox not to be publicized. The case of Cuba is exploited in a similar manner.

The desire to present positive information is naturally high in solidarity movements. This leads to selective reporting not only of data, but of program emphasis. Reading UK solidarity pamphlets, the impression gained is that investment in health was primarily through non-professional community worker programs, even though Nicaraguan health ministry policy remained overwhelmingly dominated by programs to train professional workers.

This phenomenon is not new. Consider books such as Newsholme and Kingsbury's *Red Medicine: Socialized Health in Soviet Russia* (1934), Sigerist's *Socialised Medicine in the Soviet Union* (1937) or the Webbs' *Soviet Communism: A New Civilization* (1936), in the light of later knowledge about this period.

What is remarkable about the Nicaraguan situation is how stable health policy actually has been and remains despite radical reorientations of political direction of the state. For example, see the interview with Chamorro's health minister Ernesto Salmerón in the Spring issue of *Links*. Health policy in Nicaragua was not substantially altered as a consequence of the revolution. In fact the health policy in 1979 was essentially a revival of the 1976 second health plan. It is interesting to note that this revised health plan specifically omitted the training of non professional health workers and in particular traditional birth attendants. Self-organization of this group - encouraged by the revolutionary process - managed to extend the agenda in this area. This process should perhaps remind us that true emancipation of the oppressed is only possible through their own activity.

The continuity of health policy despite radical changes in internal politics points to determinants which lie in the supranational arena. Health policy for developing countries is in many ways not defined by national political parties, but by the needs of capital,

mediated through international agencies such as WHO and UNICEF. Where then, does this leave the health Left? If there is continuity in policy irrespective of government ideology, what relevant input can activists contribute? Does it mean that health policy ought to be a no go area for *politicos*, determined solely by technically competent “experts”? Emphatically no!

Health policy formulation should (and does) occur in an explicitly political environment and must not be left to either medical or public health experts. There is certainly a role for activists in contributing to setting the objectives of the system and defining the agenda. In developing countries much of the knowledge to improve health is already at hand, but what is often absent is implementation. The Left clearly has an important role in ensuring that commitments to improve health go beyond rhetoric.

However, for the Left to be effective it needs to make its political interventions from a technically competent base, and this requires it to mature its knowledge of the subject area. Political slogans for change must be underpinned by a competent grasp of technical and empirical issues, as is recognized by Dajer. Lack of this understanding can lead to inaccurate attribution of change as appears to have occurred in the case of Nicaragua’s infant mortality rate.

It is one thing for politicians to claim that infant mortality has fallen; it is quite another for the Left to substitute propaganda for rigorously investigated scientific fact. Failure to scrutinize such rhetoric at the outset can only lead to disillusionment in the long run. Perhaps activists should treat apparent successes with the same critical attitude as is correctly brought to consideration of the failures of health policy.

ANNEX II: Sandiford P and Paulin F. Use of mid-upper-arm circumference for nutritional screening of refugees [letter]. *Lancet*, 1995; **345**(8957):1120.

This letter I wrote with Dr Frank Paulin and published in the *Lancet*, is included as an annex because it supports my use of the mid-upper arm circumference as an indicator of acute nutritional stress and risk of mortality. The data are from a household survey conducted by a GTZ funded health project in Machinga District, Malawi during the famine of 1992-3.

Dear Sir,

Bern and Nathanail (March 11, p 631) argue that (mid-upper-arm circumference) MUAC does not provide an accurate picture of the acute malnutrition rate in emergency settings and that a reliable indication of the nutritional status of the population requires a weight-for-height survey. They base their assertions on the widely held belief that weight-for-height offers the best indicator of acute malnutrition, and demonstrate that the two indicators identify quite different sets of children.

The proper way to assess a nutritional indicator to be used in emergencies however, is to determine how well it identifies children at increased risk of the adverse functional consequences of malnutrition. A number of studies have looked at the ability of different anthropometric indicators to predict mortality and have reached quite different conclusions from those of Bern and Nathanail. Of 3 studies which have assessed different anthropometric indicators in terms of their association with mortality, MUAC or MUAC for age was consistently one of the best, while weight for height consistently one the worst.^{1,2,3,4}

One explanation for the low predictive value of weight for height in situations of acute nutritional hazard is that it may only detect marasmus. With kwashiorkor, fluid retention can mask what would otherwise be low weight for height. This limitation was very obvious in data from a population-based survey of 900 children living in Machinga District (Malawi) during the 1992-3 famine. MUAC proved to have much better sensitivity and specificity as a test for oedema than weight for height or even weight for age (figure). Another disadvantage of the weight for height indicator is that it requires two measurements, each of which has its own margin of error and these errors are multiplied when the index is calculated, undermining its precision relative to single measurement indices such as the MUAC.

Weight for height was originally advocated for theoretical reasons. If, however, its predictive value is limited then, it is the use of weight for height, not mid-upper-arm

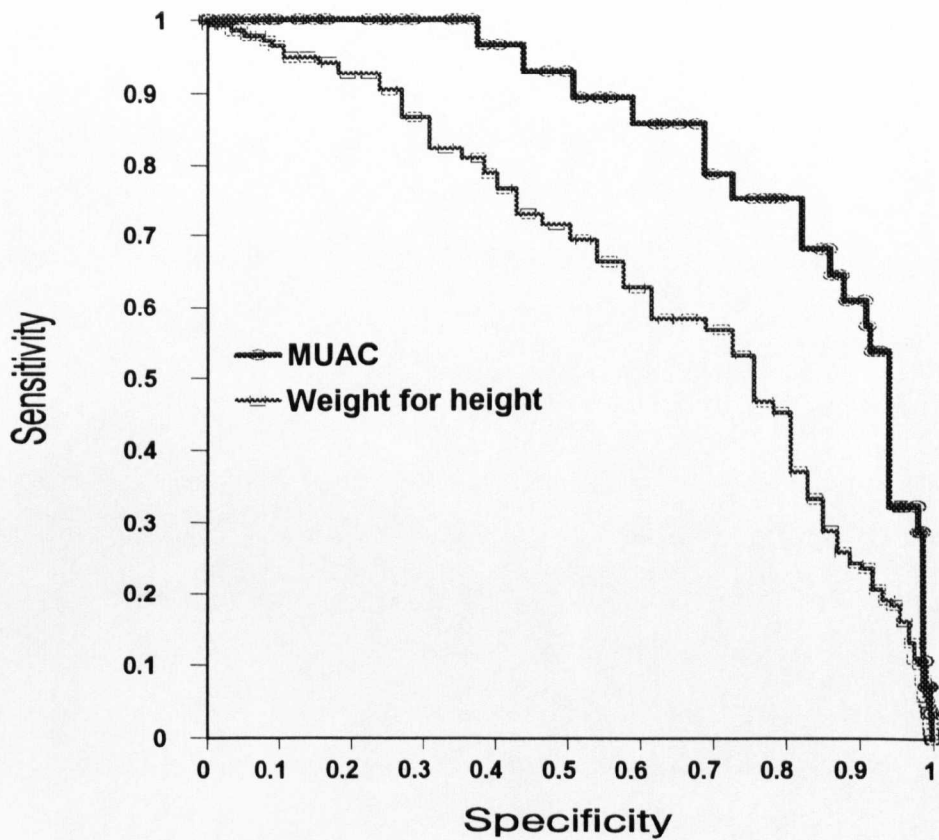
circumference which needs to be reassessed for screening nutritionally compromised populations.

P. Sandiford

F. H. Paulin

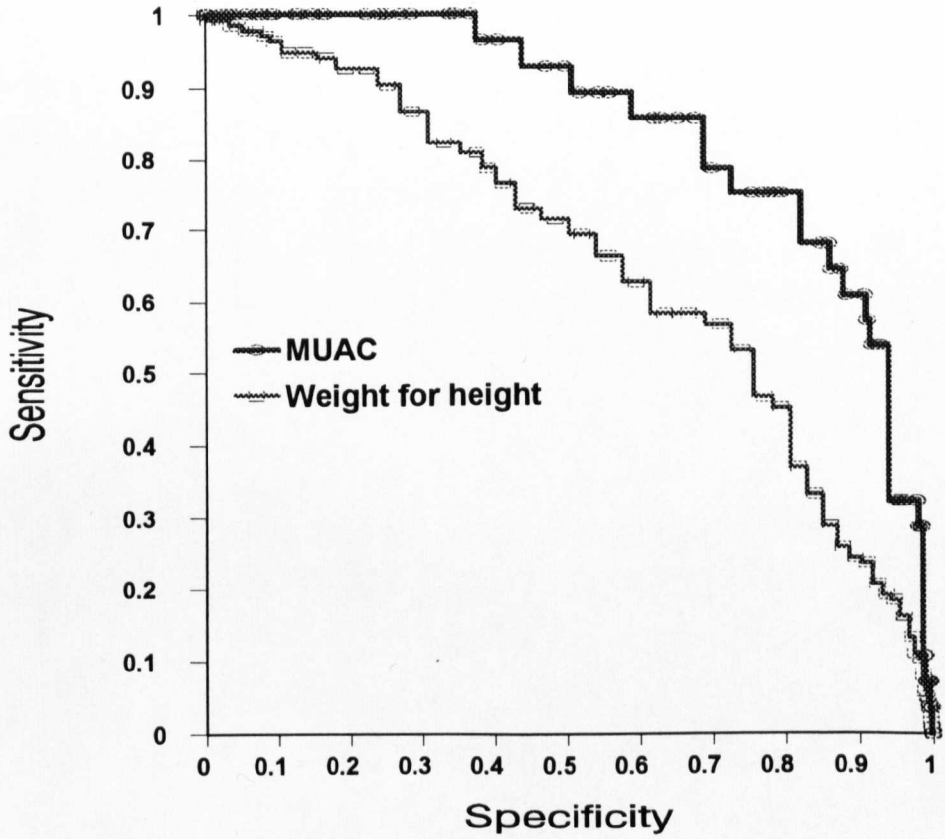
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Sensitivity/specificity of arm circumference versus weight for height in detecting kwashiorkor



Machinga District, Malawi (1992)

**Sensitivity/specificity of arm circumference
versus weight for height in detecting kwashiorkor**



Machinga District, Malawi (1992)